

1 **TITLE**

2 Effects of medical school on mental health and sleep habits

3

4 **RUNNING TITLE**

5 Mental health and sleep during medical school

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20 **CONFLICT OF INTEREST STATEMENT**

21 The authors declare no conflicts of interest in the realization of this study.

22

23 **DATA ACCESSIBILITY STATEMENT**

24 Derived data supporting the findings of this study are available from the corresponding authors on  
25 request.

26

## 27 **ABSTRACT**

28 **BACKGROUND and OBJECTIVES:** This study aims to define changes in anxiety and depression among  
29 medical students while evaluating the association of sleep habits and other risk factors, including  
30 exercise habits and a diagnosis of chronic disease. The effect of the COVID-19 pandemic was also  
31 evaluated.

32 **DESIGN:** A cohort of first- and second-year medical students was evaluated longitudinally using survey  
33 methods to quantify changes from pre-medical school and summer break to each semester in medical  
34 school throughout years one and two.

35 **METHODS:** Data was analyzed using Generalized Linear Mixed Models (GLMMs) on the numeric  
36 responses of General Anxiety Disorder-7 (GAD-7), Patient Health Questionnaire-9 (PHQ-9), and Pittsburg  
37 Sleep Quality Index. Additional assessments evaluated exercise habits, chronic disease, and impact of  
38 COVID-19 Pandemic.

39 **RESULTS:** Depression, anxiety, and sleep habits displayed a cyclical change that was associated with the  
40 academic cycle. The COVID-19 pandemic was never significant. Medical students who had a chronic  
41 disease diagnosis had increased severity. Exercise did not play a role.

42 **CONCLUSION:** The main driver for depression, anxiety, and poor sleep quality was the academic cycle,  
43 while the COVID-19 pandemic did not have an impact on mental health.

44

## 45 **KEYWORDS:**

46 Medical school, GAD-7, PHQ-9, PSQI, exercise, chronic disease, sleep quality, COVID-19

47

## 48 BACKGROUND

49           During the first two years of medical school, students are expected to reprioritize their lives to  
50 meet the long hours of lecture material, daily hands-on laboratory sessions, and personal study in  
51 preparation for both school and national exams [1]. To be a competitive applicant for residency,  
52 students also devote considerable time to extracurricular activities such as volunteer, work, and  
53 research experiences [2,3]. The schedule of students prior to medical school is often radically different  
54 and less demanding than that of a medical student [4,5]. These increased demands may account for the  
55 higher rates of burnout and mental illness reported in enrolled medical students compared to the  
56 general population [6–8]. Multiple studies have discovered a correlation between medical school  
57 enrollment and changes in mental health, including increased levels of depression [9–12], anxiety  
58 [6,9,12], stress [11–13], and burnout [14]. The feelings of burnout and depression that present in  
59 medical students also persist in medical residents and physicians [10,15]. Therefore, the ability to  
60 identify risk factors that contribute to mental health deterioration in medical students is likely to have  
61 implications for residents and physicians.

62           Risk factors which impact mental health include sleep quality and quantity, exercise, and chronic  
63 disease [16–18]. Arguably, poor sleep quality has the most significant association with poor mental  
64 health in medical students. It has been shown to be associated with an increase in stress, anxiety, and  
65 depression among medical students [12,13,19]. College students that present with depressive  
66 symptoms were found to have greater comorbid anxiety when they also experienced sleep disturbances  
67 [12,19–21]. Students with depressive symptoms were found to rate sleep quality as poor and experience  
68 increased somnolence in class [22]. Poor sleep quality, decreased quantity, and increased depression  
69 levels were shown to be independent predictors of burnout [14] and have a strong association with  
70 decreased mental health. Additionally, reduced incidence rates of depression and some anxiety  
71 disorders have been observed in exercising individuals [23]; exercise has even been shown to be

72 effective in the treatment of depression, and to a lesser extent anxiety [23,24]. Likewise, chronic disease  
73 has been shown to lead to depression and anxiety [17]. Adding to the equation, the COVID-19 pandemic  
74 came into the picture. Depression, anxiety, and sleep disorders have been linked to the pandemic  
75 among the general public [25]. More specifically, studies have noted that college students are anxious  
76 regarding cancellation of examinations and academic events [26]. The effects of these disruptions are  
77 likely to contribute negatively to students' mental health.

78 Anxiety and depression were chosen as metrics to evaluate mental health along with sleep  
79 quality due to its strong association with them. The purpose of this study was to define changes in  
80 anxiety, depression, and sleep quality of medical students in their first two years of medical school while  
81 identifying associated risk factors. The following risk factors were considered: chronic disease, sleep  
82 quantity, year of medical school, class year, exercise habits, and COVID-19 pandemic. This allows  
83 medical schools to better understand the effect that medical school has on their students, enabling  
84 them to develop preventative and coping strategies to help students minimize mental distress.  
85 Additionally, by determining the effectiveness of assessment tools and their association to risk factors, it  
86 will be possible to have reliable methods to monitor and to detect students at risk. Medical students will  
87 become future physicians that will provide an important service to our society. It is important to  
88 improve the well-being of medical students so they can become successful physicians.

89

## 90 **METHODS**

### 91 *Participants and study approach*

92 An invitation to participate in this study was sent out to all enrolled students in the class of 2023  
93 and the following year to the class of 2024 in a medical school with two separate campuses. Follow-up  
94 survey invitations were emailed to those students that signed the informed consent to participate in this  
95 study and completed the first survey. An outline of the study is presented in **Figure 1**.

96 No compensation was provided for participating in the study and all participation was voluntary.  
97 All participants signed an electronic consent form prior to participating. The research project was  
98 reviewed by the Rocky Vista University Institutional Review Board with the corresponding IRB# 2019-  
99 0070. The research project was deemed exempt from a full IRB review. No specific funding was received  
100 to conduct this study.

#### 101 *Surveys*

102 Surveys were designed to assess underlying chronic disease, sleep quantity and quality, exercise  
103 habits and levels of depression and anxiety. A chronic disease was specified as one diagnosed by a  
104 physician. Sleep quantity was assessed as average hours of sleep per night. Sleep quality was assessed  
105 the first year of the study with three questions that incorporated graded responses to quantify sleep  
106 quality changes (SQ-3). Although the sleep quality questions were common questions used in other  
107 studies to quantify sleep quality, they have never been used in this format. The Pittsburgh Sleep Quality  
108 Index (PSQI) [27] was added starting with the survey for the Summer of 2020 to supplement the  
109 evaluation of sleep quality. The original three questions assessing sleep quality remained as a part of the  
110 survey to be computed separately from PSQI. Exercise was assessed as days per week and minutes per  
111 session. The total minutes of exercise per week was calculated by multiplying these two values. Finally,  
112 to assess mental health, validated questionnaires were used to analyze levels of anxiety and depression,  
113 Generalized Anxiety Disorder-7 (GAD-7) and Patient Health Questionnaire-9 (PHQ-9), respectively  
114 [28,29]. Therefore, all subjective measurements: sleep quality, anxiety levels, and depression levels  
115 were assessed with previously validated questionnaires. Additional questions were also added in year  
116 two of the study to evaluate for self-reported effects of COVID-19, starting with the summer survey of  
117 2020. Specifically, questions were added to assess if students believed that COVID-19 had increased  
118 their levels of anxiety, depression, and/or decreased quality of sleep. An example of the survey used is  
119 available as a **supplementary file**.

120 *Statistical Analysis*

121 Data was analyzed using Generalized Linear Mixed Models (GLMMs) on the numeric responses  
122 of SQ-3, GAD-7, PHQ-9 and PSQI. These models included fixed effects of class year (class of 2023/class of  
123 2024), COVID-19 period (Pre-/ Post-), specific time points (Summer '19 through Spring '21), chronic  
124 disease diagnosis (Yes/No), average number of sleep hours (hours), and total exercise per week  
125 (minutes). Repeated measurements by participants were included in the models as a random effect. All  
126 models assumed errors to be normally distributed with mean zero and variance of  $\sigma^2$ . All modeling and  
127 descriptive statistical evaluations were performed with SAS v.9.4 (SAS Institute, Cary, NC). Statistical  
128 significance was declared at a confidence level of 95%.

129 The analysis was performed on three separate cohorts defined by the time points and class  
130 years. The first modeling analysis was performed on the full dataset which included both classes of 2023  
131 and 2024, this cohort did not analyze COVID-19 specific questions. The second modeling analysis did  
132 include the COVID-19 specific questions. The third, and last modeling analysis, was performed only on  
133 the class of 2023 cohort, this was done to separate the effect of participants from the class of 2024 that  
134 had only been in medical school during the pandemic.

135

136 **RESULTS**

137 The total number of participants in the study was 197; where 85 out of 130 students  
138 participated from the class of 2023 and 112 out of 145 students participated from the class of 2024.  
139 Participant frequencies are summarized in **Table 1** by COVID period, time point, and chronic disease  
140 diagnosis. A summary for the mean and standard deviation of all variables evaluated in this study is  
141 presented in **Table 2**. In this table, all values are presented for the full dataset, per class year cohort, per  
142 COVID-19 period, and by chronic disease diagnosis. Among all participants 27.73% had at least one  
143 missing record for one or more timepoint.

144 The GLMM modeling analysis used in this study allows for simultaneous evaluation of effects  
145 such as class year, COVID-19 period, differences across time points, chronic disease, average sleep  
146 hours, and total exercise. Therefore, estimation for individual effects on SQ-3, GAD-7, PHQ-9, and PSQI is  
147 already adjusted for other effects in the model. **Figure 2** presents the differences across time points for  
148 the study's full dataset. Significant differences were observed across time points in the individual  
149 analysis of SQ3, GAD-7, PHQ-9, and PSQI. When examining the differences across time point results for  
150 SQ-3, GAD-7, PHQ-9, PSQI, it is evident that there are similar trends. Pre-medical school for class of 2023  
151 (Summer '19); and pre-medical school for class of 2024, combined with class of 2023 who were on  
152 summer break before starting year 2 of medical school (Spring '21), reported significant lower scores for  
153 all time points. The differences across time points, a lower number of sleep hours and having a diagnosis  
154 of chronic diseases significantly increased SQ-3, PHQ-9 and PSQI. The differences across time points and  
155 having a diagnosis of chronic diseases significantly increased GAD-7. P-values for these associations are  
156 presented in **Table 3**. A separate evaluation of timepoints (pre-medical school, fall semester, and spring  
157 semester of year one) for individual class year cohorts (class of 2023 and class of 2024) displayed the  
158 same pattern (data not shown).

159 The full data was then run again in a similar fashion but included the three additional variables  
160 of self-reported change of anxiety, depression, and sleep quality due to COVID-19; labeled as "COVID-19  
161 Anxiety," "COVID-19 Depression," and "COVID-19 Quality of sleep". With this addition, the self-reported  
162 COVID-19 variables provided more information by displaying significant associations to SQ-3, GAD-7,  
163 PHQ-9 and PSQI scores; differences across time points had a significant effect on GAD-7 and PSQI;  
164 having a chronic disease diagnosis had a significant effect on SQ3, PHQ-9, and PSQI; average sleep hours  
165 had a significant effect on SQ-3 and PSQI; COVID-19 Depression had a significant effect on SQ-3, GAD-7,  
166 PHQ-9, and PSQI; COVID-19 Anxiety had a significant effect on GAD-7; and COVID-19 Quality of sleep

167 had a significant effect on SQ-3 and PSQI. No other variables had a significant effect. P-values for these  
168 associations are presented in **Table 3**.

169 Last, the data was analyzed again in a similar manner but only for the class of 2023, excluding all  
170 data from the class of 2024, with variables of COVID-19 period, differences across time points, chronic  
171 disease, average sleep hours, and total exercise accounted for when assessing for the individual effect  
172 on SQ3, GAD-7, PHQ-9, and PSQI. Time point change had a significant effect on SQ-3, GAD-7, PHQ-9;  
173 having a chronic disease diagnosis and average sleep hours had a significant effect on SQ-3, GAD-7, PHQ-  
174 9, and PSQI. No other variables had a significant effect. P-values for these associations are presented in  
175 **Table 3**.

176 In summary, the evaluations of differences across time points, along with the consideration of  
177 the effect of the COVID-19 pandemic, that was never significant, suggests that: life as a medical student  
178 (with the accompanying stress that accumulates through the academic year), having a chronic disease  
179 diagnosis, and fewer hours of sleep are the evident causes of increased levels of anxiety, depression,  
180 and a decrease in sleep quality.

181

## 182 **DISCUSSION**

183 Medical school has a significant effect on sleep quality, depression and anxiety [9–14,19,21,30–  
184 35]. The majority of analyses that have been performed are cross sectional studies that are an  
185 assessment of one time point, relying on a comparison of their results against other groups to provide  
186 context of the significance of their findings, including the general population [6,30,35], or to other  
187 assessments of medical students from around the world [5,12,30,31,36]. However, the longitudinal  
188 analysis of students in this study is unique in that it allowed the quantification of the change from pre-  
189 medical school and summer break to each semester in medical school throughout years one and two.  
190 This allowed students to act as their own controls, reducing for confounding factors. After completing



191 the assessment, the differences across time points displayed a cyclic shift in negative mental health and  
192 poor sleep quality of medical students that was associated directly with the academic year.

193 There is great variability in results of sleep quality, depression, and/or anxiety of medical  
194 students. The reported percentages of students that suffer from poor sleep quality range from 55.8-  
195 76%, anxiety from 41-73%, and depression from 10.4-65% [11–13,19,21,30–33,36]. This variation is due  
196 in part to the lack of standardized assessment tools designated to assess anxiety, depression, and sleep  
197 quality in medical students, leading to a variety of assessment tools used. Additionally, the different  
198 structures and expectations within medical schools around the world are difficult to account for. For  
199 that reason, this study does not focus on comparing the percentages of total anxiety, depression, and  
200 sleep quality to other analyses, but assesses the longitudinal change.

201 As mentioned, school structure influences results. The medical school assessed in this study is  
202 structured similarly to the general model of medical schools throughout the United States: 4-year  
203 curriculum, divided into two-years of basic science coursework and two-years of clinical clerkships [37].  
204 This study evaluated students in their first two years of basic science coursework, as third-and-fourth  
205 years change in structure and setting. No significant difference in anxiety, depression, and/or sleep  
206 quality was observed between year one and year two. However, differing levels of anxiety, depression,  
207 and sleep quality have been observed in other studies when all years of training are considered [32,38].

208 The analysis revealed that class year (class of 2023 versus class of 2024) and exercise habits  
209 (computed as minutes per week) had no effect on mental health or sleep quality. Although exercise has  
210 shown to cause reduced incidence of anxiety and depression in the general population [16], this study  
211 suggests that there is no significant effect in medical students. However, this does not rule out the effect  
212 that adding more exercise may have on students found to have anxiety and depression, as exercise has  
213 shown to have therapeutic effects on mental health [23].

214           The presence of chronic disease, diagnosed by a physician (self-reported), was shown to lead to  
215 higher anxiety and depression levels while decreasing sleep quality. A systematic review which included  
216 20 studies outlined that chronic disease may be interrelated to anxiety/depression, one causing the  
217 other or both potentially exacerbating each other [17]. A simple explanation for this finding could be  
218 that a medical student only can compensate or adjust so much. Thus, when a student is living with a  
219 chronic illness, their health is already compromised; when the pressures of medical school are added,  
220 they are limited in their reserve to compensate and are therefore more susceptible to developing  
221 increased levels of anxiety and depression.

222           In general, fewer hours of sleep were also shown to have a strong negative effect on sleep  
223 quality while also negatively affecting mental health. Number of hours of sleep was shown to  
224 significantly affect depression levels more so than anxiety levels. Evidence suggests that sleeping less  
225 than six hours leads to the development of chronic disease [39], a risk factor for increased anxiety,  
226 depression, and poor sleep quality. One study found that medical students often sacrifice sleep to meet  
227 the demands of school [13]. Helping students prioritize sufficient hours of sleep each night could have  
228 long term benefits.

229           This analysis provides insight into areas that medical schools should place focus, including sleep  
230 patterns and mental health. It has been shown that “good” sleep improves academic performance [40]  
231 and that medical students who are sleep deprived have significantly lower GPAs [41]. Anxiety,  
232 depression, and stress lead to poor academic performance in medical students [42,43]. Students often  
233 can recognize these problems and perceive its effect on their academic performance [22], but do not  
234 always know what to do to receive help. At a United States medical school where confidential mental  
235 health services were available, only 26.5% of the identified depressed students reported treatment.  
236 Notably, 20.4% of the depressed students reported experiencing suicidal ideation [33]. This highlights  
237 that the overall well-being of students should be considered.

238 Medical school should have a focus on health promotion with educational programs that  
239 emphasize the importance of sleep and mental health [21]. One suggestion to help prevent depression  
240 is to educate students on appropriate sleep hygiene and encourage students to pursue professional  
241 guidance to treat sleep disturbances [22]. Another suggestion to reduce mental health symptoms is for  
242 medical schools to institute stress coping mechanisms and improvement of interpersonal relationships  
243 [11]. There is also advice on how to establish a well-being curriculum [44].

#### 244 *Assessment of the impact of COVID-19*

245 The COVID-19 pandemic arose about halfway through the data collection period of this study  
246 and changed educational delivery dramatically during this time, incorporating a virtual learning  
247 environment to encourage social distancing [45,46]. Studies have shown that the pandemic has had a  
248 negative impact on depression, anxiety, and sleep disorders [25,26]. However, there are studies that  
249 report increases in sleep among college students, [47].

250 In this study the effect of COVID-19 was evaluated in two ways: first, by evaluating directly its  
251 effect in the model (pre- and post-COVID-19 period variable) and second, by comparing the first three  
252 time points (Summer '19 - Spring '20), representing student results from the summer, fall semester, and  
253 spring semester of the school year 2019-2020 (pre-COVID-19), to the corresponding seasons of the  
254 following year: time points 4-6 (Summer '20 - Spring '21), representing student results from the  
255 summer, fall semester, and spring semester of the school year 2020-2021 (post-COVID-19). On the full  
256 dataset, there were no differences across time points for the same season of the year and there was no  
257 effect on the change from pre- to post-COVID-19 period variable. This suggests that there was no  
258 significant contribution from the COVID-19 pandemic to anxiety, depression, or sleep quality. To further  
259 account for possible unaccounted confounding effects of putting together the two classes (2023 and  
260 2024 together) the analysis was also run with only the class of 2023. Findings also revealed that the  
261 COVID-19 period had no significant effect on any of the scores. These findings agree in part with a recent

262 report on college students where the effect of the COVID-19 pandemic on stress and sleep was not  
263 necessarily negative and suggested that students are largely resilient [48] . After COVID-19 pandemic  
264 started, 3 questions were added to the surveys to account for any self-reported effect of COVID-19 on  
265 sleep quality, anxiety, and depression. The results were significant for worse outcomes in all three  
266 categories. Change in anxiety, depression, and sleep quality as assessed by GAD-7, PHQ-9, and SQ-3,  
267 respectively, were not significant, but the self-reported responses were. These findings suggest that  
268 students that are unable to recognize the cause of their decline in mental health are likely to blame the  
269 pandemic more than the contribution of their life as a medical student.

#### 270 *Limitations and future directions*

271 A limitation of this study can be its representativeness since data was collected from a single  
272 medical school consisting of two campuses. Also, the sleep quality analysis added an additional  
273 assessment, PSQI, that was not available for the first year. Future research should be directed at  
274 expanding the medical student population surveyed across multiple universities to better generalize  
275 results. Furthermore, studies should incorporate medical students in years three and four to provide  
276 data that spans the entire medical school training.

277

#### 278 **CONCLUSION**

279 The first two years of medical school is associated with elevated levels of depression, anxiety,  
280 and poor sleep quality; the academic cycle being the most important driver. Chronic medical conditions  
281 and decreased total number of sleep hours were identified as risk factors for poor mental health and  
282 poor sleep quality among medical students. The COVID-19 pandemic did not have an impact on medical  
283 student mental health or sleep patterns. Medical schools and students themselves should take an active  
284 role in addressing sleep patterns and mental health to achieve overall better well-being, improved  
285 academic performance, and ultimately become better physicians.

286

287 **REFERENCES**

- 288 1. Slavin SJ, Schindler DL, Chibnall JT. Medical Student Mental Health 3.0. *Acad Med.* 2014;89: 573–  
289 577. doi:10.1097/ACM.0000000000000166
- 290 2. Cirone J, Saks NS. Medical Student Engagement in Extracurricular Activities. *Med Sci Educ.*  
291 2015;25: 293–297. doi:10.1007/s40670-015-0142-6
- 292 3. Almalki SA, Almojali AI, Allothman AS, Masuadi EM, Alaqeel MK. Burnout and its association with  
293 extracurricular activities among medical students in Saudi Arabia. *Int J Med Educ.* 2017;8: 144–  
294 150. doi:10.5116/ijme.58e3.ca8a
- 295 4. Ramón-Arbués E, Gea-Caballero V, Granada-López JM, Juárez-Vela R, Pellicer-García B, Antón-  
296 Solanas I. The Prevalence of Depression, Anxiety and Stress and Their Associated Factors in  
297 College Students. *Int J Environ Res Public Health.* 2020;17: 7001. doi:10.3390/ijerph17197001
- 298 5. Abdel Wahed WY, Hassan SK. Prevalence and associated factors of stress, anxiety and depression  
299 among medical Fayoum University students. *Alexandria J Med.* 2017;53: 77–84.  
300 doi:10.1016/j.ajme.2016.01.005
- 301 6. Wege N, Muth T, Li J, Angerer P. Mental health among currently enrolled medical students in  
302 Germany. *Public Health.* 2016;132: 92–100. doi:10.1016/j.puhe.2015.12.014
- 303 7. Goebert D, Thompson D, Takeshita J, Beach C, Bryson P, Ephgrave K, et al. Depressive Symptoms  
304 in Medical Students and Residents: A Multischool Study. *Acad Med.* 2009;84: 236–241.  
305 doi:10.1097/ACM.0b013e31819391bb
- 306 8. Rosenthal JM, Okie S. White Coat, Mood Indigo — Depression in Medical School. *N Engl J Med.*  
307 2005;353: 1085–1088. doi:10.1056/NEJMp058183
- 308 9. Milić J, Škrlec I, Milić Vranješ I, Podgornjak M, Heffer M. High levels of depression and anxiety  
309 among Croatian medical and nursing students and the correlation between subjective happiness

- 310 and personality traits. *Int Rev Psychiatry*. 2019;31: 653–660.  
311 doi:10.1080/09540261.2019.1594647
- 312 10. Dyrbye LN, West CP, Satele D, Boone S, Tan L, Sloan J, et al. Burnout Among U.S. Medical  
313 Students, Residents, and Early Career Physicians Relative to the General U.S. Population. *Acad*  
314 *Med*. 2014;89: 443–451. doi:10.1097/ACM.0000000000000134
- 315 11. Kumar Sg, Kattimani S, Sarkar S, Kar S. Prevalence of depression and its relation to stress level  
316 among medical students in Puducherry, India. *Ind Psychiatry J*. 2017;26: 86.  
317 doi:10.4103/ipj.ipj\_45\_15
- 318 12. Fawzy M, Hamed SA. Prevalence of psychological stress, depression and anxiety among medical  
319 students in Egypt. *Psychiatry Res*. 2017;255: 186–194. doi:10.1016/j.psychres.2017.05.027
- 320 13. Almojali AI, Almalki SA, Allothman AS, Masuadi EM, Alaqeel MK. The prevalence and association  
321 of stress with sleep quality among medical students. *J Epidemiol Glob Health*. 2017;7: 169.  
322 doi:10.1016/j.jegh.2017.04.005
- 323 14. Wolf MR, Rosenstock JB. Inadequate Sleep and Exercise Associated with Burnout and Depression  
324 Among Medical Students. *Acad Psychiatry*. 2017;41: 174–179. doi:10.1007/s40596-016-0526-y
- 325 15. IsHak W, Nikravesh R, Lederer S, Perry R, Ogunyemi D, Bernstein C. Burnout in medical students:  
326 a systematic review. *Clin Teach*. 2013;10: 242–245. doi:10.1111/tct.12014
- 327 16. Firth J, Solmi M, Wootton RE, Vancampfort D, Schuch FB, Hoare E, et al. A meta-review of  
328 “lifestyle psychiatry”: the role of exercise, smoking, diet and sleep in the prevention and  
329 treatment of mental disorders. *World Psychiatry*. 2020;19: 360–380. doi:10.1002/wps.20773
- 330 17. DeJean D, Giacomini M, Vanstone M, Brundisini F. Patient experiences of depression and anxiety  
331 with chronic disease: a systematic review and qualitative meta-synthesis. *Ont Health Technol*  
332 *Assess Ser*. 2013;13: 1–33. Available: <https://pubmed.ncbi.nlm.nih.gov/24228079>
- 333 18. Patten SB. Long-term medical conditions and major depression in a Canadian population study at

- 334 waves 1 and 2. *J Affect Disord.* 2001;63: 35–41. doi:10.1016/S0165-0327(00)00186-5
- 335 19. Al-Khani AM, Sarhandi MI, Zaghloul MS, Ewid M, Saquib N. A cross-sectional survey on sleep  
336 quality, mental health, and academic performance among medical students in Saudi Arabia. *BMC*  
337 *Res Notes.* 2019;12: 665. doi:10.1186/s13104-019-4713-2
- 338 20. Nyer M, Farabaugh A, Fehling K, Soskin D, Holt D, Papakostas GI, et al. RELATIONSHIP BETWEEN  
339 SLEEP DISTURBANCE AND DEPRESSION, ANXIETY, AND FUNCTIONING IN COLLEGE STUDENTS.  
340 *Depress Anxiety.* 2013;30: 873–880. doi:10.1002/da.22064
- 341 21. Lemma S, Gelaye B, Berhane Y, Worku A, Williams MA. Sleep quality and its psychological  
342 correlates among university students in Ethiopia: a cross-sectional study. *BMC Psychiatry.*  
343 2012;12: 237. doi:10.1186/1471-244X-12-237
- 344 22. Moo-Estrella J, Pérez-Benítez H, Solís-Rodríguez F, Arankowsky-Sandoval G. Evaluation of  
345 Depressive Symptoms and Sleep Alterations in College Students. *Arch Med Res.* 2005;36: 393–  
346 398. doi:10.1016/j.arcmed.2005.03.018
- 347 23. Ströhle A. Physical activity, exercise, depression and anxiety disorders. *J Neural Transm.*  
348 2009;116: 777–784. doi:10.1007/s00702-008-0092-x
- 349 24. Carek PJ, Laibstain SE, Carek SM. Exercise for the Treatment of Depression and Anxiety. *Int J*  
350 *Psychiatry Med.* 2011;41: 15–28. doi:10.2190/PM.41.1.c
- 351 25. Hossain MM, Tasnim S, Sultana A, Faizah F, Mazumder H, Zou L, et al. Epidemiology of mental  
352 health problems in COVID-19: a review. *F1000Research.* 2020;9: 636.  
353 doi:10.12688/f1000research.24457.1
- 354 26. Singh S, Roy D, Sinha K, Parveen S, Sharma G, Joshi G. Impact of COVID-19 and lockdown on  
355 mental health of children and adolescents: A narrative review with recommendations. *Psychiatry*  
356 *Res.* 2020;293: 113429. doi:10.1016/j.psychres.2020.113429
- 357 27. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh sleep quality index: A

- 358 new instrument for psychiatric practice and research. *Psychiatry Res.* 1989;28: 193–213.  
359 doi:10.1016/0165-1781(89)90047-4
- 360 28. Spitzer RL, Kroenke K, Williams JBW, Löwe B. A Brief Measure for Assessing Generalized Anxiety  
361 Disorder. *Arch Intern Med.* 2006;166: 1092. doi:10.1001/archinte.166.10.1092
- 362 29. Kroenke K, Spitzer RL, Williams JBW. The PHQ-9. *J Gen Intern Med.* 2001;16: 606–613.  
363 doi:10.1046/j.1525-1497.2001.016009606.x
- 364 30. Yusoff MSB, Abdul Rahim AF, Yaacob MJ. Prevalence and Sources of Stress among Universiti Sains  
365 Malaysia Medical Students. *Malays J Med Sci.* 2010;17: 30–37. Available:  
366 <http://europepmc.org/abstract/MED/22135523>
- 367 31. Karaoglu N, Seker M. Anxiety and depression in medical students related to desire for and  
368 expectations from a medical career. *West Indian Med J.* 2010;59: 196–202. Available:  
369 <http://europepmc.org/abstract/MED/21275126>
- 370 32. Jadoon NA, Yaqoob R, Raza A, Shehzad MA, Zeshan SC. Anxiety and depression among medical  
371 students: a cross-sectional study. *J Pak Med Assoc.* 2010;60: 699–702. Available:  
372 <http://europepmc.org/abstract/MED/20726214>
- 373 33. Tjia J, Givens JL, Shea JA. Factors Associated With Undertreatment of Medical Student  
374 Depression. *J Am Coll Heal.* 2005;53: 219–224. doi:10.3200/JACH.53.5.219-224
- 375 34. Azad MC, Fraser K, Rumana N, Abdullah AF, Shahana N, Hanly PJ, et al. Sleep Disturbances among  
376 Medical Students: A Global Perspective. *J Clin Sleep Med.* 2015;11: 69–74.  
377 doi:10.5664/jcsm.4370
- 378 35. Dyrbye LN, Thomas MR, Shanafelt TD. Systematic Review of Depression, Anxiety, and Other  
379 Indicators of Psychological Distress Among U.S. and Canadian Medical Students. *Acad Med.*  
380 2006;81: 354–373. doi:10.1097/00001888-200604000-00009
- 381 36. El-Gilany A-H, Amr M, Hammad S. Perceived stress among male medical students in Egypt and



- 382 Saudi Arabia: effect of sociodemographic factors. *Ann Saudi Med.* 2008;28: 442–448.  
383 doi:10.5144/0256-4947.2008.442
- 384 37. Mowery YM. A primer on medical education in the United States through the lens of a current  
385 resident physician. *Ann Transl Med.* 2015;3: 270. doi:10.3978/j.issn.2305-5839.2015.10.19
- 386 38. Corrêa C de C, Oliveira FK de, Pizzamiglio DS, Ortolan EVP, Weber SAT. Sleep quality in medical  
387 students: a comparison across the various phases of the medical course. *J Bras Pneumol.*  
388 2017;43: 285–289. doi:10.1590/s1806-37562016000000178
- 389 39. von Ruesten A, Weikert C, Fietze I, Boeing H. Association of Sleep Duration with Chronic Diseases  
390 in the European Prospective Investigation into Cancer and Nutrition (EPIC)-Potsdam Study. Bayer  
391 A, editor. *PLoS One.* 2012;7: e30972. doi:10.1371/journal.pone.0030972
- 392 40. Medeiros ALD, Mendes DBF, Lima PF, Araujo JF. The Relationships between Sleep-Wake Cycle  
393 and Academic Performance in Medical Students. *Biol Rhythm Res.* 2001;32: 263–270.  
394 doi:10.1076/brhm.32.2.263.1359
- 395 41. Maheshwari G, Shaukat F. Impact of Poor Sleep Quality on the Academic Performance of Medical  
396 Students. *Cureus.* 2019. doi:10.7759/cureus.4357
- 397 42. Paro HBMS, Morales NMO, Silva CHM, Rezende CHA, Pinto RMC, Morales RR, et al. Health-  
398 related quality of life of medical students. *Med Educ.* 2010;44: 227–235. doi:10.1111/j.1365-  
399 2923.2009.03587.x
- 400 43. Stewart, Lam, Betson, Wong, Wong. A prospective analysis of stress and academic performance  
401 in the first two years of medical school. *Med Educ.* 1999;33: 243–250. doi:10.1046/j.1365-  
402 2923.1999.00294.x
- 403 44. Moir F, Yielder J, Sanson J, Chen Y. Depression in medical students: current insights. *Adv Med*  
404 *Educ Pract.* 2018;Volume 9: 323–333. doi:10.2147/AMEP.S137384
- 405 45. Rose S. Medical Student Education in the Time of COVID-19. *JAMA.* 2020;323: 2131.

406 doi:10.1001/jama.2020.5227

407 46. Almarzooq ZI, Lopes M, Kochar A. Virtual Learning During the COVID-19 Pandemic. J Am Coll  
408 Cardiol. 2020;75: 2635–2638. doi:10.1016/j.jacc.2020.04.015

409 47. Kaparounaki CK, Patsali ME, Mousa D-P V., Papadopoulou EVK, Papadopoulou KKK, Fountoulakis  
410 KN. University students' mental health amidst the COVID-19 quarantine in Greece. Psychiatry  
411 Res. 2020;290: 113111. doi:10.1016/j.psychres.2020.113111

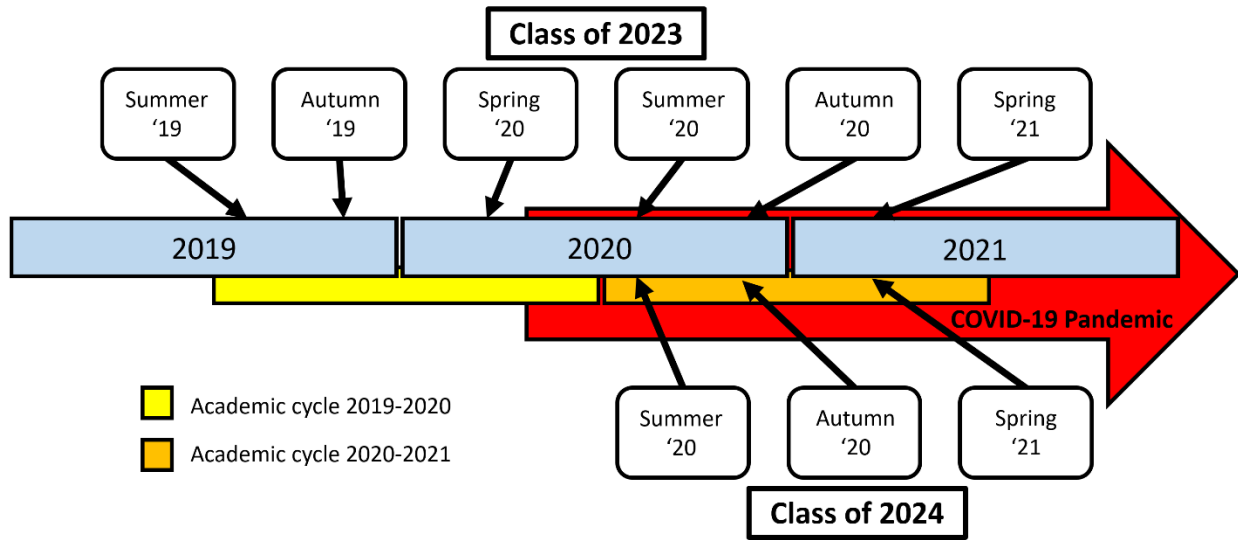
412 48. Benham G. Stress and sleep in college students prior to and during the COVID-19 pandemic.  
413 Stress Heal. 2021;37: 504–515. doi:<https://doi.org/10.1002/smi.3016>

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416 **FIGURE LEGENDS**

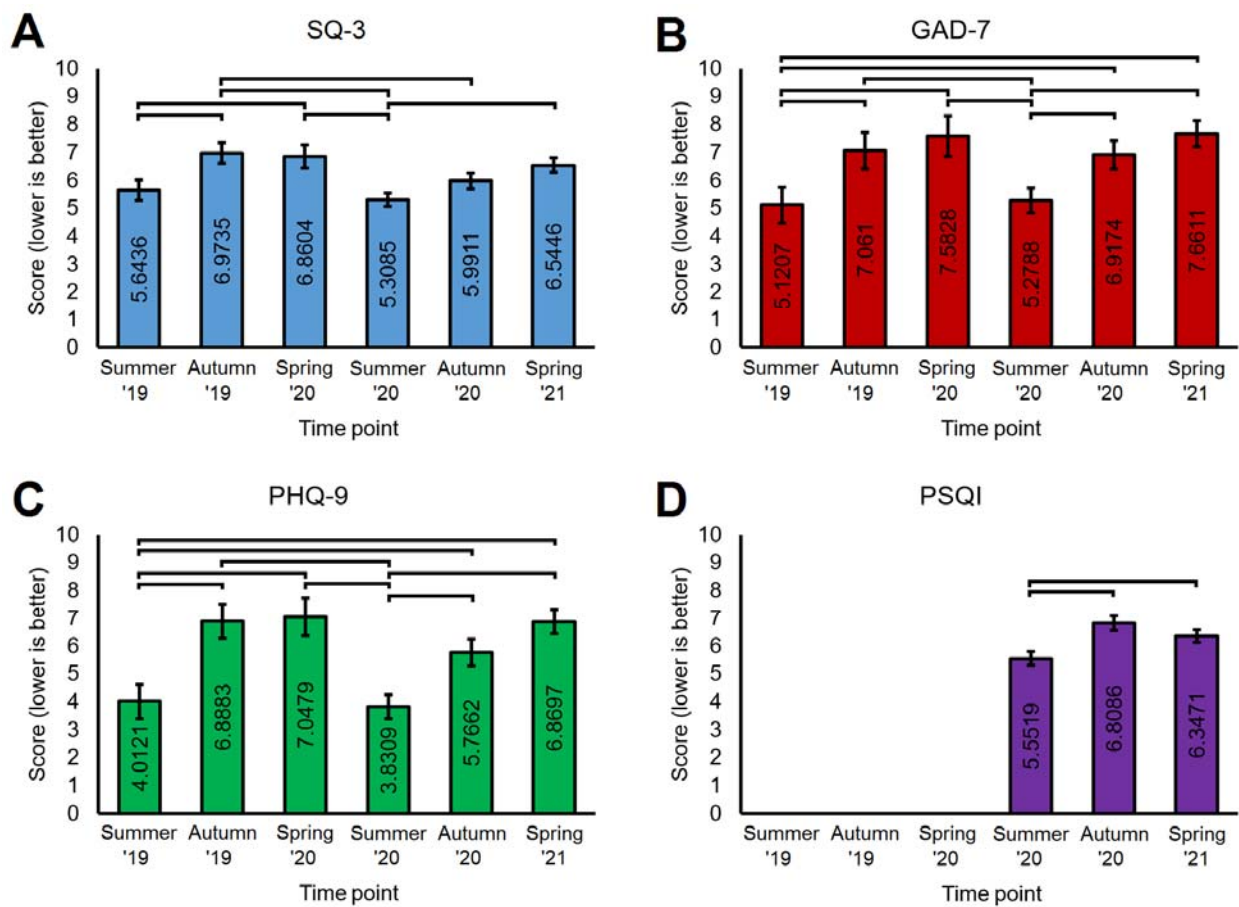
417 **Figure 1. Study timeline.**



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420 **Figure 2. Time point effect estimates** A) SQ-3. B) GAD-7. C) PHQ-9. D) PSQI. In all panels, brackets  
421 indicate pairwise differences at a  $P \leq 0.05$  level. Error bars correspond to the Standard Error of Mean  
422 (SEM).



423

424

425 **TABLES**

426 **Table 1. Participants included in the study on the full dataset and by class year cohorts.**

Variable	Full Dataset N=197	Class 2023 alone N=85	Class of 2024 alone N=112
<b>COVID-19 period</b>			
Post	149	62	112
Pre	83	83	0
<b>Time point</b>			
Summer '19	83	83	0
Autumn '19	76	76	0
Spring '20	57	57	0
Summer '20	149	37	112
Autumn '20	109	47	62
Spring '21	124	48	76
<b>Chronic disease</b>			
Yes	53	22	31

427

428

429 **Table 2. Mean and Standard Deviations in the dataset.**

Variable	Full dataset		Class year				COVID-19 Period				Chronic disease			
			2023		2024		Pre		Post		Yes		No	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Average Sleep Hours (Hours)	7.474	1.129	7.799	1.059	7.024	1.068	7.799	1.065	7.043	1.067	7.425	1.213	7.496	1.089
SQ-3	5.830	3.003	5.776	3.060	5.908	2.923	5.769	3.083	5.914	2.893	6.758	2.707	5.539	2.962
Total exercise per week (Minutes)	201.17	177.33	190.91	162.47	215.52	195.69	190.91	163.59	214.92	193.72	198.15	203.65	202.57	163.98
GAD-7	6.035	5.057	5.701	5.036	6.508	5.060	5.719	5.024	6.465	5.081	7.651	5.609	5.408	4.608
PHQ-9	5.127	5.055	5.065	5.084	5.216	5.022	5.029	5.013	5.262	5.119	7.016	5.878	4.362	4.399
COVID-19 Depression	-0.128	1.291	-0.150	1.264	-0.116	1.307	-0.157	1.263	-0.113	1.307	0.252	1.272	-0.316	1.261
COVID-19 Anxiety	0.232	1.366	0.128	1.305	0.288	1.396	0.157	1.318	0.270	1.390	0.583	1.288	0.059	1.372
COVID-19 Quality of sleep	-0.668	1.124	-0.702	1.155	-0.648	1.109	-0.672	1.162	-0.665	1.106	-0.447	1.095	-0.780	1.124
PSQI	5.864	3.190	N/A	N/A	5.940	3.195	N/A	N/A	5.902	3.181	7.291	3.185	5.150	2.949

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431

432 **Table 3. Estimates and significance testing for each model's included effects.** Significant associations  
 433 are declared at  $P \leq 0.05$  and are indicated in the table with an asterisk \*. Bonferroni corrected significant  
 434 associations are declared at  $P \leq 6.5E-4$  and are indicated with a double asterisk \*\*. Columns correspond  
 435 to the assessment tool evaluated while rows correspond to the p-value of such association. Outcomes  
 436 for the three models are presented: full dataset, dataset including COVID-19 specific questions and class  
 437 of 2023 alone.

Effect	Level	SQ-3		GAD-7		PHQ-9		PSQI	
		Estimate (SE)	P-value	Estimate (SE)	P-value	Estimate (SE)	P-value	Estimate (SE)	P-value
<b>Full Dataset</b>									
Class year	2023	6.3822 (0.5786)	0.7791	5.6064 (1.0078)	0.3217	6.6197 (0.9701)	0.3614	5.8182 (0.5382)	0.4334
	2024	6.0584 (0.6079)		7.6009 (1.0588)		4.8519 (1.0192)		6.6536 (0.5667)	
COVID-19 period	Post	6.4046 (0.5979)	0.7517	5.7693 (1.0414)	0.4112	6.6863 (1.0024)	0.3310	5.8102 (0.5304)	0.4287
	Pre	6.0360 (0.5995)		7.4380 (1.0442)		4.7854 (1.0051)		6.6615 (0.5824)	
Time point	Summer '19	5.6436 (0.3674)	0.0002**	5.1207 (0.6399)	0.0002**	4.0121 (0.6160)	2.7E-08**	N/A	0.0010*
	Autumn '19	6.9735 (0.3686)		7.0610 (0.6421)		6.8883 (0.6181)		N/A	
	Spring '20	6.8604 (0.4127)		7.5828 (0.7189)		7.0479 (0.6920)		N/A	
	Summer '20	5.3085 (0.2534)		5.2788 (0.4414)		3.8309 (0.4249)		5.5519 (0.2385)	
Chronic disease	Autumn '20	5.9911 (0.2827)	0.0001**	6.9174 (0.4925)	0.0002**	5.7662 (0.4740)	4.7E-06**	6.8086 (0.2581)	3.0E-06**
	Spring '21	6.5446 (0.2628)		7.6611 (0.4578)		6.8697 (0.4470)		6.3471 (0.2386)	
	Yes	6.7889 (0.2174)		7.5651 (0.3787)		6.9522 (0.3645)		7.2018 (0.2357)	
Average sleep hours (Hours)	No	5.6517 (0.1553)	0.0011*	5.6421 (0.2705)	0.1048	4.5194 (0.2603)	0.0194*	5.2700 (0.1722)	1.1E-22**
	Total exercise per week (Minutes)	-0.3817 (0.1161)		-0.3287 (0.2022)		-0.4570 (0.1946)		-1.4490 (0.1297)	
		-0.0007 (0.0007)	0.3193	0.0004 (0.0012)	0.7204	-0.0005 (0.0011)	0.6881	0.0005 (0.0008)	0.4997
<b>Including COVID-19 specific questions</b>									
Class year	2023	6.1085 (0.2449)	0.7100	6.4433 (0.4094)	0.9093	5.5838 (0.3969)	0.6420	6.1300 (0.2101)	0.7697
	2024	5.9947 (0.1890)		6.3850 (0.3159)		5.3533 (0.3063)		6.0531 (0.1623)	
Time point	Summer '20	5.8595 (0.2558)	0.0725	5.8870 (0.4277)	0.0230*	4.7235 (0.4146)	0.0014*	5.8624 (0.2201)	0.3517
	Autumn '20	5.7705 (0.2772)		5.9945 (0.4634)		5.0085 (0.4493)		6.3320 (0.2379)	
	Spring '21	6.5247 (0.2569)		7.3610 (0.4295)		6.6736 (0.4164)		6.0801 (0.2206)	
Chronic disease	Yes	6.5376 (0.2503)	0.0017*	6.8102 (0.3068)	0.1249	6.2041 (0.4057)	0.0034*	6.8521 (0.2149)	1.9E-08**

	No	5.5656 (0.1835)		6.0181 (0.3068)		4.7330 (0.2975)		5.3310 (0.1577)	
Average sleep hours (Hours)		-0.2944 (0.1422)	0.0391*	-0.1802 (0.2377)	0.4489	-0.2495 (0.2304)	0.2797	-1.4219 (0.1222)	1.4E- 26**
Total exercise per week (Minutes)		-0.0010 (0.0009)	0.2358	-0.0004 (0.0014)	0.7930	-0.0026 (0.0014)	0.0607	0.0003 (0.0007)	0.6398
COVID-19 Depression (Rating)		0.6917 (0.1794)	0.0001**	0.9544 (0.2999)	0.0016*	1.5804 (0.2907)	1.0E-07**	0.6156 (0.1540)	7.8E- 05**
COVID-19 Anxiety (Rating)		-0.2452 (0.1666)	0.1419	0.7670 (0.2785)	0.0062*	-0.0227 (0.2700)	0.9330	-0.0616 (0.1430)	0.6668
COVID-19 Quality of sleep (Rating)		0.4057 (0.1648)	0.0143	0.2336 (0.2755)	0.3971	0.2344 (0.2671)	0.3808	0.6443 (0.1415)	7.3E- 06**
<b>Class of 2023 alone</b>									
COVID-19 period (Pre- /Post-)	Post	6.5359 (1.1331)		4.8037 (1.9472)		7.5197 (1.8882)		5.2072 (1.0487)	
	Pre	6.1251 (0.1707)	0.7217	6.4176 (0.2933)	0.4155	5.6851 (0.2845)	0.3399	6.0282 (0.2459)	0.4477
Time point	Summer '19	5.9034 (0.6701)		4.1686 (1.1515)		4.8619 (1.1167)		N/A	
	Autumn '19	7.0983 (0.6635)		6.2299 (1.1402)		7.8824 (1.1057)		N/A	
	Spring '20	7.0565 (0.6927)		6.7931 (1.1904)		8.0658 (1.1544)		N/A	
	Summer '20	5.6837 (0.6876)	0.0183*	3.2808 (1.1817)	0.0005**	4.6566 (1.1459)	4.6E-05**	5.0444 (0.6581)	0.1916
	Autumn '20	5.8278 (0.6676)		6.4027 (1.1473)		6.6692 (1.1125)		6.1397 (0.6195)	
	Spring '21	6.4132 (0.6629)		6.7888 (1.1392)		7.4784 (1.1047)		5.6690 (0.6154)	
Chronic disease	Yes	7.0447 (0.6030)		6.9331 (1.0362)		8.2607 (1.0049)		6.6163 (0.6038)	
	No	5.6163 (0.5828)	1.8E- 05**	4.2882 (1.0016)	4.0E- 06**	4.9440 (0.9713)	3.6E-09**	4.6191 (0.5739)	0.0001**
Average sleep hours (Hours)		-0.5670 (0.1589)	0.0004**	-0.5491 (0.2731)	0.0452*	-0.6470 (0.2649)	0.0151*	-1.4341 (0.2343)	1.2E- 08**
Total exercise per week (Minutes)		-0.0011 (0.0010)	0.2783	0.0022 (0.0017)	0.1943	0.0014 (0.0016)	0.3876	-0.0032 (0.0018)	0.0859