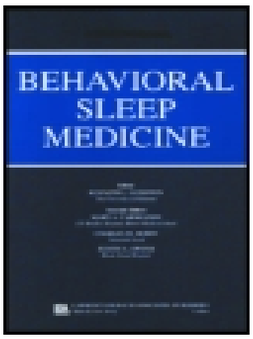

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Impact of the COVID-19 pandemic on the sleep quality of students: A meta-analysis and meta-regression

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ABSTRACT

Objective: The present systematic review aims to assess the impact of the COVID19 pandemic on the sleep quality of students.

Methods: An electronic search was performed in the databases and in gray literature for articles published up to January 2022. The results included observational studies that assessed sleep quality through validated questionnaires, comparing moments pre and postCOVID19 pandemic. The risk of bias was assessed using the Joanna Briggs Institute Critical Assessment Checklist. The Grading of Assessment, Development and Evaluation (GRADE) was used to assess the certainty of scientific evidence. Estimates of interest were calculated using random effects meta-analyses and possible confounding factors were meta-regressed.

Results: Eighteen studies were considered for qualitative synthesis and thirteen were considered for meta-analysis. Considering the comparison of means obtained by the Pittsburgh Sleep Quality Index, there was an increase in the scores obtained during the pandemic period [MD = −0.39; 95% CI = −0.72 – −0.07; I^2 = 88.31%], thus evidencing a slight worsening in the sleep quality of these individuals. Risk of bias was considered low in nine studies, moderate in eight studies, and high in one study. The unemployment rate (%) in the country of origin of each included study partially explained the heterogeneity of analysis. GRADE analysis showed a very low certainty of scientific evidence.

Conclusion: The COVID-19 pandemic may have a slight negative impact on the sleep quality of high school and college students, but the evidence is still uncertain. The socioeconomic reality must be considered when evaluating this outcome.

Introduction

COVID-19, caused by the SARS-CoV-2 virus, has been declared by the World Health Organization (WHO) a global public health emergency. Because of this, governments in different countries around the world have implemented preventive measures, including social distancing, to reduce the spread of the virus. These measures included restrictions on daily life and on face-to-face classes, meetings, and

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travel in order to keep citizens at home and isolated from social life. This situation may affect physical and mental health (Somma et al., 2020).

Fighting the pathogen is a priority in pandemic situations; however, this attention may neglect issues related to the mental health of individuals (Yadav et al., 2021). The physical, social, and mental well-being of people can be affected due to the fear of being infected by a potentially lethal virus (Dragioti et al., 2021).

Social isolation has been adopted in several countries, which has resulted in restricted access to family, friends, and other social systems that may lead to loneliness, anxiety, and depression (Zhu et al., 2021). This isolation also directly affected teaching modalities, with lengthy periods of suspension of activities in schools and universities (Genta et al., 2021; Mendes et al., 2021).

In an attempt to continue teaching and isolation, information and communication technologies (ICTs) were used to a great extent (Khademian et al., 2020). However, the possibility of excessive use of ICTs must be considered. It may compromise quality of sleep, physical activities, and mental well-being (Piya et al., 2022), in addition to altering the individual's routine by deregulating diets and moods (Li & Ye, 2021). In addition to ICTs, stress caused by the situation of insecurity in a pandemic resulted in changes in sleep quality, namely shorter sleep duration and changes in circadian rhythm (Benham, 2021). In general, sleep-related problems either arose or were aggravated during the COVID-19 pandemic. Since aspects related to sleep quality, such as duration, delay in onset, insufficiency, and excessive rate exert a significant influence on the academic performance of students, understanding the impact of COVID-19 on this population is valid and necessary (Jalilolghadr et al., 2021; Muñoz et al., 2023).

Several factors can negatively affect sleep quality (Sejbuk et al., 2023). Poor sleep was associated with older age, male gender, high body mass index (BMI), stress, and anxiety (Elizabeth et al., 2021; Gadie et al., 2017; Sejbuk et al., 2022; Tang et al., 2022). According to Çelik et al. (2019), students with poor economic status are more likely to experience depression, and consequently worse sleep quality (Çelik et al., 2019).

In a systematic review of the literature with the aim of studying the prevalence of sleep disorders in students during the pandemic, reports of the occurrence of sleep disorders are taken into account. However, questionnaires and exams are not properly standardized, and there is no criterion of comparison with moments before and during the COVID-19 pandemic (Deng et al., 2021).

The impacts the COVID-19 pandemic has caused are remarkable; it affects the population's quality of life in both the social and personal spheres. The evidence cited above highlights and supports the importance of the present study. Therefore, the objective of this systematic review is to evaluate the existing literature on the sleep quality of students exposed to the COVID-19 pandemic.

Methods

This systematic review was conducted according to the criteria described by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Checklist (Prisma; Page et al., 2021).

Eligibility criteria

The acronym "PECOS" was used to consider the eligibility of studies to be included or excluded from the review, which aims to answer the following question: "What is the impact of the COVID-19 pandemic on the quality of sleep of students?"

- *Population (P)* – Students;
- *Exposition (E)* – COVID-19 Pandemic;
- *Comparison (C)* – Not exposed to the COVID-19 pandemic;
- *Outcomes (O)* – Quality of sleep;
- *Study design (S)* – Cohort or cross-sectional observational studies;

Inclusion criteria

Studies were included with samples composed of students (children, adolescents, or adults somehow related to a school or university), regardless of school/academic level, exposed to the COVID-19 pandemic, whose sleep quality was compared before and during the pandemic. Only observational, cohort, or cross-sectional studies that used validated questionnaires to assess sleep quality were eligible.

Exclusion criteria

Studies were excluded based on the following criteria: (1) Studies that did not assess sleep quality using validated questionnaires; (2) studies that evaluated sleep quality in only one period (before or during the pandemic); and (3) literature reviews, letters to the editor, books, conference abstracts, opinion articles, technical articles, and retrospective studies. There was no exclusion of any study based on language, time of publication, gender, or ethnicity of the population.

Information sources and search strategy

The electronic search was performed on January 28, 2022, using keywords with different combinations and truncation and adapted to the following databases: EMBASE, Latin American and Caribbean Literature on Health Sciences (LILACS), PubMed/Medline, Scopus, Web of Science. A search was also performed in gray literature through Google Scholar, Open Gray, and ProQuest Dissertations & Theses Database (Online Resource 1). A manual search of the reference lists of the studies included and a consultation with an expert was performed to assess the existence of any relevant studies. References were managed and duplicates were excluded using the EndNote®X7 reference manager (Thomson Reuters, Philadelphia, PA).

Selection process

The selection of studies to be included after the search process was performed by two independent reviewers (CCC and AAM). In the first phase, reviewers read the titles and abstracts, to which the eligibility criteria were applied. In phase two, the same reviewers read the full text to apply the eligibility criteria established here. At the end of each phase, in case of disagreement between reviewers, a third reviewer (MRJ), with expertise in the subject, was consulted. To promote a correct calibration between reviewers before the beginning of the first phase the calculation of the Kappa coefficient of agreement was performed. The reading started when the agreement value between reviewers was > 0.7, indicating good agreement. The Rayyan website (http://rayyan.qcri.org) was used to ensure an independent reading by the reviewers.

Data collection process

Two reviewers (CCC and AAM) independently collected the following data from the selected studies: author, year of publication, country, study classification, sample characteristics, evaluation period, sleep quality assessment questionnaire, data on the main outcome, and conclusion. In case of absence of data, the original authors were consulted by e-mail up to three times, with an interval of one week between each interval.

Date items

The main outcome was sleep quality. The mean values and standard deviation, equivalent to the global score of the questionnaire used, for the period before and during the pandemic, were extracted from the studies. When standard deviation values were not reported and there was no description of any measurement of variability that would allow its calculation, the value from the study with the greatest variance within the analysis was then computed. This produced a more conservative result, decreasing the study's mathematical weight, and generating a larger confidence interval. Data on possible confounding factors were also extracted, such as mean age, percentage of men/women in the sample, sample's body mass index (BMI), and sample's nationality. Nationality data were used to assess the unemployment rate in the country of origin (%), considering data from the World Economic Outlook (Recoveries, 2021). To cover the different collection periods of the articles included and portray economic impacts, the data used for this variable were related to the publication in the first quarter of 2021.

Risk of bias assessment

The risk of bias of the studies included was independently assessed by two reviewers (CCC and AAM) using the Joanna Briggs Institute's critical assessment tool (Moola et al., 2017). In case of any disagreement, an experienced third reviewer (KVMT) was included for final decision. For each type of study included, an appropriate checklist was completed based on the study design. The risk of bias was categorized by domains as "high" when the study obtained a "*yes*" score corresponding to up to 49%; "moderate" between 50% and 69%; and "low" when the score corresponded to 70% or more of the evaluated domains (Taveira et al., 2018).

Effect measurements

To compare the sleep quality of students before and during the pandemic, the difference between the means (MD) of the two moments was calculated. Thus, to summarize the data obtained, the results were expressed as mean difference values, standard deviation, and 95% confidence interval (95% CI).

Synthesis of methods

A meta-analysis with a random effect model weighted by the inverse variance method was performed. To calculate the analysis variance (Tau^2), the DerSimonian-Laird method was used. Heterogeneity was evaluated by the Higgins inconsistency index (I^2). To explore heterogeneity and assess the influence of possible confounding factors on the variance observed in the analysis, a meta-regression with a random effect model was conducted considering the following factors as predictors: mean age of the sample, BMI, % of men in the sample, and unemployment rate (%). All analyses were performed using the Stata 16.0 statistical software (Stata Corp LLC, College Station, USA).

Reporting bias assessment

The existence of publication bias was assessed using the funnel plot and the Egger test considering a significance level of 5%.

A sensitivity analysis was planned for any study included in the analysis with a high risk of bias. In addition, a subgroup analysis was performed based on the study time (post-evaluation – during the pandemic or during the lockdown) and types of students (elementary/high school or college students).

Certainty assessment

The certainty of evidence of the studies was evaluated by two independent reviewers (KVMT and CMA) through the Grading of Recommendations Assessment, Development and Evaluation tool (GRADE] (Guyatt et al., 2008). The final judgment for the analyzed outcome was defined as high, moderate, low, or very low based on the five domains of the tool: risk of bias, inconsistency, imprecision, indirect evidence, and publication bias.

Results

Study selection

1,555 articles were found. After excluding duplicates, 709 articles were analyzed as for their titles and abstracts (phase 1), and 55 articles were read in full (phase 2), of which 40 were excluded based on the eligibility criteria (Online Resource 2). The search in the gray literature resulted in the inclusion of three articles. Consultation with experts and manual search of the reference lists of the studies analyzed did not lead to the inclusion of any other study. Thus, 18 studies were included for qualitative synthesis and 13 studies for quantitative synthesis (Figure 1).

Study characteristics

Of the 18 articles on the impact of COVID-19 on the sleep quality of students, six are classified as cross-sectional studies (Benham, 2021; Cellini et al., 2020; Marelli et al., 2021; Ramírez-Contreras et al., 2022; Somma et al., 2020; Viselli et al., 2021) and 12 as cohort studies (Evans et al., 2021; Genta et al., 2021; Gusman et al., 2021; Jalal et al., 2021; Johansson et al., 2021; Lee et al., 2021; Lu et al., 2021; Maher et al., 2021; Martínez-Lezaun et al., 2020; Romero-Blanco et al., 2020; Santamaria-Vazquez et al., 2021; Sañudo et al., 2020).

For cross-sectional studies, the assessment of sleep quality was performed considering two distinct groups of individuals, which were evaluated only once at different times (Benham, 2021; Ramírez-Contreras et al., 2022; Viselli et al., 2021) or in a single time based on retrospective questions on the

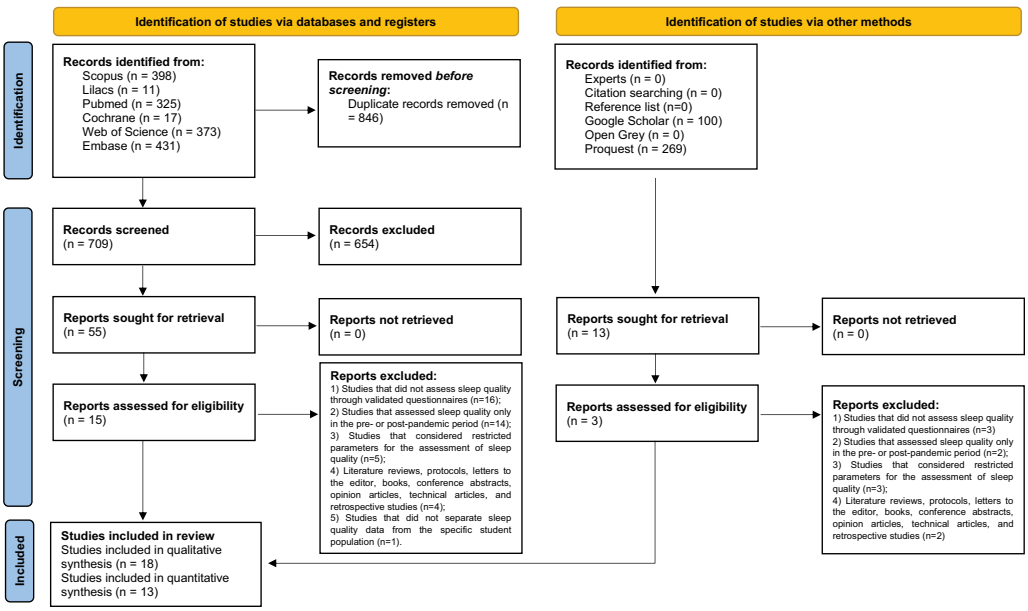

Figure 1. PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources.

period of interest (Cellini et al., 2020; Marelli et al., 2021; Somma et al., 2020). The evaluation periods were before and during the COVID-19 pandemic 19 (Benham, 2021; Marelli et al., 2021; Ramírez-Contreras et al., 2022); pre-lockdown and during lockdown (Cellini et al., 2020; Somma et al., 2020); or before the COVID-19 pandemic and during lockdown (Viselli et al., 2021).

As for cohort studies, the same population was monitored and evaluated at least twice. The periods considered for evaluation were before and during the COVID-19 pandemic (Genta et al., 2021; Gusman et al., 2021; Johansson et al., 2021; Lee et al., 2021); before the COVID-19 pandemic and during lockdown (Evans et al., 2021); before the COVID-19 pandemic and after lockdown (Lu et al., 2021); and before and during lockdown (Jalal et al., 2021; Maher et al., 2021; Martínez-Lezaun et al., 2020; Romero-Blanco et al., 2020; Santamaria-Vazquez et al., 2021; Sañudo et al., 2020).

The sample size ranged from 22 (Sañudo et al., 2020) to 1,836 participants (Johansson et al., 2021). The study population consisted of university students (Benham, 2021; Cellini et al., 2020; Evans et al., 2021; Gusman et al., 2021; Jalal et al., 2021; Johansson et al., 2021; Lu et al., 2021; Maher et al., 2021; Marelli et al., 2021; Martínez-Lezaun et al., 2020; Ramírez-Contreras et al., 2022; Romero-Blanco et al., 2020; Santamaria-Vazquez et al., 2021; Somma et al., 2020; Viselli et al., 2021), college students (Sañudo et al., 2020), high school students (Genta et al., 2021; Lee et al., 2021), and elementary school students (Lee et al., 2021). Except for ; Gusman et al., 2021), who used the Karolinska Sleep Diary, the studies included used the Pittsburgh Sleep Quality Index (PSQI). Table 1 shows the detailed characteristics of the included studies.

All studies showed a predominance of females. One study addressed students from Health Sciences, Social and Legal Sciences, Arts and Humanities, Engineering and Architecture and Sciences in the fourth year of the course (Santamaria-Vazquez et al., 2021). The study by ; Johansson et al., 2021) also presented a diversity of courses considered (medicine, economics, and sports sciences), although with a focus on relating sleep to emotional aspects, such as anxiety, depression, and stress during COVID-19.

Risk of bias in studies

Among the cross-sectional studies included, one was classified as having a low risk of bias (Ramírez-Contreras et al., 2022), four were classified as having a moderate risk of bias (Benham, 2021; Cellini et al., 2020; Marelli et al., 2021; Somma et al., 2020; Viselli et al., 2021), and one was classified as having a high risk of bias (Cellini et al., 2020). The risk of bias of cross-sectional studies (%yes/risk) ranged from 37% to 75%. Among the 12 cohort studies included, eight were classified as having a low risk of bias (Evans et al., 2021; Genta et al., 2021; Gusman et al., 2021; Johansson et al., 2021; Lu et al., 2021; Maher et al., 2021; Romero-Blanco et al., 2020; Sañudo et al., 2020), three as having a moderate risk of bias (Jalal et al., 2021; Lee et al., 2021; Martínez-Lezaun et al., 2020), and one as having a high risk of bias (Santamaria-Vazquez et al., 2021). The risk of bias of cohort studies (%yes/risk) ranged from 36% to 91%.

As for the methodological weaknesses of cross-sectional studies, the lack of clarity of inclusion criteria and the failure to identify and control confounding factors stood out. Cohort studies had no control for confounding factors, possibility of participants not being free of the outcome at the beginning of the study, and issues related to the follow-up of participants. Online Resource 3 describes the detailed characteristics of the risk of bias assessment.

Results of individual studies

Three studies applied the sleep quality questionnaire at three separate times (Benham, 2021; Johansson et al., 2021; Santamaria-Vazquez et al., 2021). There was an increase (64% to 66.5%) in the prevalence of population with a score greater than 5 for sleep quality (Benham, 2021), while another study found a decrease in this prevalence longitudinally (56% to 54% of the population; Johansson et al., 2021).

Table 1. Characteristics of the included studies.

Author, year, country	Study design	Sample (n, gender)	Mean age (Standard deviation)	Evaluation time (Month ou period)	Sleep quality assessment questionnaire	Outcomes
Benham, 2021 USA	Cross Sectional	427 (T1), 450 (T2), 345 (T3) college students 260 female/167 males (T1) 333 female/117 males (T2) 248 female/97 males (T3)	21.3 (4.86)	T1: pre-COVID-19 (March – May 2019) T2: during COVID-19 (March – May 2020) T3: during COVID-19 (June – August 2020)	PSQI	**Mean** T1: 7.18 T2: 7.23 T3: 7.2 **Prevalence** (scores greater than 5 to students) T1: 64% T2: 65% T3: 66,5%
Cellini et al., 2020 Italy	Cross Sectional	809 college students (565 female/244 males)	22.6 (2.53)	T1: pre-lockdown (before February 2020) T2: during lockdown (March 2020)	PSQI	**Mean** T1: 5,2 T2: 5,8
Evans et al., 2021 United Kingdon	Cohort	254 college students (219 female/32 males)	19.76 (1.28)	T1: pre-COVID-19 (October 2019) T2: during lockdown (March 2020)	PSQI	**Mean** T1: 6.58 ± 3.35 T2: 6.60 ± 3.16
Genta et al., 2021Brazil	Cohort	94 high school students (60 female/34 males)	15 (1) (T1) 16.4 (1.1) (T2)	T1: pre-COVID-19 (March 2019) T2: during COVID-19 (June 2020)	PSQI	**Mean** T1: 6.4 ± 2.8 T2: 6.8 ± 3.6
Gusman et al., 2021USA	Cohort	164 college students (98 female/65 males/ 1 other)	Has not been reported	T1: prior to transition to online learning T2: Online learning	Karolinska Sleep Diary	Prior to the transition to online learning, sleep quality did not change significantly, on average (b = .007, p = .91). When the university went online, sleep quality significantly improved (b = .418, p < .001). However, thereafter, the change in slope after the transition online was significant, such that the average sleep quality decreased over time
Jalal et al., 2021Saudi Arabia	Cohort	628 college students (445 females/183 males)	20.45 (1.93)	T1: pre-lockdown (March 2020) T2: During lockdown (June 2020)	PSQI	188 (29.9%) students felt that sleep quality was good before lockdown, and 126 (20.1%) students felt the same during the lockdown **Mean** (students who gained weight) T1: 7.2 ± 1.26 T2: 6.5 ± 1.05 **Mean** (students who lost weight) T1: 6.4 ± 1.05 T2: 6.3 ± 1.21

(*Continued*)

Table 1. (Continued).

Author, year, country	Study design	Sample (n, gender)	Mean age (Standard deviation)	Evaluation time (Month ou period)	Sleep quality assessment questionnaire	Outcomes
Johansson et al., 2021Sweden	Cohort	1836 (T1), 1364 (T2) and 1095 (T3) college students1358 female/478 males (T1) 1033 female/331 males (T2)837 female/ 258 males (T3)	26.5 (6.8) (T1) 26.8 (7) (T2) 27 (7.1) (T3)	T1: pre-COVID-19 (August 2019 – March 2020) T2: during COVID-19 (March – June 2020) T2: during COVID-19 (June – September 2020)	PSQI	**Prevalence** (scores greater than 5) T1: 60% T2: 56% T3: 54%
Lee et al., 2021China	Cohort	1018 elementary and high school students (610 female/408 males)	13.28 (1.07) (T1) 13.99 (1.07) (T2)	T1: pre-COVID-19 (September – October 2019) T2: after COVID-19 outbreak (June – July 2020)	PSQI	**Mean** T1: 4.81 ± 2.61 T2: 4.87 ± 2.59
Lu et al., 2021China	Cohort	5181 college students (3,220 female/1,961 males)	91,9% between 18– 24 years (T1) 99.5% between 18– 24 years (T2)	T1: pre-COVID-19 (September – October 2020) T2: after lockdown (April 2020)	PSQI	There was an improvement in sleep quality for 14% and worsening for 5% of students. **Prevalence** (scores greater than 5): T1: 19.7% T2: 10.7%
Maher et al., 2021USA	Cohort	107 college students (71 female/36 males)	21.7 (2.6)	T1: pre-lockdown (January – March 2020) T2: during lockdown (April – May 2020)	PSQI	**Mean** T1: 4.44 ± 2.41 T2: 5.80 ± 3.16
Marelli et al., 2020Italy	Cross Sectional	307 college students (230 female/77 males)	22.84 (2.68)	T1: pre-COVID-19 (not specified) T2: during COVID-19 (March – May 2020)	PSQI	**Prevalence** (scores greater than 5 to students): T1: 58% T2: 73,3%

(*Continued*)

Table 1. (Continued).

Author, year, country	Study design	Sample (n, gender)	Mean age (Standard deviation)	Evaluation time (Month ou period)	Sleep quality assessment questionnaire	Outcomes
Martinéz-de-Quel et al., 2021Spain	Cohort	693 (T1) and 161 (T2) college students 60 female/101 males (T2)	35 (11.2) (T2)	T1: pre-lockdown (March 2020) T2: during lockdown (April – May 2020)	PSQI	**Mean** T1: 6.2 ± 3.5 T2: 7.2 ± 3.9
Ramírez-Contreras et al., 2022Spain	Cross Sectional	71 (T1) and 68 (T2) college students58 female/13 males (T1)60 female/8 males (T2)	22.5 (2.3) (T1) 22.8 (3.1) (T2)	T1: pre-COVID-19 (November 2019) T2: "New-normal" (November 2020)	PSQI	**Mean** T1: 5.1 ± 2.4 T2: 5.2 ± 2.5
Romero-Blanco et al., 2020Spain	Cohort	207 college students (169 female/38 males)	20.6 (4.62)	T1: pre-lockdown (January 2020) T2: during lockdown (April 2020)	PSQI	**Mean** T1: 5.51 ± 2.89 T2: 6.42 ± 3.36 **Prevalence** (scores greater than 5): T1: 60.4% T2: 67.1%
Sañudo et al., 2020Spain	Cohort	57 (T1) and 22 (T2) college students 23 female/34 males (T1)10 female/12 males (T2)	22.5 (2.6) (T1) 22.7 (3.6) (T2)	T1: pre-lockdown (February 2020) T2: during lockdown (March – April 2020)	PSQI	**Mean** T1: 5.8 ± 2.7 T2: 6.8 ± 3.8 **Prevalence** (scores greater than 5): T1: 47% T2: 58%
Santamaria-Vazquez et al., 2021Spain	Cohort	102 (T1/T2) and 75 (T3) college students82 female/20 males (T1/T2) 56 female/19 males (T3)	21.83 (2.97) (T1/T2) 21.67 (2.23) (T3)	T1: pre-lockdown (not specified) T2: during lockdown (20 days after start of lockdown) T3: during lockdown (40 days after the start of the lockdown)	PSQI	Self-regulation of motivation (SRM) was inversely associated with latency, disturbance, daytime dysfunction, and overall sleep quality score.
Somma et al., 2020Italy	Cross Sectional	307 college students (230 female/77 males)	22.84 (2.69)	T1: pre-lockdown (before March 2020) T2: during lockdown (March to May 2020)	PSQI	**Mean** T1: 5.42 ± 2.78 T2: 6.69 ± 3.26
Viselli et al., 2021Italy	Cross Sectional	240 college students (193 female/47 males)	20.39 (1.42)	T1: pre-COVID-19 (2016 October) T2: during lockdown (March 2020)	PSQI	**Mean** T1: 5.96 ±2.64 T2: 6.61 ±2.92

Legend: T – time; PSQI – Pittsburgh Sleep Quality Index

The group of studies that measured sleep quality at two different times showed an increase in the mean Pittsburgh score: from 4.4 to 5.8 (Maher et al., 2021), from 5.5 to 6.4 (Romero-Blanco et al., 2020); the pre-lockdown questionnaire showed a score from 6.58 to 6.60 (Evans et al., 2021), pre-lockdown of 6.4 to 6.8 (Genta et al., 2021), and pre-COVID-19 from 4.81 to 4.87 (Lee et al., 2021). The prevalence was in pre-COVID-19 periods: from 19.7% to 10.7% after lockdown (Lu et al., 2021). On the other hand, there was an indication of improvement in sleep quality as soon as teaching became online, although over time authors observed a worsening of this indicator (Gusman et al., 2021). This last study showed that its sample was composed exclusively of first-year undergraduate students, and that academic and financial stress factors and interpersonal variability worsened changes in sleep quality (Gusman et al., 2021).

Studies that performed assessment in a single moment, performing data collection in a retrospective way, showed that before the lockdown poor sleep quality was 40.5%, increasing to 52.4% (Cellini et al., 2020); pre-COVID-19 from 58% to 73.3% (Marelli et al., 2021), and that there was a worsening of the mean score from 5.4 to 6.7 (Somma et al., 2020).

In addition to the interpretation of the PSQI total score, the detailing of results on the domains of this instrument is worth discussing. There was an increase in sleep latency (Benham, 2021; Marelli et al., 2021; Romero-Blanco et al., 2020; Somma et al., 2020), daytime dysfunction (Somma et al., 2020; Viselli et al., 2021), sleep disturbance (Romero-Blanco et al., 2020; Somma et al., 2020), and use of sleep medication (Benham, 2021). Specially college students reported a decrease in sleep duration (Marelli et al., 2021; Romero-Blanco et al., 2020) and sleep efficiency (Benham, 2021). On the other hand, high school students showed no impact of COVID-19 on sleep duration, sleep latency, daytime sleepiness, and sleep quality (Genta et al., 2021). Santamaria-Vazquez et al. (2021) reported that the worsening of sleep latency, disturbance, daytime dysfunction, and sleep quality directly affected students' motivation (Santamaria-Vazquez et al., 2021).

Results of syntheses

Thirteen articles were included in the meta-analysis. They compared data in a pre-pandemic period and during the pandemic. Studies were sub-grouped according to study time and type of students.

Comparing the means obtained by PSQI, there was an increase in the scores obtained during the pandemic period [MD = −0.39; 95% CI = −0.72 – −0.07; I^2 = 88.31%], thus evidencing a slight deterioration in the quality of sleep of these individuals and a larger effect size considering college students and the post-lockdown assessment. The lower limit of the confidence interval was close to the null line for both global effect and for the subgroups of college students and post-lockdown assessment, evidencing a small effect size (Figures 2 and 3).

Reporting bias

The presence of publication bias was not detected by the analysis of the funnel plot. The p value was > 0.05, obtained by Egger test, denoting the absence of funnel asymmetry (Figure 4).

One study included in the meta-analysis was classified as having a high risk of bias (Cellini et al., 2020). Another study, despite being classified as having a moderate risk of bias, used a retrospective assessment through the participants' memory regarding sleep quality in the pre-pandemic period (Somma et al., 2020). Due to the risk of bias and distortion of estimate generated by the method of measuring outcomes, a sensitivity analysis was performed. After excluding these studies, there was a decrease in effect size, with the lower limit of the confidence interval of the global effect crossing the null line [MD = −0.29; 95% CI = −0.62–0.04; I^2 = 84.60] (Figure 5).

The mean age of the sample and the % of men in the sample did not explain the variance observed in effect sizes of the studies included ($p > .05$; R^2 = 0%) when meta-regressed. Only four studies reported the BMI of the assessed sample. It was not possible to assess this predictor variable in the

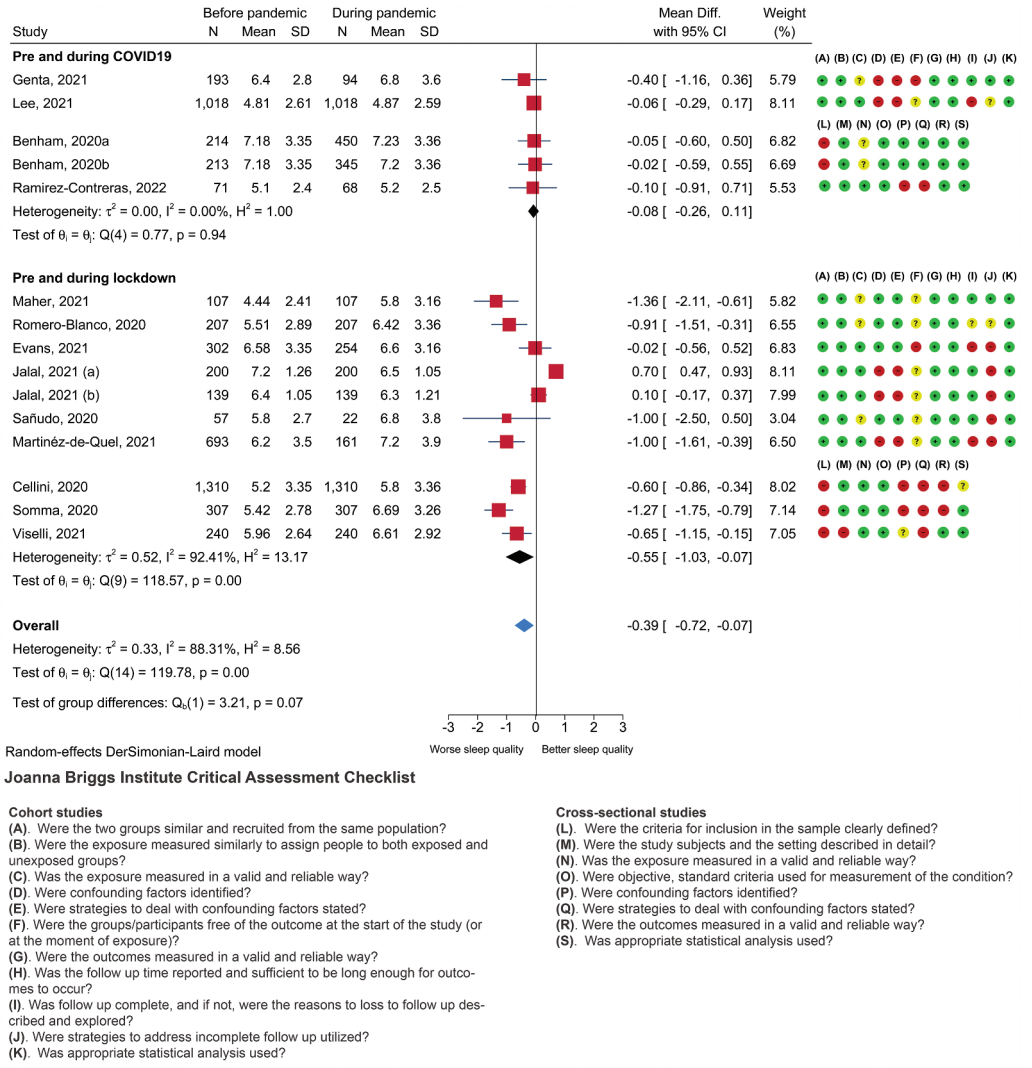

Figure 2. Forest plot of the meta-analysis of the PSQI questionnaire, considering the study time, displaying risk of bias judgments for each study included.

meta-regression model. The unemployment rate (%) in the country where data were collected explained 55.56% of the heterogeneity in the analysis (p = .038; Table 2; Figure 6).

Certainty of evidence

The certainty in the cumulative evidence was considered "very low". The main factors related to the decrease in the certainty of evidence were presence of bias that may have distorted the estimates assessed by sensitivity analysis; uncontrolled confounders in the included studies; lack of reporting of relevant information such as sample BMI; inconsistency due to existing heterogeneity, partially explained by the meta-regression model. No publication bias or conflict of interest was detected in the included studies (Table 3).

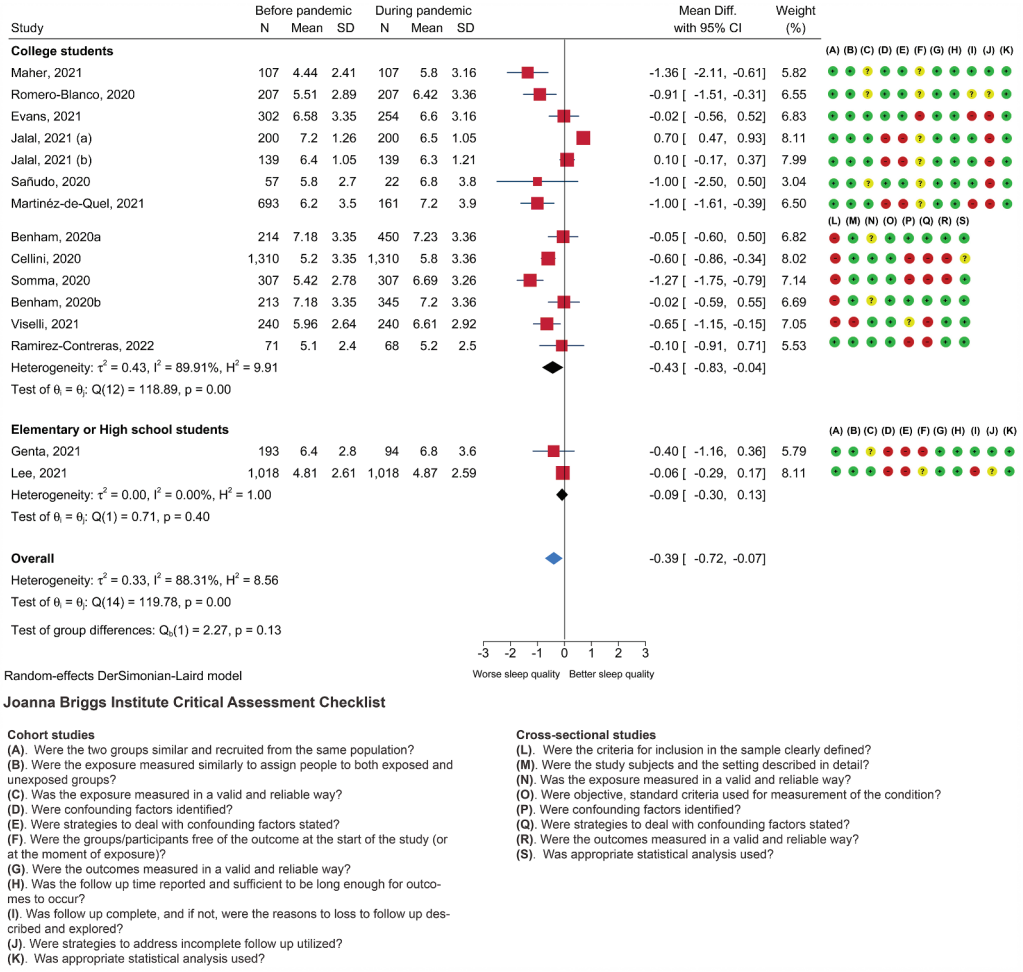

Figure 3. Forest plot of the meta-analysis of the PSQI questionnaire, considering the types of students, displaying risk of bias judgments for each study included.

Discussion

This is the first meta-analysis that evaluates the impact of the COVID-19 pandemic lockdown on students' sleep quality. The meta-analytic analysis, which took into account the period before and during the pandemic, revealed that these individuals may present a worsening in sleep quality. However, there is still uncertainty about this outcome due to the small effect size and the risk of possible bias in the literature, which may distort the global estimate when considering all existing studies.

The PSQI (Buysee, 1989) was used in most studies included in this review. This questionnaire stands out for its strong reliability and validity (Mollayeva et al., 2016). The studies excluded from this review used quality of life questionnaires. They contained, for example, only one question about sleep. Other studies did not use standardized and validated questionnaires, evaluating specific aspects related to sleep by questions such as "what time do you go to bed?/get up?" or "do you sleep well/how do you judge your sleep quality?" This, in turn, limited the understanding of sleep quality.

Sleep quality is an aspect that is difficult to measure objectively, considering that it is influenced by several components (Buysee, 1989). Among them are quantitative aspects, such as duration of sleep, and subjective aspects, such as self-perceived depth of sleep (Edinger et al., 2000). In this sense, we list

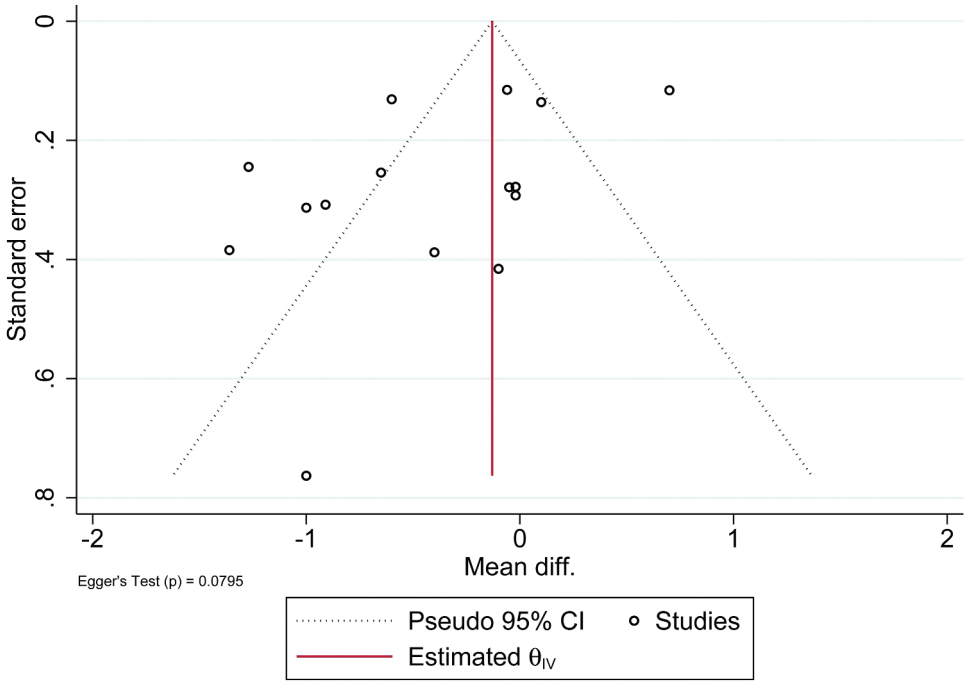

Figure 4. Funnel plot for assessing the presence of publication bias. ΘIV, meta analysis pooled estimate.

several factors that can, individually or together, affect each of these aspects. Increased screen exposure during the pandemic was associated with poor sleep quality and negative psychological impacts (Cabral et al., 2022). This may be related to a higher incidence of artificial light and a high flow of news, leading to cognitive stimulation especially before going to sleep (Almarzouki et al., 2022; Cabral et al., 2022; Demirci et al., 2015). In addition, restrictions on the practice of physical exercises and exposure to natural light might have also affected the quality of sleep of individuals since these factors are considered as protective for a good sleep (David et al., 2022).

Improved sleep is associated with better health outcomes for the individual. When considering the target population of the present study – students –, we took into account the concern with the academic performance. Adequate sleep is important to refresh students' routine and help them to learn and process memory (Maheshwari & Shaukat, 2019). Suardiaz-Muro et al. (2020), evaluating in a systematic review the relationship between sleep and academic performance of university students, concluded that inadequate sleep has a negative effect on academic performance (Suardiaz-Muro et al., 2020). Thus, from the perspective of education, identifying problems related to the quality of sleep of students is essential to circumvent possible effects caused by the COVID-19 pandemic on this population.

In the present study, there was a high heterogeneity of studies. Although there is little evidence of interactions between sleep quality and age (Gadie et al., 2017), heterogeneity could not be explained by age group as the studies had mean ages of 18 to 22 years. Only ; Genta et al., 2021) reported a mean of less than 15 years, and the study of ; Johansson et al., 2021) reported a mean of 27 years. Another more notorious confounding factor was the proportion of men and women, with the prevalence of females being practically unanimous in the samples of the studies included. This is in line with the predominance of this gender in some courses, such as in the health area (Corrêa et al., 2017). Considering the morphological differences between the genders and their direct impact on the circadian cycle, respiratory control and the action of sex hormones on sleep mechanisms, this should be an aspect

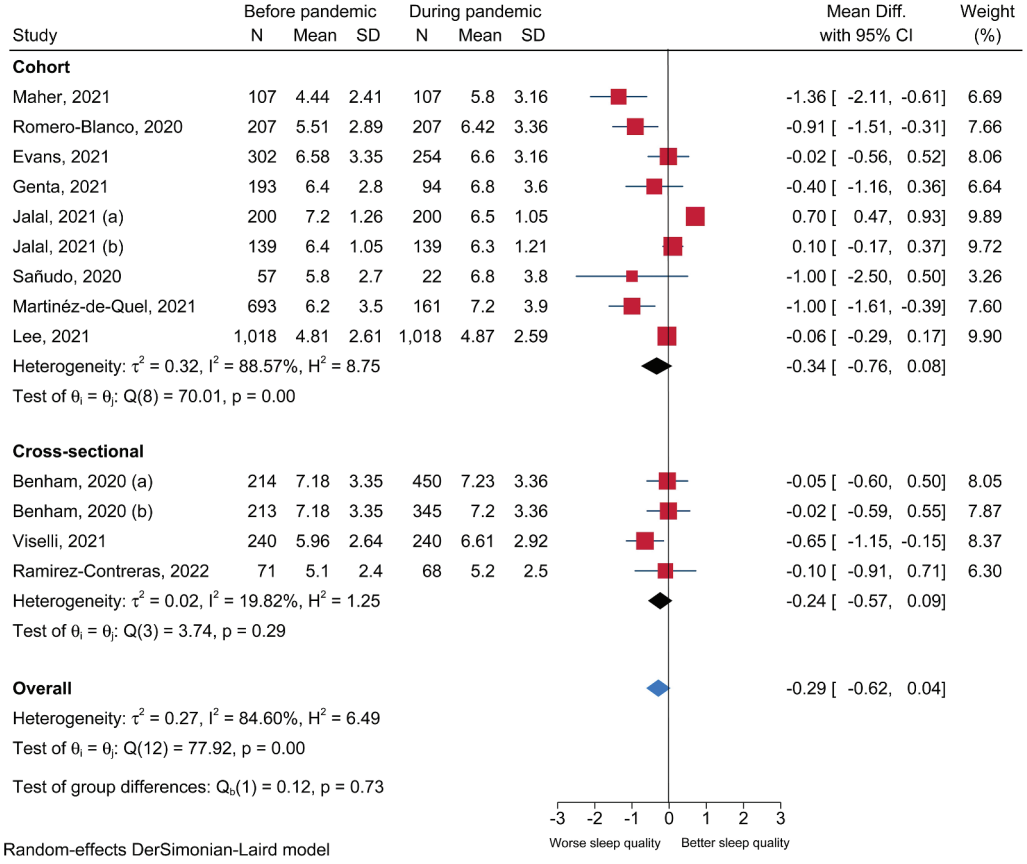

Figure 5. Sensitivity analysis with removal of studies with high risk or moderate risk and memory bias from the analysis.

Table 2. Variables predicting the observed variance between the effect sizes of the studies included in the meta-analysis.

Predictor variable	β	Standard error	p-value
Sample mean age	−0,5244	0,0388	0,177
% male	−0.0075	0,1329	0,571
Unemployment rate (%)	−0.0466	.02246	0,038

to be taken into account (Mollayeva et al., 2016). None of these confounders explained the variability between the effect sizes of the studies included when considering the meta-regression model.

Still regarding the existing heterogeneity, another important aspect is that the studies originated from different countries, which implies different socioeconomic realities and diverse ways of coping with the pandemic. According to ; Lima et al., 2021), socioeconomic factors were an aggravating factor in the increase in signs and symptoms of sleep anomalies, as they found a decrease in family income and an increase in unemployment as a result of the closure of shops and non-essential services. In this sense, the poorest population, women, young people, and couples were listed as the individuals most susceptible to the exacerbation of sleep problems. The sample BMI should also be considered, since high BMI values, even without a causal relationship, may be associated with a shorter sleep duration in children and adults (Garfield, 2019). The socioeconomic reality assessed by unemployment rate proved to be a significant predictor for sleep quality in the studies included. However, the absence of reporting and controlling of possible confounding factors may still have affected the effect sizes.

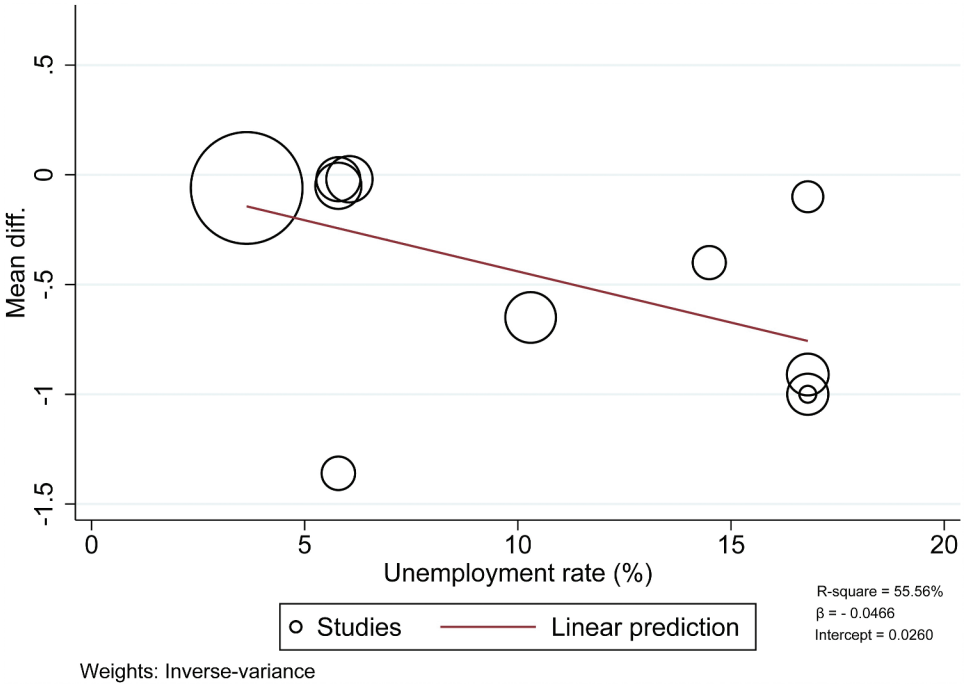

Figure 6. Bubble plot-meta regression plot of the PSQI questionnaire, regressed against the unemployment rate.

Table 3. Grading of recommendations assessment, development and evaluation summary of findings table.

	Anticipated absolute effects* (95% CI)				
Outcomes	Risk with COVID-19 pandemic period	Risk with before COVID-19 pandemic period	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
Sleep quality (PSQI)	The mean sleep quality was **6.37**	mean **0.39 lower** (0.72 lower to 0.07 lower)	(13 observational studies)	⊕○○○ Very low[a,b,c]	The evidence is very uncertain about the effect of COVID-19 pandemic period on sleep quality.

Explanations
a. Exposure was not reliably measured, confounding factors were not controlled, and it was not certain that participants were free of the outcome before the start of the study.
b. Heterogeneity in the results obtained (I-squared – 88.31)
c. Upper bound of the confidence interval near the null line.

Moreover, the multifactorial nature related to sleep quality allows only a partial explanation of this heterogeneity.

It is important to note that the present study has limitations. First, overall, the risk-of-bias analysis showed methodological weaknesses in the studies included, especially regarding the lack of control for confounding factors and the lack of certainty that the participants were free of the outcome at the beginning of the study. Although the population of most studies are university students, the difference of the population in our study (children, adolescents, and adults) must be taken into account since they have different backgrounds and experiences that may affect the estimates. According to Corrêa et al. (2017), the PSQI shows different sleep quality results even between graduation semesters, being worse for the first semesters than for the last ones (Corrêa et al., 2017). It is worth noting that, of the four cross-sectional studies included in the meta-analysis, two (Cellini et al., 2020; Somma et al., 2020)

carried out an outcome assessment by questioning sleep aspects from a previous period. Therefore, attention should be paid to a possible memory bias. To minimize this fragility, a sensitivity analysis was performed. It showed a decrease in effect size, demonstrating no effect on sleep quality. Along with the finding of heterogeneity in the results obtained in meta-analysis, these factors had an impact on GRADE, reflecting the uncertainty of effect estimates, with the possibility of future studies changing the certainty of these estimates (Guyatt et al., 2008). In addition, this review did not consider variables related to the number of cases or deaths by COVID-19 per region as confounding factors. Since the increase in insomnia symptoms is directly related to the number of cases (Morin et al., 2021), this becomes a limitation of our study. However, the data from this systematic review reinforce the need for further care focused on this public during situations of social restrictions, evidencing the importance of maintaining an established routine and social interaction on an important physiological aspect of students: sleep.

Conclusion

Exposure to the pandemic period may negatively affect the sleep quality of high school and university students. However, the existing evidence is still uncertain as for this outcome, and there may be little or no effects. Socioeconomic reality must be considered when evaluating this outcome.

Other information

The protocol of the present systematic review was registered at the International Prospective Register of Systematic Review – Center for Reviews and Dissemination University of York (PROSPERO), under identification no. CRD42020227031.

Disclosure statement

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