

A Pilot Study of Symptoms of Major Depressive Disorder in Medical Students at an Osteopathic Medical School Before and After High-Stakes Examinations

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Background: Given the high prevalence of symptoms of major depressive disorder (MDD) in medical students, identifying factors that impact the development of such symptoms is important. Previous data suggest that medical students can experience symptoms of MDD after medical school exams. It is not known if medical students experience more symptoms of MDD directly before or after exams. The aim of the current study is to determine the prevalence of symptoms of MDD in first- and second-year medical students directly before and after high-stakes medical school examinations.

Methods: Two anonymous surveys were sent via REDCap to first- and second-year medical students at the University of New England College of Osteopathic Medicine. A pre-exam survey on the day of the exam asking about the past three days' MDD symptoms, and a post-exam survey sent three days after the exam asking about MDD symptoms experienced after the exam was sent out to a total of 391 students with a response rate of 23%.

Results: First- and second-year medical students regardless of gender experienced symptoms of MDD at higher rates before exams than afterwards. Female students experienced symptoms of MDD (as defined by the DSM-5) including sadness, sleep disturbances, and feelings of guilt or worthlessness at a greater rate compared to males before exams. After exams, females were more likely to experience sleep disturbances and decreased energy. Second-year male students were the least likely to experience symptoms of MDD.

Conclusion: First- and second-year medical students can experience symptoms of MDD surrounding exams. This study highlights the emotional burden that students may carry near exams. It underscores the importance of further research on this topic to evaluate the effect exams have on the mental health of medical students during their training.

Keywords: depression, medical school, examinations, gender, MDD

Introduction

Throughout the world, greater than one-quarter of medical students experience symptoms of major depressive disorder (MDD) at some point during their medical school training.¹⁻⁵ Research has consistently shown that medical students experience higher rates of symptoms of MDD and anxiety compared to the general population.²⁻⁹ According to the National Institutes of Health, in 2020, the prevalence of MDD in the United States (US) was 8.4%, with females (10.5%) having a greater prevalence than males (6.2%).¹⁰ MDD has been shown to occur in medical students at a prevalence as high as 25%, whereas the general population has a rate closer to 10%.¹⁰ The finding that a greater proportion of female medical students experience symptoms of MDD compared to males has also been described multiple times.¹¹⁻¹⁸ However, other studies show that there is no difference,^{19,20} suggesting that the true effect of gender on the development of the symptoms of MDD in medical students is still not fully elucidated. However, it does appear more research points towards a female predominance in the development of symptoms of MDD in medical students, again consistent with the

general population.¹⁰ Given the high prevalence of symptoms of MDD in medical students, identifying factors that affect the development of these symptoms is both timely and important to the mental health of our future health care providers.

Much of the current research on the development of the symptoms of MDD in medical students is from countries outside of the United States (US), leaving this area of research largely unexplored in the US. Additionally, during the COVID-19 pandemic, a survey of medical students at forty medical schools in the US found increased rates of both symptoms of MDD and anxiety compared to pre-pandemic rates, revealing a possible exacerbation of an already largely unaddressed problem in the medical education system.²¹ Interestingly, data from other countries shows that while both anxiety and stress were increased in medical students during the COVID-19 pandemic, rates of the development of MDD did not change.^{22,23} Of note, the study noted that was conducted in the US looking at medical students during the pandemic was published in 2021, while the other studies were published in 2020; perhaps the progression of the pandemic may later show the same trend in medical students in other countries. These differences could also reflect cultural differences, as prior research has shown that attitudes towards mental illness can differ among medical students based on their country of origin.²⁴

Prior research that looked at the prevalence of the development of MDD and burnout in matriculating medical students compared to non-medical students who had finished a four-year degree found that matriculating medical students experienced lower rates of MDD and burnout compared to other students who just finished a four-year degree.²⁵ Other studies have shown that the prevalence of MDD among medical students upon entry into medical school resembles the general population, but increases during their medical education and training.^{26–28} Additionally, third-year medical students are at greater risk of developing symptoms of MDD compared to first-year medical students.²⁹ This suggests that many students do not come into medical education with symptoms of MDD, but rather the medical education process may be contributing to the development of the symptoms of MDD.²⁵ Finally, another recent study looking at matriculating medical students in Australia found that students entering medical school had significant baseline rates of depression, anxiety, and stress;²⁷ this further complicates elucidating whether students entering medical school are generally more inclined to develop symptoms of MDD, or if they come in already having either higher rates of MDD or a greater predilection to develop MDD.

According to the NIH, 66% of adults aged 18 and older who experienced an episode of MDD received treatment for their illness.¹⁰ This is in stark contrast to medical students who receive professional help for depression—with studies showing that only 15–22% of students with diagnosed MDD sought help for their diagnosis.^{1,30} One particular cross-sectional study found that 81% of medical students surveyed who met the criteria for MDD were undiagnosed at the time.³¹ Across multiple studies, barriers exist to medical students seeking professional help, included stigma, confidentiality concerns, and fear of unwanted intervention.^{30,32} The fact that medical students may have high rates of MDD but are undiagnosed—and less likely to seek help for depression—is startling, and only emphasizes that uncovering the factors that contributed to the development of MDD in this population may help prevent serious consequences in medical student's mental health and the mental health of our future physicians.

Factors that contribute to the development of symptoms of MDD in medical students include “dysfunctional coping strategies and low resilience”.³³ Other research has shown that approaching high-stakes examinations increases the manifestation of symptoms of MDD and anxiety in medical students,³⁴ and the rates of MDD are highest in medical students right after medical school exams.¹⁵ Yet, the presence of symptoms of MDD and anxiety in medical students are likely multifactorial in nature, due both to the multiple stressors and the heterogeneity of the population that makes up medical students. Developing a better understanding of the triggers of depressive symptoms in medical students may lead to better interventions to curb symptoms in this population.

The present researchers' prior work investigated the development of symptoms of MDD in medical students immediately following high-stakes medical school examinations. That research found that female medical students experienced greater development of symptoms of MDD compared to their male counterparts.¹⁵ However, in the previous work, students were surveyed only after high-stakes examinations. The aim of the current study is to determine the prevalence of symptoms of MDD in first- and second-year medical students both directly before and directly after high-stakes medical school examinations to better characterize how, and if, these examinations may be contributing to the development of symptoms of MDD in medical students. The study hypotheses were: (1) female medical students will

develop more symptoms of MDD both before and after high-stakes medical school examinations, and (2) medical students will experience symptoms of MDD both directly before and after high-stakes medical school examinations, with significantly more symptoms after examinations.

Methods

Two secure surveys were sent via university e-mail to first- and second-year medical students at the University of New England College of Osteopathic Medicine (UNECOM) in Biddeford, Maine, using the REDcap program. The survey was sent to a total of 391 students. The first survey was sent on the day of the examinations (pre-examination survey) and students were asked to record symptoms of MDD, if any, they had experienced in the three days leading up to the exam. The second survey was sent out three days after the examination (post-examination survey). The survey was sent after multiple exams to get a large enough sample size, but participants were asked to only fill out the survey once. The authors were in contact with school administrators to ensure dates of exams for the student body surveyed to ensure the surveys were sent out truly before and after exam periods. The surveys sent to students can be found in [Figure 1a](#) (pre-exam survey) and [Figure 1b](#) (post-exam survey). A consent form was attached to each survey. The survey was created by the authors and asked similar symptom questions as prior research by the authors.¹⁵ The survey asked about the symptoms of major depressive disorder (MDD) as described in the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5). Both the survey and research project were approved by the University of New England (UNE) IRB. All data were collected anonymously via REDcap. Data was stratified by gender and chronological year of medical education. Data was compiled and statistics were run using IBM SPSS software. Participants who completed the survey in full were included in the data analysis. Only one participant reported their gender as non-binary, and thus was removed from analysis for statistical comparison reasons. Two-sided chi-square tests were used to determine differences between categorical groups. $P < 0.05$ was the threshold used for considered statistical significance.

a	b
Please read the attached Informed Consent Statement and choose if you would like to participate in the survey.	Please read the attached Informed Consent Statement and choose if you would like to participate in the survey.
What gender do you identify with?	What gender do you identify with?
In the past 3 days leading up to this exam, have you experienced any of the following symptoms:	In the past 3 days since taking your exam, have you experienced any of the following symptoms:
Sadness or depressed mood?	Sadness or depressed mood?
Anhedonia or lack of interest?	Anhedonia or lack of interest?
Changes in sleep (either insomnia or hypersomnia)?	Changes in sleep (either insomnia or hypersomnia)?
Feeling of guilt or worthlessness?	Feeling of guilt or worthlessness?
Decreased energy or fatigue?	Decreased energy or fatigue?
Decreased concentration?	Decreased concentration?
Changes in appetite (increased or decreased)?	Changes in appetite (increased or decreased)?
Psychomotor agitation or retardation?	Psychomotor agitation or retardation?
Suicidal ideation?	Suicidal ideation?

Figure 1 (a) Pre-exam Survey Questions. (b) Post-exam Survey Questions.

Results

Survey Participants

A total of 91 students responded to the pre-exam survey out of 391 for a response rate of 23.3%. A total of 41 (21.5%) first-year students participated in the pre-exam survey. A total of 50 (25.0%) second-year medical students participated in the pre-exam survey. A total of 115 students responded to the post-exam survey out of 391 for a response rate of 29.4%. A total of 65 (34.0%) first-year students and 50 (25.0%) second-year medical students participated in the post-exam survey. Overall, more female medical students participated in the study compared to males (Table 1).

Symptoms of MDD Before and After Medical School Exams

When all medical students in the sample were combined (male and female first- and second-year medical students) and rates of development of symptoms of MDD were compared both before and after exams, we found that a higher percentage of medical students experienced symptoms of MDD before medical school exams compared to after medical school exams (Figure 2). This was statistically significant for all DSM-5 symptoms of MDD except for psychomotor agitation ($p = 0.06$) and suicidal ideation ($p = 0.458$) (Figure 2) which, although not statistically significant, still followed the trend of a greater percentage of students experiencing these symptoms before exams compared to after exams. For the following symptoms of MDD, a greater percentage of students experienced them before exams compared to after, and this was statistically significant for the following symptoms: sadness ($p < 0.001$), anhedonia ($p = 0.004$), sleep disturbances ($p = 0.015$), guilt or worthlessness ($p < 0.001$), decreased energy ($p = 0.001$), decreased concentration ($p = 0.006$), and changes in appetite ($p = 0.001$) (Figure 2).

Gender Differences in Symptoms of MDD Experienced Before and After Medical School Exams

In the current study, female medical students were more likely to experience symptoms of MDD both before and after medical school exams compared to male peers (Figures 3 and 4). In the 3 days leading up to medical school exams, a statistically significant percentage of female medical students, compared to male medical students, experienced the following symptoms of MDD: sadness ($p = 0.001$), sleep disturbances ($p = 0.006$), and feelings of guilt or worthlessness ($p = 0.001$) (Figure 3). The same trend followed for anhedonia ($p = 0.151$), decreased energy ($p = 0.080$), decreased concentration ($p = 0.200$), changes in appetite ($p = 0.151$), psychomotor agitation or retardation ($p = 0.385$), and suicidal ideation ($p = 0.926$) (Figure 3).

When surveyed 3 days after exams, the trend of a greater percentage of female medical students experiencing the symptom of MDD compared to males was seen for all symptoms, except for suicidal ideation ($p = 0.461$) (Figure 4). This was statistically significant for the symptoms of sleep disturbances ($p = 0.001$) and decreased energy ($p = 0.013$).

Table 1 Study Participants

Pre-exam Participants			
	Overall	First year	Second Year
Response number	91 (100%)	41/91 (45.1%)	50/91 (54.9%)
Response percent	91/391 (23.3%)	41/191 (21.5%)	50/200 (25%)
Female percent	67/91 (73.6%)	30/67 (44.8%)	37/67 (55.2%)
Male percent	24/91 (26.4%)	11/24 (45.8%)	13/24 (54.2%)
Post-exam Participants			
	Overall	First year	Second Year
Response number	115 (100%)	65/115 (56.5%)	50/115 (43.4%)
Response percent	115/391 (29.4%)	65/191 (34.0%)	50/200 (25.0%)
Female percent	80/115 (69.5%)	46/80 (57.5%)	34/80 (42.5%)
Male percent	35/115 (30.4%)	19/35 (54.3%)	16/35 (45.7%)

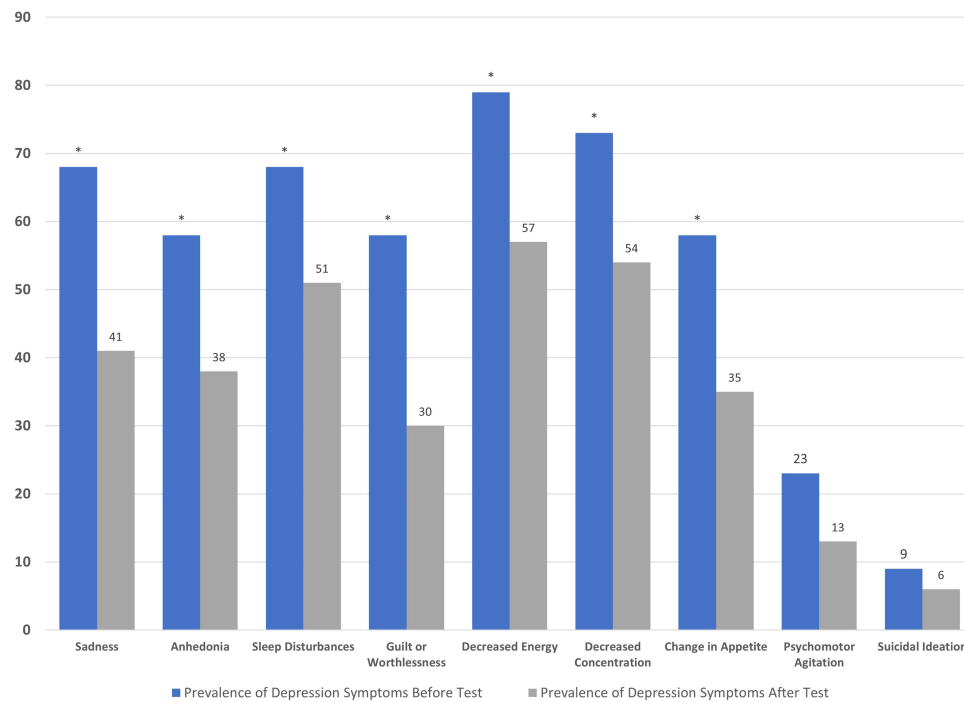


Figure 2 Prevalence of depression symptoms before and after test. * $p < 0.05$ horizontal axis is symptoms of depression, vertical axis is percentage of students who experiences symptoms.

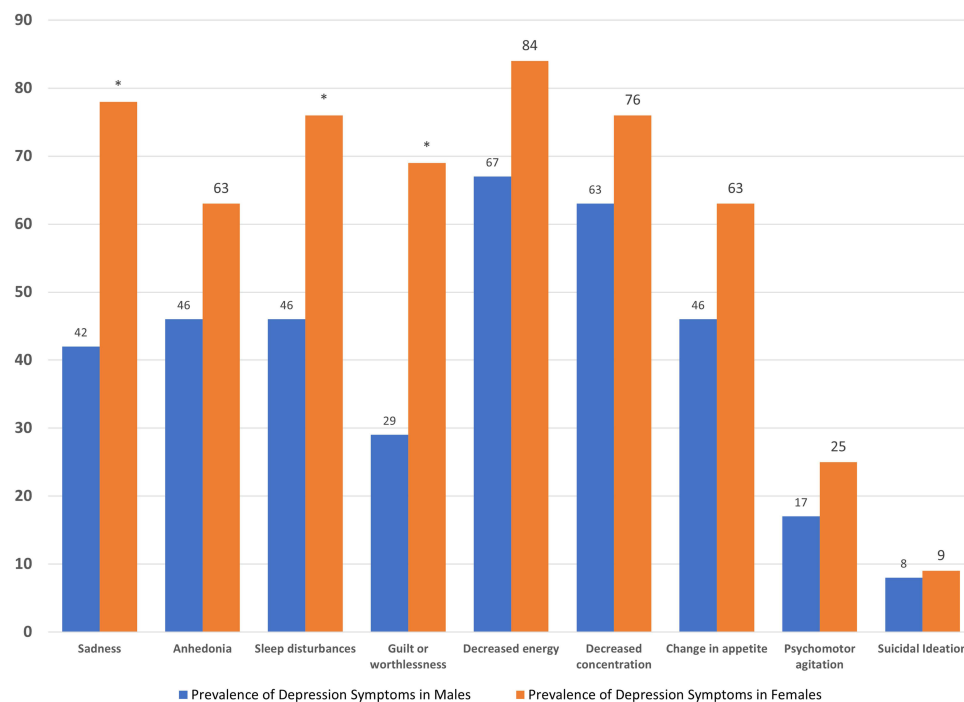


Figure 3 Overall Difference in Symptoms of Depression Before and After Exams in First- and Second-Year Medical Students. * $p < 0.05$ horizontal axis is symptoms of depression, vertical axis is percentage of students who experiences symptoms.

(Figure 4). The same trend followed for the symptoms of sadness ($p = 0.342$), anhedonia ($p = 0.157$), guilt or worthlessness ($p = 0.297$), decreased concentration ($p = 0.724$), changes in appetite ($p = 0.355$), and psychomotor agitation ($p = 0.346$), though the differences were not statistically significant (Figure 4). Of note, regardless of gender, a large percentage of students experienced at least some symptoms of MDD both before and after medical school exams.

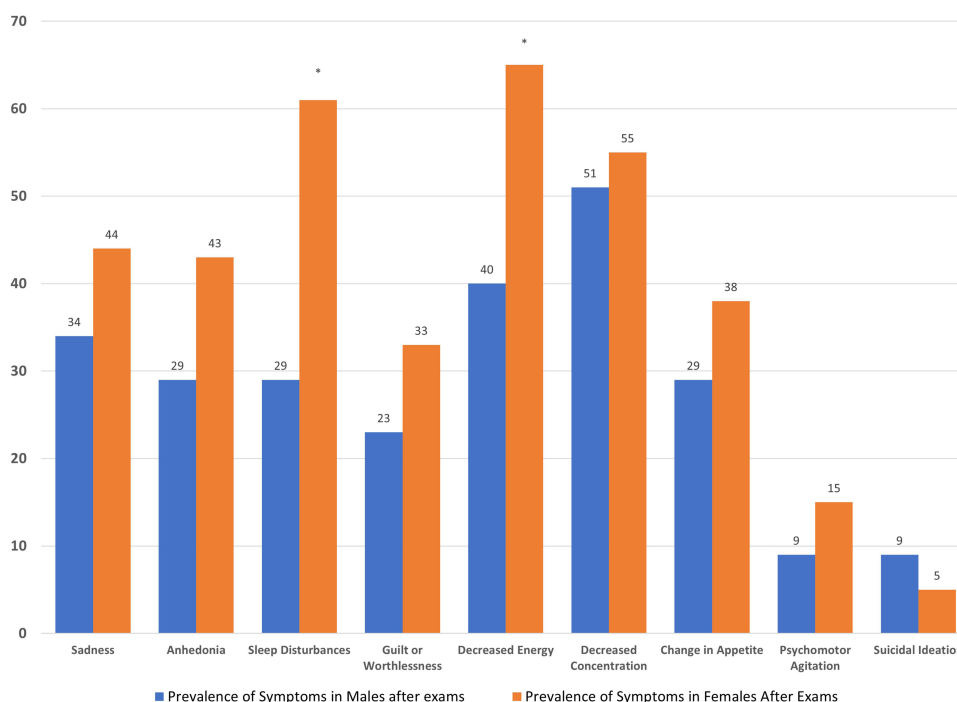


Figure 4 Differences in Symptoms of Depression in Male and Female Medical Students Before Exams. * $p < 0.05$ horizontal axis is symptoms of depression, vertical axis is percentage of students who experiences symptoms.

Symptoms of MDD in Female Medical Students Before and After Exams

When we looked at both first- and second-year female medical students, we found similar trends to that described above, with females experiencing more symptoms of MDD before exams as compared to after, which was statistically significant for sadness ($p < 0.000$), anhedonia ($p = 0.015$), feelings of guilt or worthlessness ($p < 0.000$), decreased energy ($p = 0.011$), decreased concentration ($p = 0.008$) and changes in appetite ($p = 0.002$) (Figure 5a). The same trend was seen for sleep disturbance ($p = 0.054$), psychomotor agitation or retardation ($p = 0.115$), and suicidal ideation ($p = 0.343$), but this was not statistically significant (Figure 5a). Overall, both first- and second-year female medical students exhibited similar trends, with both first- and second-year female students experiencing more symptoms of MDD before exams as compared to afterward. For first-year female medical students, this was significant for sadness ($p < 0.001$), feelings of guilt or worthlessness ($p = 0.004$), decreased energy ($p = 0.009$), and decreased concentration ($p = 0.002$) (Figure 5b). For second-year female medical students, this was significant for sadness ($p = 0.045$), feelings of guilt or worthlessness ($p = 0.001$), and changes in appetite ($p = 0.012$) (Figure 5c).

Symptoms of MDD in Male Medical Students Before and After Exams

When we looked at first- and second-year male medical students, we found a similar trend to that of females, where male medical students experienced higher rates of symptoms of MDD before exams compared to after for all symptoms, except for suicidal ideation (Figure 6a). These findings were less pronounced than the differences seen in females, with the only statistically significant difference seen for decreased energy ($p = 0.044$). Interestingly, for the symptom of anhedonia, second-year male medical students experienced this symptom more than first-year medical students, but this was not statistically significant ($p = 0.145$). When we looked at first-year male medical students and compared symptoms of MDD both before and after exams, we again uncovered a similar pattern as with first-year female medical students, where first-year male medical students experienced more symptoms of MDD before exams compared to after; however, the difference was less pronounced in males, with the only statistically significant difference seen for decreased energy ($p = 0.017$) (Figure 6b). Second-year medical students experienced similar rates of development of symptoms of MDD

before and after exams, and no statistical difference was found looking at the development of symptoms of MDD before exams and after (Figure 6c).

Discussion

In this pilot study it was found that, overall, medical students experience symptoms of MDD as defined by the DSM-5, both directly before and after medical school exams. This was not surprising, as prior research has shown that medical

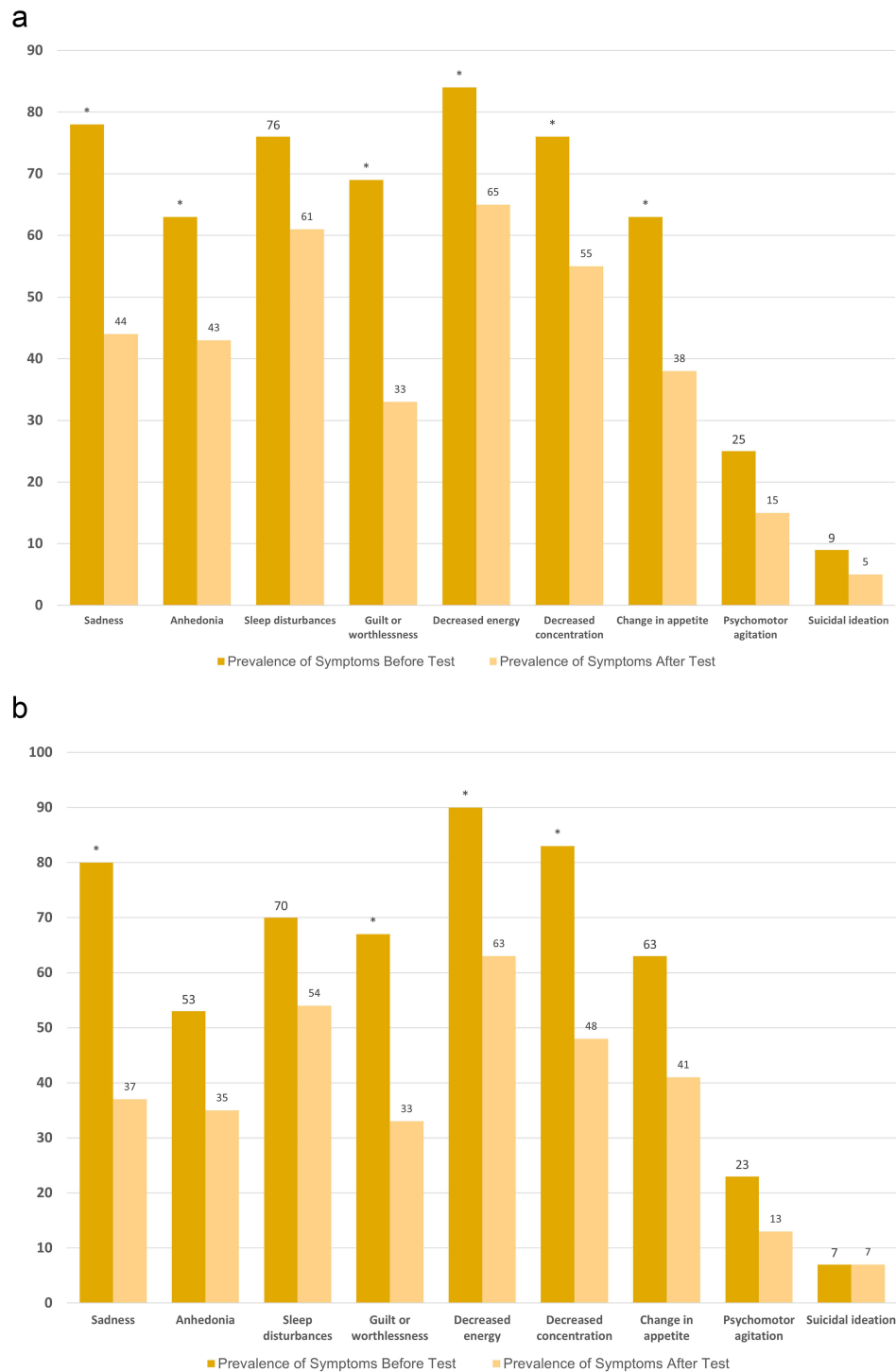


Figure 5 Continued.

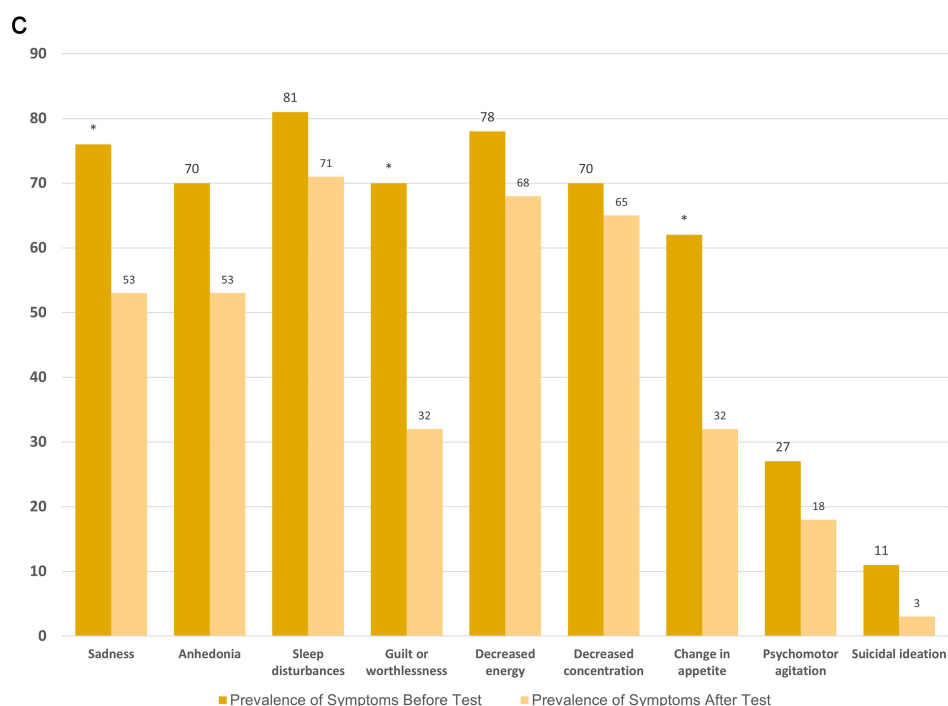


Figure 5 (a) Symptoms of Depression in Female Medical students Before and After Exams. * $p < 0.05$ horizontal axis is symptoms of depression, vertical axis is percentage of students who experiences symptoms. (b) Symptoms of Depression in First Year Female Medical Students Before and After Exams. * $p < 0.05$ horizontal axis is symptoms of depression; vertical axis is percentage of students who experiences symptoms. (c) Symptoms of Depression in Second Year Female Medical Students Before and After Exams. * $p < 0.05$ horizontal axis is symptoms of depression; vertical axis is percentage of students who experiences symptoms.

students experience high rates of development of symptoms of MDD around exams.^{15,34} This, along with a large body of research supporting that up to more than a quarter of medical students' experience depression,^{1–5} made this conclusion not surprising, yet still alarming. It was also not surprising that female medical students in this study developed more symptoms of MDD compared to their male counterparts (Figures 3 and 4). This was also consistent with prior research,^{11–18,35} and once again highlights that gender disparities exist in medical students who are most likely to experience symptoms of MDD. This is important to recognize, as female medical students in recent years make up greater than 50% of all medical students matriculated at the US allopathic and osteopathic medical schools.³⁶ In the current study, gender was looked at specifically, but understanding how symptoms of MDD affect minority populations and other underserved populations is an important next step.

We were surprised to discover that students experienced more symptoms of MDD before exams, which was statistically significant for all symptoms except for psychomotor agitation and suicidal ideation (Figure 2). We had hypothesized that medical students would experience more symptoms of MDD after exams as compared to before based on our previous study that showed that medical students experience high rates of depression directly after exams.¹⁵ In the prior study, comparisons of students' symptoms of MDD before exams to those after was not addressed. Given that research has shown that symptoms of stress and anxiety in medical students are indeed related to academic pressures,³⁷ it makes sense that the impending exam would increase these symptoms of MDD and distress before exams, and then perhaps the fatigue of preparing for and then taking the exam could contribute to symptom development after the exam.

In this pilot study, first- and second-year medical students, overall, experienced similar rates of development of symptoms of MDD around exams. Prior research is mixed, with some studies showing first-year students as more likely to develop symptoms of MDD, and that MDD symptoms decrease as students advance through the course of their medical education training.³ Other studies show that second-year medical students experience higher rates of development of symptoms of MDD compared to first-year students.³⁸ These prior studies may suggest that when students experience more symptoms of MDD varies depending not only on gender but also on cultural context. This study was conducted in the US, and many other studies have been conducted outside the US.^{24,38} It was noteworthy that there were

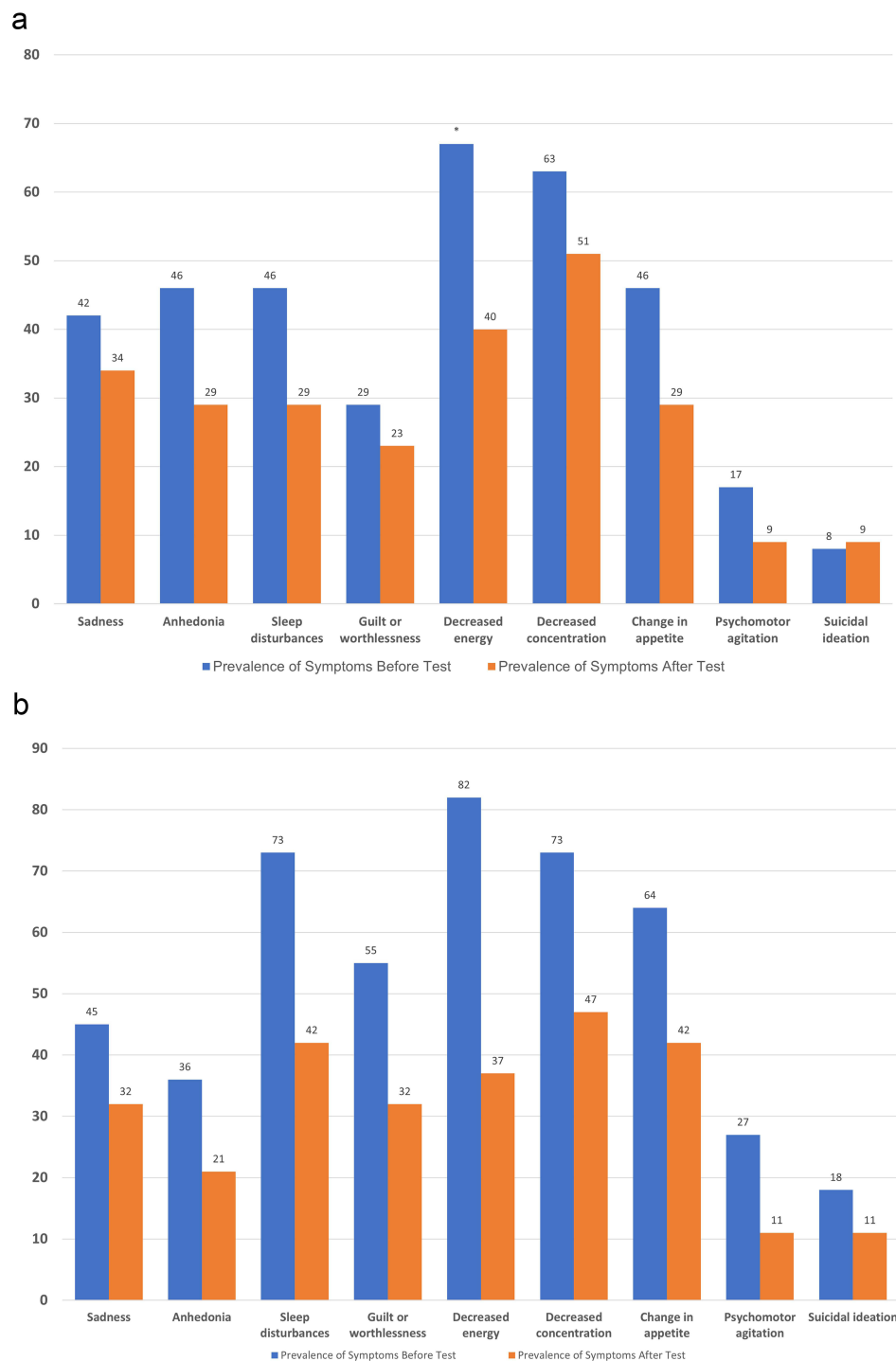


Figure 6 Continued.

very few overall differences in symptoms of MDD between first- and second-year medical students possibly indicating that stress and academic pressure do not abate over the course of the first two years of medical school.

Overall, it is worth noting the alarming rate at which the medical students surveyed in this study experienced symptoms of MDD. As noted previously, both prior research and this study point to a substantial, and perhaps under-reported, rate of development of symptoms of MDD among medical students. Additionally, there was a noteworthy number of medical students that experienced suicidal ideation both before and after exams, despite this number not

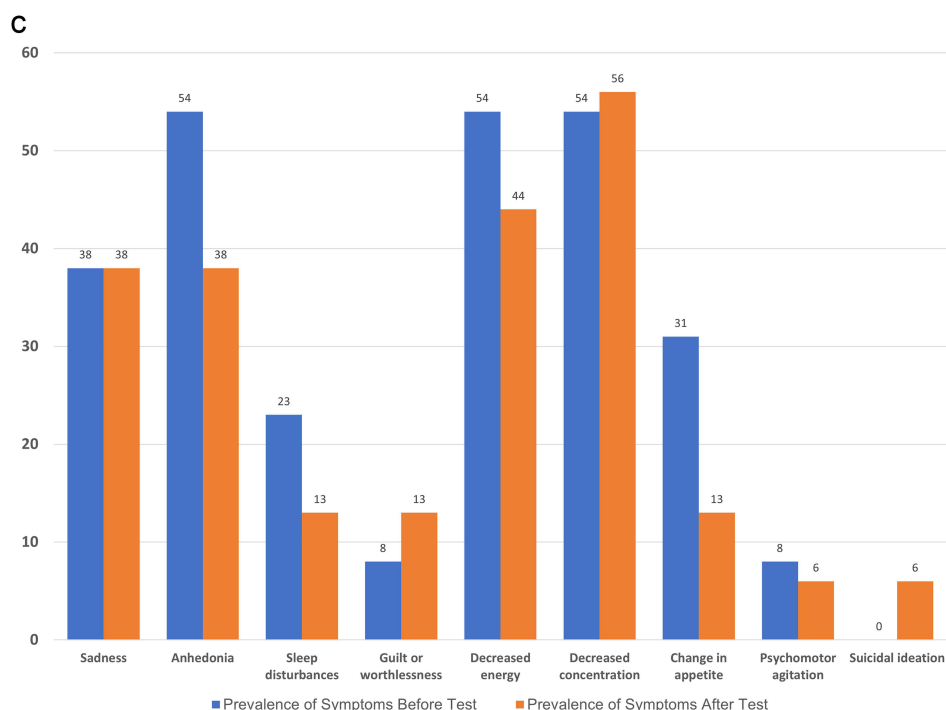


Figure 6 (a) Symptoms of Depression in Male Medical Students Before and After Exams. * $p < 0.05$ horizontal axis is symptoms of depression, vertical axis is percentage of students who experiences symptoms. (b) Symptoms of Depression in First Year Male Medical Students Before and After Exams. Horizontal axis is symptoms of depression, vertical axis is percentage of students who experiences symptoms. (c) Symptoms of Depression in Second Year Male Medical Students Before and After Exams. Horizontal axis is symptoms of depression, vertical axis is percentage of students who experiences symptoms.

reaching statistical significance (Figure 2). Given the statistically significant rates of MMD symptoms among first- and second-year medical students and the simple raw numbers of students experiencing suicidal ideation, it seems reasonable to suggest that not only is more in-depth research into the root causes of these problems needed but so too are systemic changes in how we operationalize medical education, ensuring that the mental health and wellbeing of medical students during the early years of medical education is emphasized.

Limitation

One limitation of this study was that it was done at one medical school in the US, limiting the sample size. Additionally, more female medical students responded to this study than male medical students. And overall response rates were often less than 30%. This was perhaps due to students' unwillingness to participate in the survey, due to the sensitive nature of the questions. By making the survey anonymous this hopefully allowed students to answer the survey more honestly. Although, there were some low response rate we still feel that this pilot study is an important first step in looking at symptoms of depression around high stakes medical school exams, and warrants further investigation into this topic, to see if the above results are reproducible. Because we did see high rates of symptoms of MDD in the students who did participate in the survey, we are less inclined to think that students under-reported symptoms, but whether male medical students truly experience fewer symptoms of MDD compared to females, or if they are less likely to admit to such symptoms, even in an anonymous survey, is still unknown. This study only differentiated between self-identified male and female medical students and does not specifically address symptoms or differences among students who identify as non-binary or gender nonconforming. Given the well-documented rates of MDD among this population in general,^{39,40} it is worth exploring the specific effect of medical school exams on their mental health in future research. Additionally, we only surveyed students within a three-day period before and after exams, so we do not know what the lasting consequences of these symptoms are, or how long these symptoms truly exist both before and after exams. This was why symptoms of MDD was reported and not MDD itself because the 2-week requirement of symptoms to meet full criteria of MDD as the DSM-5 was not met in this study. We did not ask about other circumstances in the students' lives,

as other stressful situations outside of medical school exams could have contributed to the development of symptoms of MDD in these medical students. However, we do believe that enough students experienced symptoms of MDD for the effects alone to not be due to random chance.

Conclusion

Overall, first- and second-year medical students experience high rates of development of symptoms of MDD surrounding medical school exams. Medical students in this study were more likely to experience symptoms of MDD before exams as compared to after. Female medical students experienced symptoms of MDD at greater rates compared to their male counterparts. Second-year male medical students were the least likely to experience symptoms of MDD around exams in this study, however this finding may be limited by small sample size and other limitations as noted previously. This study demonstrates that high-stakes medical school exams can result in a significant emotional burden for students and underscores the importance of further research on this topic to elucidate how high-stakes examinations may contribute to the overall mental health of medical students as they progress through their training and enter the physician workforce.

Compliance with Ethical Standards

Two secure surveys were sent via university e-mail to first- and second-year medical students at the University of New England College of Osteopathic Medicine (UNECOM) in Biddeford, Maine, using the REDcap program. No minors were involved in the survey, so all participants were able to consent for themselves. A consent form was attached to each survey (please see additional document with submission labeled consent form). After reading the consent, the first question of the survey was: "Please read the attached Informed Consent Statement and choose if you would like to participate in the survey". Participants were then asked to select yes or no (as noted in Figure 1a and 1b, and if they selected no, they were asked to not finish the survey. The survey remained anonymous. The survey was created by the authors and asked about the symptoms of major depressive disorder (MDD) as described in the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5). The consent form, survey, and research project were approved by the University of New England (UNE) IRB and is in compliance with the Declaration of Helsinki. All data were collected anonymously via REDcap.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

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