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Factors Contributing to Zoom Fatigue and Its Potential Link to Depression among Dental Students During the COVID-19 Pandemic

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ABSTRACT

The COVID-19 pandemic reshaped education, compelling dental students worldwide to adapt to online learning. This shift led to “Zoom fatigue,” a mental exhaustion from prolonged virtual classes. This study explored the prevalence and risk factors of Zoom fatigue among dental students in Thailand and its link to depression. An online survey was conducted among 165 preclinical and clinical dental students from a large public university in Thailand. Data on demographics, health behaviors, and validated scales for the Zoom Exhaustion & Fatigue Scale (ZEF-T) and the Patient Health Questionnaire (PHQ-9) were collected. More than half (63.6%) reported that online learning negatively impacted their lives. Most students (78.8%) spent over an hour per session, averaging 1.6 sessions daily. Zoom fatigue affected 85.4% of students, with 29.7% experiencing mild fatigue, 33.9% moderate, 20% severe, and 1.8% very severe. Major depressive disorder was present in 37% of participants. Significant predictors of Zoom fatigue included female gender, lack of sleep, underlying mental illness, online learning difficulties, and frequent online sessions. A strong association between Zoom fatigue and depression was observed ($p < 0.001$). The study highlights the high prevalence of Zoom fatigue among dental students during the pandemic. Those affected were more prone to depression, emphasizing the need for educational interventions to mitigate the psychological impact of online learning on dental students.

Keywords: Zoom Fatigue, Depression, Dental Students, COVID-19

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INTRODUCTION

The COVID-19 pandemic has brought significant changes to dental education. Initiated by the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), the crisis disrupted daily life and societal functions worldwide (1). To curb its spread, the World Health Organization (WHO) recommended preventive measures such as social distancing, restrictive regulations, and remote work (2). In the field of education, these measures triggered a paradigm shift, making face-to-face learning impractical and online lectures the norm (3).

Dental institutions worldwide, including those in Thailand, adopted online learning as an alternative to traditional classroom settings during the pandemic. A study of 13 Asian dental schools found that 94.5% conducted educational activities online, with 53.0% of students open to a predominantly online curriculum (4). Similarly, dental schools and programs in the United States and Europe implemented policies to shift in-person classroom to online platforms, reducing in-person attendance and enforcing social distancing (5,6). The Association of Dental Education in Europe (ADEE) also reported a significant shift to online learning, especially for non-clinical courses (6).

Data from the ADEE study (6) highlights the pandemic's widespread impact on European dental education, with 90% of institutions adopting online learning for non-clinical teaching. However, only 11% of undergraduate dental students were involved in non-clinical activities during their clinical education, showing a diverse range of institutional responses to pandemic changes. The study also notes that 90% of respondents believe public health education will increasingly play a role in dental curricula, signaling a consensus on the field's evolving landscape (6). Additionally, global (7–11) and Asian (4,11) studies support the view that distance learning will continue to be a major trend in dental education.

The shift from classroom to online learning has introduced a new challenge: "Zoom fatigue." Extensively studied by researchers at Stanford University (12), this phenomenon is marked by exhaustion and burnout resulting from prolonged virtual meetings. A key theory, known as 'Nonverbal Overload', attributes Zoom fatigue to factors such as eye strain from prolonged close-up viewing, increased cognitive load to process information during video calls, heightened self-awareness from constantly seeing oneself on screen, and restricted physical movement during online sessions. External factors beyond individual control, such as unstable internet connections, the pressure of responding to questions in real time, and challenging environmental conditions, can further exacerbate the issue. As a result, Zoom fatigue can significantly impact on individuals' overall well-being (12,25).

As dental education shifts to virtual learning, the psychological impact of online education on dental students remains underexplored. While research has examined Zoom fatigue and its link to mental health issues among medical students (13–16), studies on dental students, particularly in Thailand are limited. Regarding depression, previous studies report pandemic-era rates of 22.8% to 33.7% in the general population (17,18), while 37% of dental students experienced depression, with even higher rates in Asian populations (19). Notably, these figures are based on self-reported data rather than clinical diagnoses by mental health professionals. These findings suggest that dental students are particularly vulnerable, with higher depression rates than the general population.

This study aims to address the gap in research by examining the adverse effects of virtual learning on Thai dental students. Building on previous studies (12,20), we assessed the prevalence of Zoom fatigue, identified associated risk factors, and explored its relationship with depression during the COVID-19

pandemic. Our findings provide actionable insights to inform educational practices and policies, supporting the well-being of dental students as virtual learning evolves.

METHODS

Study Population and Setting

This cross-sectional online survey was conducted between May 18, 2021, and October 20, 2022. The study targeted dental students aged 18 or older enrolled in the academic year 2022 at Thammasat University. The participants were invited to respond to an anonymous questionnaire via Google Forms.

The study was conducted in compliance with the Declaration of Helsinki and was approved by the Human Research Ethics Committee of Thammasat University with approval number 051/2565; dated May 18, 2022. Signed informed consent was waived by the Ethics Committee due to the online nature of the survey; however, participants were provided with study information on the first page. The anonymity of participants was maintained throughout the study process, ensuring confidentiality and privacy of the data.

The distinction between preclinical and clinical students is as follows: preclinical students (Years 1–4) engage solely in lecture-based instruction and do not have direct patient contact or attend hospital sessions, while clinical students (years 5–6) participate in both lectures and hands-on patient care. During the COVID-19 pandemic, all lectures, seminars, and examinations for both preclinical and clinical dental students were conducted entirely online. This meant a significant increase in video call activities and reduced opportunities for clinical students to perform procedures on patients, while strict screening and safety protocols were implemented to prevent the spread of COVID-19.

Study Protocol and Survey Tools

This study used a three-part questionnaire: 1) demographic data, 2) the Thai version of the Patient Health Questionnaire (PHQ-9), and 3) the Thai version of the Zoom Exhaustion and Fatigue Scale (ZEF-T). A convenience sampling method was employed, distributing the questionnaire to a wide audience and collecting responses from individuals who voluntarily participated. The questionnaire was distributed to dental students via social media platforms (Line, Facebook, Instagram), the primary channels for official student announcements. Participants accessed the survey by scanning a QR code linked to the Google Form, and the survey was promoted multiple times to ensure wide reach. The survey tool was programmed to validate complete responses before submission.

(a) Demographic Data

The collected general information includes demographic data, academic year, underlying diseases, daily online session frequency and duration, break times during sessions, exercise frequency, sleep problems, and outdoor activity. Most questions were based on self-assessment, with examples provided to clarify terms. Low outdoor activity was defined as less than two hours per week outdoors. Online study problems included technical issues, engagement difficulties, or other challenges reported by students. Sleep problems referred to difficulties falling or staying asleep or non-restorative sleep, as self-reported. Mental

disease referred to professionally diagnosed disorders such as anxiety or depression. Exercise was categorized as 'not at all' (no exercise), 'sometimes' (less than 1–2 times per week), or 'regular' (more than 1–2 times per week).

(b) The Zoom Exhaustion & Fatigue Scale (ZEF)

The Zoom Exhaustion & Fatigue Scale (ZEF) (12) Thai version (21,22) is a 15-item questionnaire that assesses exhaustion and fatigue associated with video conferencing. It includes five categories: general fatigue, visual fatigue, social fatigue, mental fatigue (motivational fatigue), and emotional fatigue. Each item is rated on a 1-5 Likert scale. A higher score indicates a higher level of Zoom fatigue (12,28). The total ZEF score is averaged by dividing by 15, with scores interpreted as 1 = No, 2 = Mild, 3 = Moderate, 4 = Severe, and 5 = Extremely severe. The ZEF was translated through a forward-backward process with permission from Fauville G (12). The psychometric properties are detailed in Charoenporn et al. (21,22). In this study, "Zoom fatigue" is defined as the fatigue that occurs after video conferencing or studying using any type of online conference application, such as Zoom, Google Meet, Skype, FaceTime, Cloud X, Webinar, Microsoft Teams, or Cisco Webex. We also asked participants about subjective changes in their videoconferencing fatigue since the COVID-19 pandemic, comparing it to pre-pandemic levels, specifically whether it had worsened, improved, or remained the same.

(c) Patient Health Depression Questionnaire (PHQ-9)

The Thai version (24) of the Patient Health Depression Questionnaire (PHQ-9) (23) is a self-assessment tool with nine questions that measure severity of depression symptoms over two weeks. Responses are scored from 0 to 3: None (0), Some days (1), Quite often (2), and Almost every day (3). The total score ranges from 0 to 27 points, with a cutoff of ≥ 9 indicating depression (24).

Statistical Analysis

The sample size was calculated using a finite population proportion formula, based on a population of 403, a proportion of 0.217 (21), a margin of error of 0.05, an alpha level (α) of 0.05, and a Z-value of 1.959964, resulting in a minimum of 159 participants. Descriptive statistics summarized participant characteristics. A multivariable linear regression analyzed factors influencing Zoom fatigue. Pearson correlation assessed the relationship between PHQ-9 scores and Zoom fatigue scores. All statistical analyses were conducted using STATA Version 14.0 (Stata Corp LLC, College Station, TX, USA), with statistical significance set at a $p < 0.05$.

RESULTS

Table 1 presents the demographic data of the 165 Thai dental students who participated in the study. 70.9% were female, and the mean age was 21.6 years. The majority of students were in their first or second year of education (34.6% and 17.0% respectively). Most of the students had Zoom sessions at least once a week, with 31.5% having at least one session per day. The mean number of Zoom sessions per day was 1.6 (SD = 0.8), with 78.8% of these sessions lasting at least one hour. Most students (60%) had breaks of 0-30 minutes between sessions.

Table 1: Demographic characteristics and possible associated risk factors

Variables (n = 165)	N (%)
Gender:	
Male	48 (29.1%)
Female	117 (70.9%)
Age: mean (SD)	21.6 (3.4)
Education year:	
First year	57 (34.6%)
Second year	28 (17.0%)
Third year	22 (13.3%)
Fourth year	23 (13.9%)
Fifth year	16 (9.7%)
Sixth year	19 (11.5%)
Underlying disease:	
No underlying disease	144 (87.3%)
Physical disease	15 (9.1%)
Mental disease	6 (3.6%)
Exercise:	
Do not exercise	37 (22.4%)
Sometimes	106 (64.2%)
Regular	22 (13.3%)
Low outdoor activity	139 (84.2%)
Problems with online study	105 (63.6%)
Sleep problems	78 (47.3%)
Zoom session frequency	
< 1 time/month	69 (41.8%)
1-2 time/week	44 (26.7%)
> or = 1 time/day	52 (31.5%)
Number of zoom session/day: mean (SD)	1.6 (0.8)
Number of zoom session/day	
< 1 hour/session	35 (21.2%)
≥ 1 hour/session	130 (78.8%)
Breaking time between session	
0-30 minutes	99 (60%)
> 30 minutes	66 (40%)

Table 2 summarizes Zoom fatigue levels and subscales. Most participants experienced some degree of Zoom fatigue: 29.7% (N=49) reported mild fatigue, 33.9% (N=56) moderate fatigue, 20.0% (N=33) severe fatigue, and 1.8% (N=3) very severe fatigue. Only 14.6% (N=24) reported no Zoom fatigue. It was noted that the majority of pre-clinical students experienced mild or moderate levels of Zoom fatigue, whereas most clinical students experienced moderate levels.

Mean scores for ZEF subscales—general, visual, social, motivational, and emotional fatigue—ranged from 2.2 to 3.0, with social fatigue being the highest (Mean=3.0). The total ZEF score averaged 2.6 (SD = 1.0).

Regarding changes since the pandemic, 43% of respondents felt that Zoom fatigue had worsened, 34.6% reported no change, and 22.4% felt that it had improved compared to before the pandemic.

Table 2: Zoom Exhaustion and Fatigue (ZEF) total score and subscale scores

Prevalence of zoom fatigue	N (%)		
	Total (year 1-6) (N = 165)	Preclinic (year 1-4) (N = 130)	Clinic (Year 5-6) (N = 35)
No	24 (14.6%)	21 (16.2%)	3 (8.6%)
Mild	49 (29.7%)	42 (32.3%)	7 (20.0%)
Moderate	56 (33.9%)	42 (32.3%)	14 (40.0%)
Severe	33 (20.0%)	22 (16.9%)	11 (31.4%)
Extremely severe	3 (1.8%)	3 (2.3%)	0 (0%)
Zoom fatigue subscale	Mean (SD)		
General fatigue	2.8 (1.3)		
Visual fatigue	2.7 (1.0)		
Social fatigue	3.0 (1.1)		
Motivational fatigue	2.6 (1.2)		
Emotional fatigue	2.2 (1.0)		
Total ZEF score	2.6 (1.0)		

Table 3 presents the multivariable linear regression analysis of factors influencing total ZEF scores. Higher scores were significantly associated with female gender, mental health issues, sleep problems, difficulties with online study, and frequent Zoom sessions (1-2 times per week or ≥ 1 time per day). Age and education showed no significant correlation. Exercise frequency, outdoor activity, and Zoom session duration were also not significant. While break time between sessions had a negative coefficient, the association was not statistically significant.

Table 3: Factors associated with Zoom Exhaustion and Fatigue (ZEF)

Variable	Coefficient	95% confident interval	p-value*
Gender: female	4.90	0.26, 9.54	0.04
Age: year	0.17	-0.57, 0.92	0.65
Education year	1.47	-0.02, 2.92	0.06
Underlying disease			
No	ref	ref	ref
Physical disease	4.32	-2.59, 11.23	0.22
Mental disease	10.91	0.39, 21.43	0.04
Exercise			
no	ref	ref	ref
sometimes	0.47	-4.47, 5.41	0.85
regular	0.03	-7.12, 7.17	0.99
Sleep problems	6.46	2.46, 10.47	<0.01

Low Outdoor activity	-0.02	-5.48, 5.44	0.10
Problems with online study	7.03	2.76, 11.29	<0.01
Zoom session frequency			
≤ 1 time/month	ref	ref	ref
1-2 time/week	5.48	0.50, 10.47	0.03
≥ 1 time/day	6.67	1.33, 12.01	0.02
Number of zoom session per day: time	2.15	-0.55, 4.86	0.12
Duration of zoom session:			
< 1 hour/session	ref	ref	ref
≥ 1 hour/session	0.07	-4.76, 4.89	0.98
Breaking time between session:			
0-30 minutes	ref	ref	ref
> 30 minutes	-2.25	-6.38, 1.88	0.28

**Multivariable linear regression analysis*

R-squared = 0.3086, Adj R-squared = 0.2390

Table 4 shows the correlations between burnout (measured by the MBI-SS), depression (measured by the PHQ-9), and Zoom fatigue (measured by the ZEF-T). The correlation coefficient between Zoom fatigue and depression is 0.31 ($p<0.001$), indicating a moderate positive association between these two variables. This suggests that individuals experiencing higher levels of Zoom fatigue are also more likely to report symptoms of depression.

Table 4: Association between zoom fatigue and depression

	Burnout (MBI-SS)	Depression (PHQ-9)	Zoom fatigue (ZEF-T)
Burnout (MBI-SS)	1.00		
Depression (PHQ-9)	0.31 ($p=0.0001$)	1.00	
Zoom fatigue (ZEF-T)	0.48 ($P<0.0001$)	0.42 ($P<0.0001$)	1.00

**The Pearson correlation coefficient*

DISCUSSION

This study is the first to examine the prevalence of Zoom fatigue, its contributing factors, and its connection to depression among Thai dental students during the COVID-19 pandemic. Our findings show a high prevalence of Zoom fatigue among dental students, with most students reporting increased fatigue from online learning. Additionally, we observed a strong correlation between Zoom fatigue and depression in this population.

In our study, 85.4% of dental students reported at least mild Zoom fatigue, aligning with a previous study where 83.7% of Thai medical students experienced similar levels (13). However, there is no prior data on Zoom fatigue among dental students for comparison, either from before or after the pandemic. Studies suggest that dental students generally have a negative view of remote learning and prefer face-to-face instruction due to issues like poor communication and technical difficulties (26), limited social interaction, and the absence of non-verbal cues, which can lead to demotivation and isolation (27). These factors may contribute to the high prevalence of Zoom fatigue among dental students.

During the pandemic, Thai dental students faced significant challenges adapting to online learning, particularly related to Zoom fatigue. While recorded lectures provided flexibility, unstable internet, unsuitable study environments, and difficulties with practical and technical subjects online led to cognitive overload and increased stress over academic progression and graduation (28). Similar struggles were reported globally. Indian dental students experienced reduced motivation and difficulty understanding complex subjects due to the mental strain of prolonged virtual learning (29). Jordanian students faced barriers in practical training and concerns about clinical competence, partly due to the limitations of hands-on learning in a virtual setting, adding to cognitive fatigue (30). French students faced delays in graduation and heightened stress due to suspended in-person sessions (31). Likewise, U.S. students dealt with anxiety over meeting clinical requirements on time, exacerbated by the challenges of remote learning environments and mental exhaustion from continuous video-based interactions (32).

Our study found a strong correlation between Zoom fatigue and self-reported depression, indicating that dental students experiencing higher levels of Zoom fatigue are more prone to depression ($p < 0.001$). This aligns with research by Elbogen et al. and Montag et al., which also identified a significant link between the two (33,34). Similarly, a study of Thai medical students reinforced this connection, emphasizing the need to address both conditions simultaneously (13). This relationship is particularly relevant for educators and dental institutions, as symptoms of Zoom fatigue—such as social and motivation fatigue—closely resemble those of depression. Social fatigue, marked by a loss of interest in social activities after videoconferencing, resembles the anhedonia often found in major depression. Motivation fatigue, characterized by reduced drive and energy post-videoconferencing, parallels the low motivation typically seen in depressive states (35–37). Common factors like lack of control during virtual meetings, disrupted daily routines, and increased isolation may further exacerbate both conditions (38). Prolonged videoconferencing can trigger chronic stress response, contributing to depressive symptoms (39,40). Additionally, studies have linked Zoom fatigue to psychological distress, lower life satisfaction, and reduced academic well-being, which are factors associated with depression (41,42).

Our multivariable linear regression analysis revealed a significant correlation between higher total ZEF scores and several factors: being female, having a mental illness, experiencing sleep difficulties, facing challenges with online learning, and participating in Zoom sessions more frequently (at least once or twice a week or daily). These findings highlight the multifaceted nature of Zoom fatigue, with each factor contributing uniquely to its development. Women were more likely to experience Zoom fatigue, aligning with previous research (33,36,42), which suggests that women tend to experience higher levels of mirror anxiety, increased self-awareness, more negative emotions (36), and stronger emotional responses than men (40). Mirror anxiety, in particular, is associated with the social fatigue component of Zoom fatigue (36,44). Participants with pre-existing mental health conditions were also more prone to Zoom fatigue. Previous studies have shown that individuals with preexisting medical or psychiatric conditions faced heightened risk of adverse psychosocial outcomes during the COVID-19 pandemic (45–47). The cognitive demands of videoconferencing, which require sustained attention and active participation, can exacerbate symptoms of cognitive overload, leading to greater exhaustion (44,48). Sleep difficulties were

strongly associated with increased fatigue, as poor sleep quality impairs cognitive function, lowers energy levels, and weakens stress resilience (49). Sleep disturbances are bidirectionally related to psychiatric disorders such as depression, anxiety, bipolar disorder, and schizophrenia, making individuals with sleep issues more vulnerable to Zoom fatigue (50). Challenges in online learning, including technical difficulties, low engagement, and difficulty adapting, contribute to cognitive overload and higher ZEF scores (36,44,48). Struggling to understand content or maintain focus increases mental effort and exhaustion. The lack of immediate feedback and interaction in virtual settings can heighten stress, isolation, and negative emotions while reducing concentration, motivation, and performance (51). Finally, frequent Zoom use has been consistently associated with higher fatigue levels, as increased videoconferencing sessions correlate with greater exhaustion (12,13,27,43).

Our findings suggest that dental institutions should consider reducing the number of online sessions per week and providing additional support for students, particularly those new to this format. Screening for risk factors such as comorbid mental illnesses or sleep problems is also recommended to help mitigate Zoom fatigue and depression.

Limitations

Several limitations must be acknowledged. First, this is the first national study on Zoom fatigue among dental students, with no prior research available for comparison. Second, the cross-sectional survey design prevents establishing a causal relationship between Zoom fatigue and depression. Future studies should explore this relationship further. Additionally, this design does not allow for assessing changes in psychological states over time during the pandemic.

It is also important to note that the majority of participants were pre-clinical dental students. Clinical-year students, who typically have greater time constraints and are less active online, may have contributed disproportionately fewer responses. Additionally, since the sample was drawn from a single dental education center, the findings may not be generalizable. Expanding future research to multiple centers would improve external validity and provide a more comprehensive understanding of Zoom fatigue among dental students.

Zoom fatigue is a relatively new concept, with a limited body of research and a lack of standardized criteria, which complicates prevalence comparisons. Additionally, this study did not distinguish between fatigue from online lectures and interactive meetings. Future research should clarify this distinction to better understand the phenomenon.

CONCLUSION

In conclusion, Zoom fatigue was prevalent among Thai dental students, indicating the negative consequence of online learning among these future dentists. Both instructors and learners should acknowledge Zoom fatigue and its link to depression. Students who are female, have mental health issues, sleep problems, difficulties with online learning, or frequent Zoom sessions should be routinely screened for Zoom fatigue. This study offers valuable insights for educators and policymakers striving to optimize online learning while protecting students' mental health.

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REFERENCES

1. Wu YC, Chen CS, Chan YJ. The outbreak of COVID-19: An overview. *J Chin Med Assoc.* 2020 Mar;83(3):217–20. <https://doi.org/10.1097/jcma.0000000000000270>
2. Nussbaumer-Streit B, Mayr V, Dobrescu AI, Chapman A, Persad E, Klerings I, et al. Quarantine alone or in combination with other public health measures to control COVID-19: a rapid review. *Cochrane Database Syst Rev.* 2020 Sep 15;9(9):CD013574. <https://doi.org/10.1002/14651858.cd013574>
3. Camargo CP, Tempiski PZ, Busnardo FF, Martins M de A, Gemperli R. Online learning and COVID-19: a meta-synthesis analysis. *Clinics (Sao Paulo).* 2020;75:e2286. <https://doi.org/10.6061/clinics/2020/e2286>
4. Chang TY, Hsu ML, Kwon JS, Kusdhany MFLS, Hong G. Effect of online learning for dental education in asia during the pandemic of COVID-19. *Journal of Dental Sciences.* 2021 Oct;16(4):1095–101. <https://doi.org/10.1016/j.jds.2021.06.006>
5. American Dental Education Association [Internet]. The Association. 2023 [cited 2024 Mar 28]. A Pandemic Resource Guide for Dental Education. Available from: https://www.adea.org/COVID19-Update/Pandemic_Guide/
6. Quinn B, Field J, Gorter R, Akota I, Manzanares M, Paganelli C, et al. COVID-19: The immediate response of european academic dental institutions and future implications for dental education. *Eur J Dent Educ.* 2020 Nov;24(4):811–4. <https://doi.org/10.1111/eje.12542>
7. Aboalshamat K. Awareness of, beliefs about, practices of, and barriers to teledentistry among dental students and the implications for Saudi Arabia Vision 2030 and coronavirus pandemic. *J Int Soc Prevent Communit Dent.* 2020;10(4):431. https://doi.org/10.4103/jispcd.jispcd_183_20
8. Isiekwe IG, Adeyemi ET, Aikins EA, Umeh OD. The COVID-19 pandemic and orthodontic practice in Nigeria. *J Orthod Sci.* 2021;10:5. https://doi.org/10.4103/jos.JOS_40_20
9. Qutieshat AS, Abusamak MO, Maragha TN. Impact of Blended Learning on Dental Students' Performance and Satisfaction in Clinical Education. *J Dent Educ.* 2020 Feb;84(2):135–42. <https://doi.org/10.21815/jde.019.167>

10. Spanemberg JC, Simões CC, Cardoso JA. The impacts of the COVID-19 pandemic on the teaching of dentistry in Brazil. *J dent educ.* 2020 Nov;84(11):1185–7.
11. Yu-Fong Chang J, Wang LH, Lin TC, Cheng FC, Chiang CP. Comparison of learning effectiveness between physical classroom and online learning for dental education during the COVID-19 pandemic. *Journal of Dental Sciences.* 2021 Oct;16(4):1281–9. <https://doi.org/10.1016/j.jds.2021.07.016>
12. Fauville G, Luo M, Queiroz ACM, Bailenson JN, Hancock J. Zoom Exhaustion & Fatigue Scale. *Computers in Human Behavior Reports.* 2021 Aug;4:100119. <https://doi.org/10.1016/j.chbr.2021.100119>
13. Charoenporn V, Hanvivattanakul S, Jongmekwamsuk K, Lenavat R, Hanvivattanakul K, Charernboon T. Zoom fatigue related to online learning among medical students in Thailand: Prevalence, predictors, and association with depression. *F1000Res.* 2024 Jun 11;13:617. <https://doi.org/10.12688/f1000research.146084.2>
14. De Oliveira Kubrusly Sobral JB, Lima DLF, Lima Rocha HA, De Brito ES, Duarte LHG, Bento LBBB, et al. Active methodologies association with online learning fatigue among medical students. *BMC Med Educ.* 2022 Dec;22(1):74. <https://doi.org/10.1186/s12909-022-03143-x>
15. Peng P, Hao Y, Liu Y, Chen S, Wang Y, Yang Q, et al. The prevalence and risk factors of mental problems in medical students during COVID-19 pandemic: A systematic review and meta-analysis. *J Affect Disord.* 2023 Jan 15;321:167–81. <https://doi.org/10.1016/j.jad.2022.10.040>
16. Shah SMA, Mohammad D, Qureshi MFH, Abbas MZ, Aleem S. Prevalence, Psychological Responses and Associated Correlates of Depression, Anxiety and Stress in a Global Population, During the Coronavirus Disease (COVID-19) Pandemic. *Community Ment Health J.* 2021 Jan;57(1):101–10. <https://doi.org/10.1007/s10597-020-00728-y>
17. Pappa S, Ntella V, Giannakas T, Giannakoulis VG, Papoutsis E, Katsaounou P. Prevalence of depression, anxiety, and insomnia among healthcare workers during the COVID-19 pandemic: A systematic review and meta-analysis. *Brain, Behavior, and Immunity.* 2020 Aug;88:901–7. <https://doi.org/10.1016/j.bbi.2020.05.026>
18. Salari N, Hosseini-Far A, Jalali R, Vaisi-Raygani A, Rasoulpoor S, Mohammadi M, et al. Prevalence of stress, anxiety, depression among the general population during the COVID-19 pandemic: a systematic review and meta-analysis. *Global Health.* 2020 Dec;16(1):57. <https://doi.org/10.1186/s12992-020-00589-w>
19. Santabábara J, Ozamiz-Etxebarria N, Idoiaga N, Olaya B, Bueno-Novitol J. Meta-Analysis of Prevalence of Depression in Dental Students during COVID-19 Pandemic. *Medicina.* 2021 Nov 21;57(11):1278. <https://doi.org/10.3390/medicina57111278>
20. Riedl R. On the stress potential of videoconferencing: definition and root causes of Zoom fatigue. *Electron Mark.* 2022;32(1):153–77. <https://doi.org/10.1007/s12525-021-00501-3>

21. Charoenporn V, Hanvivattanakul S, Jongmekwamsuk K, Lenavat R, Hanvivattanakul K, Charernboon T. Psychometric Properties of the Zoom Exhaustion & Fatigue Scale -Thai version (ZEF-T). *Journal of the Psychiatric Association of Thailand*. 2022 Dec 27;67(4):386–96. <https://he01.tci-thaijo.org/index.php/JPAT/article/view/259376>
22. Charoenporn V, Charernboon T. Validity and reliability of the Thai version of the Zoom Exhaustion and Fatigue Scale (ZEF-T). *Fatigue: Biomedicine, Health & Behavior*. 2023 Oct 2;11(2–4):105–12. <https://doi.org/10.1080/21641846.2023.2208490>
23. Kroenke K, Spitzer RL, Williams JBW. The PHQ-9: Validity of a brief depression severity measure. *J Gen Intern Med*. 2001 Sep;16(9):606–13. <https://doi.org/10.1046/j.1525-1497.2001.016009606.x>
24. Lotrakul M, Sumrithe S, Saipanish R. Reliability and validity of the Thai version of the PHQ-9. *BMC Psychiatry*. 2008 Dec;8(1):46. <https://doi.org/10.1186/1471-244X-8-46>
25. Bailenson JN. Nonverbal Overload: A Theoretical Argument for the Causes of Zoom Fatigue. *Technology, Mind, and Behavior*. 2021 Feb;2(1):1–5. <https://doi.org/10.1037/tmb0000030>
26. Noor R, Singh D, Agarwal A, Mansoori S, Ansari MI. Perception of dental students towards the online method of dental education during the COVID-19 pandemic. *Journal of Oral Biology and Craniofacial Research*. 2022 Mar;12(2):223–7. <https://doi.org/10.1016/j.jobcr.2022.02.002>
27. Lestari PW, Fayasari A. Zoom Fatigue during the COVID-19 Pandemic: Is it Real?. *Kesmas*. 2022; 17(2):151-156. <https://doi.org/10.21109/kesmas.v17i2.5707>
28. Pothidee T, Chaimee C, Phutla R, Rodchalean A. The Effect of COVID-19 Pandemic Among Dental Students, Naresuan University. *Khon Kaen Univ Dent J*. 2024;27(1):1–11. <https://he01.tci-thaijo.org/index.php/KDJ/article/view/262527>
29. Shrivastava KJ, Nahar R, Parlani S, Murthy VJ. A cross-sectional virtual survey to evaluate the outcome of online dental education system among undergraduate dental students across India amid COVID-19 pandemic. *Eur J Dent Educ*. 2022;26(1):123–30. <https://doi.org/10.1111/eje.12679>
30. Hattar S, AlHadidi A, Sawair FA, et al. Impact of COVID-19 pandemic on dental education: online experience and practice expectations among dental students at the University of Jordan. *BMC Med Educ*. 2021;21:151. <https://doi.org/10.1186/s12909-021-02584-0>
31. Gaudin A, Arbab-Chirani R, Pérez F. Effect of COVID-19 on Dental Education and Practice in France. *Front Dent Med*. 2020;1:4. <https://doi.org/10.3389/fdmed.2020.00005>
32. Hung M, Licari FW, Hon ES, Lauren E, Su S, Birmingham WC, et al. In an era of uncertainty: Impact of COVID-19 on dental education. *J Dent Educ*. 2021;85(2):148–56. <https://doi.org/10.1002/jdd.12404>
33. Elbogen EB, Lanier M, Griffin SC, Blakey SM, Gluff JA, Wagner HR, et al. A National Study of Zoom Fatigue and Mental Health During the COVID-19 Pandemic: Implications for Future Remote Work.

Cyberpsychology, Behavior, and Social Networking. 2022 Jul 1;25(7):409–15.
<https://doi.org/10.1089/cyber.2021.0257>

34. Montag C, Rozgonjuk D, Riedl R, Sindermann C. On the associations between videoconference fatigue, burnout and depression including personality associations. *Journal of Affective Disorders Reports*. 2022 Dec;10:100409. <https://doi.org/10.1016/j.jadr.2022.100409>

35. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders - Fifth Edition*. [Internet]. American Psychiatric Association; 2013 [cited 2024 Oct 19]. Available from: <https://psychiatryonline.org/doi/book/10.1176/appi.books.9780890425596>

36. Fauville G, Luo M, Queiroz ACM, Bailenson JN, Hancock J. Nonverbal Mechanisms Predict Zoom Fatigue and Explain Why Women Experience Higher Levels than Men. *SSRN Journal Electronic Journal*. 2021. doi:10.2139/ssrn.3820035

37. Peper E, Wilson V, Martin M, Rosegard E, Harvey R. Avoid Zoom Fatigue, Be Present and Learn. *NR*. 2021 Mar 29;8(1):47–56. <https://doi.org/10.15540/nr.8.1.47>

38. Al Hussaini MH, Kausar S, Ul Huda Shah MT, Munawar N. Impact of Social Isolation on Anxiety and Depression Post COVID-19 Pandemic: Challenges and Solutions. *JPHS*. 2024 Jul 24;3(02):99–110. <https://doi.org/10.56741/jphs.v3i02.660>

39. Pariante CM, Lightman SL. The HPA axis in major depression: classical theories and new developments. *Trends in Neurosciences*. 2008 Sep;31(9):464–8. <https://doi.org/10.1016/j.tins.2008.06.006>

40. Zorn JV, Schür RR, Boks MP, Kahn RS, Joëls M, Vinkers CH. Cortisol stress reactivity across psychiatric disorders: A systematic review and meta-analysis. *Psychoneuroendocrinology*. 2017 Mar;77:25–36. <https://doi.org/10.1016/j.psyneuen.2016.11.036>

41. Deniz ME, Satıcı SA, Doeniyas C, Griffiths MD. Zoom Fatigue, Psychological Distress, Life Satisfaction, and Academic Well-Being. *Cyberpsychology, Behavior, and Social Networking*. 2022 May 1;25(5):270–7. <https://doi.org/10.1089/cyber.2021.0249>

42. Sukhanonsawat N, Boonkwan C, Vattanavanit V. Medical Students' Zoom Fatigue in a Thai Medical School During the COVID-19 Pandemic. *EIMJ*. 2024 Mar 29;16(1):47–55. <http://dx.doi.org/10.21315/eimj2024.16.1.4>

43. Oducado RMF, Dequilla MaACV, Villaruz JF. Factors predicting videoconferencing fatigue among higher education faculty. *Educ Inf Technol*. 2022 Aug;27(7):9713–24. <https://doi.org/10.1007/s10639-022-11017-4>

44. Bailenson JN. Nonverbal overload: A theoretical argument for the causes of Zoom fatigue. *Technology, Mind, and Behavior*. 2021 Feb 23;2(1). <https://psycnet.apa.org/doi/10.1037/tmb0000030>

45. Hao F, Tan W, Jiang L, Zhang L, Zhao X, Zou Y, et al. Do psychiatric patients experience more psychiatric symptoms during COVID-19 pandemic and lockdown? A case-control study with service and

research implications for immunopsychiatry. *Brain, Behavior, and Immunity*. 2020 Jul;87:100–6. <https://doi.org/10.1016/j.bbi.2020.04.069>

46. Vindegaard N, Benros ME. COVID-19 pandemic and mental health consequences: Systematic review of the current evidence. *Brain, Behavior, and Immunity*. 2020 Oct;89:531–42. <https://doi.org/10.1016/j.bbi.2020.05.048>

47. Xiong J, Lipsitz O, Nasri F, Lui LMW, Gill H, Phan L, et al. Impact of COVID-19 pandemic on mental health in the general population: A systematic review. *Journal of Affective Disorders*. 2020 Dec;277:55–64. <https://doi.org/10.1016/j.jad.2020.08.001>

48. Wiederhold BK. Connecting Through Technology During the Coronavirus Disease 2019 Pandemic: Avoiding “Zoom Fatigue.” *Cyberpsychology, Behavior, and Social Networking*. 2020 Jul 1;23(7):437–8. <https://doi.org/10.1089/cyber.2020.29188.bkw>

49. Lim J, Dinges DF. A meta-analysis of the impact of short-term sleep deprivation on cognitive variables. *Psychological Bulletin*. 2010 May;136(3):375–89. <https://doi.org/10.1037/a0018883>

50. Krystal AD. Psychiatric Disorders and Sleep. *Neurologic Clinics*. 2012 Nov;30(4):1389–413. <https://doi.org/10.1016/j.ncl.2012.08.018>

51. Besser A, Flett GL, Zeigler-Hill V. Adaptability to a sudden transition to online learning during the COVID-19 pandemic: Understanding the challenges for students. *Scholarship of Teaching and Learning in Psychology*. 2022 Jun;8(2):85–105. <https://psycnet.apa.org/doi/10.1037/stl0000198>