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REVIEW ARTICLE

Mental health and wellbeing of undergraduate students in engineering: A systematic literature review

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Abstract

Background: The wellbeing of college students today is at risk because of rising occurrences of mental health issues in higher education. Concurrently, undergraduate students perceive engineering courses and programs to be among the most arduous, and least welcoming and accommodating, in higher education. Although research related to mental health and wellbeing (MHW) in engineering is growing, a systematic review of this research has yet to be conducted.

Purpose: This systematic literature review identifies and synthesizes empirical scholarship related to the MHW of undergraduate engineering students.

Scope/Method: Specified search terms and inclusion criteria were used to identify 34 empirical studies related to engineering undergraduates' MHW. Content and qualitative thematic analyses were conducted to characterize and synthesize trends in research quality and outcomes across studies.

Results: Undergraduate engineering students experience a variety of mental health issues that negatively affect their experiences in engineering education. Stress is the most prevalent mental health issue identified; anxiety, depression, and post-traumatic stress disorder (PTSD) are also reported. Heavy academic workloads, sleep issues, and the nature of engineering education culture are identified as impediments to MHW in engineering education.

Conclusions: Although MHW in engineering is a growing area of research internationally, current MHW research in engineering is nascent and focused on the characterization of student mental health issues. Researchers underutilize qualitative and mixed-methods approaches, longitudinal and experimental designs, guiding frameworks, and robust sampling techniques. Academic and mindfulness interventions, as well as the use of mental wellness constructs from positive psychology, show promise for supporting MHW in engineering.

KEYWORDS

mental health, wellbeing, engineering education, undergraduates

1 | INTRODUCTION

It is known that the onset of mental health issues peaks at the time when traditional-age students pass through their undergraduate education (Kessler et al., 2008; Slade et al., 2009). The occurrence of a mental health issue is characterized by a psychological state of dysfunction that results in distress and deviance from the typical behavioral norms (Worthy et al., 2020). Mental health issues not only threaten the overall wellbeing of college students but also negatively affect students' academic success and retention (Bruffaerts et al., 2018). A recent study conducted across 373 college campuses between 2013 and 2021 suggests that approximately 60% of college students across the nation meet diagnostic criteria for having at least one mental health issue (Lipson et al., 2022). As the prevalence of stress, depression, and even suicidal ideation and action rises among college students (Gallagher, 2008), higher educational institutions are obligated to identify and implement effective approaches for cultivating mental health and wellbeing (MHW) within their student bodies (Flatt, 2013).

In recent years, a growing awareness of the declining state of college students' MHW has catalyzed an increase in mental health research that is conducted in higher education (Deziel et al., 2013). This increase is evidenced by the prevalence of several research reviews in higher education on mental health (e.g., Fernandez et al. (2016), Nair and Otaki (2021), and Urbina-Garcia (2020)). The profound implications of the COVID-19 pandemic helped in accelerating this trend; researchers and practitioners now urgently call for effective psychological interventions and prevention plans (Son et al., 2020) as well as improvements in student accessibility to professional mental health services in higher education. Recently, MHW research has extended into post-secondary education contexts, such as engineering education (Korsten et al., 2021).

Engineering has earned a (dis)reputation as one of the most stressful disciplines of study in higher education (Danowitz & Beddoes, 2018). Engineering is considered so demanding, in fact, that engineering students often accept poor mental health as an intrinsic characteristic of life in college (Jensen & Cross, 2019). Importantly, research has also shown that engineering students (i) perceive the condition of their MHW to be worse than that of undergraduate students in other majors (Foster & Spencer, 2003), and (ii) seek psychological support at lower rates than non-engineering majors do (Lipson et al., 2016). Yet, despite the growing focus on MHW in higher education generally and engineering education specifically, research related to the MHW of undergraduate engineering students has not been subject of a comprehensive empirical literature review.

2 | BACKGROUND

It is widely understood that the existing psychological research related to human MHW strongly prefers theoretical constructs of mental illness over those related to health and wellbeing (Slade, 2010). Historically, mental health research has stemmed from a medical model of health and illness wherein the absence of mental illness is considered commensurate with the state of mental wellbeing or wellness (Greenspoon & Saklofske, 2001; Slade, 2010). Therefore, prior researchers who have investigated MHW were more likely to employ deficit-based approaches that seek to characterize the presence and treatment of mental health problems within a population. Alternatively, less attention has been given to understanding the positive aspects of mental health by characterizing and cultivating human mental strengths, which can act as prevention mechanisms for mental health problems within the population (Asghar & Minichiello, 2022b; Slade, 2010).

Positive or assets-based mental health research and practice is rooted in positive psychology, which is defined as the "scientific study of positive experiences and positive individual traits" (i.e., human mental strengths) (Lee Duckworth et al., 2005, p. 630). Positive psychology emerged as a distinct sub-field of traditional psychology at the start of the 21st century (Lee Duckworth et al., 2005). Positive psychological perspectives extend beyond diagnoses of mental illnesses by conceptualizing the existence of positive mental health characterized by mental health strengths such as hope, optimism, and resilience. Moreover, positive psychologists consider these human strengths to be important components of an overall healthy human psyche. Therefore, throughout this article, we use the term "mental health and wellbeing (MHW)," adapted by Asghar and Minichiello (2022b) from Brown (2016, p. 66), to describe our perspective, which considers both the negative (i.e., mental illness) and positive (i.e., mental strengths) aspects of human mental health.

3 | PURPOSE

To our knowledge, the existing research related to MHW in undergraduate engineering education is yet to be systematically synthesized. Therefore, the purpose of this study was to investigate the current state of empirical scholarship

related to the MHW of undergraduate engineering students using the systematic literature review (SLR) methodology. By identifying and synthesizing this literature, we not only gained new understandings of the current trends related to the MHW of engineering students but also identified gaps in the current literature. The current work also supports higher education policy change and/or development by helping to shift attention and resources toward improving MHW among all students and facilitating positive cultural change in this regard.

4 | RESEARCHER POSITIONALITY

In describing our positionality as researchers, we provide a context for the knowledge we produce for the field of engineering education (Slaton & Pawley, 2018) and support transparency in our work for the purpose of gaining the trust of the research community (Hampton et al., 2021). The first author is a native of Pakistan who is currently a doctoral student in engineering education in the United States. He has an academic background that includes post-secondary degree attainment in engineering and also in both clinical and educational psychology. His clinical training, which took place at a public mental health facility in Pakistan, provided him with substantial opportunities to work closely with diverse people medically diagnosed with mental illnesses. These experiences were grounded in a traditional medical model of psychological health, one that identifies mental wellness as solely the state of a lack of mental illness. While conducting research for this systematic review, the first author came across a variety of sources from engineering and other disciplines that have investigated mental health from a wellness, rather than an illness, perspective. Exposure to these resources has spurred him to broaden his understanding of mental health and to make a personal paradigm shift toward alternative positive psychological perspectives of MHW.

The second author is a White woman who was formally trained as a mechanical engineer, engineering instructor, and education researcher in the United States. She is currently employed as an associate professor of engineering education in a college of engineering at a predominantly and historically White land-grant institution located in the western United States. She has taught undergraduate engineering science courses for well over a decade. Her engineering teaching experiences include some pivotal moments engaged in emergency remote teaching during the COVID-19 pandemic. Over time and particularly during these pandemic-related experiences, the she has witnessed and engaged with increasing numbers of engineering students suffering under multiple pressures (e.g., time, financial, academic performance, familial, health, and wellness) that converge within the context of the 4-year undergraduate engineering program. These experiences have motivated her to work to understand the condition of MHW in engineering and to adopt and/or assist in developing new instructional strategies able to relieve the burden of stress and anxiety felt by many of today's undergraduate engineering students.

The third author is an Asian male and a Lecturer in the Department of Psychology at an institution of higher education located in Pakistan. Apart from being an instructor, he is an experienced researcher in the fields of child psychopathology, developmental psychopathology, and intervention and prevention sciences. As a clinical psychologist, he believes that students need both mental and physical health and wellbeing to thrive in academic and social settings. His positionality in this research is informed by his professional experiences in clinical settings where he has worked with more students from engineering with mental health issues than from any other major field. These experiences have led him to explore MHW specifically within engineering education contexts.

5 | METHODOLOGY

As the field of engineering education has evolved over several decades, researchers in this field have successfully adopted and adapted research methodologies from other disciplines to examine important educational and social issues within the context of engineering education (Froyd et al., 2012; Lohmann & Froyd, 2010). The SLR methodology is an accountable, explicit, and rigorous review type (Gough et al., 2017), which was initially developed to guide informed decision making about medical interventions and diagnostic tests (Higgins et al., 2019). The appearance of published SLRs has since expanded into other fields that employ the SLR methodology to identify and synthesize existing findings on a specific research topic, to identify gaps that exist in the available literature, and to guide the direction of future research on a specific topic (Balaid et al., 2016; Borrego et al., 2014; Gopalakrishnan & Ganeshkumar, 2013; Green, 2005). The appearance of SLRs in engineering education research (EER) has grown substantially since Borrego et al. (2014) presented a strong rationale for their use in engineering education (cf. Asghar & Minichiello, 2022a).

To conduct this SLR, we employed a five-step procedure adapted from the process suggested by Borrego et al. (2014):

1. Decide to do a systematic review and formulate research questions;
2. Find and catalog research articles;
3. Critique and appraise research articles;
4. Synthesize the data; and
5. Address limitations.

5.1 | Deciding to do a systematic review and formulating research questions

Considering potential reasons for engaging in systematic review processes, SLRs are commonly conducted to describe the state of knowledge on a well-defined topic (Borrego et al., 2014; Petticrew & Roberts, 2008). Petticrew and Roberts (2008) add that systematic reviews are conducted "when a general overall picture of the evidence on a topic is needed to direct future research efforts" (p. 21). These two reasons drove our decision to conduct this systematic review. In this SLR, our goal was to describe the current state of scholarship related to MHW of undergraduate engineering students to provide what may be the first general picture of the empirical research in this area and to guide future research in this area. To serve these two purposes, three research questions (RQs) were developed and used to guide this work:

> **RQ1.** (Critical appraisal): What is the state of the research quality of empirical studies related to the mental health and wellbeing of undergraduate students in engineering?
>
> **RQ2.** (Scoping): What is the state of research practice of empirical studies related to the mental health and wellbeing of undergraduate students in engineering?
>
> **RQ3.** (Synthesis): What are the major findings of empirical studies related to the mental health and wellbeing of undergraduate students in engineering?

RQ1 relates to the critical appraisal, or a systematic assessment, of the included studies to evaluate their coherence with widely accepted norms related to high-quality research (Burls, 2014). RQ2 provides a scoping review, or overview, of the MHW issues and problems and potential causes or correlates, if any, investigated by the included studies. RQ3 provides a qualitative synthesis of the findings of the included studies.

5.2 | Finding and cataloging research articles

5.2.1 | Preparing for the study

Initially, while still designing this SLR, we carried out preparatory searches on multiple databases to assess the extent of existing empirical research studies related to the MHW of students in engineering. General search terms such as "mental health of engineering students," "mental health research in engineering education," and "mental health of engineering undergraduates" were used. These searches revealed that research related to student MHW in engineering has been conducted (i) in interdisciplinary contexts (e.g., Kalkbrenner et al., 2020; Leahy et al., 2010); (ii) with undergraduate engineering students only (e.g., Castaldo et al., 2016; Joshi et al., 2016; Rulifson & Bielefeldt, 2020); (iii) with graduate students only, and (iv) with a combined sample of undergraduate and graduate engineering students (e.g., Berdanier et al., 2020; Miles et al., 2020). These initial, preparatory searches were used to develop the focus of our SLR on research related to undergraduate engineering students.

5.2.2 | Source identification and inclusion assessment

Source identification

To select appropriate search keywords for source identification, a scoping search was carried out in spring 2021 using Education Source via EBSCO and SCOPUS databases. Initially, study parameters such as the research topic

(i.e., MHW), the nature of the studies (i.e., empirical), the participants (i.e., undergraduate students), and the study context (i.e., engineering education) guided the formulation of the search strings. We note that these parameters later became formal inclusion criteria for identified studies.

Next, we consulted with a subject librarian and two domain experts (one in engineering education and one in psychology) to ensure that we were including relevant and important keywords. As we reflected on the experiences of the first and third authors who had experience with medical models of MHW, we paid special attention to ensure the use of both deficit (e.g., mental illness; mental disorder) and anti-deficit (e.g., mental wellness; mental wellbeing) keywords and the identification of studies investigating both negative and positive aspects of psychological health.

The subject librarian was also consulted to determine the search databases. Five databases were recommended that are freely available for our use as university employees: Education Source, ERIC, IEEE Xplore, ProQuest, and Scopus. With the help of the subject librarian, the search strings were organized according to the requirements of each database as shown in Table 1. Preliminary searches were made to ensure that the keywords and search strings yielded appropriate research resources.

Table 1 provides the final search strings for each database searched in spring 2021. Note that we have included the details of the database search field settings to ensure the repeatability of the search process.

A total of 729 (ERIC, Education Source via EBSCO = 474, SCOPUS = 108, ProQuest = 7, and IEEE Xplore = 140) articles were identified using the search strings provided in Table 1. Article information for these 729 articles was copied to the Mendeley desktop application and processed to remove 19 duplicates. After the removal of duplicates, a *.bib file with the remaining 710 article titles and references were downloaded from Mendeley and converted to a *.csv Microsoft Excel file with the help of JabRef, a free desktop application. Two additional studies that did not appear in our database searches (i.e., Danowitz & Beddoes, 2020b; Schneider, 2007) were later identified through citation searching (Rethlefsen et al., 2021) via manual screening of the reference lists of identified articles during the full-text assessment. Thus, a total of 712 articles were analyzed for inclusion.

Inclusion assessment

Abstracts and full articles were assessed for inclusion in a two-step process. As suggested by Borrego et al. (2014), two members of the research team independently assessed every article, meeting regularly over an online video conferencing application to discuss and reach consensus on whether an article would be carried to the next level of inclusion assessment.

Five inclusion criteria (IC) were used to select sources for inclusion in the review:

IC1. Studies published during the first two decades of the 21st century (i.e., 2000–2020),
IC2. Studies published in English,
IC3. Studies published in archival journals or peer-reviewed conference proceedings,
IC4. Empirical research conducted with undergraduate engineering students, and
IC5. Studies conducted in engineering education settings.

These five inclusion criteria were developed to support our ability to answer our research questions. Because we did not know the specific date that MHW research began in the context of engineering education a priori, we intentionally set a wide publication timeframe (i.e., 2000–2020) to capture the earliest articles published as this body of research developed. We included only articles written in English because it is the only language shared by all authors. We restricted our review to journal articles and peer-reviewed conference proceedings to ensure that the research we synthesized had been appraised for and met minimum expectations for research quality. We included only empirical studies that were conducted with (at least some) undergraduate students in engineering, and we required all included studies to have been conducted within engineering education, and not interdisciplinary education (e.g., STEM) contexts, to maintain our ability to make interpretations and claims concerning engineering disciplinary education. Ultimately, to be included, an article was required to meet all five of the inclusion criteria.

In the first step of the inclusion assessment process, the title and abstracts of the 712 articles (i.e., the 710 identified through database searches and two identified through citation searches) were assessed for inclusion. To help ensure that relevant studies were not excluded from the review, all identified studies that were conducted with engineering student participants were retained through the title and abstract assessment. In other words, we did not distinguish between studies that might have interdisciplinary student participants or undergraduate and graduate student participants at this stage. If it was not obvious from reading the abstract that the study did or did not have engineering student

TABLE 1 Literature databases and search strings.

Database	Search string	Database search setting
ERIC and Education Source (via EBSCOhost)	(mental health OR mental illness OR mental disorder OR mental wellness OR mental wellbeing OR psychological health OR psychological illness OR psychological disorder OR psychological wellness OR psychological wellbeing OR psychological counselling)	Search all fields
	AND (Engineer*)	Search all fields
	AND (college students OR undergraduates OR university students))	Search all fields
IEEE Xplore	((“All Metadata”: “mental health” OR “mental illness” OR “mental disorder” OR “mental wellness” OR “mental wellbeing” OR “psychological health” OR “psychological illness” OR “psychological disorder” OR “psychological wellness” OR “psychological wellbeing” OR “psychological counselling”)	Search all metadata
	AND (“All Metadata”: Engineer*)	Search all metadata
	AND (“All Metadata”: “college students” OR undergraduates OR “university students”))	Search all metadata
ProQuest	((“mental health” OR “mental illness” OR “mental disorder” OR “mental wellness” OR “mental wellbeing” OR “psychological health” OR “psychological illness” OR “psychological disorder” OR “psychological wellness” OR “psychological wellbeing” OR “psychological counselling”)	Search article abstracts
	AND (Engineer*)	Search article abstracts
	AND (“college students” OR undergraduates OR “university students”))	Search article abstracts
SCOPUS	((“mental health” OR “mental illness” OR “mental disorder” OR “mental wellness” OR “mental wellbeing” OR “psychological health” OR “psychological illness” OR “psychological disorder” OR “psychological wellness” OR “psychological wellbeing” OR “psychological counselling”)	Search article titles abstracts and keywords
	AND (Engineer*)	Search article titles, abstracts, and keywords
	AND (“college students” OR undergraduates OR “university students”))	Search article titles, abstracts, and keywords

participants, the methods section of the study was also reviewed to understand the details of the participant sample and reach a conclusion.

As shown in Figure 1, a total of 585 studies were excluded during the title/abstract assessment. Of these 585 articles, 582 articles did not include engineering students as participants, and 3 articles were retracted by the publishers as reported by the Mendeley desktop application. These three articles were excluded after manual verification of their retraction notices in the Mendeley application by the first author.

During the second step of the inclusion assessment process, the remaining 127 studies, each of which had passed the initial title and abstract assessment, were fully assessed for inclusion based on full-text readings. The full-text assessment revealed that 93 of these 127 studies did not meet all five inclusion criteria. Of these 93 studies that did not meet all five inclusion criteria, 43 studies were conducted within interdisciplinary education (and not engineering education) contexts, 36 studies were found not to be related to MHW, 5 studies did not have any engineering students as participants, 4 studies were not empirical, 2 studies had only engineering graduate students as participants, 2 studies were not conducted in engineering education settings, and 1 study was not written in English. The entire inclusion assessment process is visually represented by the PRISMA flow diagram (Liberati et al., 2009) shown in Figure 1.

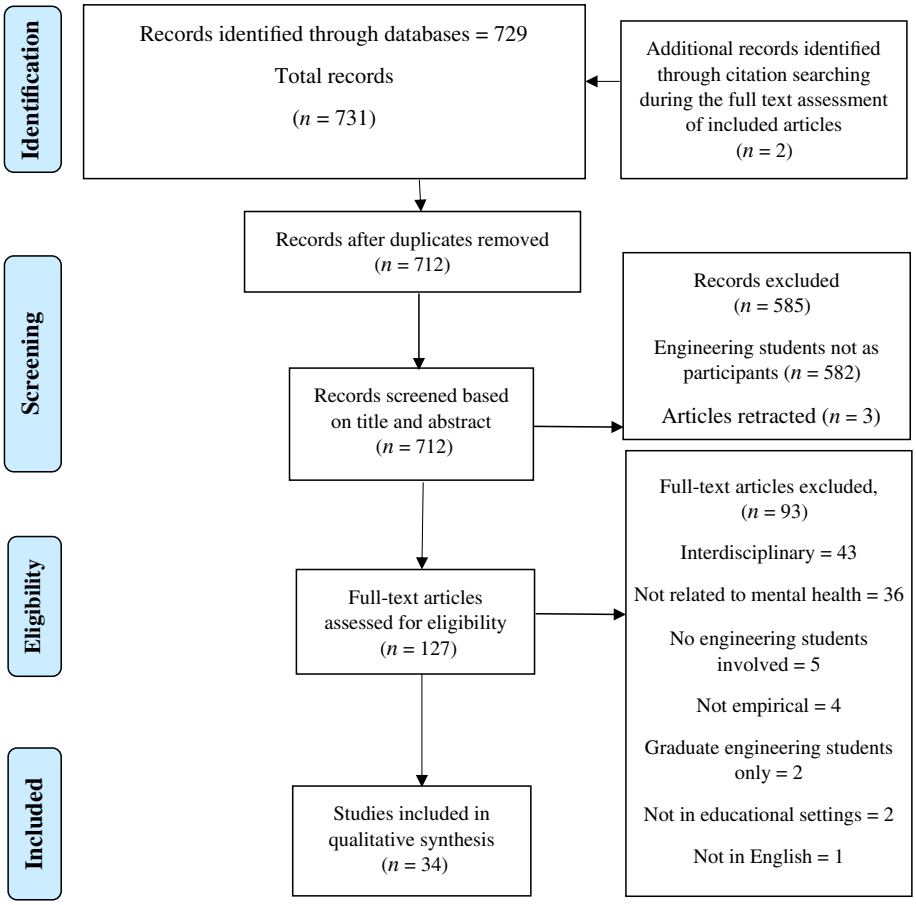

FIGURE 1 PRISMA flow diagram of the article selection process.

We note that in making inclusion decisions, we were initially unsure about the type (i.e., undergraduate or graduate) of the student participants in some of the identified articles. Specifically, the type of student participants in four studies (Iraola-Real et al., 2019; Joshi et al., 2016; Oner & Kazanasmaz, 2020; Yasdin et al., 2020) was not clear after reading the full texts. To make final inclusion decisions about these articles, the first author contacted the lead authors of these four articles via email, or their ResearchGate (ResearchGate | *Find and share research*, 2022) accounts if email addresses could not be located. The lead author of Joshi et al. (2016) responded that all their participants were undergraduates, while the lead author of Oner and Kazanasmaz (2020) informed us that their participants were both undergraduate and graduate students. Therefore, these studies met the inclusion criteria and were included in the review.

The lead authors of Iraola-Real et al. (2019) and Yasdin et al. (2020), however, did not respond. For these two papers, the research team made decisions about inclusion based on other information presented within the articles. The work of Iraola-Real et al. (2019) was included because the study participants were reported as being between 16 and 26 years of age ($M = 18.41$, SD = 2.71). Thus, the age of the participants led us to decide that there was a high probability that some, if not most, of the participants were undergraduates. The work of Yasdin et al. (2020) was also included because it engaged with a comparatively large number of student participants ($N = 112$), which made it seem likely that the participants were undergraduates rather than graduate students. Finally, 34 articles were included in the review (Figure 1).

5.3 | Critique and appraisal of research sources

Each of the 34 included articles was assessed for research quality in two ways. Because the peer-review process aims to limit critically flawed research from being published (De Vries et al., 2009), the first level of quality assessment was performed by requiring that all studies included in the review to have been published in peer-reviewed conference

proceedings or journals. The second level of quality assessment was performed after the inclusion decisions were complete as we critically appraised the research design of each study. We note that studies were not excluded from the review based on this second level quality assessment process.

To conduct the second level quality assessment, the first and second authors extracted detailed information, such as participant demographics and sample size, sampling techniques, data collection methods, theoretical/conceptual frameworks, and author-reported limitations, from the coding table used to quantitatively characterize the included studies (see Section 5.4 for a discussion of coding table development). This information was then used to examine the base of literature from methodological and research design perspectives. Collating and reporting on this information across all included articles as a group to ensure that we reached relevant conclusions and useful recommendations for future work. The results of the critical appraisal are reported in Section 6 as an answer to RQ1.

5.4 | Data synthesis

Following Denton et al. (2020), we conducted both descriptive (i.e., quantitative) content analysis (i.e., scoping review) and qualitative synthesis across all 34 included studies. To conduct the descriptive (i.e., quantitative) content analysis (Schreier, 2014, Chapter 12) of study characteristics, we first met as a research group to develop an a priori coding frame. The first and third authors then analyzed each article using the following codes: author, year of publication, the country where the study took place, type of article (i.e., journal or conference paper), name of journal or conference, number of participants, participant demographics, study purpose, research approach (i.e., qualitative, quantitative, mixed methods), theoretical/conceptual framework (if applicable), research design, sampling technique, data collection methods, and author-reported limitations. Coded information about participant demographics and sample size, sampling techniques, study purpose, research approach, research design, and data collection methods can be found in the Appendix. Other coding information is provided in sections where applicable.

After each study had been read and coded by both authors, they met virtually, on several occasions, to discuss coding inconsistencies or discrepancies until consensus was reached. If consensus between the first and third authors could not be reached, the second author was consulted to help reach a final decision. Once the coding and documentation were complete, the first author constructed appropriate data tables, totals, and percentages to describe the results. The findings of this descriptive (i.e., quantitative) characterization of included studies are reported in Section 6 to answer RQ2.

To conduct the qualitative synthesis, we employed inductive coding and thematic analysis (Saldaña, 2021) to synthesize findings across the included studies. To gather the qualitative data used in this analysis, the first author extracted detailed textual statements of purpose and findings from each study. Findings from each study were read and analyzed individually and then compared across the studies to identify recurring themes. Specifically, the first and second authors jointly and collaboratively conducted the inductive analysis by iteratively employing coding, categorizing, and theming processes to the qualitative data. The authors met several times to compare and refine inductively derived codes and categories and to develop joint interpretations of the data in terms of full thematic statements. The results of the qualitative synthesis in the form of these resultant themes are presented in Section 6 to answer RQ3.

5.5 | Address limitations

Conscious and deliberate efforts were made by the research team to ensure the validity and reliability of this systematic review. As suggested by Borrego et al. (2014), at least two independent researchers were involved at every stage of the review. Specifically, to decrease researcher self-selection bias that could lead to the exclusion of relevant studies, at least two independent researchers were involved in the abstract and full article assessment of every study considered for inclusion in this review. Additionally, at least two independent researchers conducted quality appraisal, content analysis, and qualitative synthesis tasks to mitigate researcher interpretative bias that would jeopardize the overall quality of this review and its reported findings.

Despite the attentive use of systematic processes, limitations to this SLR remain. First, this SLR reports on studies located using widely representative databases that are freely available for use by the researchers at the first and second author's institution (i.e., ERIC and Education Source [via EBSCOhost], IEEE Xplore, ProQuest, SCOPUS). Despite our use of multiple robust databases to locate articles, it is possible that there were studies that fulfilled the inclusion criteria that were not identified for this review simply because they were not indexed within these databases.

The methodological literature indicates that this limitation can be mitigated by consulting a librarian to help develop robust search strategies (Koffel, 2015). Therefore, we consulted a subject librarian from our university library who assisted in database selection and the development of database-specific search strings to reduce researcher self-selection bias in our source identification and assessment processes.

Another limitation of this systematic review is the potential to include studies that have not ensured quality by following standardized research procedures (Cook et al., 1997). For example, studies included in this SLR may suffer from publication bias if researchers did not report findings when the null hypothesis was not rejected (Hubbard & Armstrong, 1997). We attempted to mitigate this limitation first by including only those studies published in refereed journals and peer-reviewed conference proceedings, and then by carefully coding each article for its research methodology and the authors' stated limitations. However, we note that many studies included in this review, even though they were published in peer-reviewed or refereed publications, did not describe the use of a theoretical/conceptual framework and/or did not state limitations of the research. To help mitigate this limitation, we employed a second level of critical appraisal by documenting and reflecting on key elements of methodological quality and research design of each included article. We then developed our recommendations for future research based on this critical appraisal of the included articles.

Lastly, because the construct of mental health stemmed originally from a medical model of health and illness, the absence of mental illness has been historically considered the state of mental wellbeing or wellness (Greenspoon & Saklofske, 2001). This historical emphasis on mental health as a negative construct (i.e., mental illness) may unknowingly influence researchers to search for sources that focus on these negative views of mental health. To mitigate the potential for researcher bias stemming from these human tendencies to possess only partial perspectives and thus give one perspective more weight than another (Gao, 2020b), an engineering education researcher with expertise in MHW and a psychology domain expert was involved in the search string formulation (Borrego et al., 2015). Based on their guidance, we purposefully developed database search strings that included both deficit and anti-deficit keywords to ensure that our search for sources was broadly inclusive of models and constructs associated with MHW.

6 | FINDINGS

The following sections report on the findings of this SLR of 34 empirical studies related to the MHW of undergraduate engineering students. First, we present an overview of the publication trends of the included research. Next, we present answers to the three research questions used to guide the critical appraisal, descriptive characterization, and qualitative results synthesis across included studies.

6.1 | Publication trends

6.1.1 | Publication timeline

Findings indicated that most (22/34) of the studies included in the review were published in peer-reviewed conference proceedings rather than archival journals (Figure 2). In 2020, there were twice as many conference papers published than journal papers, highlighting the still emerging nature of mental health research in engineering education.

On searching databases for articles published between 2000 and 2020, we found that the earliest work related to the MHW of engineering undergraduates was published in 2007. At about this time, social and behavioral science (SBS) research had started to influence engineering education research (Lohmann & Froyd, 2010). This new and emerging emphasis of SBS research might explain the increasing trend of publications, including both conference proceedings and journal articles, related to MHW in engineering since 2007 (Figure 2). The total number of articles published in 2020 (15) accounts for nearly one-half of those published since 2000 (34), which suggests there is a rapidly increasing base of literature on this topic.

6.1.2 | Publication international contexts

Our findings further revealed that, while a substantial number of studies (16/34) were conducted within the United States, more than one-half of the studies (18) were conducted within 11 other countries. These 18 studies originated within many

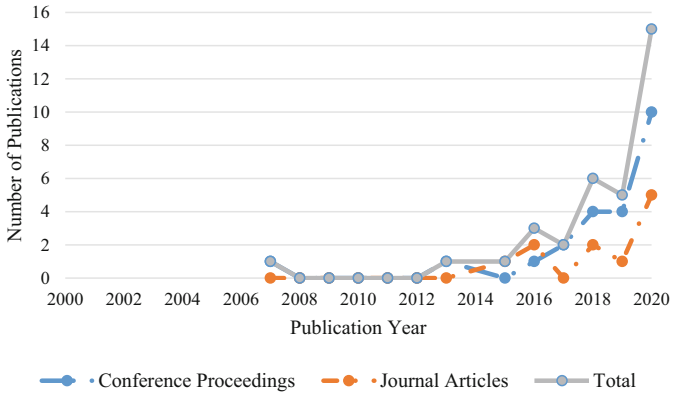

FIGURE 2 Undergraduate engineering student MHW studies published between 2000 and 2020.

FIGURE 3 Countries where MHW in engineering education studies were conducted.

different parts of the world, including Canada, China, Croatia, India, Italy, the Middle East, Malaysia, North and South America, Southeast Asia, Western Europe, and the United Kingdom (Figure 3). This finding suggests that the issues related to MHW in engineering education are recognized internationally and that MHW in engineering education constitutes an area of global research interest.

As shown in Figure 3, 16 studies were conducted in the United States and 18 studies were conducted in other countries. Of the 18 studies conducted outside of the United States, 4 studies were conducted in India, and 3 studies were conducted in China. Two studies each were published in the United Kingdom and Canada. In the rest of the countries (i.e., Thailand, Philippines, Peru, Malaysia, Jordan, Italy, and Croatia), a single study each was published. We note that a majority of studies (20/34) originated within predominantly English-speaking countries (i.e., Canada, United Kingdom, United States); this result may have been influenced by the fact that our inclusion criteria required that all studies included in this review be published in English. Thus, given the global nature of this literature base, it is possible that studies about MHW in undergraduate engineering education not reported in this SLR could exist and have been published in languages other than English.

6.1.3 | Publication venues

A majority of the studies (22/34) were published in peer-reviewed conference proceedings. Specifically, eight studies were published in the proceedings of the American Society of Engineering Education (ASEE) Annual Conference and

three studies were published in the proceedings of the IEEE Frontiers in Education (FIE) Conference. Most conferences that published studies related to engineering students' MHW are focused on science, technology, engineering, and mathematics (STEM) contexts. Interestingly, the majority of conferences publishing this work are either international or not based in the United States, further highlighting the global nature of MHW issues in engineering education.

Twelve studies were published within a variety of archival journals; the maximum number of articles related to engineering students' mental health published in any single journal (i.e., *IOS Press* and *Revista Argentina* de *Clínica Psicológica*) was 2. Interestingly, most (7/12) journals that published this work, including the *Canadian Journal for the Scholarship of Teaching and Learning*, *International Journal of Pharmacy and Technology*, *IOS Press*, *Procedia Manufacturing*, *Revista Argentina de Clínica Psicológica*, *Systematic Reviews in Pharmacy*, and *Widening Participation and Lifelong Learning*, are not specifically related to the field of engineering education. Notably, five of the journals, namely the *Canadian Journal for the Scholarship of Teaching and Learning*, the *International Journal of Pharmacy and Technology*, the *International Journal of Engineering and Technology (UAE)*, *Procedia Manufacturing*, and *Revista Argentina de Clínica Psicológica*, are either international in scope or non-U.S. journals.

6.2 | Critical appraisal of included studies

In this section, we answer RQ1 (critical appraisal): *What is the state of the research quality of empirical studies related to the MHW of undergraduate students in engineering?*

During our quality assessment, we observed recurring methodological issues across the included articles. We identify these issues because they can result in limited or weak generalizability and/or transferability of findings outside of the immediate research context. Several methodological issues contributed to this limitation, including small sample sizes for quantitative studies, limited use of random and purposive sampling techniques, limited use of guiding theoretical/conceptual frameworks from social science or psychology, and reliance on descriptive statistics, self-reports, and ad hoc survey instruments for quantitative studies.

For example, most quantitative studies reported findings based on data collected from participant sample sizes less than 100 without reporting justifications for their sample sizes (i.e., power analysis) or stating their underlying reasons for the sample sizes they attained. For example, the lowest number of participants in a single quantitative study was 10 (Coley & Jennings, 2019). Although this small sample size (for a quantitative study) seemed justifiable for this pilot study of Black undergraduate engineering students, the authors did not explicitly state their reasoning. Only two studies (Gao, 2020a; Zhang & Luo, 2020) employed random sampling techniques, while 20 studies relied on convenience sampling. Out of 23 quantitative and 4 mixed-methods studies, 17 used inferential statistical analysis to develop their findings, while 10 others relied on descriptive statistics.

Both ad hoc and standardized scales were used for quantitative data collection. Six studies used ad hoc (non-standardized) scales; ad hoc scales are scales that rely on face validity, are constructed to address a specific need, and/or are applied without much evaluation (Furr, 2011). All standardized scales implemented in the included studies originated within the field of psychology. Most scales were not validated specifically for engineering students, nor was any statistical fit analysis (e.g., confirmatory factor analysis) performed. An exception is Jensen and Cross's (2018) use of the Identification with Academics Subscale, which they adapted for engineering students.

Researchers often use existing theory (i.e., theoretical frameworks) or multiple constructs from a variety of theories (i.e., conceptual frameworks) to (i) describe how different ideas in their study relate and interact (Ivey, 2015), and (ii) ground the research in accepted foundations of existing scholarship (Merriam & Simpson, 2000). Limited connection to established frameworks tends to limit the broader generalizability and/or transferability of findings. We note that only eight of the included studies made use of either type of framework. As shown in Table 2, two studies used theoretical frameworks, while six studies employed conceptual frameworks.

Another issue we noted that affected the research quality of the included articles was the limited acknowledgment and description of author-reported research limitations across the studies. We noted that only 10/34 studies described the limitations inherent to their work. This lack of information related to the contextual and methodological limitations made it difficult to fully assess the extent and potential causes of threats to the research reliability, validity, and trustworthiness that existed within the included studies.

TABLE 2 Theoretical and conceptual frameworks employed by the included studies.

Studies	Guiding frameworks
Theoretical frameworks	
Abiade and Moliski (2020)	A subset of cognitive-behavioral therapy called acceptance and commitment therapy
Gao (2020a)	Maslow's hierarchy of needs
Jensen and Cross (2018); Jensen and Cross (2019); Mirabelli et al. (2020)	Social identity theory
Conceptual frameworks	
Coley and Jennings (2019)	Mental health promotion quality framework
Goodwin (2020)	Dichotomous framework distinguishing between performance and mastery goal orientations
Kurata et al. (2015)	Effect of workload on academic performance with several secondary tasks as moderating factors

6.3 | Descriptive characterization of included studies

In this section, we answer RQ2 (scoping): *What is the state of research practice of empirical studies related to the mental health and wellbeing of undergraduate students in engineering?*

6.3.1 | General characteristics

To investigate the breadth of potential MHW issues in engineering education, studies in this review employed a variety of approaches (i.e., quantitative, qualitative, mixed methods), research designs (i.e., cross-sectional, experimental, longitudinal, pretest–posttest), and sampling techniques (i.e., random, purposive, convenience). Overall, most studies were quantitative (23/34) and cross-sectional (31/34) in nature; seven (7/34) studies were quasi-experimental. Mixed-methods approach was the least used research approach (4/34), longitudinal was the least used research design (3/34), and random sampling was the least used sampling technique (2/34). Few studies reported on participant intersectional identities (e.g., race, ethnicity, non-binary gender). For example, less than one-fourth (8/34) of the studies provided information about the breakdown of their participant sample based on major categories of race/ethnicity (i.e., Asian, Black, Hispanic or Latinx, and White) and only 6 studies provided the participants an option to identify their gender as other than the traditional binary responses. (Refer to the Appendix for a summary of the data.)

6.3.2 | Data collection techniques

Participant self-reporting through closed- and/or open-ended questionnaires or interviews was the most prominent method used to collect data (28/34 studies). In the remaining six studies, researchers employed varied forms of physiological measurements to collect participant data. Three studies (Joshi et al., 2016; Khan et al., 2018; Oweis et al., 2018) measured the stress responses of participants in different ways. Khan et al. (2018) collected 1.5 mL saliva samples, Oweis et al. (2018) used wearable devices to measure participants' galvanic skin response (GSR), and Joshi et al. (2016) measured participants' systolic blood pressure. Three other researchers used alternative approaches to gather data about participants' mental states. Oner and Kazanasmaz (2020) measured visual discomfort to identify the effects of luminance variations on student mental health. To identify signs of mental fatigue among their participants, Chen et al. (2017) measured participants' speech patterns, and Zeba et al. (2019) recorded electroencephalograms (EEGs).

6.3.3 | MHW issues and their causes

Table 3 summarizes the MHW issues and problems investigated and any potential causes or correlates as identified by the 34 included studies. A substantial number of studies (12/34) investigated student mental health generally, without

TABLE 3 Mental health issues and their causes identified in the included studies.

Articles	MHW issues investigated	Potential causes of MHW issues
Health in general		
Andrews et al. (2020)	Mental health	Not identified
Chierichetti (2020)	Mental health	Lack of socialization due to COVID-19
Danowitz et al. (2018)	Mental health	Not identified
Deziel et al. (2013)	Mental health	Competitive nature of engineering programs
Huerta (2018)	Mental health	Not identified
Johnson-Glauch et al. (2020)	Mental and physical health	Sleep deprivation
Keerthika et al. (2018)	Mental health	Social media is not a potential cause
Kurata et al. (2015)	Mental and physical health	Overall workload (academic and job), Sleep deprivation
Oner and Kazanasmaz (2020)	Mental health	Luminance variations
Sankar et al. (2016)	Mental health	Internet addiction
Yasdin et al. (2020)	Mental health	Cyberbullying
Zhang and Luo (2020)	Mental health	Not identified
Common mental health problems (CMHP)		
Coley and Jennings (2019)	Anxiety, depression, worry	Not identified
Danowitz and Beddoes (2018)	Anxiety, depression, PTSD	Not identified
Danowitz et al. (2018)	Anxiety, depression, PTSD	Nature of the engineering program
Danowitz and Beddoes (2020a)	Distress, panic syndrome, PTSD	Not identified
Jensen and Cross (2018)	Stress, anxiety, depression	Not identified
Aree et al. (2020)	Anxiety	Not identified
Goodwin (2020)	Depression	Not identified
Castaldo et al. (2016)	Stress	Exam pressure
Danowitz and Beddoes (2020b)	Stress	Changes in living conditions due to COVID-19
Abiade and Moliski (2020)	Stress	Imposter syndrome
Jensen and Cross (2019)	Stress	Not identified
Mayildurai et al. (2019)	Stress	Sleep deprivation
Miller and Jensen (2020)	Stress	Not identified
Mirabelli et al. (2020)	Stress	Heavy academic workload
Joshi et al. (2016)	Stress	Not identified
Khan et al. (2018)	Stress	Not identified
Oweis et al. (2018)	Stress	Not identified
Rulifson and Bielefeldt (2020)	Stress	Heavy academic workload
Schneider (2007)	Stress	Competitive nature of engineering programs, heavy academic workload, sleep deprivation
Other mental health problems		
Iraola-Real et al. (2019)	Schizophrenia	Not identified
Chen et al. (2017)	Mental fatigue	Academic activities
Zeba et al. (2019)	Mental fatigue	Exam pressure

Abbreviation: PTSD, post-traumatic stress syndrome.

focusing on any particular mental health problem; 2 of these studies (i.e., Johnson-Glauch et al., 2020; Kurata et al., 2015) investigated general physical health in addition to mental health.

More than one-half of the studies (19/34) investigated common mental health problems (CMHPs), which include anxiety, depression, stress, panic syndrome, and post-traumatic stress disorder (PTSD). They are mental health problems that produce variations of human emotional distress and often co-occur (Nigatu et al., 2016). Among these 19 studies, 4 studies (Coley & Jennings, 2019; Danowitz & Beddoes, 2018; Danowitz & Beddoes, 2020a; Jensen & Cross, 2018) characterized the co-occurrence of CMHPs among undergraduate engineering students while placing less emphasis on investigating the underlying causes of these issues. These studies identified the prevalence of several CMHPs, including anxiety, depression, distress, panic syndrome, PTSD, and worry, among undergraduate engineering students in their research contexts.

Among all CMHPs, stress was most frequently identified and studied in engineering education contexts; stress was studied in isolation in 12 studies and with other CMHPs (i.e., anxiety and depression) in 1 other study (Jensen & Cross, 2018). Researchers reported several stress correlates, including imposter syndrome (Abiade & Moliski, 2020), exam pressure (Castaldo et al., 2016), changes in living conditions due to COVID-19 (Danowitz & Beddoes, 2020b), sleep deprivation (Mayildurai et al., 2019; Schneider, 2007), academic workload (Mirabelli et al., 2020; Rulifson & Bielefeldt, 2020; Schneider, 2007), and the competitive nature of engineering programs (Schneider, 2007).

Two studies (Chen et al., 2017; Zeba et al., 2019) investigated the occurrence of mental fatigue among undergraduate engineering students caused by general academic activities (Chen et al., 2017) and exam pressure (Zeba et al., 2019). One study (Iraola-Real et al., 2019) investigated Schizophrenia and did not find any significant existence of it in either their male or female participants. Schizophrenia is a more severe MHW issue under the Diagnostic and Statistical Manual V (DSM V) of the American Psychiatric Association (American Psychiatric Association, 2013).

6.4 | Synthesis of findings of the included studies

In this section, we answer RQ3 (synthesis): *What are the major findings of empirical studies related to the mental health and wellbeing of undergraduate students in engineering?*

Using thematic analysis techniques, we developed three recurrent themes related to the state of MHW of undergraduate students in engineering from the findings of the included studies: (i) Undergraduate students in engineering experience a variety of mental health issues that negatively affect their experiences in engineering education; (ii) The MHW of undergraduate students in engineering is affected by engineering cultural norms; and (iii) The MHW of undergraduate students in engineering may be supported through targeted interventions. These three themes are further described in the following sections.

6.4.1 | Undergraduate students in engineering experience a variety of mental health issues

From our synthesis, we conclude that the current condition of MHW of undergraduate engineering is unsatisfactory for supporting academic performance and retention in undergraduate engineering programs. The existence of anxiety, depression, panic, stress, and worry appears as a normative occurrence in the undergraduate engineering contexts represented in this review (see e.g., Coley and Jennings (2019), Danowitz and Beddoes (2018), Danowitz and Beddoes (2020a), and Jensen and Cross (2018)). Studies also reported that, when compared to the general public, participants were twice as likely to exhibit anxiety, depression, or PTSD (Danowitz & Beddoes, 2018), and several times more likely to display signs of panic syndrome and psychological distress (Danowitz & Beddoes, 2020a).

Among the many MHW issues reported across studies, stress was the issue most frequently investigated and reported on. Our results indicate that stress in undergraduate engineering education is pervasive (Mayildurai et al., 2019), status quo (Jensen & Cross, 2019), and chronic (Mirabelli et al., 2020). Most studies investigated and characterized stress in undergraduate engineering education and did not experimentally determine the causes of this stress. Of the studies that did report on potential causes of stress in engineering education, the heavy academic workload was the most frequent stress correlate reported (Castaldo et al., 2016; Mirabelli et al., 2020; Rulifson & Bielefeldt, 2020; Schneider, 2007).

More broadly, reported levels of other MHW issues experienced by undergraduate engineering students were not consistent and ranged from moderate to clinically diagnosable levels. The existence of moderate to severe depression among engineering undergraduate students was reported in two studies (Goodwin, 2020; Jensen & Cross, 2018).

Jensen and Cross (2018) reported severe or extremely severe levels of anxiety, depression, and stress among some of their participants. Coley and Jennings (2019), who examined the MHW of Black engineering undergraduates, reported the existence of severe depression, severe anxiety, and high levels of worry such that all issues approached clinically diagnosable levels. Clinically diagnosable levels of mental health conditions were also reported by 28.4% of participants in the study conducted by Danowitz and Beddoes (2020a).

Our analyses further revealed that most studies did not report or make explicit distinctions/comparisons between the outcomes for students from underrepresented groups in engineering, including women and students from racially or ethnically minoritized groups in engineering. Therefore, comparisons between the condition of the MHW of engineering undergraduate students who identify as women or as being from minoritized groups in engineering cannot be determined from this review. However, studies (4/34) that did make these types of distinctions reported that women and students from minoritized groups in engineering experience overall poorer MHW compared to their counterparts from dominant groups (i.e., White male students) (Chierichetti, 2020; Danowitz & Beddoes, 2020a; Deziel et al., 2013; Schneider, 2007).

The MHW of undergraduate students in engineering is affected by engineering cultural norms

Results of our synthesis suggest that engineering undergraduate students often perceive the engineering education environment and its cultural norms to be major sources of stress (Jensen & Cross, 2018; Jensen & Cross, 2019; Mirabelli et al., 2020). For example, students consider "all-nighters" to be a "rite of passage" in becoming an engineer (Mirabelli et al., 2020, p. 5). Students accept poor mental health as normal and even necessary, expressing views such as "the engineering student life is stressful and sometimes detrimental to mental health" (Jensen & Cross, 2018, p. 2). Consequently, the ongoing identity formation of undergraduate students as engineers may be inappropriately influenced by their understanding of engineering as an academically and psychologically tough field where mental health is supposed to be poor by default. In this environment, seeking help for MHW issues can be perceived by engineering undergraduates as a threat to their self-esteem and their identification as an engineer (Goodwin, 2020), rather than as an opportunity to improve their daily life.

Within engineering disciplines, programmatic cultures are also perceived and identified as being good or bad for engineering students' MHW. For example, computer engineering students (CPE) were not satisfied with the nature of their program and perceived electrical engineering students to have a superior quality of MHW (Danowitz et al., 2018). The lack of satisfaction with the nature of the program existed because "many students appear to view CPE as more of an experience in double-majoring (in electrical and computer science) than a separate degree program" (Danowitz et al., 2018, p. 4). Deziel et al. (2013) reported conflicting results and reported electrical engineering students having the lowest state of MHW when compared to students from other engineering departments. In another study, common mental health problems were reported to be negatively correlated with department inclusion efforts on a significant level (Jensen & Cross, 2018). Further, depression (Goodwin, 2020) and acceptance of an engineering stress culture (Mirabelli et al., 2020) were reported to be detrimental to help-seeking behavior.

To support students to develop engineering identities that are not overwhelmingly influenced by academic and psychological struggles, Jensen and Cross (2019) emphasized making improvements in the quality of teaching, counseling, and extracurricular activities, and in creating an overall positive collegiate environment. As one example of this strategy, Abiade and Moliski (2020) described their implementation of a summer bridge program to support future academic success and cultivate positive mental health among incoming engineering students. The program, which focused on helping students develop "culturally affirming" engineering identities by enabling them to begin their engineering studies equipped with academic and MHW coping skills, received high approval from participating students (Abiade & Moliski, 2020, p. 2).

6.4.2 | The state of MHW of undergraduate engineering students can be improved through targeted interventions

Across the included studies, several researchers (10/34) reported on the implementation of targeted interventions that led to improvements in the condition of MHW of their participants. To a large extent, researchers used wellbeing interventions in conjunction with existing undergraduate engineering academic activities (e.g., Abiade & Moliski, 2020;

TABLE 4 MHW interventions employed in the included studies.

Studies	Interventions
Disciplinary	
Abiade and Moliski, (2020)	Identity and transitions laboratory (ITL), a set of learning modules deployed over 6 weeks
Andrews et al. (2020)	Academic study skills support
Psychological	
Andrews et al. (2020) Aree et al. (2020)	Mindfulness-based meditation; Buddhism approach traditionally known as Vipassana
Huerta (2018)	45 min overview of mindfulness
Johnson-Glauch et al. (2020)	Action plan for mental wellness
Joshi et al. (2016)	Deep breathing technique (DBT)
Miller and Jensen (2020)	Optional mindfulness activities
Physiological	
Khan et al. (2018)	A week-long fall break
Oweis et al. (2018)	Different levels of sports involvement
Zhang and Luo (2020)	Swimming lessons lasted for 16 weeks, once a week, for 60 min each time.

Andrews et al., 2020; Aree et al., 2020; Huerta, 2018; Johnson-Glauch et al., 2020; Joshi et al., 2016; Miller & Jensen, 2020). In other cases, interventions were short, simple, and stand-alone, such as deep breathing exercises (Joshi et al. (2016); others could be integrated into student activities completed outside of school, such as sporting activities (Oweis et al., 2018; Zhang & Luo, 2020).

As shown in Table 4, the nature of these interventions differed, however. We found that the MHW interventions employed across studies could be grouped into three broad categories: (i) disciplinary (i.e., engineering education-focused) interventions, (ii) psychological interventions, and (iii) physiological interventions. Two studies (Abiade & Moliski, 2020; Andrews et al., 2020) investigated the use of disciplinary-focused MHW interventions. These interventions provided participants with content and/or practice related to academic and professional skills needed for academic success and identity development in engineering education.

Five studies focused on improving wellbeing through psychological interventions, including mindfulness activities (Aree et al., 2020; Huerta, 2018; Joshi et al., 2016; Miller & Jensen, 2020) and personal action plans for mental wellness (Johnson-Glauch et al., 2020). These psychological interventions focused on enabling participants to become more aware of their inner mental processes and to create a positive sense of wellbeing to fight stress (Aree et al., 2020; Joshi et al., 2016; Miller & Jensen, 2020) and improve their mental health in general (Huerta, 2018; Johnson-Glauch et al., 2020).

Lastly, three studies (Khan et al., 2018; Oweis et al., 2018; Zhang & Luo, 2020) explored the use of physiological interventions to positively influence participants' condition of MHW. In two of these studies, researchers independently reported positive MHW outcomes in terms of decreased stress levels from two different physiological interventions: a week-long fall break from studies (Khan et al., 2018), and daily involvement in sporting activities (Oweis et al., 2018). Others (Zhang & Luo, 2020) reported that once-a-week swimming lessons contributed positively to participants' overall MHW.

7 | DISCUSSION AND IMPLICATIONS

In the following sections, we discuss the findings of this SLR and the implications of these findings for future research and practice in this area.

7.1 | Designing empirical studies of mental health and wellbeing in engineering

Overall, we offer a critique of the existing research related to MHW in three areas: (i) the lack of explicit connection of the research design and findings to explanatory or organizing theoretical/conceptual frameworks, (ii) an over-reliance

on cross-sectional and other single-engagement research designs that may not treat participants with adequate levels of care or provide for the in-depth understandings of intersectional experiences of MHW, and (iii) predominant reuse of existing scales instead of developing new or adapting existing scales specifically for the context of engineering education.

7.1.1 | Theoretical and conceptual frameworks

Historically, theoretical/conceptual frameworks have been underutilized by engineering education researchers (Beddoes & Borrego, 2011; Koro-Ljungberg & Douglas, 2008). Generally, our review indicated that the current research related to MHW in engineering lacks an explicit connection to theory. While less than one-quarter (8/34) of the studies in this review employed a theoretical/conceptual framework, increasing use of frameworks over time was noted: seven of eight studies that employed frameworks were published in/after 2018. This trend of increasing use of frameworks over time may point to a growing level of sophistication in research design as research in this area continues to mature.

7.1.2 | Study designs and methods

Of the 34 studies synthesized in this review, only 3 (Oweis et al., 2018; Rulifson & Bielefeldt, 2020; Zhang & Luo, 2020) were conducted longitudinally. All other studies were either cross-sectional or pretest–posttest studies with a limited time frame provided between the pre and posttests. Longitudinal studies are especially useful for evaluating the relationship between risk factors and the development of illnesses (both mental and physical), and the outcomes of treatments (interventions) over extended periods (Caruana et al., 2015). The importance of longitudinal studies was emphasized by Danowitz and Beddoes (2020a), Goodwin (2020), and Mirabelli et al. (2020), who suggested that longitudinal studies should be carried out by researchers in the future. As MHW is a personal matter that must be treated with care, longer term engagement with participants might assist in developing deeper understandings of the experiences of engineering students concerning their personal perceptions of MHW.

7.1.3 | Use of standardized test batteries and scales

In the field of engineering education, there is ample evidence of researchers (i) constructing and validating standardized test batteries and scales specifically for the context of engineering (e.g., Godwin, 2016; Lawanto & Santoso, 2014; Uzuntiryaki & Aydın, 2009), and (ii) adapting standardized test batteries/scales developed in other fields for research in engineering contexts (e.g., Borrego et al., 2018; Korkmaz & Altun, 2014; Li et al., 2021). With the exception of Jensen and Cross (2018), who adapted the Identification with Academics Subscale for use with engineering students, our synthesis did not locate any further evidence of researchers constructing and validating MHW scales for research in engineering education contexts. To add to the statistical reliability and validity of quantitative MHW research in EER, future researchers may focus on filling this gap either by constructing and validating new scales expressly for engineering students or adapting existing scales, such as from the fields of traditional and positive psychology, for engineering students.

7.1.4 | Including and reporting the outcomes of diverse students in engineering

Although most studies (20/34) provided binary gender demographic information for their participants (see also Appendix), substantially fewer studies reported on other student demographics (i.e., race, ethnicity, non-binary gender). For example, less than one-fourth (8/34) of the studies provided information about the breakdown of their participant sample based on major categories of race/ethnicity (i.e., Asian, Black, Hispanic or Latinx, and White) (see also Appendix) and only 4 studies (e.g., Chierichetti, 2020; Danowitz & Beddoes, 2020a; Deziel et al., 2013; Schneider, 2007) reported research outcomes based on gender and non-dominant racial/ethnic groups status. Only Coley and Jennings (2019) based their study solely on students from a non-dominant racial/ethnic group (i.e., Black). There were no studies that provided information about the inclusion or MHW outcomes based on non-binary

gender. We further note the absence of studies that included and reported MHW outcomes for undergraduate engineering students with other diverse intersectional identities, such as students with disabilities and student veterans, who have been reported in the literature to experience higher levels of MHW issues than the general population (Honey et al., 2011; Murphy et al., 2008; Runnals et al., 2014).

Based on the very limited number of studies in this review that included and reported on the MHW outcomes of women and/or students from minoritized groups in engineering, the exact status of their MHW may not be derived from this synthesis. We argue that it is imperative that future researchers in this area purposefully include and report on, to the greatest extent possible, the MHW outcomes for intersectionally diverse students in engineering. The National Institute of Health (NIH), for example, mandated several years ago that it would only fund research involving human subjects that ensures the inclusion of women and participants from non-dominant racial and ethnic groups (National Institutes of Health, 2017). In engineering, Pawley's (2017) call to make diversity the "expected condition" in EER has provided a new standard for research design and dissemination in the field. This new standard aims to ensure that claims made about people "in general" are not derived from data generated only with those from the dominant group (Pawley, 2017, p. 2). Our review findings underscore this need for future researchers to include and make explicit the MHW experiences and outcomes of all diverse student groups in engineering.

7.2 | Stress as the "gateway" to other problems

While the overall condition of mental health of undergraduate students in engineering was shown to be poor by the studies included in this review, stress was reported in more than one-third (14/34) of the studies and more than any other mental health issue. Based on this data, we suggest that stress may be considered one of the most prevalent MHW problems in engineering education today.

According to the American Psychological Association ("Stress effects on the body," 2022), stress acts as a "gateway" to more severe mental and physical health issues by adversely affecting many systems of the human body, including the cardiovascular, endocrine, gastrointestinal, musculoskeletal, nervous, and respiratory. Additionally, heavy academic workloads (Mirabelli et al., 2020; Rulifson & Bielefeldt, 2020; Schneider, 2007) and sleep deprivation (Johnson-Glauch et al., 2020; Mayildurai et al., 2019; Schneider, 2007) were among the major factors linked by this review to experiences of stress in undergraduate engineering education. Heavy academic workloads have been shown to dampen students' motivation for learning (Kurata et al., 2015), while sleep deprivation has been shown to inhibit learning by reducing students' ability to function cognitively (Curcio et al., 2006; Patrick et al., 2017). These important factors, which are linked to increased stress, should be further investigated because their effects can extend beyond MHW and inhibit student learning and academic performance through other mechanisms.

7.3 | Improving the balance of MHW research in engineering research

Overall, we noted a deficit bias across the studies synthesized in this review, as more studies focused on characterizing the presence of mental illness among engineering students. Only 10 studies (see Section 6.4.3) researched the MHW of engineering undergraduates from a wellbeing and wellness perspective to investigate means that positively influence the MHW of engineering undergraduates. We see this bias as the continuance of an existing trend within the larger research community and society to focus on mental illness research over mental wellbeing and wellness research (Asghar & Minichiello, 2022b; Slade, 2010).

There are, however, recent calls to shift the culture in engineering education from one of stress and poor mental health to one of thriving (Gesun, 2021) and wellness (Jensen, 2021) to support students in reaching their full potential. To move this assets-based MHW research agenda forward, it will be important for the EER community to *also* engage in work that seeks to understand the conditions and necessities of students' mental health in engineering from a positive perspective. We argue that an added focus on the positive side of mental health is critical since human mental strengths can alter their overall mental health by preventing, alleviating, or lessening the experience of mental health problems (Ben-Shahar, 2007; Seligman, 2006). One suggestion for future researchers may be to utilize theories and methods espoused in the recent positive psychology movement. Established positive psychology frameworks such as the PERMA (Seligman, 2012) and ABCDE (Seligman, 2006) models could help identify and develop approaches to cultivating human mental strengths within engineering culture.

7.3.1 | Integrating interventionist studies into the MHW in engineering research base

Importantly, our synthesis did uncover recent evidence of a positive perspective with regard to student mental health that is currently emerging among researchers in EER. This newer perspective is focused on building human mental strengths amid the existence of MHW problems. Specifically, we located studies that employed (i) disciplinary-based interventions to support engineering academic performance (Abiade & Moliski, 2020; Andrews et al., 2020) and affirm engineering identity (Abiade & Moliski, 2020); (ii) psychology-based interventions that introduce students to mindfulness exercises (Aree et al., 2020; Huerta, 2018; Joshi et al., 2016; Miller & Jensen, 2020) able to reduce stress and anxiety in the moment while cultivating students' mental strengths; and (iii) physiology-based interventions that encouraged time away from studies and physical exercise to improve and maintain student wellbeing over time. These studies are notable for their focus on increasing positive energy among engineering students that, while worthwhile in their own right, can also counter the effects and development of other MHW problems. We encourage continued research on positive mental health interventions in quasi/experimental research designs to contribute to a balanced base of MHW literature and to provide practitioners with practical and tested approaches for shifting the mental health culture in their engineering classrooms.

8 | CONCLUSIONS

The purpose of this systematic literature review was to examine the empirical research published between 2000 and 2020 and relating to the MHW of engineering undergraduate students. This review found that the MHW of engineering undergraduates is a growing area of international research focus. Although this literature is nascent, we observed an increasing trend in research related to MHW in engineering over the past 20 years.

Stress was the most prevalent MHW issue identified among others (i.e., anxiety, depression, panic syndrome, PTSD, and worry). Academic workload, the nature of engineering programs, exams, and sleep deprivation were identified as plausible causes of the mental health problems identified. Qualitative research approaches, longitudinal research designs, and the use of guiding theoretical frameworks were underutilized, and the inclusion and reporting on data generated with women and students from non-dominant groups were lacking, overall.

During our synthesis of findings across studies, we identified three overarching themes. These findings indicate that an overall unsatisfactory condition of the MHW of engineering undergraduates exists. Academically challenging curricula and cultures that accept and reify stress as the norm act as contributing factors to the adverse MHW conditions of engineering undergraduates. Yet, despite a generally adverse educational environment, the existing literature suggests that the MHW of engineering undergraduates can be improved through scalable interventions that target engineering disciplinary issues (i.e., academic support and identity development), support the development of basic psychological mental strengths, and/or engage physiological means to reduce levels of adverse mental health issues such as stress.

Overall, our findings provide valuable insights in three areas: engineering education policy, engineering teaching practice, and EER. For engineering education policymakers, our findings provide perhaps the first overall picture of undergraduate student MHW in engineering. In doing so, they emphasize the urgent need for holistic institutional and programmatic MHW support of undergraduate engineering students *as well as* the teaching faculty who play pivotal roles in engineering students' MHW. For engineering educators, our findings provide evidence and encouragement that ongoing efforts toward developing and implementing targeted interventions in engineering courses and co-curricular activities can be effective in supporting MHW of engineering students. Finally, for the engineering education research community, our findings suggest directions for future research that can *qualitatively* uncover new knowledge about contextual causes of engineering student mental health issues, and *quantitatively* implement and test generalizable MHW interventions. Together, findings from these new MHW research directions can be used to transform engineering learning environments into places where undergraduates not just survive their engineering education but rather thrive within it.

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APPENDIX

ARTICLE SUMMARY

Citation	Sampling technique and participant demographics	Study purpose	Research approach	Research design	Data collection instrument/ technique
Abiade and Moliski (2020)	Convenience $N = 33$	The purpose of the study is to "describe a program recently implemented at an institution to proactively prepare students to deal with poor mental health, periods of intense stress, and mental and emotional disorders (MED) generally" (p. 1).	Qualitative[a]	Cross-sectional	Open-ended survey
Andrews et al. (2020)	Convenience $N = 1368$	This study is "aimed to tackle an attrition rate in a faculty of engineering that was twice the university average" (p. 8).	Quantitative	Cross-sectional	Data analytics of existing data
Aree et al. (2020)	Convenience $N = 44$	"This paper presents a case study to illustrate a mindfulness meditative approach for helping electrical and computer engineering students to alleviate their anxiety during the transition from high school to college" (p. 161).	Quantitative	Cross-sectional (quasi-experimental)	TU-Launched mobile app (mind mood) to collect mind checkup results through a questionnaire on this application
Castaldo et al. (2016)	Convenience[b] $N = 42$	"This study aims to detect mental stress due to oral academic examination via ultra-short-term HRV analysis (3 min), using advanced data mining methods" (p. 3805).	Quantitative[a]	Cross-sectional (quasi-experimental)	Heart Rate Variability (HRV) via 3-lead electrocardiogram (ECG)
Chen et al. (2017)	Purposive $N = 30$ Native Chinese speakers 50% male, 50% female	This study aims "to implement fatigue detection from speech" (p. 214).	Quantitative	Cross-sectional (quasi-experimental)	Soochow University Speech Processing Researches-Learning Fatigue Detection (SUSP-LFD) corpus to measure fatigue level
Citation	Sampling technique and participant demographics	Study purpose	Research approach	Research design	Data collection instrument/ technique
Chierichetti (2020)	Convenience $N = 35$ 86% male, 11% female 3% others	"This paper analyzes the role that non-academic factors played in students' experience in an aerospace engineering department at a public, Hispanic serving institution during the initial outbreak of the COVID-19 pandemic" (p. 1).	Mixed methods	Cross-sectional	Semi-structured interview

Citation	Sampling technique and participant demographics	Study purpose	Research approach	Research design	Data collection instrument/ technique
	37% White, 26% Asian-American, 14% Hispanic or Latinx				
Coley and Jennings (2019)	Purposive $N = 10$ 80% male, 20% female all Black	This study is "seeks to gain an understanding of the cost of persistence in engineering through the lens of students' self-reported measures of anxiety and depression" (p. 1).	Quantitative[a]	Cross-sectional	Generalized Anxiety Scale (GAD-7) (Spitzer et al., 2006) Patient Health Questionnaire (PHQ-9) (Kroenke et al. (2001)) Penn State Worry Questionnaire (PSWQ) (Meyer et al., 1990)
Danowitz and Beddoes (2018)	Convenience $N = 900$ 59% male, 40% female, 1% others 64% White, 14% Asian, 11% Latinx	"The goal of this study was to get comprehensive baseline data of mental health in engineering students" (p. 2).	Quantitative[a]	Cross-sectional	CAGE-AID survey (Cameron & Gusman, 2003) Kessler Survey Instrument (KSI) (Kessler et al., 2002) Patient Health Questionnaire (PHQ) (Spitzer et al., 1999) Primary Care Post Traumatic Stress Disorder Scale (PC-PTSD) survey (Brown & Rounds, 1994)
Danowitz et al. (2018)	Convenience[b] $N = 91$	This study "explore potential causes of measured differences in mental health between students in a joint Computer Engineering Program and students in the two home departments (Electrical Engineering and Computer Science)" (p. 1).	Qualitative	Cross-sectional	Open-ended survey
Danowitz and Beddoes (2020a)	Convenience[b] $N = 700$ 52% male, 45% female, 3% others 62% White, 17% Asian, 11% Latinx	This study "characterizes mental wellness in engineering at five institutions across the Western United States to better understand what mental health issues most affect the broader engineering student community" (p. 1).	Quantitative	Cross-sectional	Kessler 6 (Kessler et al., 2002) Patient Health Questionnaire (PHQ) (Spitzer et al., 1999) Primary Care Post Traumatic Stress Disorder Scale (PC-PTSD) (Brown & Rounds, 1994)

(Continues)

Citation	Sampling technique and participant demographics	Study purpose	Research approach	Research design	Data collection instrument/ technique
Citation	Sampling technique and participant demographics	Study purpose	Research approach	Research design	Data collection instrument/ technique
Danowitz and Beddoes (2020b)	Convenience $N = 1300$ 61% male, 39% female 57% White, 13% Asian, 16% Latinx, 7% African American, and 4% Native American	"The purpose of this study was to understand the ways in which the COVID-19 pandemic is affecting engineering students' mental wellness, specifically stress, and how the effects differ for different groups of students" (p. 1).	Quantitative	Cross-sectional	The modified version of the Holmes-Rahe Social Readjustment Rating Scale (HRSRRS) (Holmes & Rahe, 1967)
Deziel et al. (2013)	Convenience[b] $N = 312$ 70% male, 30% female	"The aim of this paper is to illustrate how data mining algorithms can be used to analyze mental health data and to encourage further work on applying machine learning to better understand mental wellbeing" (p. 1).	Quantitative	Cross-sectional	Ad-hoc survey. Responses measured via WEKA data mining toolkit.
Gao (2020a)	Random $N = 594$ 68% male, 38% female, 4% others	"This paper aims to identify and improve the psychological needs of students majoring in electrical engineering" (p. 868).	Quantitative	Cross-sectional	Ad hoc survey instrument
Goodwin (2020)	Purposive $N = 582$, all male 89% White European American, 1% Black African-American, 3% Asian Pacific Islander, 2% Hispanic Latino, 5% were of other races	"This study looks at the attitudes toward psychological help-seeking and academic help-seeking and how it impacts engineering student success" (p. 1).	Quantitative	Cross-sectional	Beck Depression Inventory (BDI) (Beck et al., 1988) HS-Tendencies Scale (Karabenick & Knapp, 1991) Attitudes Toward Psychological Help-Seeking (ATTPHS)—Short Form (Fischer & Farina, 1995)
Huerta (2018)	Convenience $N = 92$	"The purpose of this study is to evaluate whether engineering students would be receptive to integrating contemplative practices (e.g., mindfulness meditation) to cultivate and reinforce resilient behavior in both their personal lives and in their education" (p. 3).	Mixed methods	Cross-sectional	Subjective Reflection Brief Resilience Scale (BRS) (Smith et al., 2008) Mindfulness Attention Awareness Scale (MASS) (Brown & Ryan, 2003)

Citation	Sampling technique and participant demographics	Study purpose	Research approach		Research design	Data collection instrument/ technique
Citation	Sampling technique and participant demographics	Study purpose	Research approach		Research design	Data collection instrument/ technique
Iraola-Real et al. (2019)	Purposive[b] $N = 135$ 70% male, 30% female	"The present study has its objective to analyze the schizophrenic features in students of the engineering discipline of two private universities of Lima-Peru" (p. 1).	Quantitative		Cross-sectional	Revised Schizophrenia Quality of Life Questionnaire (SQLS-R4) (Wilkinson et al., 2000)
Jensen and Cross (2018)	Convenience[b] $N = 1203$ 67.6% male, 31.9% female, 0.5% others 49% White, 14% Asian, 5% Latinx	"The objectives of the current study are to (i) understand how students perceive and experience engineering stress culture (ESC) and how this differs across engineering disciplines and (ii) illuminate the relationships between anxieties, stress, perceptions of inclusion, and identification with their engineering major" (p. 3).	Quantitative	Mixed methods	Cross-sectional	Identification with Academics Subscale translated to engineering (Jones et al., 2010) Engineering Department Inclusion Level (EDIL) Survey (Lee et al., 2014) Depression Anxiety Stress Scales (DASS21) (Randall et al., 2017)
Jensen and Cross (2019)	Convenience $N = 216$	"The overarching goal of the project is to understand how a culture of stress develops in engineering and how it impacts student perceptions of inclusion in engineering disciplines and their level of identification with engineering" (p. 1).	Qualitative[a]		Cross-sectional	Open-ended survey responses
Johnson-Glauch et al. (2020)	Convenience $N = 27$ 67% male, 33% female 48% White, 22% Asian/ Pacific Islanders, 19% Latinx	"The purpose of our study is to explore the types of goals related to mental wellness that are important to engineering students and to identify changes in self-efficacy associated with engaging in activities related to improving mental wellness" (p. 2).	Mixed methods		Cross-sectional	Free-response Survey The Self-Efficacy Scale (Sherer et al., 1982)
Joshi et al. (2016)	Purposive[b] $N = 123$	"In the current study the objective is to see the effect of Deep Breathing Technique (DBT) on the blood pressure i.e. in turn manage stress" (p. 786).	Quantitative		Cross-sectional (quasi-experimental	Blood pressure measurements. ACON make (US) model No. OB 11-111 was used for measurement
Keerthika et al. (2018)	Convenience[b] $N = 250$ 74% male, 26% female	"This study aims to find the influence that Facebook plays as a social networking medium on engineering students at an undergraduate level" (p. 514).	Quantitative[a]		Cross-sectional	Ad hoc survey instrument

(Continues)

Citation	Sampling technique and participant demographics	Study purpose	Research approach	Research design	Data collection instrument/ technique
Citation	Sampling technique and participant demographics	Study purpose	Research approach	Research design	Data collection instrument/ technique
Khan et al. (2018)	Purposive[b] $N = 16$ Only males	This study aims "to measure the ratio of two metabolic hormones (cortisol and dehydroepiandrosterone [DHEA]) in first-year male engineering students in order to document possible changes in their stress levels before and after the break" (p. 1).	Quantitative	Cross-sectional	Ten 1.5-mL saliva collection microtubes
Kurata et al. (2015)	Purposive $N = 23$ 43% male, 57% female	"This study aims to investigate the effects of overall workload on academic performance of working engineering students as basis of strategies that may help the students better adapt in situations requiring high workload" (p. 3361).	Qualitative	Cross-sectional	Interviews were measured with NASA TLX rating tool (Hart & Staveland, 1988)
Mayildurai et al. (2019)	Convenience $N = 300$	"This study attempts to identify the causes of stress on engineering student" (p. 74).	Quantitative	Cross-sectional	Ad hoc survey instrument
Miller and Jensen (2020)	Convenience $N = 19$	The purpose of this study is to introduce mindfulness in an online engineering core course during the COVID-19 pandemic.	Qualitative[a]	Cross-sectional (quasi-experimental)	Student subjective reflections
Mirabelli et al. (2020)	Convenience $N = 30$ 67% male, 30% female, 3% others	"Our study sought to identify factors that mediate engineering students' perceptions of identity, stress, and inclusion" (p. 1).	Qualitative[a]	Cross-sectional	Interviews
Oner and Kazanasmaz (2020)	Purposive[b] $N = 20$ 75% males, 25% females	"The aim of this study was to compare the differences in students' cognitive performance, visual comfort, lighting appraisal, and well-being as they were exposed to various luminance patterns" (p. 1).	Quantitative	Cross-sectional (quasi-experimental)	Karolinska Sleepiness Scale (KSS) (Akerstedt & Gillberg, 1990); Glare Sensation Vote (GSV) (Hopkinson, 1956); Nasa TLX rating tool (Hart & Staveland, 1988)
Oweis et al. (2018)	Purposive[b] $N = 19$ civil engineering students 57% male, 43% female	"The purpose of this study was to find statistical differences between students with different sports activity lifestyles and their stress levels" (p. 4).	Quantitative[a]	Longitudinal	Galvanic skin response (GSR) via Microsoft Band 2 wearable device

Citation	Sampling technique and participant demographics	Study purpose	Research approach	Research design	Data collection instrument/ technique
Citation	Sampling technique and participant demographics	Study purpose	Research approach	Research design	Data collection instrument/ technique
Rulifson and Bielefeldt (2020)	Purposive $N = 34$ 38% male, 62% female	This study explores the varied health stresses of undergraduate students and the broad spectrum of resilience strategies they applied through longitudinal interviews.	Qualitative[a]	Longitudinal	Longitudinal interviews over 4 years
Sankar et al. (2016)	Convenience[b] $N = 100$ 74% male, 26% female	"The purpose of this study was to determine the prevalence of Internet addiction among engineering students in Tamil Nadu, a southern state of India and to analyze its impact on their academic performance" (p. 18150).	Quantitative	Cross-sectional	Young's Diagnostic Questionnaire (YDQ) (Young, 1998)
Schneider (2007)	Convenience $N = 938$ 67% male, 33% female 27% Asian Americans 7% students from non-dominant groups	This study investigates factors that affect engineering students' perceived stress.	Quantitative	Cross-sectional	Ad hoc survey instrument
Yasdin et al. (2020)	Purposive $N = 112$	"This study aims to describe the impact of cyberbullying on the soft skills of college students" (p. 325)	Mixed methods	Cross-sectional	Ad hoc survey instrument and Interviews
Zeba et al. (2019)	Purposive $N = 14$ 43% male, 57%	Assessment of mental fatigue during the examination period with P300 Oddball Paradigm. (Title)	Quantitative[a]	Cross-sectional (quasi-experimental)	Electroencephalogram (EEG) was recorded with 16 channel VAmp EEG amplifier
Zhang and Luo (2020)	Random[b] $N = 600$	"This paper discusses the validity of the influence of sports on college students' mental health" (p. 9).	Quantitative	Longitudinal	Symptom Checklist-90 (SCL-90) (Bai and Repetti (2018))

Note: (1) Ad hoc surveys rely on face validity, are constructed to address a specific need, and are applied without much evaluation (Furr, 2011). (2) Citations for data collection instruments were provided by the authors of the synthesized studies.

[a] Studies included a limitations section.

[b] Studies used inferential statistical analysis.

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EFFECTS OF ACADEMIC STRESS ON MENTAL HEALTH ISSUES AMONG UNIVERSITY STUDENTS

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KEYWORDS

Academic Stress, Mental Health, University Students, Pakistan

ARTICLE HISTORY

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ABSTRACT

The objective of the study was to explore the effect of academic stress on the mental health of the undergraduate university students. The research was designed as a quantitative causal-comparative study. For the collection of data, standardized instruments were adopted. The instrument was thus duly validated by experts and a pilot study from 60 participants. The population of the study comprised undergraduate university students of the Lahore district. A proportionate stratified random sampling technique was used to select the sample. The selected sample comprised 528 students. The data was analyzed using SPSS version 25. Data analysis included independent sample t-test, ANOVA, and multiple regression analysis. The results revealed the significant correlation between the variables and academic stress was found a significant predictor of mental health issues. It is therefore recommended that the institutions should develop awareness among the students and their parents, regarding the issues under study. Moreover, enhancing the depth and breadth of the research scope can help to get further probe into the issue under considerations.

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INTRODUCTION

The stress is considered a part of the student's life and can impact the student's coping mechanisms according to their needs for academic life (Fincham, Strauss, Marin & Cavanagh, 2023). Academic stress is a mental distress associated with any anticipated dissatisfaction correlated with student failure, or even awareness of possibility of such a failure (Busari, 2014). Pascoe, Hetrick and Parker, 2022) defined academic stress as a requirement linked to academics that taxes or exceeds existing resources (explicit or implicit). Academic stress, she says, reflects the belief of individual's academic

resentment, academic conflict, academic friction, and academic anxiety. Academic stress can be a burden that mostly happens during an academic performance due to a person's extra work relative to his/her capacities or abilities. Academic stress has been emphasized separately by many authors and as pursues. Steare, Muñoz, Sullivan and Lewis (2023) defined academic stress as among the commodities of a physiological battle to regulate the obligation or examination the teacher must obtain from authority in field in question. Yang and Yang (2022) claimed that higher educational stress caused the limited opportunity for achievement. Wang, García, Ren and Liu (2022) have found that academic workload is associated favorably with inherent stress level. Cavioni, Grazzani and Ornaghi (2020) claimed that mental health is a way of thinking, feeling, and acting in the person's everyday life.

The people with healthy relationships recognize their abilities, are ready to tolerate defeat, able to regulate respect and appreciate their sentiments. The term mental health is composed of two words,' mental' and' health' The term 'mental' connotes something that is purely related towards a person's intellectual functioning. It also preserves the bond with others and a general power that could be called equilibrium of one in sense of socio-culture. The word 'Health' relates to specific fitness as well as to individual unconscious psychological equilibrium, linking of his psychological system with the outer environment, and individual's social activity (Coninck, Matthijs & Lancker, 2022; Khan & Sabah, 2020). Mental health is seen as level of real well-being in which people understand their capacity, can cope with ordinary life pressures, can function productively and credibly, or can contribute to society, as per world health organization (Salari et al., 2020). Khan and Sabah (2020) identified "mental health as a dynamic condition of effective teamwork that enables people to use their skills in line with the society's widespread norms." Simple psychological and behavioral skills; willingness to understand, and convey, another's feelings and empathize with everyone; resilience and ability to deal with the deleterious events in life and act in social roles; and healthy body-mind relationships are essential elements of mental well-being that lead to varying degrees of the status of the internal circuit.

Health means both body and mind function efficiently and in harmony. Mental health is a state of consciousness characterized by emotional well-being, relative security from anxiety and disabling symptoms, and dealing with ordinary life stress and demands (Green, Faizi, Jalal & Zadran, 2022). Lipson, Lattie and Eisenberg, (2019) pointed out that, given the cultural diversity between the burden of instructional components or academic stress and mental health problems in adolescent populations, forgotten studies explicitly stipulate a notable link. Thus, it is theorized that although the other costs are taken into consideration, there will be a beneficial affiliation between high educational stress, mental health and phenomenon of developmental issues forgotten by surveys were primarily due to the unfavorable mental health (such as depression and suicidal behavior) and several did not even realize favorable mental health conditions (happiness). It accounts for the adaptive and mental reactions of one. The perceived pleasure was thus coupled with depression, suicidal activity (making plans, imagining, etc.), and alcohol usage (cigarettes, narcotics, etc.) in the measured outcome. The educational system, assessment system, value system, teacher efficiency,

school situation, and school environment are some of the factors that affect a child's mental health (Wang et al., 2022b).

Objectives of Study

1. To explore difference in academic stress on demographic variables among undergraduate students.
2. To explore the effect of the academic stress on the mental health issues of undergraduate students.

Research Hypotheses

Ho1: There are no significant group differences in stress on the gender of undergraduate students.
Ho2: There is no significant group mean difference in stress in the age of undergraduate students.
Ho3: There is no significant effect of academic stress on mental health issues among the students.

Significance of Study

1. School administrators, course content designers, and counselors to include learners with the educational career guidance and advice.
2. For parents to help their children study and to be specific about their academic needs and therefore reduce their academic stress.
3. For students, it may be helpful to understand the unknown mental burdens and to learn how to minimize them.

LITERATURE REVIEW

Stress has become a trademark experienced by students across the world as a health or pathological condition and negative emotional, cognitive, behavioral, and physiological response (Steare et al., 2023b). The stress in coping is especially academic in origin brought about by examinations, class rankings, and large syllabuses (Azad & Kaur, 2024). They also cite aspects related to workload and interactions with other students and faculty; concerns like too many assignments add to this stress. Stress is usually the strain that originates from pressures or challenging occurrences (Chen et al., 2024). It is defined by Tran et al. (2022) as the process that entails perceiving and dealing with environmental issues. A moderate amount of stress can have positive impacts on the learning and intellectual abilities of person more details (OECD, 2021). Yet high stress levels come with negative consequences that include psychological issues like depression & anxiety as stated by Sutherland (2018). The students in viable academic arena undergo examining stress, class attendance troubles, comprehension snags that cause decreased self-esteem & mental health disorders Mccloud et al. (2023). These pressure sources include workload, perceived as excessive, conflict with other people (Tran et al., 2022b).

Thus, practicing time management, strengthening the social network, and utilizing recreational activities should be considered important methods of combating the academic stress, as stated by (Dessauvagie et al., 2022). Transactional Model of Stress by Adams et al. (2021) centered around cognitive appraisal as key to dealing with stress. Stress is a process that is caused by a relationship between how an individual appraises his environment and demands arising from that environment. This model is suitable for the first-time university students, given the many difficulties that they

experience. Mofatteh (2021) observes that proper mental health leads to proper physical, social, and occupational interaction in day-to-day life. Anxiety-related disorders like depression which are fuelled by intense academic pressure often led to poor performance of students and disruption of their personal lives (Steare et al., 2023c). Antecedent noted, that mentally healthy people can manage daily stressors, stated by WHO in 2020 (OECD, 2021). In past, student pressure to succeed academically has forced them to work hard in the classroom tests, examinations, and assessments as promoted by their teachers, tutors and parents (World Health Organization, 2022). Extracurricular activities have likewise increased pressure because students have to excel in the academics as well as in other activities.

The lack of counselling and guidance services also elaborate this problem, which leaves students baffled on matters relating to the career paths hence boosting stress levels (Bataineh, 2013). These stresses come in many forms; overburdening homework load, high parental expectations, and social conditioning that compels a child into unwanted actions. This stress can be very damaging to their mental well-being, increasing their likelihood of suffering from depression or anxiety (Adegoyega et al., 2020). Stress has been described by Ang and Huan (2006) as any change that threatens an organism's homeostasis, while the stressors are situations that one thinks of as stressful and which destabilize the individual. Incongruities, changes, and catastrophes; minor daily interferences, and major life changes; catastrophic changes and stressful incidents are considered important sources of stress (Rahiman et al., 2023). The effects of stress are profound and involve the cognition, emotion, and physical well-being of an individual. Therefore, the cognitive aspect has been focused on by different studies in Pakistani context. In the cognitive domain of learning, critical thinking (higher-order) skills have been focused being twenty-first-century skills to be focused on to be developed in the students of today.

Similarly, different studies have been conducted focusing on the critical thinking skills based on teachers' perspectives and practices, policy documents, and textbooks analysis (Naseer, et al., 2021; Jamil, et al., 2024; Muhammad Jamil, Muhammad Aslam, et al., 2024; Muhammad Jamil, Tahira Bibi, et al., 2024; Muhammad Jamil, Tahira Batool Bokhari, et al., 2024; M Jamil et al., 2024; Muhammad Jamil, Wahid Mehmood, et al., 2024; Jamil & Muhammad, 2019; Jamil et al., 2020; Jamil et al., 2021; Azmat, et al., 2021). The symptoms are worry, violence, physical manifestations such as nail biting, and irregular pulse rates (Agolla & Ongori, 2009). These stress reactions are not necessarily sequential and might precipitate a fight-or-flight state (Bataineh, 2013). The key is to know stress and manage it well. The transactional model of occupational stress posits that stress is derived from the transactions between environment's demands and individual's capacity to cope with the stresses (Wang et al., 2022b). To this extent, one can therefore manage the stressors if not their occurrence by adequately evaluating and handling the vice that is a result of stressors. Mental health and emotional status depend on people's psychological and emotional state, which allows, hinders them from performing various tasks effectively in school, workplace & within communities (Cavioni et al., 2020).

The accomplishment of the goals in life determines the state of mental health, whereby one is in a position to handle the pressures in life (Mitchell, 2020). Academic pressure brings about discursive

formation of mental health problems among adolescents such as anxiety and depression (Magier et al., 2023). Academic guidance: The proper mental health intervention and stress management are required to assist students in going through all these challenges and stay healthy. Mental health issues such as depression, form part of common psychiatric disorders in America; they affect about one in four adults (Nazari et al., 2023). Symptoms of depression are as follows: Depression includes consistent low moods, anxiety, lack of value and interest in daily endeavors, sleeping disorders, change in appetite leading to loss of weight or gain, lack of strength, and ideas of dying or death. This includes migraines and digestive disorders that have no medical cure for the condition. The phenomenon of academic stress affects young people's psychological well-being, in particular university students. The OECD (2021) has a more positive view of mental health by describing it as a state in which an individual can function acceptably in day-to-day life, be productive, and easily integrate into society.

Mental health disorders for instance, mood, anxiety disorders, and suicidal risk factors are prevalent among students and are also leading causes of disability globally as classified by Global Burden of Disease study (Coley et al., 2018). The prevalence of psychological health issues among students is a growing global concern. Around 20 percent of the children and university students experience psychiatric illnesses, with nearly 50 percent of adult psychological problems originating during undergraduate years (Reda Ismail, 2022). Suicide is a leading cause of death among 18-24-year-olds, second only to road accidents (DeLisle, 2011). Despite this, the development of psychosocial interventions for adolescents and young adults has lagged, particularly in developing countries where healthcare facilities are inadequate (Stafford et al., 2016). Academic pressure is a significant source of stress, contributing to the depression among students. Various teaching practices and high expectations exacerbate these issues, impacting students' mental health & academic performance (Ruddy et al., 2005). Addressing these challenges needs holistic approach that includes improving access to mental health services, enhancing the data collection, and developing innovative coping strategies for students.

Different studies have been conducted about the current variables of the study in national and international contexts. For example, effect of university-level students' stress on their performance (Ali et al., 2021); the impact of stress on the secondary and higher education (Pascoe et al., 2020); university students' stress regarding COVID-19 (Keyserlingk et al., 2022); stress and burnout of school teachers (Naz et al., 2022); academic stress and mental well-being of the college students (Barbayannis et al., 2022); academic stress and emotional well-being (Clabaugh et al., 2021); risk factors associated with stress (Mofatteh, 2021). In conclusion, academic stress significantly impacts students' mental health, leading to issues like anxiety, depression, and cognitive impairments. The effective stress management and mental health support are vital for students to navigate academic challenges & maintain overall well-being. Depression includes consistent low moods, anxiety, lack of value in daily endeavors, sleeping disorders, change in appetite leading to loss of weight or gain, lack of strength, and ideas of dying/death. Future research should explore stress-coping strategies & mental health intrusions to support students in academic environment. With inclusive approach,

educational institutions can foster a healthier environment that promotes both academic success and mental well-being.

RESEARCH METHODOLOGY

This research was quantitative. The ex-post facto research design is descriptive survey research. Using the word ex post facto to describe something that incorporates past activities, such as a raise in pay ex post facto, subsidizes for job users have since done. Population for research included all undergraduate university students of Lahore. A proportionate stratified random sampling method was used for the study. The selected sample included 550 students, 58% from public, and 42% from private universities. A questionnaire was used to collect data from the participants. It included participants' demographic information (age, gender, and year) academic stress scale, and mental health scale. The perceived level of academic stress of students was measured by academic stress inventory developed by Ang and Huan (2006a). It comprised total of 34 items and 7 factors about the teacher phobia, exam anxiety, group study phobia, peers' phobia, time management issues, and self-inflicted stress.

On the other hand, mental health was measured by a standardized questionnaire GHQ-12 (The General Health Questionnaire) by Cavioni et al. (2020). Mental health can be evaluated through the identification of signs of anxiety, depression, and emotions of effectiveness. The most commonly used screening tool for the common mental illnesses is the 12-item General Health Questionnaire (GHQ-12). The research instrument was duly validated by expert opinion (Content validation), and pilot study (construct validation). In this connection, the data were collected from sixty respondents for pilot testing by the researcher, which was more than ten percent of the total sample size. The reliability analysis revealed 0.99 and 0.82 for the academic stress scale, and mental health scale respectively which indicated that the tool was good and reliable, as per the criteria proposed by Fraenkel et al. (2012).

FINDINGS OF STUDY

Analysis to Explore Difference in Academic Stress on Demographic Variables among Undergraduate Students.

The two most studied, widely influencing demographic variables i.e., gender and age, were selected for study. An Independent sample t-test was used to explore difference in the academic stress on gender of undergraduates.

Table 1 Academic Stress of Students Based on Gender

Gender	N	Mean	SD	T	Df	Sig. (2 – tailed)
Male	202	124.8020	19.81382	.569	.526	.000
Female	326	123.7362	21.59824	.580	453.798	

The results from the table indicate a significant difference (p = .000) amid both genders was found. The mean values indicate that males were more influenced by stress and mental health issues than females. So, null hypothesis "there is no significant difference of stress on gender of undergraduate students" was rejected. Second selected demographic variable was age. To find group difference of

academic stress on age, analysis of variance (ANOVA) was applied. Following results were obtained from this analysis.

Table 2 Academic Stress of Students Based on Age

PR	SS	Df	Mean Squares	F	Sig.
Between Groups	286.281	3	95.410	.217	.000
Within Groups	230372.830	524	439.643		
Total	230659.061	527			

The table indicates that significant difference in stress was found in age variable of undergraduates. Thus, the null hypothesis "there is no significant difference between students' academic stress based on age" was rejected.

Analysis to Explore the Effect of Academic Stress on Mental Health of Undergraduate Students

Multiple regression analysis was made to test this research objective. Results of this test are given in following table.

Table 3 Effect of Academic Stress on Mental Health

Model	R	R2	Adjusted R2	Std. Error of Estimate
1	.772a	.522	.52	4.29325

Predictors: SS, TTS, PS, TMS, TS, SGS, RS

The table indicates that the value of R2 = .522, which means that a one percent rise in mental stress can alleviate mental health issues to 52.2%. Further detailed analysis was conducted to test the unique contribution of each study variable is described in following table that ultimately provide valuable information.

Table 4 Contribution of Each Sub-Variable of Stress towards Mental Health Issues

Model 1	Unstandardized Coefficient		Standardized Coefficient	t	Sig.
	B	St. Error	Beta		
Constant	40.927	1.216		33.657	.000
Teacher Stress	-.346	.052	.391	-6.699	.000
Result Stress	.133	.080	.096	1.661	.000
Test Stress	.065	.063	.045	1.032	.000
Study in Group Stress	-.665	.074	.494	-8.985	.000
Peer Stress	.026	.066	.014	.390	.000
Time Management Stress	.307	.081	.137	3.811	.000
Self-inflicted Stress	-.034	.056	.020	-.612	.000

a. Dependent Variable: MH

The results from the above table indicate that each sub-variable had a significant effect over the dependent variable i.e., mental health. The values of beta further revealed predictors' effect over mental health issues in order of study in group (49.4%); teacher stress (39.1%); time management

stress (13.7%); result stress (9.6%); rest stress (4.5%); self-inflicted stress (2.0%); and peer stress (1.4%) respectively. In this connection, from the above two tables, it was found that the hypothesis "There is no significant effect of academic stress on the mental health of undergraduate students" was therefore rejected.

DISCUSSIONS

This study aimed to find out to determine the effect of academic stress on mental health among undergraduate students from Lahore. The findings showed that there was a significant relationship between academic stress and the mental health of undergraduate students. Research conducted by Nikitha et al, (2014) concluded that academic stress is the primary source of stress among students and can lead to low self-esteem. Poor self-esteem affects many mental disorders, like psychological distress and disability where this research reported same results as mentioned in the other studies. The same results from the previous research studies (Barbayannis et al., 2022; Prowse et al., 2021). The same results were also revealed in a study conducted by Keinan and Perlberg (1986) that the potential effects of intense stress are emotions of anger, depression, and anxiety. Oh, Mckean et al. (2000) conclude that anxiety, depression, or pain are not triggered by pressures alone. Conversely, stress is triggered by interaction and response amid stressful events and the interpretation of person to these stimuli.

Gupta and Khan (1987) revealed in their study that academic stress is a mental disorder concerning some anticipated disappointment associated with the academic failure, or even knowledge of the probability of such failure. Sapru (2006) reported that for most teenagers in stressed and unstressed classes, the proportion of people were in the 18-21 age group. In this linking, the findings also show that there is a significant difference between the age group of students. While the 18-21 age group of students takes more stress and is more influenced than other age groups of students. Nationally and globally, in the 18-24 age groups, death is the second largest cause of the death that is only exceeded by road accidents (WHO, 2008). Consequently, Global Burden of Disease (GBD) reports by the World Health Organization indicate that the monopolar mood symptoms, schizophrenia, bipolar disorder, drug use, and self-inflicted diseases are some of the leading causes of the infection diverse rates, which both compensate for 22 percent of all existence-years (disease burden) suffered (Gore, 2011).

The results indicated a significant positive relationship based on year while in the first year of the degree program, students are more influenced than in other years of learning. Prabu (2015) showed in his study that challenges and difficulties encountered by undergraduates in the first year differ from those encountered by their non-student colleagues or those in final year. The study indicated a significant difference between genders. The result revealed that females are more influenced by males. In literature, some studies showed that males are more influenced than females; some show females are more influenced than males. Starting from here Prince et al., (2007) examined that the results of impact of academic stress on mental health on both men and women are far below average and that female score was significantly higher than that of males. Same results were from previous studies (Barbayannis et al., 2022; Prowse et al., 2021). Another study led by (Wells, 2002) that 70%

of males take academic stress than females while remaining 30% of females take more academic stress than males.

CONCLUSION

This study was an attempt to determine how academic stress affects the mental health of university students. The results of the study showed significant effect of academic stress on the mental health of undergraduate students. It was also found that the factors of academic stress, TS (teacher stress), RS (results stress), TTS (test stress), SGS (group stress), PS (peer stress study), TMS (time management stress), SS (self-inflicted stress) were related to mental health among undergraduate students. The result showed significant difference in gender-based academic stress of undergraduate students, females are more influenced than males. The study also showed significant difference between the students ' academic stress based on age. While a significant difference was also shown between the students ' academic stress based on year, moreover students from 3rd year are more influenced than other years of learning.

Recommendations

1. The educational institutions and universities should arrange the workshops, seminars, stress management skills, and different training centers.
2. The universities should provide motivational sessions, therapy, and intellectual stimulation to reduce stress on the mental health of students.
3. A mixed method approach should be done on it which helps to explore causes of stress. Future studies should be led in other areas of Pakistan.

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