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THE EFFECT OF STRESS ON THE SLEEP QUALITY OF MEDICAL STUDENTS

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Annotation: A high academic load, everyday unsettlement, and session periods create the preconditions for the development of depression and stress in medical students, which, in turn, contributes to sleep disorders. Numerous publications have shown a connection between stress and poor sleep quality. It is likely that both of these phenomena interact according to the feedback principle: not only does stress cause insomnia, but insomnia also aggravates the manifestations of stress. The effect of stress and insomnia on academic performance has not been proven. In contrast, some studies showed that insomnia was associated with higher grade point averages in college students, which could be explained by neglecting sleep in favor of extra studying and homework. Extensive use of electronic devices takes extra time away from sleep and may also disrupt circadian rhythms due to artificial light. The COVID-19 pandemic and the tense socio-economic events of recent years have contributed to increased psychological distress among students, which requires preventive and health measures, since stress and insomnia at a young age lay the foundation for the development of somatic pathology in later life.

Key words: stress, depression, insomnia, burnout syndrome, survey.

Introduction

Chronic stress constitutes an integral aspect of modern human life. The prevalence of stress within the human population is notably high, and in recent years, following the pandemic and socio-economic crisis, various stress symptoms have been identified in 99.8% of individuals [Sorokin, 2020]. Prolonged and highly intensive stressors elicit unfavorable physiological reactions, which are executed through the activation of the hypothalamus-pituitary-adrenal axis, leading to the release of glucocorticoids, adrenaline, and norepinephrine. These hormones impact the endocrine system, metabolic processes, and the immune system, contributing to the onset of various diseases. If the stress factor possesses excessive strength and persists over time, maladaptive reactions arise, almost invariably culminating in depression. Numerous studies underscore the connection between chronic stress and depression [Tausk, 2023].

Education in medical institutions is characterized by a high level of stress among students. The physical and emotional well-being of medical students significantly declines by the end of the first year of study, partially recovering thereafter but not reaching initial levels. The perceived stress level is characterized as moderately high on the Perceived Stress Scale (PSS) and remains relatively stable throughout the entire learning period [McKerrow, 2020]. Among the general causes of stress, the exceptionally high academic workload inducing substantial cognitive strain is noteworthy. Additionally, among male students, factors such as irregular nutrition, strict instructors, and incomprehensible textbooks are pertinent, while group conflicts are of lesser concern. Female students are particularly troubled by life away from parents and the challenge of organizing their daily routines. Exam-related anxiety is heightened during examination periods. Stress predominantly manifests at the psychological level, leading to reduced productivity, sleep disturbances, and chronic time constraints. Physiologically, stress may manifest as tachycardia, muscle tension, and tremors. Stress-induced illnesses among students are relatively infrequent [Novgorodceva, 2015].

Reduction in cognitive abilities amid stress can be partially explained by the nervous system's ability to disengage for self-preservation purposes. Under stress, neurons and glial cell membranes may undergo reversible depolarization, leading to temporary neural function disengagement due to the propagation of the depolarization process. Such a property of the nervous system across different animal species has evolved to manage complex behaviors requiring energetically costly and rapid information processing. This mechanism likely represents a response to stressful environmental conditions, providing an energy advantage that enhances survival chances [Robertson, 2020].

Insomnia (sleep disturbances for three or more nights per week over three or more months) is prevalent in 10-12% of adults. Insomnia is associated with mental health, cardiovascular diseases, and type 2 diabetes. Increased fatigue, decreased productivity, reduced quality of life, and dissatisfaction with social interactions are common experiences among individuals suffering from insomnia [Espie, 2019]. Among medical students, the prevalence of insomnia is higher than in the general population and significantly varies across countries, ranging from 26% to 76.4%, with approximately half of the students reporting sleep quality disturbances [Alqudah, 2019; Cardoso, 2022; Dąbrowska-Galas, 2021; Eleftheriou, 2019]. Insomnia may be partly linked to increased physical exertion, but chronic stress can also influence its onset.

The aim of this study is to investigate the relationship between stress and sleep quality.

Materials and Methods

Literature search was conducted using the PubMed and Google Scholar databases. The search depth spanned 10-15 years among openly accessible sources. Key search phrases employed included: "medical students' sleep" (Google Scholar – 10 years – 13,700 results); "stress spread" (PubMed – 5 years – 4,030 results); "spread of psychological stress among people" (PubMed – 5 years – 508 results); "spread of insomnia among people" (PubMed – 5 years – 78 results); "insomnia cognitive impairment" (PubMed – 5 years – 1,185 results); "sleep quality stress" (PubMed – 5 years – 3,757 results); "medical students' academic workload" (Google Scholar – 10 years – 8,310 results). Uninformative, duplicate, and irrelevant sources were filtered out. Ultimately, 41 articles were selected.

Results and Discussion

Stress and Sleep Disruptions

Among medical students, stress and insomnia are prevalent, as their workload is twice as high as that of students in technical universities [Zlata, 2017]. Increased cognitive strain, the need for constant adaptation to changing class schedules, living away from family, and exam periods contribute to the development of depression and stress, often accompanied by sleep disturbances. Sleep disorders appear 35 times more frequently in depressive states and 2.7 times more often in cases of anxiety [Golenkov, 2010]. There exists a subtle yet statistically significant association between sleep disturbances and depression (β of the association = 0.11; $p < 0.001$) [Marino, 2021]. Chronic stress can lead to burnout, defined as a combination of emotional exhaustion, depersonalization, and a diminished sense of personal accomplishment. This issue is prevalent among healthcare professionals worldwide. The combination of persistent stress, heavy workloads, demanding physical and emotional environments, and an overall sense of helplessness creates an imbalance between demands and control, leading to the development of psychological distress [Jun, 2020].

A meta-analysis comprising 21 studies revealed that the overall odds ratio for predicting depression in individuals with insomnia was 2.60 (95% CI: 1.98-3.42). The adjusted model showed an odds ratio of 2.10. Thus, individuals without depression but experiencing insomnia have a twofold risk of developing depression compared to those without insomnia [Baglioni, 2011]. Consequently, for a significant number of people, insomnia may precede depression and possibly act as its causative factor. In turn, anxiety may contribute to insomnia due to the amplification of rumination (repeated dwelling on unpleasant situations). In the publication by U. Akram et al., insomnia symptoms were associated with doubts about future actions and concerns about future criticism. This association was partially mediated by preceding anxiety symptoms. The authors concluded that insomnia symptoms are linked to the intensification of negative perfectionistic thinking in the form of doubts about one's actions and potential criticism from parents. Therefore, insomnia treatment should aim to alleviate anxiety symptoms [Akram, 2015].

Sleep disturbances are widespread among medical students and vary significantly across populations. A survey of 681 medical students (293 males and 388 females) revealed that sleep disturbances were identified in 47.9% of students. Difficulties falling asleep were reported by 8.8%, shortened sleep duration by 8.5%, frequent awakenings by 5.9%, frequent anxious dreams by 15.4%, poor morning awakening quality by 30.8%, and overall poor sleep quality by 4% of respondents.

The mentioned sleep disturbances were more prevalent among students in the 1st to 3rd years compared to those in the 6th year. 57.6% of junior students went to sleep after midnight, whereas only 46.1% of senior students did so ($p < 0.01$). Sleep disorders were more frequently observed in

cases of late bedtime, irregular sleep patterns, personal or academic issues, difficulties with rapid falling asleep, and exposure to external noise ($p < 0.01$). Co-residence with parents had a negative impact. Bedtime and unresolved problems negatively affected sleep duration, while adherence to a routine also influenced sleep quality ($p < 0.01$). These disturbances led to daytime sleepiness, decreased information processing, memory impairment, reduced efficiency, and fatigue. However, these effects were more pronounced among freshmen. Subsequently, students seem to adapt significantly to the demanding academic environment [Golenkov, 2010]. Undoubtedly, the beginning and initial years of medical education create a stressful situation due to the high academic workload and the need to adapt to a new regimen of physical and intellectual activity.

A study assessing sleep quality among students at the beginning and end of the academic year, using the Spielberg-Hanin questionnaire and the Pittsburgh Sleep Quality Index (PSQI), identified an elevated level of personal anxiety at the start of the academic year. Concurrently, situational anxiety indicators were associated with daytime sleep dysfunction at the beginning of the learning process. The level of situational anxiety was moderate in both groups. Sleep onset duration at the beginning of the academic year was 5 minutes longer, and bedtime was half an hour later than at the end of the year. Sleep efficiency was disrupted in both groups. These findings indicate a higher level of stress at the beginning of the academic year when students adjust their physical and mental activity regimen to adapt to the learning process. Daytime sleepiness is likely related to a feedback loop with anxiety, as it both contributes to anxiety and may be its consequence [Zlata, 2017].

A survey of 270 North Ossetian students (60 males, 210 females) using the Munich Chronotype Questionnaire assessed sleep duration, sleep onset time (2-2.5 hours after melatonin onset), mid-sleep, which classified chronotype (early or late), and social jetlag (difference in mid-sleep between weekends and weekdays) on different days of the week. Sleep onset time on weekends averaged a delay of 29 minutes compared to weekdays, and jetlag shifted 1 hour 36 minutes towards the morning. BMI was higher in males, while jetlag was more pronounced in females. The later the chronotype, the more frequently students used stimulants and antidepressants, suggesting a potentially higher level of depression in such individuals. The prevalence of late chronotypes among medical students correlates with reduced social adaptability. Differences in jetlag depending on work or weekend days indicate systematic disruptions of normal circadian rhythms, leading to adaptation failure, dysregulation, and contributing to neuroendocrine-immune system pathology [Datieva, 2021].

A survey of 382 students from Astrakhan Medical University revealed that 49.2% of them suffered from sleep disorders. 62% experienced difficulties falling asleep, with 49.7% of cases associated with studying and 17% with stress. Only 13.4% of respondents had a normal sleep duration (8-9 hours), while the rest experienced varying degrees of sleep deficit. 8.4% of students practiced regular daytime sleep. 13.6% of students took sleep-inducing medications, and 59.4% reported nocturnal awakenings. In contrast to the previous study, students at Astrakhan University tended to fall asleep later on weekdays than on weekends. Sleep disturbances caused difficulties in daily life for 72% of students, resulting in lethargy, irritability, daytime sleepiness, and impaired memory and attention. The most common cause of insomnia was stimulating mental activity before sleep, including computer work. Consumption of tea, coffee, and tobacco also hindered normal sleep [Antonova, 2022].

A study conducted by E.N. Dudnik and colleagues focused on investigating the quality of life, emotional burnout syndrome (EBS), and sleep quality among medical students. In the second half of the first year of study, 155 students (47 under the distributive system and 108 under the modular

system) were assessed using the SF-36 questionnaire (quality of life), V.V. Boyko's methodology (EBS), and the Pittsburgh Sleep Quality Index. It was found that the quality of life was below normal values in both groups on scales related to role functioning, social functioning, and emotional functioning. Students under the distributive system had lower average scores, indicating a lower quality of life compared to those under the modular system. Unsatisfactory values were also noted on the EBS scales and the Pittsburgh questionnaire, especially among students under the distributive system. A negative correlation was observed between sleep quality and indicators such as overall health, role physical functioning, and vitality scale. Therefore, poor sleep quality negatively affects the quality of life among medical students [Dudnik, 2017]. The learning schedule itself can be a significant factor in the development of insomnia, a decrease in the quality of life, and the emergence of EBS. Personal characteristics of students may exacerbate psychological disorders during stress. For instance, neuroticism and extraversion can serve as additional risk factors for the development of emotional burnout syndrome [Palamar, 2022].

A comparison of the sleep quality among medical students (University #1 - I.I. Mechnikov North-Western State Medical University) and students from two non-medical universities (University #2 and University #3) revealed multiple significant sleep disturbances among medical students, surpassing those of students from other institutions. The average sleep duration for medical students was 5.7 hours, compared to 6.5 and 6.8 hours in other institutes. The impact of academic workload was notably acknowledged by 85% of medical students (vs 81% and 43%). Conversely, the influence of dormitory residency was less significant (37% vs 62% and 50%). The average bedtime for medical students was 1 hour 15 minutes (vs 0 hours 50 minutes and 1 hour 10 minutes); the average wake-up time was 6 hours 40 minutes (vs 7 hours 30 minutes and 7 hours 50 minutes); emotional lability was at 64% (vs 51% and 52%). Additionally, compared to non-medical university students, medical students more frequently reported increased irritability, headaches, dizziness, tachycardia, a greater impact of sleep quality on daily activities, difficulty handling information flow, and articulating thoughts. Their sleep was more often interrupted, and the quality of awakening was poorer [Krutikova, 2020]. Clearly, these results are associated with the heightened academic workload and the need to study materials late into the night, resulting in shorter, disrupted, and lower-quality sleep.

The quality of sleep and stress levels can be influenced by the consumption of energy drinks. A survey of 272 nursing students revealed that those who consumed energy drinks reported poorer sleep quality, fewer hours of sleep, and a higher perceived stress level compared to consumers of only caffeine and those not consuming caffeine at all [Higbee, 2022]. Deliberate consumption or avoidance of stimulating beverages allows for targeted modulation of insomnia and stress.

A meta-analytic review, encompassing 34 studies, demonstrated a moderate correlation between sleep quality, insomnia, and stress among undergraduate students across different majors. The authors highlighted the high heterogeneity of the included data, emphasizing the need for careful interpretation of the results [Gardani, 2023].

The Role of Electronic Devices in Sleep Disruption

Frequent computer use emerges as one of the factors contributing to insomnia among students. Excessive Internet use leads to dependency and sleep disturbances, accompanied by anxiety, depressive symptoms, and aggressive behavior, as well as contributing to migraines and back pain. Delayed onset of sleep, poor sleep quality, and duration are associated with the time spent online. A systematic review of 12 studies demonstrated that the Internet influences sleep quality and quantity, provoking insomnia [Kokka, 2021].

The manifestations of insomnia and stress may be influenced by smartphones and other electronic gadgets. A cross-sectional study involved 761 students from Belgrade and Nis Universities (Czech Republic). All participants were surveyed using the International Physical Activity Questionnaire (IPAQ-SF), Smartphone Addiction Scale (SAS-SV), Pittsburgh Sleep Quality Index (PSQI), and Depression Anxiety and Stress Scale (DASS-21). The prevalence of smartphone addiction among medical students was 21.7% (22.9% among males and 21.1% among females); however, among females, the average SAS-SV score was significantly higher ($p=0.032$). Univariate logistic analysis revealed a significant association between smartphone addiction and daily use exceeding 4 hours ($OR=2.39$, $p<0.001$), poor sleep quality ($OR=1.65$, $p=0.005$), as well as elevated levels of stress ($OR=1.75$, $p=0.003$) and depression ($OR=2.29$, $p<0.001$). Multifactorial regression analysis determined that smartphone usage exceeding 4 hours per day ($OR=2.39$, $p<0.001$) and an elevated level of depression ($OR=2.51$, $p<0.001$) are independent significant factors associated with smartphone addiction [Nikolic, 2023]. Thus, the link between depression and smartphone addiction is established; however, it remains unclear whether addiction is a consequence of depression, its cause, or a factor exacerbating it. Further investigation of the causal relationship will help refine the potential therapeutic implications of smartphone withdrawal in treating depression and insomnia.

A similar study was conducted among 420 Jordanian dental students who were surveyed using the Smartphone Addiction Scale (SAS-SV) and the Pittsburgh Sleep Quality Index (PSQI). The correlation between the data from both questionnaires was significant ($r=0.137$, $p=0.005$). According to the authors, this suggests that the higher the level of smartphone dependence, the poorer the sleep quality. In addition, a significant correlation was found between the Perceived Stress Scale-10 (PSS-10) score and the total PSQI score ($r=0.348$, $p<0.001$). Thus, students who perceived stress more strongly had poorer sleep quality [Sanusi, 2022]. Identifying students with critical smartphone dependence, stress, and insomnia will allow for timely implementation of preventive measures (counseling, psychotherapy, stress management).

The Influence of Stress and Sleep Quality on Academic Performance

Cognitive impairments are quite prevalent in the human population, especially among the elderly. Mild cognitive impairments (per 1000 person-years) reach 22.5 or more for individuals older than 75 years [Gillis, 2019]. In young individuals, cognitive impairments are usually associated with some pathology. Depressive disorders can be a cause of neurocognitive impairments in young people. Poor concentration and memory, slowed information processing speed, and difficulties in organizing thinking (executive dysfunction) are central features of major depressive disorder [Allott, 2016]. An analysis of data from 1524 adults in the state of Pennsylvania showed that individuals who slept less than 6 hours per day had twice the risk of cognitive impairments and vascular cognitive impairments, which are markers of cardiometabolic health. Meanwhile, those surveyed who slept more than 6 hours did not have increased risks according to these indicators [Fernandez-Mendoza, 2021]. People with insomnia exhibit mild or moderate cognitive deficits and impairment in working memory compared to good sleepers; however, the accuracy of thinking/actions remains unchanged [Brownlow, 2020]. Similar impairments may be relevant for medical students who need to master a large amount of information. It can be assumed that insomnia in medical students may impact their academic performance.

The Relationship Between Sleep Quality, Stress, and Academic Performance in Medical Students was Investigated by A.D. Alotaibi et al., who conducted a survey of 230 students in their 2nd and 3rd years, studying at the Medical College of Imam Muhammad Ibn Saud Islamic

University (Saudi Arabia). The survey was administered electronically, and students independently completed a questionnaire, which included the Pittsburgh Sleep Quality Index (PSQI, 0-21 points), the Kessler Psychological Distress Scale (K10, 10-50 points), and questions about the current grade point average, demographic information, and lifestyle factors. The average PSQI score was 8.13 ± 3.46 points. 77% of respondents reported poor sleep quality, and 63.5% reported some level of psychological stress (average K10 score: 23.72 ± 8.55). A statistically significant association was found between poor sleep quality, increased levels of psychological stress ($p < 0.001$), and daytime sleepiness ($p = 0.035$). A stepwise logistic regression model showed that stress and daytime sleepiness were associated with poor sleep quality. However, no statistically significant association was found between stress, daytime sleepiness, and academic performance [Alotaibi, 2020]. The authors also noted that the deterioration of sleep quality was associated with increased street noise.

A similar study was conducted in Saudi Arabia among students enrolled in the medical programs at Suleiman Al-Rajhi and Al-Qassim Colleges. A total of 206 students were surveyed using the Pittsburgh Sleep Quality Index (PSQI), Depression, Anxiety, and Stress Scale (DASS-21, 0-21 scale), and the average academic performance score (threshold – 4 points). The prevalence of poor sleep quality was 63.2%, and it was more common among physically inactive students who spent a significant amount of time in front of the computer. The prevalence of depression, anxiety, and stress was 42%, 53%, and 31%, respectively. Sleep quality was significantly associated with depression ($p = 0.03$), anxiety ($p = 0.007$), and stress ($p = 0.01$). Somewhat unexpectedly, poorly sleeping students demonstrated higher academic performance than those who slept well ($p = 0.04$) [Al-Khani, 2019]. Presumably, the neglect of sleep for the sake of completing homework and self-study played a role here. This is likely relevant only when normal adaptation is maintained, and poor sleep has not yet affected academic performance.

A survey of 138 dental students in Shiraz, Iran, revealed that participants experienced a moderate level of stress and poor sleep quality. The scores of PSQI (Pittsburgh Sleep Quality Index) and DES (Dental Environment Stress) did not significantly differ based on gender, year of study, marital status, or place of residence ($p > 0.05$). 52.9% of students had an average academic performance. There was a significant correlation between gender and average academic score, as well as between place of residence and average academic score. No significant association was found between stress, sleep quality, on one hand, and academic performance on the other. Meanwhile, a direct correlation was observed between sleep quality and stress related to the dental environment (DES questionnaire) [Jowkar, 2022].

The cited publications do not confirm a connection between stress, insomnia, and academic performance. Since the focus is on a young population, it is likely that the adaptation disruption processes related to insomnia have not yet developed and do not impact the learning efficiency of medical students. Additionally, more sensitive cognitive tests should be employed to capture the association between insomnia, stress, and cognitive impairments.

Pandemic and Stress

The recent COVID-19 pandemic has become an additional stress factor for medical students. A survey of first-year medical students in India, utilizing the 20-item self-report questionnaire from the World Health Organization (WHO-SRQ 20), assessed the level of psychological stress. The prevalence of stress was 25.5%. Students experiencing stress were more concerned about adverse financial consequences due to the COVID-19 pandemic (OR=3.01; 95% CI: 1.29-7.04), online learning mode (OR=3.44; 95% CI: 1.25-9.42), and adverse impacts on social support. The pandemic was a significantly associated factor with psychological distress among medical students

[Shyadligeri, 2022]. Thus, this study highlighted the need for professional counseling and assistance for all students in need. Social support for students could have a beneficial effect on stress mitigation and its perception [Kaurin, 2021].

The normal functioning of individuals in their environment is determined by biological, psychological, and social factors. During the COVID-19 pandemic, society experienced high levels of depression (19%) and anxiety (14%), with 25.4% of individuals reporting a deterioration in mental health. Anxiety was associated with various factors, including concerns about mask shortages, challenges of remote work, and the overall state of affairs [Choi, 2020]. Among 983 Malaysian university students, 20.4%, 6.6%, and 2.8% experienced anxiety levels ranging from minimal to moderate, moderate to severe, and most severe during the COVID-19-related quarantine [Sundarasan, 2020].

Surveying 1385 Malaysian medical students using the Patient Health Questionnaire-9 (PHQ-9) and the Insomnia Severity Index (ISI) during the second wave of the COVID-19 pandemic, it was concluded that depression and insomnia are significantly correlated ($p=0.05$). There exists a connection between the severity of insomnia and the manifestation of depression among medical students. Depression and insomnia were diagnosed in 54.9% and 33.9% of them, respectively [Iqbal, 2023].

Surveying 2474 university students in Wuhan, China, amid the COVID-19 pandemic, revealed that 24.5% experienced high levels of stress, 31.3% had clinical insomnia, and 80% were identified (via PSQI) as generally poor sleepers. Key factors associated with high stress levels, clinical insomnia, and poor sleep quality included female gender, chronic diseases, pre-quarantine sleep disturbances, and caffeine consumption [Dongol, 2022]. Furthermore, the fear level of COVID-19 was higher with significant stress, clinical insomnia, and poor sleep quality.

The alarming trends of psychological distress among medical students necessitate appropriate measures, as the learning period lays the groundwork for numerous health disorders in future physicians. Relaxation techniques and psychological counseling could alleviate some tension and improve the psychoemotional well-being. Physical activities are capable of enhancing sleep and helping cope with stress, providing a good alternative to pharmaceutical therapy [Zhai, 2021]. Insomnia therapy can significantly improve the quality of life and psychological well-being. Digital cognitive-behavioral therapy for insomnia, conducted by K. Espie et al. over 24 weeks, led to a 2.95-fold improvement in psychological well-being, a 1.76-fold improvement in functional health, and an increase in the quality of life at the end of the treatment course [Espie, 2019]. Undoubtedly, other techniques need to be developed to enhance the well-being of students during their medical education.

Conclusion

The substantial burdens experienced by medical students during their education do not pass without consequences for their psychological health, often leading to stress, depression, and insomnia. The literature reviewed indicates a connection between sleep disturbances and stress, and this connection may have a bidirectional cause-and-effect nature. In other words, insomnia can be both a cause and a consequence of depression, anxiety, and stress. Contrary to expectations, sleep disruption either did not correlate or positively correlated with academic performance. In the context of normal adaptation, this may suggest a disregard for sleep in favor of academic pursuits. Apparently, students experience the highest stress levels in their first year of education, attributed to the adjustment of activity patterns, sleep-wake cycles, and the high cognitive strain to which they are yet to adapt.

The use of electronic devices becomes an additional factor exacerbating insomnia and stress manifestations. The prevalence of blue light in gadget screens can impact melatonin production and disrupt circadian rhythms, contributing to the development of insomnia. Additionally, responsible students dedicate more time to homework, often involving interaction with computers. Mental strain and insomnia can lead to emotional burnout and a loss of interest in the profession. Therefore, significant attention should be devoted to preventing these adverse phenomena in the student environment.

Recent events, including the period of the COVID-19 pandemic, have been characterized by heightened stressful conditions, highlighting the issue of psychological and mental disorders in the human population. Medical students, by virtue of their professional competence, are compelled to confront all aspects of the pandemic, undergoing clinical practice and interacting with patients. The introduction of distance learning, economic hardships, and uncertainty about future prospects have significantly increased stress levels in the student environment. Organizing psychological support for medical students, providing consultations, physical activities, and adopting relaxation methods can be crucial in preserving the physical health of future physicians, preventing their departure from the profession.

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