

Université de Montréal

Un examen de la portée de la littérature dans les premiers jours de la crise du COVID-19

Dormir en temps de crise

Par

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RESUME

Au cours des premiers jours de la pandémie et dans le contexte d'une menace mondiale apparemment inconnue, plusieurs perturbateurs majeurs potentiels du sommeil ont été identifiés par des chercheurs et des praticiens du sommeil à travers le monde. La pandémie de COVID-19 a combiné plusieurs caractéristiques qui, prises individuellement, ont montré qu'elles affectaient négativement la santé du sommeil dans la population générale. Ces caractéristiques comprenaient le stress, les restrictions sur les interactions sociales en personne, ainsi que l'adversité financière. En conséquence, les chercheurs et les praticiens se sont précipités pour identifier des preuves qui pourraient être utilisées pour améliorer les politiques de santé publique et se sont inspirés des premières études COVID-19, des précédentes épidémies de maladies infectieuses, ainsi que de la littérature scientifique portant sur l'isolement social et l'adversité financière. Pour remédier à l'absence d'un résumé complet de la recherche sur le sommeil dans ces trois domaines distincts, je mène une revue systématique et qualitative de la littérature, en utilisant la version adaptée du cadre d'Arksey et O'Malley pour les examens de la portée. Au cours de ce travail, nous avons systématiquement examiné 16 959 résumés et nous nous sommes efforcés de « cartographier » et de résumer les preuves scientifiques pertinentes existantes disponibles en début 2020 sur la santé du sommeil dans le contexte de : 1) la COVID-19, les autres pandémies et/ou crises ; 2) l'isolation sociale, la solitude ou le confinement ; et 3) l'adversité économique ou financière. Des facteurs modérateurs potentiels tels que l'âge, le sexe, l'origine ethnique, le statut socio-économique, la prédisposition psychologique, la profession et d'autres circonstances personnelles dans ces 3 contextes ont également été inclus dans notre revue. Pour conclure, nous soulignons la nécessité de développer des interventions de santé publique qui favorisent la santé du sommeil et qui peuvent réduire l'impact potentiel des crises futures.

Mots-clés: Sommeil, COVID-19, Crise, Pandémie, Isolement social, Solitude, Incertitude économique, Récession, Revue systématique.

ABSTRACT

During the early days of the pandemic and in the context of a seemingly unknown global threat, several potential major sleep disruptors were identified by sleep researchers and practitioners across the globe. The COVID-19 pandemic combined several features that, individually, had been shown to negatively affect sleep health in the general population. Those features included stress, restrictions on in-person social interactions, as well as financial adversity. Accordingly, researchers and practitioners scrambled to identify evidence that could be used to inform public policy and drew on early COVID-19 studies, past infectious disease outbreaks, as well as from the scientific literature on social isolation and financial adversity. To address the lack of a comprehensive summary of sleep research across these three distinctive domains, I lead a systematic, qualitative review of the literature, using the adapted version of Arksey and O'Malley's framework for scoping reviews. Over the course of this work, we systematically screened 16,959 abstracts and we endeavored to "map" and summarize the existing relevant scientific evidence available in early 2020 on sleep health in the context of: 1) COVID-19, other pandemics and/or crises; 2) social isolation, loneliness or confinement; and 3) economic or financial adversity. Potential moderating factors such as age, sex, ethnicity, socioeconomic status, psychological predisposition, occupation and other personal circumstances across these 3 contexts were also included in our review. To conclude, we highlight the need to develop public health interventions that foster sleep health and that can lessen the potential impact of future crises.

Keywords: Sleep, COVID-19, Crisis, Pandemic, Social Isolation, Loneliness, Economic Uncertainty, Recession, Systematic review.

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Buenas noches,

-Guido

INTRODUCTION

Sleep health can be defined as a multidimensional pattern of sleep-wakefulness that promotes physical and mental well-being (Buysse, 2014). These multidimensional patterns are adapted to individual, social and environmental demands (Buysse, 2014). The most often studied sleep health dimensions are: 1) duration: amount of time spent sleeping; b) sleep quality: satisfaction with one's sleep; c) timing: wake up and going to bed times; d) continuity: time spent sleeping in relation to the time spent in bed; e) Alertness: the capacity to sustain attention (opposite of sleepiness); f) regularity: the extent to which individuals maintain regular sleep amounts and timing (Buysse, 2014). Good sleep health can will therefore mean regular sufficient (and efficient) sleep duration, of good quality, at an earlier time that leads to a high level of alertness (Buysse, 2014).

In industrialized countries, deficient sleep is a serious public health problem, reflected by a high prevalence nationwide of insufficient sleep, and unrecognized and untreated sleep disorders (Colten Hr, 2006). Although sleep has been identified as a critical issue for public health and public safety, approximately one third of adult Canadians report sleeping less than the recommended amount of seven or more hours per night and an even greater proportion of Canadians report symptoms compatible with an insomnia diagnosis (Chaput JP, 2018). According to Statistics Canada, between 2007 and 2015 there was a 42% increase in the prevalence of insomnia symptoms in adults (Chaput JP, 2018). Accumulated chronic sleep loss is thought to have widespread and detrimental consequences for health including increased risk of atherosclerosis and cardiovascular disease (Knutsson & Boggild, 2000; Knutsson, Hallquist, Reuterwall, Theorell, & Akerstedt, 1999), increased rate of weight gain and associated health risks such as diabetes and cancer (Cappuccio, D'Elia, Strazzullo, & Miller, 2010a), increased likelihood of Alzheimer's disease (Musiek, Xiong, & Holtzman, 2015), impaired immune function (Cohen, Doyle, Alper, Janicki-

Deverts, & Turner, 2009; Lange, Dimitrov, Bollinger, Diekelmann, & Born, 2011; Lange, Perras, Fehm, & Born, 2003; S. R. Patel et al., 2012; Prather et al., 2012; Spiegel, Sheridan, & Van Cauter, 2002), and increased mortality (Cappuccio, Cooper, D'Elia, Strazzullo, & Miller, 2011; Cappuccio, D'Elia, Strazzullo, & Miller, 2010b). In the short term acute sleep loss is associated with disruption to a broad spectrum of cognitive and affective processes (Goel, Rao, Durmer, & Dinges, 2009; Yoo, Gujar, Hu, Jolesz, & Walker, 2007), decreased productivity (Barnes & Watson, 2019) and increased risk of accidents (Hursh, 2011).

Sleep, Health and Functioning

Deficient sleep, in particular poor sleep quality and short sleep duration, as well as sleep disorders such as insomnia and obstructive sleep apnea have long been identified as independent predictors of cardiovascular disease. For example, during normal sleep, nocturnal blood pressure decreases somewhere between 10% to 20% on average, primarily through decreased sympathetic nervous system activation (Ziegler, 2003). In deficient sleepers and in those with sleep disorders, the nocturnal 'dip' in blood pressure can be attenuated (Y. Wang et al., 2015; Ziegler, 2003). Average nocturnal blood pressure is regarded a strong marker of cardiovascular disease, even stronger than daytime blood pressure, and this has been shown in studies aimed at comparing the use of ambulatory portable blood pressure monitors to hospital setting measurements (Dolan et al., 2005). One comparative study found that for each 5% deficit in nocturnal blood pressure dip there was a 20% increase in risk of cardiovascular mortality after adjusting for a host of potential confounders (Ohkubo et al., 2000). Longitudinal studies have shown that individuals who reported being short sleepers were up to 70% more likely to develop hypertension compared to individuals reporting normal amounts (Cappuccio et al., 2007; Stranges et al., 2008). Sleep disorders such as obstructive

sleep apnea, a sleep breathing disorder characterized by pauses in breathing during sleep, is highly comorbid with hypertension (Yaggi et al., 2005). To that end, the apnea hypopnea index, which refers to the number of apneic or hypo apneic events per hour during sleep (and an indicator of obstructive sleep apnea severity), is highly correlated with hypertension severity (Hla et al., 1994). Conversely, different meta-analyses of randomized controlled trials have shown that treatment of obstructive sleep apnea leads to modest improvements in hypertension (Alajmi et al., 2007; Bazzano, Khan, Reynolds, & He, 2007). Similarly, experimental studies in adults and young adults (university students) have shown that extending sleep (allowing individuals to sleep longer than normal) leads to reductions in nocturnal blood pressure (Haack et al., 2013; Stock, Lee, Nahmod, & Chang, 2020).

Deficient sleep is also related to cardiometabolic disruption including increased risk of diabetes. For example, deficient sleep is associated with insulin resistance and glucose tolerance (Buxton et al., 2010; Spiegel, Leproult, & Van Cauter, 1999). Experimental studies have shown that as little as five nights of sleep restriction (5 hours' time in bed per night) can significantly increase insulin resistance in healthy individuals (Buxton et al., 2010). Another experimental study showed that up to 4 nights of sleep restriction can decrease glucose metabolism up to 40% compared to normal sleep (Spiegel et al., 1999). Epidemiological studies have also found a link between diabetes and different dimensions of sleep health. For example, using data from the Multi-Ethnic Study of Atherosclerosis, it was shown that sleeping less than 5 hours (using objective sleep measures) was associated with 30% higher odds of elevated fasting glucose or hypoglycemic medication use compare to those that slept 5 hours or more per night (Bakker et al., 2015). A meta-analysis of longitudinal studies published in 2010 showed that both poor sleep quality and short sleep duration are associated with a higher risk of diabetes incidence after accounting for major confounders such

as age and body mass index (Cappuccio et al., 2010a). In this study, the risk of developing diabetes was estimated at 28% for individuals who reported sleeping less than 6 hours per night, and 84% in those who reported difficulties maintaining their sleep (a common insomnia-like symptom) (Cappuccio et al., 2010a). The underlying pathways linking deficient sleep and diabetes remain poor understood, although experimental studies have shown that short sleep leads to dysregulation of hormones responsible for appetite regulation, which leads to poor meal choices and increasing caloric intake (Spaeth, Dinges, & Goel, 2013).. Experimental short sleep has also been shown to decrease motivation to exercise, potentially leading to weight gain, which is closely linked to type 2 diabetes (Spaeth et al., 2013). Conversely, studies where chronic short sleepers were allowed to sleep more than usual showed that sleeping longer was associated with healthier food choices, decreased appetite and decreased insulin resistance (Leproult, Deliens, Gilson, & Peigneux, 2015; Tasali, Chapotot, Wroblewski, & Schoeller, 2014).

Deficient sleep is also linked to disruption to a broad range of cognitive and affective processes, with important ramifications to health, productivity and safety with an important economic cost. Acute lack of sleep is associated with different cognitive impairments including slowed reaction time and complex decision making. Chronic sleep restriction has been reported to increase the risk of developing dementia. For example, in one longitudinal study who followed participants for over 25 years, those who reported sleeping on average less than 7 hours per night were at a 30% higher risk of developing dementia, and this higher risk was independent of sociodemographic, behavioral, cardiometabolic and mental health factors (Sabia et al., 2021). Those with sleep disorders, in particular those with obstructive sleep apnea, are also more likely to develop dementia (Osorio et al., 2015). Conversely, studies comparing the trajectory of treated and untreated obstructive sleep apnea patients have shown that treatment adherence leads to better long-term

cognitive outcomes (Dunietz, Chervin, Burke, Conceicao, & Braley, 2021). Sleep has been hypothesized to serve the function of clearing ‘waste’ from brain (Xie et al., 2013). Experimental studies have shown that sleep deprivation affects for example the clearance of tau protein, whose accumulation has an important role in the pathogenesis of some types of dementia (Benedict, Blennow, Zetterberg, & Cedernaes, 2020).

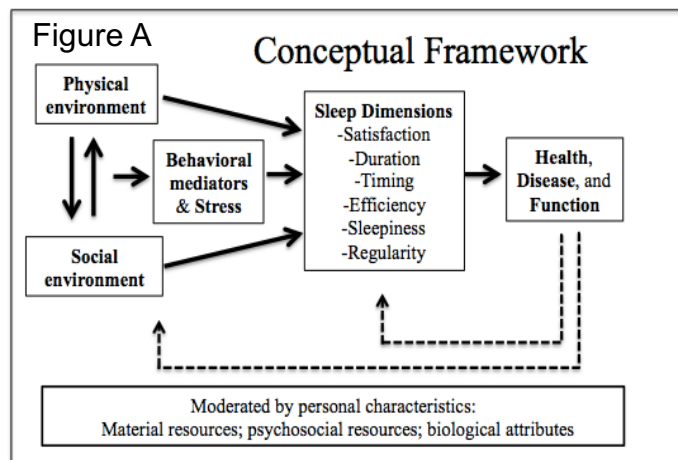
Cognitive impairments associated with sleep loss and/or sleepiness are also associated with an increased risk of accidents, including a higher risk of motor-vehicle crashes (Dawson & McCulloch, 2005). For example, the relationship between culpability of a motor-vehicle crash is highly correlated with sleep duration (Tefft, 2018). Drivers who report having slept less than 6 hours per night are 30% more likely of being culpable for their crashes compared to those sleeping normal amounts (Tefft, 2018). Falling asleep while driving is also more likely to occur in short sleepers. Compared to those sleeping normal amounts, sleeping 6 hours per night (or less) is associated with a 2.6-fold increased risk of having reported having fallen asleep on the wheel (Centers for Disease & Prevention, 2013). Slowed reaction time, impaired decision making (risk-taking) or obstructive sleep apnea also led to higher risk for car crashes, and this relationship seems to be independent of sleepiness (Gottlieb, Ellenbogen, Bianchi, & Czeisler, 2018). Sleep loss and sleep disorders can also affect productivity (Barnes & Watson, 2019). Lack of sleep can not only lead to attentional deficits but it can also affect motivation, creativity, cognitive flexibility and emotional regulation, all of which are important predictors of workplace performance (Barnes & Watson, 2019).

Lack of sleep is an important predictor of mortality with an important economic cost. A meta-analysis published in 2010, using data from 16 prospective studies and pooling data from over a 100,000 individuals, the authors showed that short sleep duration is associated with a 12% increase

in all-cause mortality (Cappuccio et al., 2010b). Interestingly, despite the large numbers differences between study designs, the authors identified very little heterogeneity between studies and no evidence of publication bias, suggesting that the estimated effect is likely due to a real effect and not reflective of within study differences (Cappuccio et al., 2010b). The economic cost associated with insufficient sleep in Canada has been estimated to 0.85% to 1.56% of the annual GDP, and this estimation is based on the health burden associated with insufficient sleep, increase mortality risk and overall productivity loss (Hafner, 2016).

Conceptual Framework: Sleep Health

The conceptual framework for this thesis is grounded in the “neighbourhood health” model proposed by Diez-Roux and Mair (2010) (Diez Roux & Mair, 2010) and the “sleep health” framework proposed by Buysse (2014) (Buysse, 2014). This adapted conceptual model



(figure A), posits that the complex interplay of social and physical environments, behavioural mediators and stress can influence various dimensions of sleep that in turn can affect outcomes of health, disease and function. The model also recognizes that the relationships between sleep and outcomes of health, disease and function can be reciprocal: just as sleep affects health, disease and function in one direction, in another, health, disease and function influence both the interplay of physical and social environment, stress and behavioural mediators as well as sleep-wake function.

Personal characteristics such as material resources, psychosocial resources and biological attributes can act as effect measure modifiers.

Sleep Health and Coronavirus Disease 2019 pandemic

A wealth of sleep health epidemiological research has shown that technological, demographic, cultural and geographic disparities may affect the quality and quantity of sleep and/or its association with health at the population level (Simonelli et al., 2018). Sleep disparities may be partially driven by modifiable factors for adequate sleep quality and quantity such as having a safe, predictable place for sleep and being able to devote adequate time to obtain sufficient sleep that is essential for health and optimal functioning (N. P. Patel, Grandner, Xie, Branas, & Gooneratne, 2010; Simonelli et al., 2013). Social (and physical) environmental sleep disruption are timely issues as the Coronavirus Disease 2019 pandemic (COVID-19) has reshaped public spaces and their use, as well as the home environment, as social distancing measures and school and business closures mandate where people study, work and spend leisure time. In the context of COVID-19 in Canada, provincially mandated stay-at-home orders and temporary closure of nonessential businesses and organizations have left many without employment and forced others to work from home, shifting socially-imposed daily routines and sleep schedules.

During the early days of the pandemic and in the context of a novel global threat, three potential major sleep disruptors were continuously discussed in media outlets by sleep researchers and practitioners across the globe. The COVID-19 pandemic combined several features that, individually, had been shown to negatively affect sleep health in the general population. Those features included states of crises, restrictions on in-person social interactions, as well as financial adversity. To address the lack of a comprehensive summary of sleep research across these three distinctive domains, we undertook three parallel systematic reviews based on the following

themes: (1) Sleep in times of (health) crises; (2) Sleep and social isolation; and (3) Sleep and economic uncertainty. Using a scoping review framework, we systematically identified and summarized findings from these three separated bodies of work.

Objectives

The objective of this study was to systematically examine and collate all the available evidence (as of early 2020) on the following three themes:

- 1) Sleep in the context of COVID-19, other pandemics and/or other types of health crises
- 2) Sleep and social isolation, loneliness or confinement
- 3) Sleep in the context of economic or financial adversity

I will achieve my objective by conducted a scoping review using the Arksey and O'Malley's framework for scoping reviews (Arksey & O'Malley, 2005), in accordance with the following steps: (a) identifying the research question, (b) identifying relevant studies, (c) selecting studies, (d) charting the data, (e) collating, summarizing and reporting results. During this scoping exercise, we endeavored to “map” and summarize the existing, relevant scientific evidence, available in early 2020. Scoping reviews differ from traditional systematic reviews in many ways. For example, scoping reviews can be seen as a hypothesis-generating exercise, while systematic reviews can be seen as hypothesis-testing (Moher, Stewart, & Shekelle, 2015; Tricco et al., 2016). Regardless of study quality, scoping reviews allow to present a broad overview of the existing evidence on an emerging topic (Peters et al., 2015; Tricco et al., 2016). Scoping reviews also allow to define key concepts and identify research gaps, in line with the objective of this thesis (Peters et al., 2015).

First article. Thesis by Article

(The following revised manuscript was re-submitted to Sleep Medicine Reviews in July 2021)

Sleep in times of crises: a scoping review in the early days of the COVID-19 crisis

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Summary

During the early days of the pandemic and in the context of a seemingly unknown global threat, several potential major sleep disruptors were identified by sleep researchers and practitioners across the globe. The COVID-19 pandemic combined several features that, individually, had been shown to negatively affect sleep health in the general population. Those features included stress (crises), restrictions on in-person social interactions, as well as financial adversity. To address the lack of a comprehensive summary of sleep research across these three distinctive domains, we undertook three parallel systematic reviews based on the following themes: (1) Sleep in times of crises; (2) Sleep and social isolation; and (3) Sleep and economic uncertainty. Using a scoping review framework, we systematically identified and summarized findings from these three separated bodies of works. Potential moderating factors such as age, sex, ethnicity, socioeconomic status, psychological predisposition, occupation and other personal circumstances are also discussed. To conclude, we propose novel lines of research necessary to alleviate the short- and long-term impacts of the COVID-19 crises and highlight the need to prepare the deployment of sleep solutions in future crises.

Keywords: Sleep, COVID-19, Crisis, Pandemic, Social Isolation, Loneliness, Economic Uncertainty, Recession, Systematic review.

Glossary of terms:

Loneliness: Discrepancy between an individual's desired and actual relationships. It is thus an unpleasant emotional interpretation of one's own social circumstances.

Social isolation: Absence of social interactions, contacts, and relationships with family and friends, with neighbors on an individual level, and with "society at large" on a broader level.

Financial adversity: Insufficient financial resources to adequately meet one's household's needs.

Pandemic: An outbreak of a disease that occurs over a wide geographic area (such as multiple countries or continents) and typically affects a significant proportion of the population.

Abbreviations box

COVID-19: Coronavirus disease of 2019

ISI: Insomnia severity scale

OR: Odds ratio

OSA: Obstructive sleep apnea

PHQ: Patient health questionnaire

PSQI: Pittsburgh sleep quality index

PTSD: Post-traumatic stress disorder

SARS: Severe acute respiratory syndrome

INTRODUCTION

In 2020, the coronavirus disease (COVID-19) pandemic caused sickness and deaths, leading to important disruption in individuals' lives and the global economy. Public health measures aimed

at limiting the spread of COVID-19, and fear of infection affected everyday routines, by limiting social, educational and work activities. Consequently, the COVID-19 pandemic reshaped public spaces and their use, as well as the home environment, as social distancing measures, and school and business closures mandated where people studied, worked and spent leisure time. In the context of COVID-19, government-imposed stay-at-home orders and temporary closure of nonessential businesses and organizations left many without employment and forced others to work or attend classes from home, causing stress and interfering with daily routines and sleep-wake schedules.

During the early days of the pandemic and in the context of a seemingly unknown global threat, several potential major sleep disruptors were identified by sleep researchers and practitioners across the globe. The COVID-19 pandemic combined several features that, individually, had been shown to negatively affect sleep health in the general population. Those features included a state of crisis characterized by increased stress, in addition to restrictions on in-person social interactions, as well as financial adversity. Accordingly, researchers and practitioners scrambled to identify evidence that could be used to inform public policy and drew on early COVID-19 studies (as well as from the scientific literature on social isolation and financial adversity). To address the lack of a comprehensive summary of sleep research across these three distinctive domains, we undertook a systematic, qualitative review of the literature, using the adapted version of Arksey and O'Malley's framework for scoping reviews (Arksey & O'Malley, 2005). In this review we endeavored to "map" and summarize the existing, relevant scientific evidence, available in early 2020 on sleep health in the context of: 1) COVID-19, other pandemics and/or crises; 2) social isolation, loneliness or confinement; and 3) economic or financial adversity. We also aimed

to identify new avenues for research to understand whether sleep is impacted by global crises in order to guide the future development of public health interventions.

METHODS

Using the Arksey and O'Malley's framework for scoping reviews, we followed the following step: (a) identifying the research question, (b) identifying relevant studies, (c) selecting studies, (d) charting the data, (e) collating, summarizing and reporting results. In accordance the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (Moher, Liberati, Tetzlaff, & Altman, 2009), we undertook three parallel systematic reviews based on the following themes: (1) Sleep in times of crises; (2) Sleep and social isolation; and (3) Sleep and economic uncertainty. The three independent searches were conducted using different databases according to each theme. We searched these databases from inception between May 30 and July 15, 2020. For each of the key concepts for each systematic search, a librarian with expertise in systematic reviews developed a comprehensive list of its various synonyms, adapted to each database using a mix of terms from thesauri and keywords linked with appropriate Boolean and proximity operators. We performed our searches with a pool of various terms based on a combination of the key concepts previously identified across several electronic databases (see Table S1 for full search strategy). The study populations consisted of children, adolescents, adults and older adults. We did not apply any language restriction in the search strategy per se, but at the stage of screening for abstracts, we excluded the small numbers of articles published in other languages than English or French. Records were exported from each database into a master EndNote library, and duplicates were removed with Covidence.

Search 1: Sleep and pandemics or other crises

Studies were eligible for inclusion if they satisfied the following criteria: they reported data on sleep variables in the context of “COVID-19”, “pandemics” or “crises” (see Table S1 for complete list of terms). In mid-July 2020, this search yielded 838 articles from CINAHL (EBSCO); 3,748 articles from EMBASE (ELSEVIER); 2,089 articles from Medline (OVID); 1,022 articles from Psycinfo (OVID); 2,583 articles from Web of science: Core Collection (Clarivate).

Search 2: Sleep and social isolation

Studies were eligible for inclusion if they satisfied the following criteria: they reported data on sleep in the context of “social isolation”, “loneliness”, “confinement” or “social support” (see Table S1 for complete list of terms). On June 1, 2020, this search yielded 1,468 articles from Medline (OVID); 3,322 articles from EMBASE (ELSEVIER); 1,174 articles from Psycinfo (OVID); 139 articles from Psychology and behavioral sciences collection (EBSCO); 1,530 articles from Web of science: Core Collection (Clarivate).

Search 3: Sleep and financial adversity

Studies were eligible for inclusion if they satisfied the following criteria: they reported data on sleep parameters in the context of “economic crisis”, “financial adversity”, or “job insecurity” (see Table S1 for complete list of terms). In mid-July 2020, this search yielded 343 articles from CINAHL (EBSCO); 1,272 articles from EMBASE (ELSEVIER); 568 articles from Medline (OVID); 303 articles from Psycinfo (OVID); 732 articles from Web of science: Core Collection (Clarivate).

Screening

Screening processes were conducted using Covidence (covidence.org), an online platform that supports meta-analysis collaboration between multiple researchers. Two trained research assistants (JPD and XM) screened the title and abstract of each articles to determine which ones potentially met inclusion criteria. If the initial screening failed to result in consensus (i.e., a mismatch of yes/no/maybe), the final decision to include or exclude a study was made by another investigator (either GS or DP). Following this initial screening phase, the two research assistants (JPD and XM) conducted a more thorough full-text assessment to confirm study eligibility.

The inclusion criteria were reporting on sleep health parameters in the context of: 1) COVID-19, other pandemics and/or crises; 2) social isolation, loneliness or confinement; and 3) economic or financial adversity. The exclusion criteria for the studies were: a) studies targeting special or clinical populations, with the exception of sleep disorders; b) reviews or meta-analysis; c) commentaries; d) editorials; e) dissertations; f) poster presentations; g) articles in languages other than French or English; h) psychometric scale evaluation; i) book sequence or chapters; j) animal studies; k) recommendations or guidelines. At this point, all recommendations to include or exclude studies were reviewed by two investigators (GS and DP).

Data extraction

The data extraction fields were determined through an iterative process. The study team identified the main areas of interest as follows: (a) study sample characteristics, (b) study design, (c) study measures, and (d) study outcomes. For each study, relevant data were extracted with customized data extraction forms. All final data were double entered into a Microsoft Excel database and

included authors, title, year of publication, type of study (longitudinal, cross-sectional, interventional), study design (cohort, laboratory, survey, etc.), country, sample size, type of population (children, adolescents, adults, older adults), construct or exposure assessed, sleep measures used and summary findings. The data were extracted by JD and XM and checked by GS for accuracy and data quality.

RESULTS

Search 1: COVID-19, other pandemics and/or crises

A total of 6,024 entries were identified in our first original search, including 137 duplicates. During screening, 5,403 studies were removed, leaving a total of 484 studies for full text review. After the additional exclusion of 269, 215 unique records reporting on sleep health parameters across different contexts of crises remained for data extraction (See figure 1). Table S2 and Tables S5-S7 group the final 215 studies in the following manner: sleep in the context of infectious outbreaks (79 studies), sleep in the context of natural disasters (78 studies); sleep in the context of terrorist attacks (22 studies); sleep in the context of war (13 studies); sleep in the context of anthropogenic disasters (23 studies). Only a handful studies relied on objective sleep measures (polysomnography or actigraphy).

Sleep in the context of infectious outbreaks

Sleep in early COVID-19 studies in the general population

At the beginning of the COVID-19 pandemic, early reports primarily from China and Europe showed a large proportion of respondents reporting sleep problems. These population-based surveys showed a large proportion (30-74%) of respondents reporting insomnia-like symptoms or

sleep perturbations (Francois Beck, Leger, Fressard, Peretti-Watel, & Verger, 2020; Demir, 2020; W. Fu et al., 2020; Gualano, Lo Moro, Voglino, Bert, & Siliquini, 2020; Hartley et al., 2020; Marelli et al., 2020; Stanton et al., 2020; Yuan et al., 2020; Zhao, Lan, Li, & Yang, 2020) and sometimes longer sleep duration (Di Renzo et al., 2020). Shifts to later sleep time and/or longer sleep duration were especially prominent in young adults, adolescents and children (Cellini, Canale, Mioni, & Costa, 2020; Di Renzo et al., 2020; Marelli et al., 2020) often concomitant with worse sleep quality (Cellini et al., 2020; Kaparounaki et al., 2020; Marelli et al., 2020; Yuan et al., 2020). Children and teens also had lower physical activity levels, spent less time outside, and presented more sedentary behaviors and increased leisure screen time (Moore et al., 2020), which contribute to worsened sleep. Conversely, children and youth who had the recommended amount of daily physical activity had no or little change in sleep duration since the onset of the COVID-19 pandemic (Guerrero et al., 2020).

Anxiety-related insomnia was more common in quarantined than non-quarantined youths (Saurabh & Ranjan, 2020). Even individuals who already had chronic insomnia before the pandemic got worse sleep quality, duration and efficiency scores on the Pittsburgh sleep quality index (PSQI) during the pandemic (Yang et al., 2020). Of note, COVID-related insomnia was associated with high suicide risk in adults (Caballero-Domínguez, Jiménez-Villamizar, & Campo-Arias, 2020).

Importantly, people who were directly threatened by the coronavirus had an elevated risk of insomnia (Guo, Feng, Wang, & van Ijzendoorn, 2020; Lin et al., 2020). Insomnia was indeed high in infected patients (68%) and in their family members or friends (48%) (Shi et al., 2020). In patients with confirmed COVID-19, 89% reported sleep problems (severe in 52%) and 81% of

individuals with suspected COVID-19 reported sleep problems (severe in 15%) (Francois Beck et al., 2020).

Moderating/mediating factors in the association between COVID-19 and sleep in the general population

In general, more young adults reported disturbed sleep than did older individuals (Francois Beck et al., 2020; Cellini et al., 2020; Lin et al., 2020; Yuan et al., 2020; Huang & Zhao, 2020) and more women reported sleep problems than men (Antunes et al., 2020; Francois Beck et al., 2020; Demir, 2020; W. Fu et al., 2020; Gualano et al., 2020; Hartley et al., 2020; Lin et al., 2020; Moore et al., 2020)(Huang & Zhao, 2020). Another important risk factor is prior psychological disposition. The increase in sleep difficulties was more prominent for people with a higher level of depression, anxiety, and stress symptomatology (Amerio et al., 2020; Cellini et al., 2020). The mediation effect of anxiety on poor sleep during COVID-19 was stronger in people with low levels of self-esteem than in those with high levels of self-esteem (Zhao et al., 2020). Other risk factors for poor sleep during the early days of COVID-19 include socioeconomic status (Francois Beck et al., 2020; W. Fu et al., 2020), education level (W. Fu et al., 2020), living in urban areas (W. Fu et al., 2020) and working in the medical field (W. Fu et al., 2020). Conversely, social capital appeared to enhance sleep quality via reducing anxiety and stress (Han Xiao, Yan Zhang, Desheng Kong, Shiyue Li, & Ningxi Yang, 2020b).

Sleep in the general population in the context of other infectious disease outbreaks

We identified a handful of studies describing sleep health patterns in the context of two other infectious disease outbreaks: severe acute respiratory syndrome (SARS) 2003 (Chen et al., 2006;

S. Lee, Chan, Chau, Kwok, & Kleinman, 2005; S. M. Lee, Kang, Cho, Kim, & Park, 2018; Maunder et al., 2003; McAlonan et al., 2007; Su et al., 2007; H. Y. R. Yu, Ho, So, & Lo, 2005) and Ebola 2014 (Mohammed et al., 2015; Sipos, Kim, Thomas, & Adler, 2018). These studies showed that in residents of Amoy Garden, the first officially recognized site of the community SARS outbreak in Hong Kong, the insomnia rate reported via a questionnaire was 50% in affected residents, 56% in people with affected family members compared to 32.5% in other residents (S. Lee et al., 2005). Another study, also relying on self-report, found that 25% of midlife women living elsewhere in Hong Kong during SARS reported restless sleep (H. Y. R. Yu et al., 2005). During the Ebola outbreak in West Africa, up to 12% of American soldiers deployed reported symptoms compatible with insomnia compared to 4.9% at pre-deployment (Sipos et al., 2018). Finally, in individuals who contracted Ebola, 75% reported having “lost much sleep over worry” whereas 33.3% of people who had been in contact with a confirmed case reported this as a major problem (Mohammed et al., 2015).

Sleep in healthcare workers during COVID and other outbreaks

Among the diverse occupations studied, healthcare workers had the highest prevalence of poor sleep quality as measured with the PSQI (Huang & Zhao, 2020). The proportion of healthcare workers with symptoms of insomnia is high (18-75%) (Huang & Zhao, 2020; Jahrami et al., 2020; Lai et al., 2020; Shechter et al., 2020; Wang et al., 2020; Zhang et al., 2020; Zhou et al., 2020). In pediatric doctors and nurses, anxiety levels (self-rating anxiety scale) were correlated moderately with the PSQI (Cheng et al., 2020). Medical and nursing staff with insomnia, as measured by the insomnia severity index (ISI), were suspected to have comorbid sleep apnea syndrome (based on pulse oximetry) attributable to stress (Zhuo, Gao, Wang, Zhang, & Wang, 2020). The prevalence

of insomnia varied depending on their degree of involvement with infected patients. It was higher in those working directly with infected patients (Wang et al., 2020; Zhan et al., 2020), and thus particularly in nurses (Lai et al., 2020; Shechter et al., 2020; Zhan et al., 2020; Zhang et al., 2020; Zhou et al., 2020). The same relationship between insomnia rate and proximity of the medical staff to infected patients was reported for the SARS (Su et al., 2007) and the Middle East Respiratory Syndrome (S. M. Lee et al., 2018) pandemics.

Moderating/mediating factors in the association between COVID and other pandemics and sleep in healthcare workers

A sex effect was found in healthcare workers: sleep impairments are higher in women than in men (Lai et al., 2020; Zhan et al., 2020; Zhang et al., 2020). Another important factor in moderating the sleep quality in medical staff was the level of social support from the media, which was also significantly associated with perceived self-efficacy (Han Xiao, Yan Zhang, Desheng Kong, Shiyue Li, & Ningxi Yang, 2020a). In fact, anxiety, stress, and self-efficacy were found to be mediating variables in the relationship between social support and sleep quality (Han Xiao et al., 2020a). The feeling of not having enough personal protection equipment was also linked with higher prevalence of insomnia in healthcare workers (Zhang et al., 2020). An intervention study during the SARS pandemic demonstrated that a systematic prevention program for nursing staff, which included a series of in-service training, detailed work force allocation, adequate protective equipment, and the availability of a mental health team, decreased anxiety and depression levels and improved sleep quality on the PSQI (Chen et al., 2006). Personalized psychoneuroimmunity prevention measures also helped decrease psychiatric symptoms and insomnia in workforce returning to work following the first COVID-19 confinement in China (Tan et al., 2020).

Sleep in the context of other types of crises

Our review of the literature identified 136 studies on sleep in the context of other types of crises, namely natural disasters, health disasters, wars (civilian populations) or terrorist attacks. The results of these studies are shown in supplementary Table S5-S7. As a whole, these studies showed poor sleep health during the acute phase of the crises, and some showed that poor sleep could persist for several years. Victims, close relative of victims and first responders seemed to be at a particularly high risk of adverse poor sleep health after exposure.

Search 2: Sleep and social isolation or loneliness

A total of 7,717 entries were identified in our second original search, including 2,971 duplicates. During screening, 4,436 studies were removed, leaving a total of 310 studies for full text review. After the additional exclusion of 232, 78 unique records examined the relationship between sleep and different domains of sociality and remained for data extraction (See figure 2). Table S3 groups the studies in the following manner: sleep and loneliness (42 studies); sleep and social isolation (15 studies); sleep and social support (20 studies); sleep and social cohesion (8 studies). Seven studies were included in more than one category of sociality outcomes, primarily by assessing sleep in the context of both loneliness and social isolation. Only a handful of studies (12 studies) relied on objective sleep measures, and these studies more often focused on children, adolescents or older adults, populations hypothesized to be more vulnerable to the impacts of sociality on health (and vice versa). Most of the studies came from high-income countries, highlighting existing gaps in knowledge in sleep health in low and middle-income countries.

Sleep and loneliness or social isolation

Loneliness represents the discrepancy between an individual's desired and actual relationships. It is thus an unpleasant emotional interpretation of one's own social circumstances. Social isolation can be defined structurally as the absence of social interactions, contacts, and relationships with family, friends and neighbors on an individual level, and with "society" on a broader level. During the early days of the COVID-19 pandemic, several professional societies warned about the potential impact of social restrictions on health (and sleep). In our review, we only captured a small fraction of the array of studies that would later be published on the topic, as these studies were primarily published in the second half of 2020 (and forward). These population-based studies for example showed a high prevalence of loneliness, and a strong association between loneliness and sleep quality (Groarke et al., 2020). Our review on this topic will highlight the evidence on different dimensions of sociality and sleep, the evidence that was available in the early days of the COVID-19 pandemic.

Studies have generally found a negative impact of loneliness and social isolation on sleep efficiency, sleep duration or sleep quality (Doane & Thurston, 2014; Y. Y. Fu & Ji, 2020; Harris, Qualter, & Robinson, 2013; Chris Segrin & Burke, 2015; C. Segrin & Domschke, 2011; Chris Segrin & Passalacqua, 2010; Tavernier & Willoughby, 2015; Wakefield, Bowe, Kellezi, Butcher, & Groeger, 2020; B. Yu, Steptoe, Niu, Ku, & Chen, 2018). This negative influence has been shown with both objective (polysomnography (Cacioppo et al., 2002) and actigraphy (Doane & Thurston, 2014; Kurina et al., 2011)) and subjective (questionnaires, surveys (Aanes, Hetland, Pallesen, & Mittelmark, 2011; C. Segrin & Domschke, 2011; B. Yu et al., 2018)) measures and observed across the life span, and independently of depression (Cacioppo et al., 2002). In older adults, the

relationship seemed especially notable: a significant and inverse correlation between the degree of social isolation and the mean score of sleep quality has been reported (Zohre & Ali, 2018). One study differentiated between objective and perceived social isolation in older adults and found that, while the latter was strongly associated with sleep disturbances, objective social isolation was only weakly associated with sleep problems (Cho et al., 2019), the person's experience of social isolation or loneliness thus appearing central in this association. Interestingly, these results were independent of sociodemographic characteristics, body mass index, medical comorbidity, smoking, alcohol consumption, and physical activity, all of which are potential confounding factors. In an international survey of people suffering from insomnia, loneliness was among the top three reasons given by the participants for their insomnia (Allaert & Urbinelli, 2004).

A handful of studies on sleep evaluated health impacts of loneliness. One study found an association between loneliness and both sleep efficiency/quality and poorer antibody response to an influenza vaccine (Pressman et al., 2005) while others suggested that sleep difficulties mediate the effect between loneliness and general health problems (Cacioppo et al., 2002; Peltzer & Pengpid, 2019; C. Segrin & Domschke, 2011). Two studies tested whether loneliness and social isolation have long-term negative consequences on sleep. Adolescents with relatively high levels of loneliness from middle childhood to pre-adolescence (8–11 years of age) were more likely to report trouble sleeping, taking longer to get to sleep, and waking up during the night than adolescents with low loneliness levels (Harris et al., 2013). Similarly, in older adults, social isolation contributes to poor sleep quality 6 years later (B. Yu et al., 2018).

Depending on the studies, different confounding factors have been controlled for, but this did not affect the direction of the association observed between sleep and loneliness or social isolation. To that effect, differences in loneliness between monozygotic twins were reported to be significantly associated with within-twin pair differences in subjective sleep quality at age 18, i.e. the lonelier twin reported worse overall sleep quality on the PSQI (T. Matthews et al., 2017), thus obviating the general and various influences of the familial milieu.

Moderating/mediating factors of the relationship between loneliness or social isolation and sleep

Although it can be argued from the numerous studies previously cited that loneliness seems to directly affect sleep quality, other studies claim that the effect of loneliness on sleep is mediated by depression (Wakefield et al., 2020) or by stress (Chris Segrin & Burke, 2015), anxiety and rumination (Zawadzki, Graham, & Gerin, 2013). However, several studies specifically controlled for depression (Harris et al., 2013; Kurina et al., 2011) and observed a persisting negative association between loneliness and sleep quality nonetheless. In addition, a sex effect was found for the influence of loneliness or social isolation on sleep; this relationship being stronger in men than in women (Chris Segrin & Burke, 2015; Win, Yamazaki, Kanda, Tajima, & Sokejima, 2018).

Loneliness as a mediator or moderator in the relationship between stress and sleep quality

In addition to its direct effects on sleep, loneliness was also shown to be a strong mediator of the relationship between stress and poor sleep quality especially in the elderly (Aanes et al., 2011) and a significant moderator in the bidirectional association between daily stress and objective sleep duration and latency (Doane & Thurston, 2014). A study on paramedics also reported that individuals with low levels of social support had poor sleep quality in the face of high occupational

stress whereas those who had high levels of support did not show significant effects of occupational stress on sleep (Pow, King, Stephenson, & DeLongis, 2017). Socially-isolated individuals also have much greater odds of having insomnia when living in neighborhoods with low employment rates than socially-connected individuals (Riedel et al., 2012).

Sleep and Social Cohesion

The neighborhood social environment is also associated with sleep health. A lower neighborhood social cohesion, defined as the level of solidarity and connectedness shared within a group of people living in proximity, was shown to have a negative impact on objectively-measured (Bagley, Fuller-Rowell, Saini, Philbrook, & El-Sheikh, 2018; D. A. Johnson et al., 2017) and self-reported (Dayna A. Johnson et al., 2016; Murillo, Ayalew, & Hernandez, 2019; Win et al., 2018) sleep in children, adults and older adults. Children exposed to high levels of neighborhood social fragmentation experienced poor sleep efficiency and a shorter sleep duration on actigraphy (Bagley et al., 2018). Studies in adults found that those who reported living in a neighborhood with low social cohesion were more likely to report shorter sleep duration (Dayna A. Johnson et al., 2016; D. A. Johnson et al., 2017; Win et al., 2018; Young, Gerber, Ash, Horan, & Taveras, 2018) and poor sleep quality (Dayna A. Johnson et al., 2016; Young et al., 2018), whereas in neighborhoods with medium to high levels of social cohesion, individuals reported longer sleep duration and higher sleep efficiency (Murillo et al., 2019). In older adults, a relationship was found between a positive neighborhood social environment and early timing of sleep and longer sleep duration (D. A. Johnson et al., 2017).

Social support has a protective effect on sleep

One of the protective factors for the negative effects of confinement on sleep is social support or social capital. Social support can be defined as the experience of being loved, cared for, esteemed, and part of a social network characterized by mutual assistance and obligation. Social capital is defined as a collection of actual or potential resources that include social trust, belonging, and participation. Increased levels of social capital were positively associated with increased quality of sleep during COVID-19 self-isolation (H. Xiao, Y. Zhang, D. Kong, S. Li, & N. Yang, 2020). However, the combination of high anxiety and stress reduced the positive effects of social capital on sleep quality (H. Xiao et al., 2020).

Good social support is positively correlated with several indicators of high-quality sleep such as duration, efficiency, latency and quality (Jin et al., 2014) or lower PSQI score (Liu et al., 2016). Interestingly, people with a high levels of social exposure are found to have higher amounts of slow-wave sleep than people with lower social exposure (Butt, Ouarda, Quan, Pentland, & Khayal, 2015). In older adults with insomnia or without insomnia, higher social support is associated with better perceived sleep quality, shorter sleep latencies on the Pittsburgh sleep diary (Troxel, Buysse, Monk, Begley, & Hall, 2010) or less time spent awake during the night as measured by actigraphy (Troxel et al., 2010) In studies that divided social support into subcategories, emotional support was the component most strongly associated with better self-reported sleep outcomes (Matsumoto et al., 2015). However, it is important to mention that some studies found no effect of social support on objective measures of sleep (Chung, 2017; Paulsen & Shaver, 1991).

In general, social support, in counteracting loneliness, has beneficial effects on both sleep, general health (C. Segrin & Domschke, 2011) and depression (Y. Y. Fu & Ji, 2020). Inversely, a low social

support in already highly stressful or traumatic situations can aggravate the sleep difficulties. For example, lack of social support showed a stronger association with long-lasting sleep difficulties than do non-modifiable or hardly modifiable consequences caused directly by an earthquake (Matsumoto et al., 2015).

Search 3: Sleep and economic uncertainty, financial adversity, or food/job insecurity

A total of 3,218 entries were identified in our third original search, including 1,427 duplicates. During screening, 1,570 studies were removed, leaving a total of 221 studies for full text review. After the additional exclusion of 129 studies, 92 unique records examining the relationship between sleep health and different aspects of economic difficulties remained for data extraction (see figure 3). Table S4 groups the studies in the following manner: sleep and financial difficulties (33 studies); sleep and job insecurity (23 studies); sleep and economic crisis (14 studies); sleep and food insecurity (21 studies). A single study was included in more than one category of economic outcome. In the 92 studies included in our review, six used polysomnography or actigraphy and 32 used a validated questionnaire to measure sleep outcomes. The majority of the studies (n = 82) measured the effect of economic difficulties on sleep health in adults, 10 studies were conducted in children and adolescents.

During the early days of the COVID-19 pandemic, an abrupt stop in the global economic activity led to many countries to implement economic measures aimed at mitigating the economic and financial consequences of a poor economic outlook. In our review, we only captured a small fraction of the array of studies that would later be published on the topic, as these studies were primarily published in the second half of 2020 (and forward). These population-based studies for

example would later show a close link between financial stress and poor sleep (Robillard et al., 2020). Our review on this topic will highlight the evidence on different dimensions of financial vulnerability and sleep, evidence that was available in the early days of the COVID-19 pandemic.

Sleep and economic uncertainty or financial adversity

Economic or financial adversity refers to having insufficient financial resources to adequately meet one's household's needs. Several studies, including large cohort or population-based studies, have shown a relationship between high level of financial adversity and lower sleep efficiency, poorer sleep quality or insomnia with both objective (Mona El-Sheikh et al., 2013; M. Hall et al., 2008; M. H. Hall et al., 2009) and subjective (F. Beck, Guignard, & Léger, 2010; M. H. Hall et al., 2009) measures. An international survey of people suffering from insomnia reported that financial strain was amongst the top five reasons evoked by participants as the cause of their insomnia (Allaert & Urbinelli, 2004). Similarly, focus groups identified economic insecurity as the main cause of their difficulty sleeping: "No money, no car, no job, no sleep" (Sonnega, Sonnega, & Kruger, 2019). In addition, participants mentioned economic insecurity as the main cause of sleep disparities in their community (Sonnega et al., 2019). Indeed, the differences in sleep duration often reported between ethnic groups (shorter in African Americans and Hispanics than in Caucasians) was shown to be strongly mediated by financial hardship (K. A. Matthews et al., 2019). African American children who are worse off financially had more sleep/wake problems than those with more financial resources whereas no such effects were found for European American children (Mona El-Sheikh et al., 2013). Another study found, on the contrary, that financial strain has similar effects on sleep, independent of race (including African Americans) (M. H. Hall et al., 2009). Finally, a strong positive association was found between over-indebtedness and self-reported sleep onset and

maintenance difficulties and sleep medication use, which was independent of conventional socioeconomic measures (Warth et al., 2019).

Familial economic hardship also affect adolescents' subjective sleep quality (Bao et al., 2016), and perceived economic discrimination has been identified as a strong mediator (Bao et al., 2016). In infants and children, familial economic difficulties are mainly linked to difficulties falling asleep or short sleep (Duh-Leong et al., 2020; Mona El-Sheikh et al., 2013) and the adoption by parents of suboptimal sleep practices for their children (Duh-Leong et al., 2020). One study found that financial strain induced greater night-to-night variability in polysomnography characteristics in women (Zheng et al., 2012).

Sleep and food insecurity

Studies investigating more specifically food insecurity in adults found objectively shorter sleep duration and poorer sleep efficiency (Troxel et al., 2019) or poorer subjective sleep quality (El Zein et al., 2019; Narcisse et al., 2018) or quantity (Narcisse et al., 2018). Moreover, poor sleep quality and quantity was found to partially mediate the relationship between food insecurity and obesity across several ethnicities and races (Narcisse et al., 2018). The link between food insecurity and sleep in children and adolescents is not as clear but some studies report a connection between food insecurity and insufficient sleep in children and adolescents (Becerra, Bol, Granados, & Hassija, 2018; King, 2017). Finally, one study reported that 70% of mothers in food-insecure households did not implement a nightly bedtime routine for their toddlers (Covington, Rogers, Armstrong, Storr, & Black, 2019). A bedtime routine increases sleep duration through a decrease in nocturnal awakenings (Covington et al., 2019).

Sleep and job insecurity or threat of unemployment

Job insecurity is yet another important factor to consider. Young adults exposed to prolonged precarious employment report insufficient sleep (E. S. Lee & Park, 2019). Job or salary insecurity is associated to subjective sleep problems (Kristiansen et al., 2011; Mai, Hill, Vila-Henninger, & Grandner, 2019) or insufficient sleep (Khubchandani & Price, 2017). However, data from a survey conducted in 31 European countries suggest that it is the subjective employment insecurity rather than the objective precarity *per se* that relates to sleep disturbances (Mai, Jacobs, & Schieman, 2019). Men report more work-related sleep problems than women in general (Maume, Hewitt, & Ruppner, 2018) although this sex effect is reduced in countries where there is more sex parity in work-family role obligations (Maume et al., 2018). Even extensive organizational changes at work can cause sleep disturbances (Greubel & Kecklund, 2011).

Unemployment is associated with increased difficulty falling asleep and sleep maintenance problems (Navarro-Carrillo, Valor-Segura, & Moya, 2019; Palmer et al., 2017) and to reporting a sleeping problem lasting more than 6 months (Paine, Gander, Harris, & Reid, 2004). Long-term unemployment was associated with a trajectory of decreasing self-reported sleep duration over 5 years (Virtanen et al., 2008). Expectedly, in an economic recession, it is more the prospectively unemployed individuals, especially the blue-collar workers, who report suffering more from insomnia, fatigue, parasomnias and who used more hypnotics than the continuously employed people (Hyypä, Kronholm, & Alanen, 1997). The perceived personal impact of a crisis is also key in this relationship (Navarro-Carrillo et al., 2019). The increase in sleep disturbances and nightmares can be seen years after the financial crisis has started (Nena et al., 2014). The

probability of sleep problems and nonrestorative sleep increases with the seriousness or number of material hardships, or the persistence of economic difficulties (Kalousová, Xiao, & Burgard, 2019).

Sleep and local or global economic vulnerability

In addition to personal economic vulnerability and regardless of personal characteristics, local economic predicaments such as areas with high unemployment rates can negatively influence self-reported sleep duration (Perales & Plage, 2017). Not surprisingly, however, the correlation between poor local economic conditions and short sleep duration is even stronger for economically vulnerable individuals (Perales & Plage, 2017). However, one large US population-based study found on the contrary that higher state unemployment rates are associated with more sleep time when controlling the mediating effects of the respondent's own employment status and household income (Antillón, Lauderdale, & Mullahy, 2014). Similarly, a five-percentage point increase in unemployment rate in Canada was associated with three more hours of sleep per week for both men and women (Brochu, Armstrong, & Morin, 2012). During the Iceland economic crisis of 2008, an increase in the proportion of people reporting getting the recommended number of hours of sleep was seen and this effect was greater in the working age population (Ásgeirsdóttir, Corman, Noonan, Ólafsdóttir, & Reichman, 2013). Prescriptions for sleep aids and benzodiazepines increased in the US following the economic recession of 2008 and this increase was more marked for men compared to women (Cascade, Kalali, Kwentus, & Bharmal, 2009). On the other hand, the number of patients visiting a sleep clinic went down during an economic crisis and people requiring a continuous positive airway pressure machine were less likely to get one (Pataka, Chavouzis, Fekete Passa, Pitsiou, & Argyropoulou, 2013).

Moderating/mediating/protective factors of the relationship between economic uncertainty and sleep

One might believe that age would be a moderating factor in the relation between economic uncertainty and sleep. A longitudinal study showed that the proportion of sleep problems and insufficient sleep duration related to the 2008 recession has increased mainly for young men (20 to 40 years) in France (Malard, Chastang, & Niedhammer, 2017). A United Kingdom longitudinal study of two nationally representative cohorts showed that sleep loss because of worrying usually declines with age (from age 50 onward), but not as much in an economic turndown (Dregan & Armstrong, 2009). Indeed, financial strain had a significant influence on sleep disturbances in the elderly (61–85 years), even after adjusting for factors known to impact sleep in late-life such as age, sex, mental and physical health (M. Hall et al., 2008). Of course, in times of crises, a common denominator underlying the various ordeals is stress and unemployment can then add up and exacerbate sleep outcomes. For example, following the fireworks storage facility explosions in Enschede (Netherlands) in 2000, unemployed individuals suffered from worse sleeping difficulties and higher levels of post-traumatic stress, anxiety and depression up to 4 years later than employed individuals (Bosmans & Van der Velden, 2018). Perceived stress was found to mediate relations between both income-to-needs ratio and subjective sleep problems in women (M. El-Sheikh, Keiley, Bagley, & Chen, 2015). On the other hand, a longer duration of sleep appears to be a protective factor against the development of future anxiety symptoms due to job insecurity or organizational injustice in otherwise healthy employees (Kim et al., 2020).

DISCUSSION

In this review, based on the existing evidence available in the early days of the COVID-19 pandemic, we systematically uncovered, collated and summarized key findings on potential circumstantial ways by which the COVID-19 pandemic may directly or indirectly affect sleep health. Overall, we identified that states of crises (characterized by stress, anxiety, loss of loved ones and/or material losses), social isolation and loneliness, as well as financial stress, job or food insecurity, are all associated with poor sleep health. Conversely, greater social support and social cohesion are associated with better sleep health, highlighting the potential positive role that our communities play at fostering healthy sleep. Government-imposed stay-at-home orders, tele-work and tele-school, and enforced social distancing may likely have an impact in our sleep not only through heightened stress but also as social and environmental cues play an important role in entraining our internal biological clocks. The experienced challenges during these unprecedented times may likely differ in intensity depending on the individuals' age, sex, socioeconomic status, family circumstances, psychological predisposition and occupation. Taken together, our findings suggest that crises such as the COVID-19 pandemic likely posits compounding adverse sleep health impacts that warrant public health attention. Despite some promising evidence on the efficacy of web-based sleep intervention applications for health care workers (Espie et al., 2012), our review did not identify any study aimed to test rapid deployment of sleep interventions in either healthcare workers or in the general population, suggesting lack of preparedness.

Research agenda: State of crisis and sleep

Our review of the evidence shows lack of consistent good quality data on what sleep looks like during different crises. Most studies aimed to compare the prevalence of poor sleep of those exposed compared to non-exposed, rather than to fully capture the array of contextual factors that

may be shaping sleep patterns during the acute phase of a crisis, as well as in its aftermath. Even in the context of lack of prospective studies at the acute time of these crises, given how common sleep tracking devices are, retrospective data could be used to understand sleep patterns and practices that were adaptive in the contexts of crises, in particularly among frontline workers and other populations at risk of poor sleep. Identifying behaviour and practices that are associated with healthy sleep in contexts of crises may help develop crises management responses that include promoting better sleep and sufficient rest. Sleep problems were already highly prevalent globally before COVID-19 (Simonelli et al., 2018), and those who were not sleeping sufficiently may have been at an increased risk of adverse mental health outcomes (Breslau, Roth, Rosenthal, & Andreski, 1996). An important unanswered question is the extent to which sleep satiation (i.e., sleeping sufficiently) prior to a crisis leads to better crisis coping and management. In other words, is a better-slept society able to navigate a crisis better than a sleep deprived society? Increased sleep satiation is associated with better cognitive processing, decision-making and emotional regulation, improved fatigue and mood, all of which likely underlie performance and coping (Alger, Brager, Balkin, Capaldi, & Simonelli, 2020; Godbout, Carrier, Bastien, & Morin, 2020; Morin et al., 2020).

Research agenda: Sociality and sleep

Social factors, such as social isolation or loneliness, are associated with inadequate sleep and increased risk of poor sleep health in the general population. Overall, evidence using objective sleep measures is lacking, in particular in adults, suggesting the need for better studies that allow us to evaluate the independent association between these social factors and sleep, as well as its directionality. Further, the potential impacts of emerging widespread use of virtual technology in

the context of tele-school, tele-work and tele-socialization is likely to change the way we learn, work and socialize in years to come, prompting new questions on their impacts on sleep health. Some of these behaviors may be adaptive such as normalizing virtual gatherings as socially acceptable, and thus fostering connection, the capacity to take classes at a the preferred (circadian) time during online schooling or decreased commuting time. Conversely, increased screen time at home, prolonged social isolation, lack of outdoor time or changes in diet may have negative consequences on sleep health. Being satisfied with one's social life and being active are protective factors against insomnia (Ohayon, Zulley, Guilleminault, Smirne, & Priest, 2001). This underlines the importance of intervention programs on enhancing social support for behavior change and sleep health, particularly in vulnerable populations. Other important considerations relate to family dynamics, and the reconfiguration of the home environment to accommodate both work and schooling demands. In this particular context, disparities related to access to sufficient space at home, childcare and outdoor activities may exacerbate sleep health related problems.

Research agenda: Economic uncertainty and sleep

Our review of the evidence shows that job insecurity, fear of losing a job, food insecurity and financial stress are associated with poor sleep health. However, only a handful of studies relied on objective sleep measures. Several economic actions were put in place across the globe with the goal of dampening the economic and financial hit caused in response to the COVID-19 pandemic. These measures aimed at supporting the economy and specially to help individuals in precarious situations could have a positive impact on sleep health, yet still this needs to be investigated.

Opportunities for Intervention and Public Policy

Our review of the evidence highlighted several potential pathways by which states of crises may affect sleep health. Our review also highlights the need to develop and deploy interventions aimed at promoting better sleep health in times of crises. Along these lines, measures that target social and/or financial factors that are closely link to different dimensions of sleep health are further warranted. In the context of COVID-19, social interventions for example could be aimed at fostering social cohesion, providing social support, increasing perceived safety, promoting social connection and preventing social isolation. In the context of COVID-19, financial interventions for example could target financial stress by providing tax breaks and/or universal (like) basic income or could target threat of unemployment by providing wage subsidies to employers to prevent layoffs. Other interventions that may improve both social and financial means may be related to providing support for childcare. The wide range of policies and measures taken by different governments may serve as quasi-experiments to help us identify policies that lead to better sleep health. Additionally, the study of these policies and their link to sleep health could help us identify groups that benefitted the most (and the least) and inform future development of public health interventions.

Limitations

The heterogeneous group of studies identified in this review carries several limitations to consider. The first limitation is that very few studies used an objective measure of sleep; the majority of studies used either validated questionnaires, such as the PSQI, non-validated questionnaires or only one or a few questions. Therefore, a response bias can easily be introduced which can overestimate convergent validity: worse conditions (e.g., loneliness, financial strain) = worse sleep. Second, studies based on open surveys (volunteered self-report) have a selection bias, in

particular when lacking sampling plans, quotas or weights. Third, key concepts, such as social support, loneliness, financial uncertainty or job insecurity, are defined very differently in the various studies, affecting comparability between studies. Fourth, since the majority of studies are observational (cross-sectional), the relationships identified should not be readily interpreted as causal relationships. Fifth, only a handful of studies were conducted in low- and middle-income countries, decreasing the generalizability of our findings. Finally, very few studies had pre-pandemic sleep data. Despite all those limitations, there is enough evidence of the negative impacts on sleep resulting from the various characteristics of the current and past crises (stress, social isolation, economic hardship) to warrant to justify concrete actions to protect the population's sleep.

Conclusions

Crises, as well as associated social and economic adverse circumstances are associated with both short term, and long term adverse negative sleep consequences. Efforts to understand the aspects of sleep affected by crises and their underlying pathways, and to develop interventions to alleviate sleep health impacts of crises are warranted.

PRACTICE POINTS

- States of crises (characterized by stress, anxiety, loss of loved ones and/or material losses), social isolation and loneliness, and financial stress or food insecurity, are all associated with adverse sleep health outcomes.
- Clinicians should consider financial and social factors as potential sources (or contributors) of deficient sleep in their patients.

- Public health measures aimed at decreasing individuals' financial and/or social burden during a crisis may lead to improved sleep.

Contributions

GS, DP, JC and CB contributed to the conceptualization of the study. GS designed the study and lead the searches, screening, data extractions and data presentation. GS designed the data extraction and data presentation plan. GS DP, JPD and XM screened and extracted the studies included in this review. GS checked the tables for accuracy. GS, DP, JC and CB contributed to the writing of the first draft of this manuscript. All the authors contributed to the version of this manuscript submitted to Sleep Medicine Reviews in May. GS made the changes in the manuscript in response to the Sleep Medicine Reviews reviewers and drafted the response to comments.

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CONCLUSIONS

States of crises (characterized by stress, anxiety, loss of loved ones and/or material losses), social isolation and loneliness, and financial stress or food insecurity, seem to be associated with adverse sleep health outcomes. The COVID-19 pandemic is unique compared to previous recent pandemic as the COVID-19 pandemic has a strong concomitant economic impact and severely impacted sociality, which appear to be closely linked to sleep health. Based on our early scoping work, it was clear that the COVID-19 pandemic would not only have a strong social and economic impact, but it was anticipated that COVID-19 would have broad sleep health ramifications, in particular for those of lower income, racialized minorities, those without safety nets and those with pre-existing mental health conditions. To our point, since our initial searches in early 2020, over 2,000 articles have been published on ‘sleep’ and ‘COVID-19’ alone since the start of the pandemic.

Conceptual framework: Sleep Health

Guided by our conceptual framework depicted in figure A, our systematic review highlights different pathways by which the environment likely shapes sleep and health. For example our findings fit well with the hypothesis that urban and housing level factors might shape sleep through direct environmental disruption (e.g. noise from the neighbourhood, air or road traffic, public or exterior lighting, temperature) (Mantua et al., 2019; Simonelli et al., 2017), indirect environmental disruption (e.g. safety, low social cohesion, social isolation) (Johnson et al., 2017; Simonelli et al., 2017; Simonelli et al., 2015) and behaviour (e.g. stress, physical activity, diet, use of green space) (Astell-Burt, Feng, & Kolt, 2013; Billings et al., 2016). Our scoping review supports the idea that proximal environmental factors can affect sleep via disruption of behavioral mediators, such as stress or physical activity. Our systematic review also supports our proposed framework by

identifying numerous studies that showed that proximal environmental factors can affect distal health outcomes such as mental health, and that sleep may mediate (or at least partially mediate) these associations (Hale et al., 2013). Conversely, our scoping review also highlighted the existence of a bidirectional association between sleep and health, and of sleep, health and behavioral mediators. Finally, our systematic review supports our proposed conceptual model by identifying numerous factors that moderate the relationship between environmental exposures, sleep and health outcomes. In particular, we found that higher material resources and ‘higher’ psychological resources were protective factors in the context of exposure to an adverse physical and/or social environment. For example, those with overall higher resources coped better during city mandated lockdowns, and lower anxiety symptoms were associated with better sleep during lockdowns (Xiao, Zhang, Kong, Li, & Yang, 2020). Our scoping review also identified several gaps in the literature, in particular the lack of use of objective sleep measures, lack of longitudinal studies and lack of diverse and representative samples globally.

Sleep Health and Coronavirus Disease 2019 pandemic

The COVID-19 context created several compounding challenges that likely amplified the association between social and physical environmental determinants and sleep, thus exposing sleep inequities. A range of stressors, included the limited scientific knowledge about COVID-19, lack of a vaccine and treatment early on, fear of being infected or infecting someone, the uncertainty concerning the duration of the crisis, loss of revenue and job losses, social restrictions, new family and work balance challenges, and the constant reminder of the presence of the pandemic, likely lead to a high and sustained level of stress, distress or discouragement, and thus adversely impacting sleep (Cellini, Canale, Mioni, & Costa, 2020). Stress may enhance vigilance and

adversely impact sleep through activation of the hypothalamic-pituitary-adrenal axis (Smith & Vale, 2006), which initiates physiological and behavioral changes in order to face (real or perceived) threats (Akerstedt, 2006; Smith & Vale, 2006; Steptoe, O'Donnell, Marmot, & Wardle, 2008). Additionally, sociality plays a fundamental role in society and in human well-being, and there is increasing experimental evidence of the potential impact of social isolation on sleep. Most of the experimental or quasi-experimental work on sleep and social isolation has been performed in relation to space exploration with hopes to understand the impact of long-term confinement on sleep disruption (Barger et al., 2012; Mairesse et al., 2019; Vigo et al., 2013). The underlying idea is that humans require synchronization to the 24-hour day that is accomplished by various environmental inputs (also called “zeitgebers”), such as light-dark cycles, exercise, feeding-fasting cycles and social interactions (Van Someren & Riemersma-Van Der Lek, 2007). In other words, these environmental inputs allow humans to stay synchronized to the 24-hour day, rather than relying solely on their internal (biological) clock that is slightly longer than 24 hours (Van Someren & Riemersma-Van Der Lek, 2007). Lack of synchronization between the internal (longer than 24 hours) circadian clock and the 24-hour period can lead to chronodisruption with important negative health consequences (Van Someren & Riemersma-Van Der Lek, 2007).

The magnitude of sleep impacts experienced in the context of COVID-19 may differ in intensity depending on age, gender, socioeconomic status, and occupation (S. Wang et al., 2020; Xiao et al., 2020). Moreover, several public health measures used to decrease new cases of COVID-19 included case isolation, shelter-at-home orders, and closures of schools and workplaces (Nussbaumer-Streit et al., 2020; Viner et al., 2020), which likely had a dramatic impact on the complex interplay of social, behavioural and environmental factors that shape individuals' sleep. Multidisciplinary approaches that can provide us with a greater understanding of the complex

interplay of social and physical environmental predictors of sleep health and efforts to minimize unintended effects of public health interventions are needed to improve sleep health, especially in those at high risk of deficient sleep.

Potential Sleep Health Lessons From the COVID-19 Pandemic

Our review identified potential several mechanisms by which states of crises may affect sleep health. In the context of health crises, where sociality and economic activity may be severely impacted, public health measures that decrease financial burden associated with an economic slow-down and/or measures that foster positive aspects of sociality such as social support, connectedness and safety may lead to better sleep outcomes. Globally, and within Canada, there were many different government measures put in place during the COVID-19 pandemic. Some of these measures included restrictions on social activity, wage subsidies program, universal income programs, closure of schools and daycares, limitations on mobility, etc. Using different sources of sleep data, over the next few years we should be able to assess which measures were associated with better sleep health outcomes, and whether better sleep health outcomes led to better mental health outcomes. Similarly, co-occurrent changes in the context of COVID-19 may have actually had a positive impact on sleep. For example, the ability to work from home may have allowed individuals to move outside of the city to greener areas without increasing their commute time. There is extensive evidence showing that living closer to greener space is associated with better sleep, and longer commute time is associated with increased risk of being a short sleeper (Astell-Burt et al., 2013; Petrov et al., 2018). Environmental aspects such as air and noise pollution may have also decreased due to the economic slow-down and travel restrictions globally. With extensive evidence linking air quality to sleep outcomes (Billings, Hale, & Johnson, 2019), it is

possible that the sleep of those living in areas where air pollution decreased, benefitted from the air quality improvement. Transportation accounts for most of the noise pollution in cities (Kim et al., 2012). Decreased air/road travel in 2020 led to decreased air and road traffic, and thus likely decreased noise pollution in areas close to major roads and airports. Although it is possible that less transportation noise led to better sleep, it is important to highlight that airports have among the stricter rules on operating hours due to the close link between noise pollution and health (Basner & McGuire, 2018). It is also possible that while transportation noise decreased, noise from neighbors increased as in many parts of the world adults and children were mandated to stay at home for extended periods of time.

Limitations

Several limitations were acknowledged in the limitations paragraph of the article included in this thesis. In addition to the limitations already highlighted, the following limitations should be acknowledged. First, our scoping review only included studies published in scientific journals in French or English. Since scientific journals are more unlikely to publish ‘non-findings’, only including studies published in journals may lead to publication bias. Using language filters also potentially excludes research findings, in particular from low- and middle-income countries. Another limitation of this thesis is the ‘restrictive’ operational definition of crisis, that reflected a health crisis, which could be broadly defined as a situation that affects humans in one or more geographical areas with a significant impact on community health, loss of life and important economic consequences. Using this operational definition excluded other types of crises such as ‘personal crises’ or ‘identity crises’ for example, which may also be relevant to sleep. Another limitation of this review is the fact that few of the studies came from low- and middle-income

countries. For some of the domains, the clear majority of the studies came from a handful of high-income countries, which reflects the lack of sleep health data from most of the world. Another important limitation of the study is the lack of a discussion of the magnitude of the associations identified in this review. This point should be addressed in future work, most appropriately in the context of a meta-analysis. Investigating the long-term effect of different health crises on sleep health was outside of the initial scope of this work, thus future work should aim to investigate and identify “sleep when back to normal”. Despite having extracted comprehensive data on the limitations of these studies, these data were not reported in the final tables due to space constraints and a lack of a system that allowed clear comparability between studies. The data extracted on limitations could be used for three individual critical reviews, to highlight the main methodological problems and to provide an assessment of the quality of the studies included in this review. Studies reporting on sleep in the context of COVID-19 were likely conducted in different settings with different public health measures in place, and thus affecting their comparability.

References for the Introduction and Conclusions

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Appendix 1: Supplementary Figures

Figure 1. Flow chart of included studies search 1.

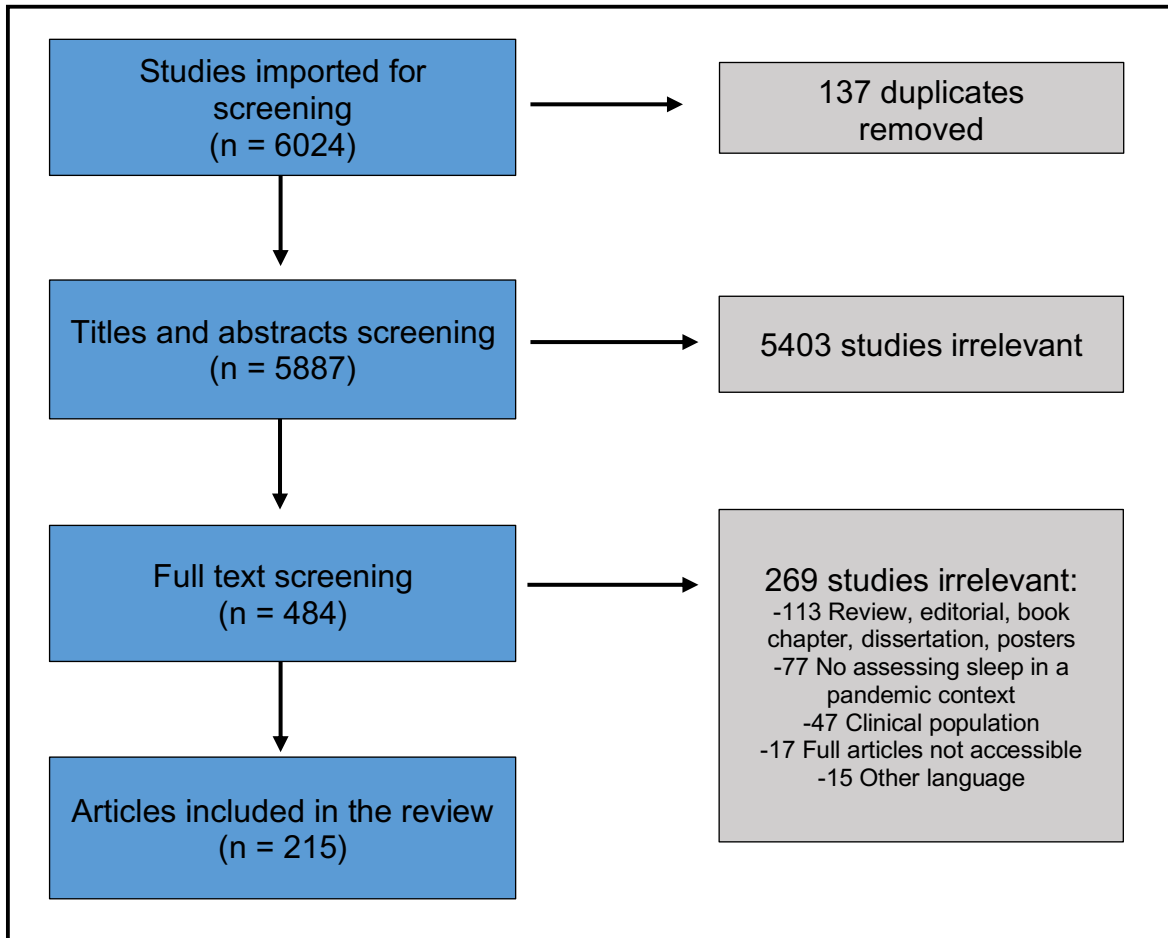


Figure 2. Flow chart of included studies search 2.

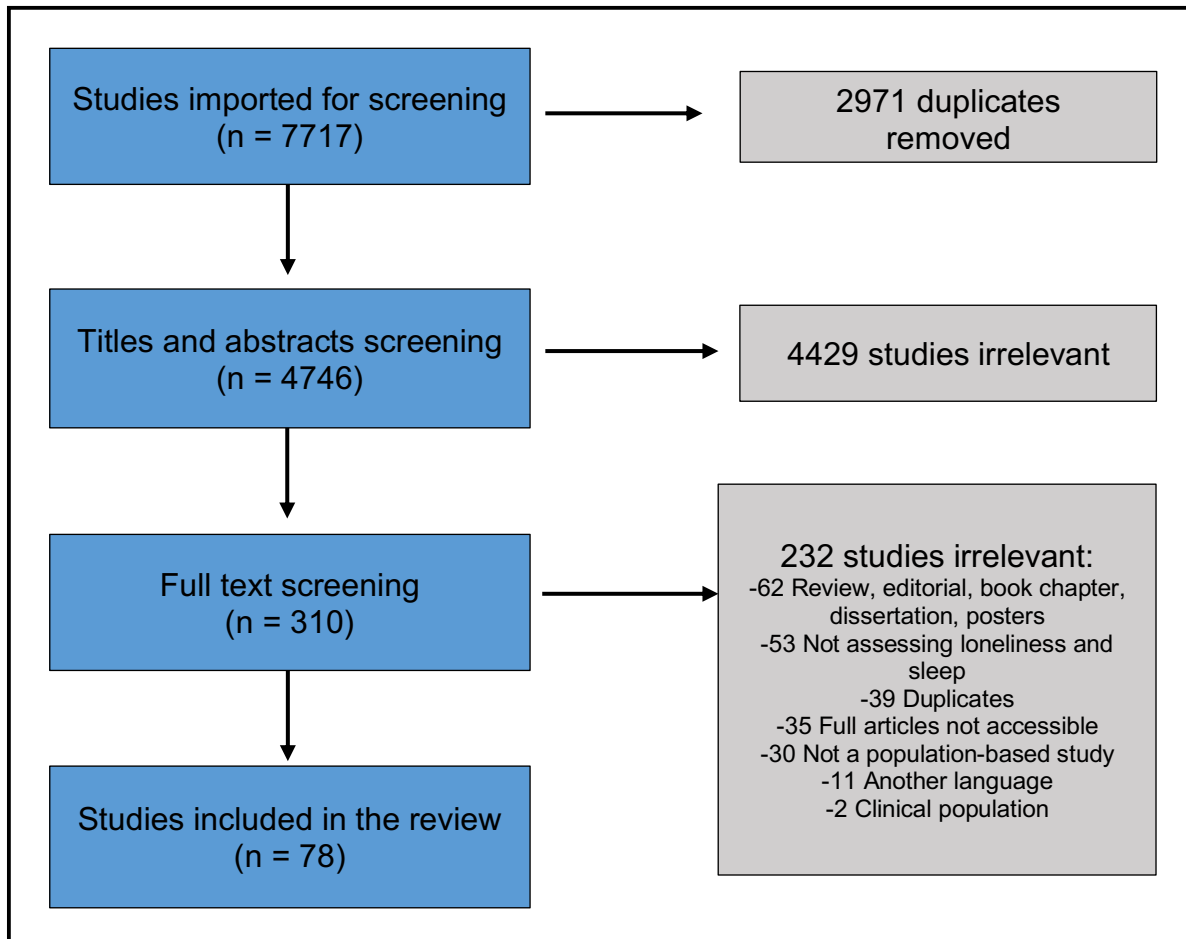
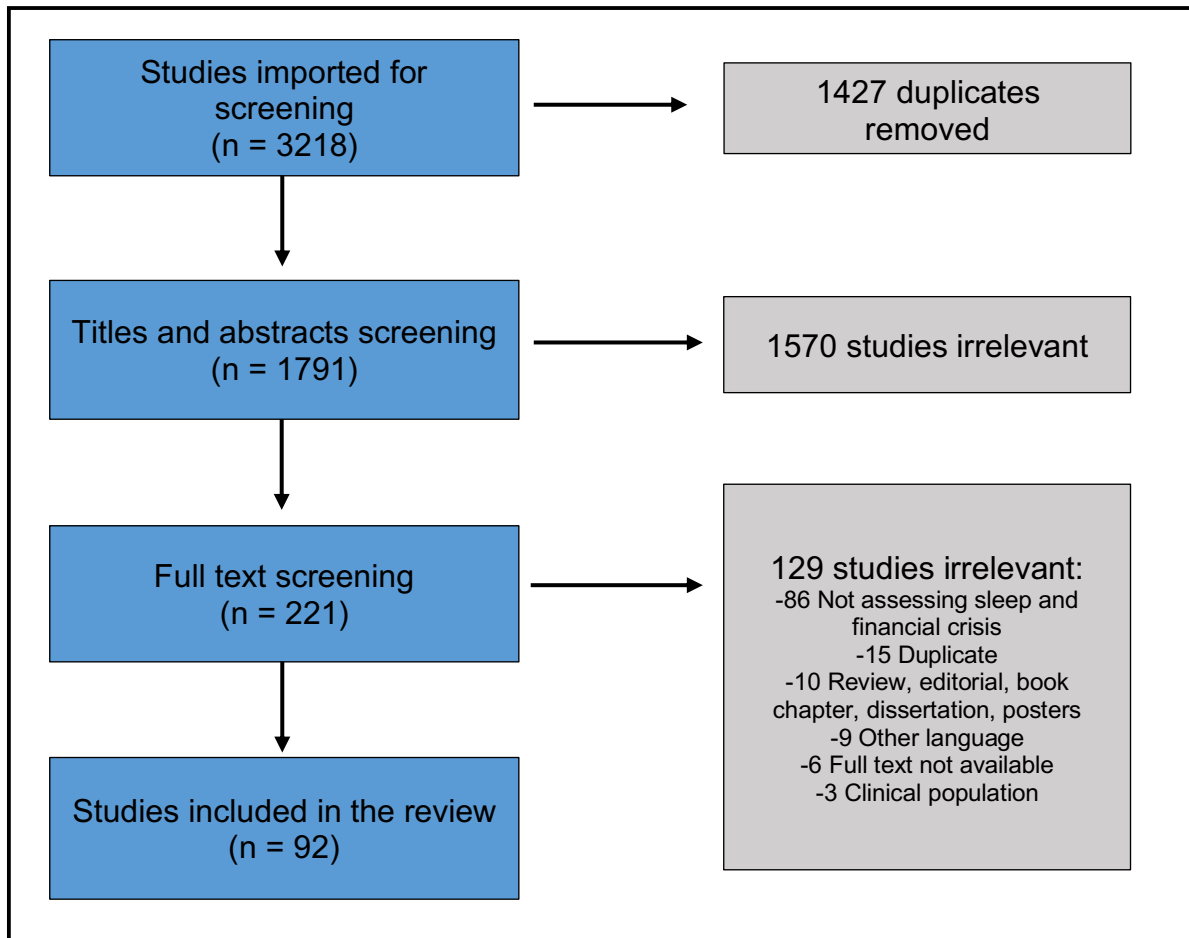


Figure 3. Flow chart of included studies search 3



Appendix 2: Supplementary Tables

Table S1. Search strategy

Search 1: COVID-19, other pandemics and/or crises

EMBASE:

AND #1

AND #2

AND #3

AND #4

AND #5

#1

(sleep*:ti,ab,kw OR 'sleep'/de OR ((sleep NEAR/3 (apnea OR lack OR dept OR deficit OR deprivation OR loss OR walk*)):ti,ab,kw) OR 'sleep disordered breathing'/de OR 'central sleep apnea syndrome'/de OR 'upper airway resistance syndrome'/de OR 'sleep deprivation'/de OR 'sleep debt'/de OR 'sleep walking'/de OR somnambulism*:ti,ab,kw OR dyssomnia*:ti,ab,kw OR insomnia*:ti,ab,kw OR 'insomnia'/de OR parasomnia*:ti,ab,kw OR 'parasomnia'/de)

#2

(pandemic*:ti,ab,kw)

#3

('pandemic'/de OR epidemic*:ti,ab,kw OR 'epidemic'/de OR (((H1N1 OR MERS OR SARS OR Ebola OR Zika OR Coronavirus* OR COVID-19 OR "2019-nCoV infection" OR influenza) NEAR/6 Outbreak\$):ti,ab,kw) OR "disease outbreak*":ti,ab,kw OR 'pandemic influenza'/de OR 'coronavirus disease 2019'/de OR "Middle East respiratory syndrome Coronavirus":ti,ab,kw OR ((MERS NEAR/2 (COV OR coronavirus)):ti,ab,kw) OR 'Middle East respiratory syndrome coronavirus'/de OR "severe acute respiratory syndrome coronavirus":ti,ab,kw OR 'Severe acute respiratory syndrome coronavirus 2'/de OR (SARS NEAR/2 (COV OR coronavirus)):ti,ab,kw OR 'SARS coronavirus'/de)

#4

((crisis NEAR/1 (sanitary or health*)):ti,ab,kw)

#5

(disaster*:ti,ab,kw OR 'disaster'/de OR ((avalanche* OR "cyclonic storm*" OR drought* OR earthquake* OR flood* OR landslide* OR "tidal wave*" OR tornadoe* OR tsunami OR wildfire*):ti,ab,kw) OR 'natural disaster'/exp OR (("terrorist attack" NEAR/3 (biologic* OR chemical OR radiological OR nuclear OR drug* OR device*)):ti,ab,kw) OR bioterrorism:ti,ab,kw OR OR 'bioterrorism'/de OR "chemical terrorism":ti,ab,kw OR 'chemical terrorism'/de OR "nuclear terrorism":ti,ab,kw OR 'nuclear terrorism'/de OR "september 11 terrorist attacks":ti,ab,kw OR 'terrorism'/de OR ("mass disaster" OR "mass casualty incident*"):ti,ab,kw) OR 'mass disaster'/de OR ((war OR wars OR warfare):ti,ab,kw) OR 'war'/de OR (((army OR armed OR civil) NEAR/1 conflict*):ti,ab,kw) OR 'war exposure'/de)

MEDLINE (Ovid):

AND #1

AND #2

#2 OR #3

#1

(sleep*.ti,ab,kw. OR sleep/ OR ((sleep adj3 (apnea or lack or dept or deficit or deprivation or loss or walk*)):ti,ab,kw) OR Sleep Apnea Syndromes/ OR sleep deprivation/ OR somnambulism*.ti,ab,kw OR Somnambulism/ OR dyssomnia?.ti,ab,kw OR dyssomnias/ OR parasomnia?.ti,ab,kw OR parasomnias/ OR insomnia?.ti,ab,kw OR "Sleep Initiation and Maintenance Disorders"/)

#2

(pandemic?.ti,ab,kw OR Pandemics/ OR epidemic?.ti,ab,kw OR Epidemics/ OR (((H1N1 or MERS or SARS or Ebola or Zika or Coronavirus* or COVID-19 or 2019-nCoV infection or influenza) adj6 Outbreak?):ti,ab,kw) OR "disease outbreak?".ti,ab,kw OR Disease Outbreaks/ OR "Middle East respiratory syndrome Coronavirus".ti,ab,kw OR Middle East Respiratory Syndrome Coronavirus/ OR (MERS adj2 (COV OR coronavirus)).ti,ab,kw OR "Severe acute respiratory syndrome coronavirus".ti,ab,kw OR ((SARS adj2 (COV OR coronavirus)).ti,ab,kw))

#3

((Crisis adj1 (sanitary or health*)).ti,ab,kw OR disaster?.ti,ab,kw OR Disaster/ OR ((avalanche? or cyclonic storm? or drought? or earthquake? or flood? or landslide? or tidal wave? or tornadoe? or tsunami or wildfire?).ti,ab,kw) OR exp Natural Disasters/ OR ("terrorist attack" adj3 (biologic* or chemical or radiological or nuclear or drug* or device*)).ti,ab,kw) OR bioterrorism.ti,ab,kw OR bioterrorism/ OR chemical terrorism.ti,ab,kw OR chemical terrorism/ OR nuclear terrorism.ti,ab,kw OR ((mass disaster or mass casualty incident*).ti,ab,kw) OR mass casualty incidents/ OR september 11 terrorist attacks/ OR ((war or wars or warfare).ti,ab,kw) OR (((army or armed or civil) adj1 conflict*).ti,ab,kw) OR Armed Conflicts/ OR gulf war/ OR iraq war, 2003-2011/ OR War Exposure/)

PSYCINFO (OVID):

AND #1

AND #2

AND #3

#1

(sleep*.ti,ab,id OR sleep/ OR ((sleep adj3 (apnea or lack or dept or deficit or deprivation or loss or walk*)).ti,ab,id) OR sleep apnea/ OR sleep deprivation/ OR sleepwalking/ OR somnambulis*.ti,ab,id OR dyssomnia?.ti,ab,id OR insomnia?.ti,ab,id OR insomnia/ OR parasomnia?.ti,ab,id OR parasomnias/)

#2

(pandemic?.ti,ab,id OR pandemics/ OR epidemic?.ti,ab,id OR epidemics/ OR (((H1N1 or MERS or SARS or Ebola or Zika or Coronavirus* or COVID-19 or 2019-nCoV infection or influenza) adj6 Outbreak?).ti,ab,id) OR "disease outbreak?".ti,ab,id OR "Middle East respiratory syndrome Coronavirus".ti,ab,id OR ((MERS adj2 (COV or coronavirus)).ti,ab,id) OR "severe acute respiratory syndrome coronavirus".ti,ab,id OR ((SARS adj2 (COV or coronavirus)).ti,ab,id)))

#3

((crisis adj1 (sanitary or health*)),ti,ab,id) OR disaster?.ti,ab,id OR disasters/ OR ((avalanche? or "cyclonic storm?" or drought? or earthquake? or flood? or landslide? or "tidal wave?" or tornadoe? or tsunami or wildfire?).ti,ab,id) OR natural disasters/ OR (("terrorist attack" adj3 (biologic* or chemical or radiological or nuclear or drug? or device?)).ti,ab,id) OR terrorism/ OR bioterrorism.ti,ab,id OR bioterrorism/ OR "chemical terrorism".ti,ab,id OR "nuclear terrorism".ti,ab,id OR "september 11 terrorist attacks".ti,ab,id OR (("mass disaster" or "mass casualty incident*").ti,ab,id) OR ((war or wars or warfare).ti,ab,id) OR war/ OR (((army or armed or civil) adj1 conflict*).ti,ab,id))

CINAHL (EBSCO):

AND #1

AND #2

AND #3

#1

((TI (sleep*) OR AB (sleep*)) OR (MH "Sleep") OR (TI (sleep N3 (apnea OR lack OR dept OR deficit OR deprivation OR loss OR walk*)) OR AB (sleep N3 (apnea OR lack OR dept OR deficit OR deprivation OR loss OR walk*))) OR (MH "Sleep Apnea Syndromes") OR (MH "Sleep Apnea, Central") OR (MH "Sleep Apnea, Obstructive") OR (MH "Sleep Deprivation") OR (TI (somnambulism*) OR AB (somnambulism*)) OR (MH "Somnambulism") OR (TI (dyssomnia*) OR AB (dyssomnia*)) OR (MH "Dyssomnias") OR (TI (insomnia*) OR AB (insomnia*)) OR (MH "Insomnia") OR (TI (parasomnia*) OR AB (parasomnia*)) OR (MH "Parasomnias"))

#2

((TI (pandemic*) OR AB (pandemic*) OR (TI (epidemic*) OR AB (epidemic*)) OR (MH "Disease Outbreaks") OR (TI ((H1N1 OR MERS OR SARS OR Ebola OR Zika OR Coronavirus* OR COVID-19 OR "2019-nCoV infection" OR influenza) N6 Outbreak\$) OR AB ((H1N1 OR MERS OR SARS OR Ebola OR Zika OR Coronavirus* OR COVID-19 OR "2019-nCoV infection" OR influenza) N6 Outbreak\$)) OR (MH "Coronavirus") OR (MH "Coronavirus

Infections") OR (MH "Influenza, Pandemic (H1N1) 2009") OR (TI ("Middle East respiratory syndrome Coronavirus")) OR AB ("Middle East respiratory syndrome Coronavirus")) OR (TI (MERS N2 (COV OR coronavirus)) OR AB (MERS N2 (COV OR coronavirus))) OR (MH "Middle East Respiratory Syndrome") OR (TI ("severe acute respiratory syndrome coronavirus") OR AB ("severe acute respiratory syndrome coronavirus")) OR (MH "Severe Acute Respiratory Syndrome") OR (TI (SARS N2 (COV OR coronavirus)) OR AB (SARS N2 (COV OR coronavirus))) OR (MH "SARS Virus"))

#3

((TI (crisis N1 (sanitary OR health*)) OR AB (crisis N1 (sanitary OR health*))) OR (TI (disaster*) OR AB (disaster*)) OR (MH "Disasters") OR (TI (avalanche* OR "cyclonic storm*" OR drought* OR earthquake* OR flood* OR landslide* OR "tidal wave*" OR tornadoe* OR tsunami OR wildfire*) OR AB (avalanche* OR "cyclonic storm*" OR drought* OR earthquake* OR flood* OR landslide* OR "tidal wave*" OR tornadoe* OR tsunami OR wildfire*)) OR (MH "Natural Disasters") OR (TI ("mass disaster" OR "mass casualty incident*") OR AB ("mass disaster" OR "mass casualty incident*")) OR (MH "Mass Casualty Incidents") OR (TI ("terrorist attack" N3 (biologic*OR chemical OR radiological OR nuclear OR drug* OR device*)) OR AB ("terrorist attack" N3 (biologic*OR chemical OR radiological OR nuclear OR drug* OR device*))) OR (TI (bioterrorism) OR AB (bioterrorism)) OR (MH "Bioterrorism") OR (TI ("chemical terrorism") OR AB ("chemical terrorism")) OR (MH "Chemical Warfare") OR (TI ("nuclear terrorism") OR AB ("nuclear terrorism")) OR (MH "Nuclear Warfare") OR (TI ("september 11 terrorist attacks") OR AB ("september 11 terrorist attacks")) OR (TI (terrorism) OR AB (terrorism)) OR (MH "Terrorism") OR (TI (war OR wars OR warfare) OR AB (war OR wars OR warfare)) OR (MH "War") OR (TI ((army OR armed OR civil) N1 conflict*) OR AB ((army OR armed OR civil) N1 conflict*)))

WEB OF SCIENCE Core collection (CLARIVATE):

AND #1

AND #2

AND #3

#1

(TS=(sleep*) OR TS=(dyssomnia\$) OR TS=(insomnia\$) OR TS=(parasomnia\$) OR TS=(somnambulis\$) OR TS=(sleep NEAR/3 (apnea OR lack OR dept OR deficit OR deprivation OR loss OR walk*)))

#2

(TS=pandemic\$ OR TS=epidemic\$ OR TS=((H1N1 OR MERS OR SARS OR Ebola OR Zika OR Coronavirus* OR COVID-19 OR "2019-nCoV infection" OR influenza) NEAR/6 Outbreak\$) OR TS="disease outbreak\$" OR TS="Middle East respiratory syndrome Coronavirus" OR TS=(MERS NEAR/2 (COV OR coronavirus) OR TS=("severe acute respiratory syndrome coronavirus") OR TS=(SARS NEAR/2 (COV OR coronavirus)))

#3

(TS=(crisis NEAR/1 (sanitary or health*)) OR TS=disaster\$ OR TS=(avalanche\$ OR "cyclonic storm\$" OR drought\$ OR earthquake\$ OR flood\$ OR landslide\$ OR "tidal wave\$" OR tornadoe\$ OR tsunami OR wildfire\$) OR TS=("terrorist attack" NEAR/3 (biologic* OR chemical OR radiological OR nuclear OR drug\$ OR device\$)) OR TS=bioterrorism OR TS=("chemical terrorism") OR TS=("nuclear terrorism") OR TS=("september 11 terrorist attacks") OR TS=("mass disaster" OR "mass casualty incident*") OR TS=(terrorism) OR TS=(war OR wars OR warfare) OR TS=((army OR armed OR civil) NEAR/1 conflict*))

#1 OR #2 OR #3

Search 2: Sleep and social isolation or loneliness

EMBASE:

AND #1

AND #2

#1 OR #2

AND (#3 OR 2)

#1

(dyssomnia*:ti,ab,kw OR insomnia*: ti,ab,kw OR 'insomnia'/de OR parasomnia*: ti,ab,kw OR (sleep NEAR/3 (apnea OR lack OR deficit OR loss OR walking)):ti,ab,kw OR 'sleep disordered breathing'/de OR 'central sleep apnea syndrome'/de OR 'upper airway resistance syndrome'/de OR somnambulism*:ti,ab,kw OR 'sleep walking'/de OR sleep*:ti,ab,kw OR 'sleep'/de OR 'sleep deprivation'/de OR 'sleep debt'/de)

#2

((social OR socially) NEAR/1 (isolat* OR alienation OR deprivation OR distanc* OR withdrawal)):ti,ab,kw) OR 'social isolation'/de OR 'psychosocial withdrawal'/de OR solitude:ti,ab,kw OR loneliness:ti,ab,kw OR 'loneliness'/de OR 'social distance'/de OR quarantine*:ti,ab,kw OR 'quarantine'/de OR alienation:ti,ab,kw OR 'social alienation'/de OR 'alienation'/de OR seclusion:ti,ab,kw OR confin*:ti,ab,kw)

#3

((social OR socially) NEAR/1 (support* OR cohesion)):ti,ab,kw OR 'social support'/de)

MEDLINE (Ovid):

AND #1

AND #2

AND #3

AND #3

AND #4

AND #5

#2 OR #4

#1

(sleep*.ti,ab,kw OR sleep/ OR sleep deprivation/ OR dyssomnia*.ti,ab,kw OR dyssomnias/ OR insomnia*.ti,ab,kw OR parasomnia*.ti,ab,kw OR parasomnias/ OR "Sleep Initiation and Maintenance Disorders"/ OR somnambulism*.ti,ab,kw OR Somnambulism/ OR (sleep adj3 (apnea or lack or deficit or loss or walking)).ti,ab,kw OR Sleep Apnea Syndromes/)

#2

((social\$2 adj1 (isolat* or alienation or deprivation or distanc* or withdrawal)).ti,ab,kw OR social isolation/ OR social distance/ OR alienation.ti,ab,kw OR social alienation/ OR

solitude.ti,ab,kw OR loneliness.ti,ab,kw OR loneliness/ OR social distance/ OR confin*.ti,ab,kw
OR quarantine*.ti,ab,kw)

#3

(quarantine/)

#4

((social\$2 adj1 (cohesion or support*).ti,ab,kw OR social support/)

#5

(social support/)

PSYCINFO (OVID):

AND #1

AND #2

AND #3

#2 OR #3

#1

(sleep* OR sleep/ OR (sleep adj3 (apnea or lack or deficit or loss or walking))ti,ab,id) OR sleep
deprivation/ OR dyssomnia*.ti,ab,id OR insomnia*.ti,ab,id OR insomnia/ OR
parasomnia*.ti,ab,id OR parasomnias/ OR sleep apnea/ OR somnambulism*.ti,ab,id OR
sleepwalking/)

#2

((social\$2 adj1 (isolat* or alienation or deprivation or distanc* or withdrawal)).ti,ab,id OR
social isolation/ OR solitude OR loneliness OR loneliness/ OR social deprivation/ OR alienation
OR alienation/ OR seclusion OR patient seclusion/ OR confin* OR quarantine* OR “withdrawal
(defense mechanism)”/)

#3

((social\$2 adj1 (cohesion or support*).ti,ab,id OR social support/)

Psychology and Behavioral Sciences Collection (EBSCO) :

AND #1

AND #2

AND #3

#1

((TI (sleep N3 (apnea or lack or deficit or loss or walking)) OR AB (sleep N3 (apnea or lack or deficit or loss or walking)) OR (TI (sleep*) OR AB (sleep*)) OR (DE "SLEEP") OR (TI (insomnia*) OR AB (insomnia*)) OR (DE "INSOMNIA") OR (DE "INSOMNIACS") OR (TI (dyssomnia*) OR AB (dyssomnia*)) OR (TI (parasomnia*) OR AB (parasomnia*)) OR (DE "SLEEP deprivation") OR (DE "SLEEP deprivation -- Social aspects") OR (DE "APNEA") OR (DE "SLEEP apnea syndromes") OR (TI (somnambulism*) OR AB (somnambulism*)) OR (DE "SLEEPWALKING") OR (DE "STAY-at-home orders"))

#2

(TI ((social OR socially) N1 (isolation* OR alienation OR deprivation OR distance* OR withdrawal)) OR AB ((social OR socially) N1 (isolation* OR alienation OR deprivation OR distance* OR withdrawal))) OR DE "SOCIAL isolation" OR DE "SOCIAL distance" OR (TI (alienation) OR AB (alienation)) OR DE "SOCIAL alienation" OR (TI (loneliness) OR AB (loneliness)) OR DE "LONELINESS" OR (TI (seclusion) OR AB (seclusion)) OR (TI (solitude) OR AB (solitude)) OR DE "SOLITUDE" OR (TI (quarantine*) OR AB (quarantine*)) OR (TI (quarantine*) OR AB (quarantine*)) OR DE "QUARANTINE")

#3

(TI((social OR socially) N1 (support* OR cohesion)) OR AB ((social OR socially) N1 (support* OR cohesion)) OR DE "SOCIAL support")

WEB OF SCIENCE Core collection (CLARIVATE):

AND #1

AND #2

AND #3

#1 OR #3

#1

(TS=sleep* OR TS=dyssomnia* OR TS=insomnia* OR TS=parasomnia* OR TS=somnambulis* OR TS=(sleep NEAR/3 (apnea OR lack OR deficit OR loss OR walking))

#2

(TS=((social OR socially) NEAR/1 (isolat* OR alienation OR deprivation OR distanc* OR withdrawal)) OR TS=alienation OR TS=loneliness OR TS=solitude OR TS=seclusion OR TS=confin* OR TS-quarantine*)

#3

(TS=((social OR socially) NEAR/1 (cohesion OR support*)))

Search 3: Sleep and economic uncertainty, financial adversity, or food/job insecurity

EMBASE:

AND #1

AND #2

#1

(sleep*:ti,ab,kw OR 'sleep'/de OR ((sleep NEAR/3 (apnea OR lack OR dept OR deficit OR deprivation OR loss OR walk*)):ti,ab,kw) OR 'sleep disordered breathing'/de OR 'central sleep apnea syndrome'/de OR 'upper airway resistance syndrome'/de OR 'sleep deprivation'/de OR 'sleep debt'/de OR 'sleep walking'/de OR somnambulis*:ti,ab,kw OR dyssomnia*:ti,ab,kw OR insomnia*:ti,ab,kw OR 'insomnia'/de OR parasomnia*:ti,ab,kw OR 'parasomnia'/de)

#2

((economic* NEAR/3 constraint*):ti,ab,kw OR (economic* NEAR/3 crisis):ti,ab,kw OR (economic* NEAR/3 difficult*):ti,ab,kw OR (economic* NEAR/3 hardship*):ti,ab,kw OR (economic* NEAR/3 problem*):ti,ab,kw OR (economic* NEAR/3 insecurit*):ti,ab,kw OR 'economic recession'/de OR (economic* NEAR/3 recession):ti,ab,kw OR (economic* NEAR/3 depression):ti,ab,kw OR (economic* NEAR/3 slowdown):ti,ab,kw OR (economic* NEAR/3

uncertainty):ti,ab,kw OR (economic* NEAR/3 vulnerabilit*):ti,ab,kw OR (financial NEAR/3 crisis):ti,ab,kw OR (financial NEAR/3 hardship*):ti,ab,kw OR (financial NEAR/3 Instabilit*):ti,ab,kw OR (financial NEAR/3 insecurit*):ti,ab,kw OR (financial NEAR/3 problem*):ti,ab,kw OR (financial NEAR/3 strain):ti,ab,kw OR ("bank* crisis"):ti,ab,kw OR (food NEAR/3 insecurit*):ti,ab,kw OR 'food insecurity'/de OR (insecurit* NEAR/3 job*):ti,ab,kw OR ((loss or losing) NEAR/3 job*):ti,ab,kw OR ((loss or losing) NEAR/3 employment*):ti,ab,kw OR (layoff*):ti,ab,kw OR unemployment:ti,ab,kw OR ("threat of unemployment"):ti,ab,kw OR 'unemployment'/de OR ("market crash"):ti,ab,kw)

MEDLINE (Ovid):

AND #1

AND #2

#1

(sleep*.ti,ab,kw. OR sleep/ OR (sleep adj3 (apnea or lack or dept or deficit or deprivation or loss or walk*)).ti,ab,kw OR Sleep Apnea Syndromes/ OR sleep deprivation/ OR somnambulis*.ti,ab,kw OR Somnambulism/ OR dyssomnia?.ti,ab,kw OR dyssomnias/ OR parasomnia?.ti,ab,kw OR parasomnias/ OR insomnia?.ti,ab,kw OR "Sleep Initiation and Maintenance Disorders"/)

#2

((economic* adj3 constraint*).ti,ab,kw OR (economic* adj3 crisis).ti,ab,kw OR (economic* adj3 difficult*).ti,ab,kw OR (economic* adj3 hardship).ti,ab,kw OR (economic* adj3 problem*).ti,ab,kw OR (economic* adj3 insecurit*).ti,ab,kw OR Economic Recession/ OR (economic* adj3 recession).ti,ab,kw OR (economic* adj3 depression).ti,ab,kw OR (economic* adj3 slowdown).ti,ab,kw OR (economic* adj3 uncertainty).ti,ab,kw OR (economic* adj3 vulnerabilit*).ti,ab,kw OR (financial adj3 crisis).ti,ab,kw OR (financial adj3 hardship*).ti,ab,kw OR (financial adj3 instabilit*).ti,ab,kw OR (financial adj3 insecurit*).ti,ab,kw OR (financial adj3 problem*).ti,ab,kw OR (financial adj3 strain*).ti,ab,kw OR (bank* crisis).ti,ab,kw OR (insecurit* adj3 food).ti,ab,kw OR (insecurit* adj3 job*).ti,ab,kw OR ((loss or losing) adj3

job*).ti,ab,kw OR ((loss or losing) adj3 employment*).ti,ab,kw OR (layoff*).ti,ab,kw OR (unemployment).ti,ab,kw OR (threat of unemployment).ti,ab,kw)

PSYCINFO (OVID):

AND #1

AND #2

#1

(sleep*.ti,ab,id OR sleep/ OR (sleep adj3 (apnea or lack or dept or deficit or deprivation or loss or walk*)).ti,ab,id OR sleep apnea/ OR sleep deprivation/ OR sleepwalking/ OR somnambulism*.ti,ab,id OR dyssomnia?.ti,ab,id OR insomnia?.ti,ab,id OR insomnia/ OR parasomnia?.ti,ab,id OR parasomnias/)

#2

((economic* adj3 constraint*).ti,ab,ib OR (economic* adj3 crisis).ti,ab,ib OR (economic* adj3 difficult*).ti,ab,ib OR (economic* adj3 hardship*).ti,ab,ib OR (economic* adj3 problem*).ti,ab,ib OR (economic* adj3 insecurity*).ti,ab,ib OR Economic Recession/ OR (economic* adj3 recession).ti,ab,ib OR economic* adj3 depression).ti,ab,ib OR (economic* adj3 slowdown).ti,ab,ib OR (economic* adj3 uncertainty).ti,ab,ib OR (economic* adj3 vulnerability).ti,ab,ib OR (financial adj3 crisis).ti,ab,ib OR (financial adj3 hardship*).ti,ab,ib OR (financial adj3 Instabilit*).ti,ab,ib OR (financial adj3 insecurity*).ti,ab,ib OR (financial adj3 problem*).ti,ab,ib OR Financial Strain/ OR (financial strain).ti,ab,id OR ("bank* crisis").ti,ab,ib OR (insecurity* adj3 food).ti,ab,ib OR (insecurity* adj3 job*).ti,ab,ib OR ((loss or losing) adj3 job*).ti,ab,ib OR ((loss or losing) adj3 employment*).ti,ab,ib OR layoff*.ti,ab,ib OR unemployment.ti,ab,ib OR ("threat of unemployment").ti,ab,ib OR Unemployment/ OR ("market crash").ti,ab,ib)

CINAHL (EBSCO):

AND #1

AND #2

#1

(TI (sleep*) OR AB (sleep*) OR (MH "Sleep") OR TI (sleep N3 (apnea OR lack OR dept OR deficit OR deprivation OR loss OR walk*)) OR AB (sleep N3 (apnea OR lack OR dept OR deficit OR deprivation OR loss OR walk*)) OR (MH "Sleep Apnea Syndromes") OR (MH "Sleep Apnea, Central") OR (MH "Sleep Apnea, Obstructive") OR (MH "Sleep Deprivation") OR TI (somnambulis*) OR AB (somnambulis*) OR (MH "Somnambulism") OR (TI (dyssomnia*) OR AB (dyssomnia*)) OR (MH "Dyssomnias") OR (TI (insomnia*) OR AB (insomnia*)) OR (MH "Insomnia") OR (TI (parasomnia*) OR AB (parasomnia*)) OR (MH "Parasomnias"))

#2

((TI (economic* N3 constraint*) OR AB (economic* N3 constraint*)) OR (TI (economic* N3 crisis) OR AB (economic* N3 crisis)) OR (TI (economic* N3 difficult*) OR AB (economic* N3 difficult*)) OR (TI (economic* N3 hardship*) OR AB (economic* N3 hardship*)) OR (TI (economic* N3 problem*) OR AB (economic* N3 problem*)) OR (TI (economic* N3 insecurit*) OR AB (economic* N3 insecurit*)) (MH "Economic Recession")) OR (TI (economic* N3 recession) OR AB (economic* N3 recession)) OR (TI (economic* N3 depression) OR AB (economic* N3 depression)) OR (TI (economic* N3 slowdown) OR AB (economic* N3 slowdown)) OR (TI (economic* N3 uncertainty) OR AB (economic* N3 uncertainty)) OR (TI (economic* N3 vulnerabilit*) OR AB (economic* N3 vulnerabilit*)) OR (TI (financial N3 crisis) OR AB (financial N3 crisis)) OR (TI (financial N3 hardship*) OR AB (financial N3 hardship*)) OR (TI (financial N3 instabilit*) OR AB (financial N3 instabilit*)) OR (TI (financial N3 insecurit*) OR AB (financial N3 insecurit*)) OR (TI (financial N3 problem*) OR AB (financial N3 problem*)) OR (TI (financial N3 strain) OR AB (financial N3 strain)) OR (TI ("bank* insecurit*") OR AB ("bank* insecurit*")) OR (TI (insecurit* N3 food) OR AB (insecurit* N3 food)) OR (TI (insecurit* N3 job*) OR AB (insecurit* N3 job*)) OR (TI ((loss or losing) N3 job*) OR AB ((loss or losing) N3 job*)) OR (TI ((loss or losing) N3 employment*) OR AB ((loss or losing) N3 employment*)) OR (TI (layoff*) OR AB (layoff*)) OR (TI ("threat of unemployment") OR AB ("threat of unemployment")) OR (TI (unemployment) OR AB (unemployment)) OR ((MH "Unemployment")) OR (TI ("market crash") OR AB ("market crash"))

WEB OF SCIENCE Core collection (CLARIVATE):

AND #1

AND #2

#1

((TS=(sleep*) OR (TS=(dyssomnia\$)) OR (TS=(insomnia\$)) OR (TS=(parasomnia\$)) OR (TS=(somnambulis\$)) OR (TS=(sleep NEAR/3 (apnea OR lack OR dept OR deficit OR deprivation OR loss OR walk*))))

#2

(TS=(economic* NEAR/3 constraint*) OR (TS=(economic* NEAR/3 crisis)) OR (TS=(economic* NEAR/3 difficult*)) OR (TS=(economic* NEAR/3 hardship*)) OR (TS=(economic* NEAR/3 problem*)) OR (TS=(economic* NEAR/3 insecurit*)) OR (TS=(economic* NEAR/3 recession)) OR (TS=(economic* NEAR/3 depression)) OR (TS=(economic* NEAR/3 slowdown)) OR (TS=(economic* NEAR/3 uncertainty)) OR (TS=(economic* NEAR/3 vulnerabilit*)) OR (TS=(financial NEAR/3 crisis)) OR (TS=(financial NEAR/3 hardship*)) OR (TS=(financial NEAR/3 Instabilit*)) OR (TS=(financial NEAR/3 insecurit*)) OR (TS=(financial NEAR/3 problem*)) OR (TS=(financial NEAR/3 strain*)) OR (TS=("bank* crisis")) OR (TS=(insecurit* NEAR/3 food)) OR (TS=(insecurit* NEAR/3 job*)) OR (TS=((loss or losing) NEAR/3 job*)) OR (TS=((loss or losing) NEAR/3 employment*)) OR (TS=(layoff*)) OR (TS=(unemployment)) OR (TS=("threat of unemployment")) OR (TS=("market crash"))

Table S2. Summary of studies on sleep and infectious outbreaks

Authors & year	Type of Study	Country	(n) Sample	Sleep measures	Summary findings
2003 SARS Outbreak					
<u>Healthcare workers (HCW)</u>					
Chen et al., 2006 ²⁷	Longitudinal	Taiwan	116 nursing staff	PSQI	Nursing staff members could not sleep well at the SARS outbreak. Their sleep quality started to improve 2 weeks after the initiation of SARS prevention controls.
Lee et al., 2018 ²⁸	Longitudinal	Korea	1 st survey: 359 HCW 2 nd survey: 70 HCW	Items from IES-R Korean version	In the first survey, the HCW who performed MERS related tasks had higher IES-R scores, including sleep and numbness, than those who did not. In the second survey, the home quarantined HCW showed higher scores in sleep and numbness than those who were not quarantined, and the healthcare.
McAlonan et al., 2007 ³⁰	Longitudinal	China	176 HCW	Unvalidated measure	More high-risk HCW reported fatigue and poor sleep despite their confidence in infection-control measures. Despite similar perceived stress levels between high-risk and low-risk HCW, high-risk workers remained highly stressed 1 year later.
Su et al., 2007 ³¹	Cross-sectional	Taiwan	102 nurses	PSQI	Insomnia was greater in the SARS unit nurses and there was significant reduction in insomnia rate at the end of the study.
<u>General Population</u>					
Maunder et al., 2003 ²⁹	Longitudinal	Canada	19 individuals who developed SARS	Reported in interviews	Patients deprived of family visits experienced insomnia and interpersonal friction with staff. Insomnia was common as a result of treatment with corticosteroids, anxiety, physical discomfort and hospital routines. Patients with SARS experienced the effects of insomnia on mood and coping.
Yu et al., 2005 ³³	Cross-sectional	China	126 women	Unvalidated measure	A quarter of the women surveyed felt their sleep was restless.
COVID-19 Pandemic					
<u>Children and adolescent studies</u>					

Guerrero et al., 2020 ¹⁶	Cross-sectional	Canada	1,472 parents	Parents' report	Characteristics associated with adherence to the recommendation(s) included having no to little change in sleep duration since the COVID-19 outbreak began and having parents older than 35 years old. Characteristics associated with non-adherence to the recommendation(s) included low parental perceived capability to support children's sleep and increases in sleep duration since the COVID-19 outbreak began.
Saurabh & Ranjan, 2020 ¹⁷ <u>Adult studies</u> <i>Healthcare workers (HCW)</i>	Intervention	India	252 individuals	Reported in interviews	Anxiety related insomnia was more common in the quarantine group.
Amerio et al., 2020 ²⁵	Cross-sectional	Italy	131 general practitioners	ISI Items from PHQ-9	Individuals reported higher severity for both anxiety and insomnia.
Azoulay et al., 2020 ¹³⁰	Cross-sectional	France	1058 HCW	Question in a survey	Among the bedside HCPs, 37.8% reported insomnia.
Cai et al., 2020 ¹³¹	Cross-sectional	China	1 173 FHCW and 1 173 NFHCW	ISI	The rate of mental problems, such as anxiety, depression, and insomnia, was significantly increased in frontline medical workers, compared with non-frontline medical workers.
Cai et al., 2020 ¹³²	Longitudinal	China	709 HCW in the outbreak period and 621 HCW in the stable period	ISI	Over one-third of the frontline nurses suffered symptomatic insomnia during the outbreak period; while insomnia declined to similar levels between the frontline and non-frontline nurses during the stable period.
Cheng et al., 2020 ⁴²	Cross-sectional	China	534 pediatric HCW	PSQI	Among the respondents, 30% had poor sleep quality, and their level of anxiety was moderately associated with sleep quality. 36.7% staff had difficulty falling asleep and 15.3% staff had low sleep efficiency.
Dabholkar et al., 2020 ¹³³	Cross-sectional	India	40 HCW	Unvalidated measure	Quarantined HCPs who developed symptoms experienced insomnia. Almost 57.5% reported several psychological conditions including insomnia.

Elkholy et al., 2020 ¹³⁴	Cross-sectional	Egypt	502 HCW	7-items of ISI	Overall, 69.5% of all participants reported symptoms of insomnia.
Fan et al., 2020 ¹³⁵	Cross-sectional	China	44 nurse practitioners and supervisor nurse	Interviews (report of insomnia)	Most TNs had psychological problems including insomnia. Workload and facing morbidity and mortality and worked under enormous pressure, most TNs was associated with experienced insomnia.
Geoffroy et al., 2020 ¹³⁶	Intervention	France	149 HCW	Reported as reasons to call the hotline	Nine individuals (out of 149) reported calling the hotline because of insomnia.
Jahrami et al., 2020 ³⁶	Cross-sectional	Bahrain	138 HCW	PSQI	Female sex and professional background predicted poor sleep quality and stress. Up to 75% of the total sample reported poor sleep.
Kang et al., 2020 ¹³⁷	Cross-sectional	China	994 HCW	ISI	Thirty-four percent of HCW reported mild disturbances, 22.4% reported moderate disturbances, and 6.2% reported severe disturbances.
Lai et al., 2020 ³⁷	Cross-sectional	China	1,257 HCW	ISI Items from IES-R	Being a frontline HCW engaged in direct diagnosis, treatment, and care of patients with COVID-19 was associated with a higher risk of symptoms of insomnia.
Qi et al., 2020 ¹³⁸	Cross-sectional	China	1,306 HCW	PSQI AIS	Medical workers under COVID-19 outbreak suffered from elevated sleep disturbances, especially for FMW. By comparison, non-FMW work in a relatively mild environment and have less possibility of being infected, thus having fewer sleep disturbances. Female FMW had worse sleep quality than male FMW.
Que et al., 2020 ¹³⁹	Cross-sectional	China	2,285 HCW	ISI	Compared with HCW who did not participate in front-line work, front-line HCW had a higher risk of insomnia.
Sahin et al., 2020 ¹⁴⁰	Cross-sectional	Turkey	939 HCW	ISI	The prevalence of insomnia among the HCWs was 50.4%. A greater proportion of insomnia was observed in women, individuals with a history of psychiatric illness, and those requiring psychiatric support.

Sharif et al., 2020 ¹⁴¹	Cross-sectional	Africa Asia Europe North America South America	375 neurosurgeons	Unvalidated measure	Among all neurosurgeons, 25% experienced insomnia. 24.8 % reported sleeping badly.
Shechter et al., 2020 ³⁸	Cross-sectional	USA	657 HCW	Items from PHQ Unvalidated measure	Severity of sleep disturbances differed by group, with nurses/advanced practice providers reporting the worst sleep problems, and house staff not differing significantly from attending physicians.
Tu et al., 2020 ¹⁴²	Cross-sectional	China	100 nurses	PSQI	Frontline nurses had short sleep duration, long sleep latency and insomnia symptoms.
Wang et al., 2020 ³⁹	Cross-sectional	China	123 pediatric HCW	PSQI	38% of the pediatric HCW suffered from sleep disturbance. Contact with the COVID-19 patients and depression were independently associated with sleep disturbance. Anxiety was not significantly associated with sleep disturbance in HCW.
Wankowicz et al., 2020 ¹⁴³	Cross-sectional	Poland	441 HCW	ISI	A significant proportion of participants experienced symptoms of insomnia, with over 90% prevalence of these symptoms in the group of employees having direct contact with persons suspected or infected with SARS-CoV-2
Wu & Wei, 2020 ¹⁴⁴	Cross-sectional	China	120 HCW	PSQI	Sleep quality of front-line medical staff at fever clinics was generally lower than that of medical staff at non-fever clinics. Having Negative emotions was associated with different sleep outcomes.
Wu et al., 2020 ¹⁴⁵	Cross-sectional	China	4,268 HCW	Unvalidated measure	Psychological stress was associated with sleep quality of HCW and they experienced difficulty in sleep, light sleeping, more dreaming, waking up easily, and more night behavior such as turning over.
Xiao et al., 2020 ⁴⁵	Cross-sectional	China	180 HCW	PSQI	Social support of the medical staff did not directly affect their sleep quality but had an indirect effect through several paths or

					steps. The combination of anxiety, stress, and self-efficacy of medical staff affected their sleep quality.
Yin et al., 2020 ¹⁴⁶	Cross-sectional	China	371 HCW	PSQI	HCWs reported more difficulty falling asleep and short sleep duration.
Zhan et al., 2020 ⁴⁴	Cross-sectional	China	1,794 nurses	AIS The FS-14	The incidence rate of sleep disorders among nurses in Wuhan was higher during the COVID-19 crisis. Females' insomnia levels were higher than males'. Nurses with more working experience had higher mean AIS scores. The more night shifts nurses had, the higher the mean AIS scores were.
Zhang et al., 2020 ¹⁴⁷	Cross-sectional	China	1,563 HCW	Reported insomnia ISI	Insomnia symptoms were associated with being a doctor, currently working in an isolation unit, being worried about being and perceived lack of helpfulness in terms of psychological support from news or social media with regard to COVID-19. More than one-third of the medical staff suffered insomnia symptoms during the COVID-19 outbreak.
Zhang et al., 2020 ⁴⁰	Cross-sectional	China	2,182 HCW	ISI	Medical health workers during the COVID-19 epidemic had high prevalence rates of severe insomnia.
Zhou et al., 2020 ⁴¹	Cross-sectional	China	1,931 HCW	PSQI	Older age was associated with poor sleep quality. Nurses were more likely to report poor sleep quality when compared to other health professionals. Health professionals who were familiar with crisis response were less likely to report poor sleep quality. Apart from female nurses, health professionals working in external emergency medical team in Hubei province (China) were also more likely to experience poor sleep quality.
Zhou et al., 2020 ¹⁴⁸	Cross-sectional	China	606 FMS	ISI	Symptoms of insomnia in frontline medical staff were more serious than those in the general population. In frontline medical staff, daily working hours were positively associated with insomnia. BMI was positively associated with insomnia in frontline medical staff; younger age was associated with insomnia.
Zhuo et al., 2020 ⁴³	Longitudinal	China	30 HCW with insomnia symptoms	Oximetry	Participants with comorbid moderate to severe SAHS had significantly higher ISI and SRQ scores than those in the insomnia group. ISI was positively correlated with total sleep

<i>General Population</i>					
Antunes et al., 2020 ²⁴	Cross-sectional	Portugal	1,404 individuals	ISI Items from the SRQ-20	time, and negatively correlated with deep sleep. Patient SRQ scores were positively correlated with TST, sleep efficiency (SE) and REM (rapid eyes movement) sleep %. SRQ-20 and sex were risk factors for insomnia with comorbid SAHS.
Beck et al., 2020 ⁸⁵	Cross-sectional	France	1,005 individuals	Unvalidated measure	Considering sleeping habits, most participants reported maintaining routine habits, particularly the number of hours of sleep. The authors reported gender differences in sleep satisfaction. Women had trouble sleeping more often than men and reported the most severe problems. Young people (aged 18-34 years) reported sleep problems slightly more frequently than elderly people. 16% of participants reported they had taken sleeping pills during the last 12 months, and 41% of them reported using these drugs since the lockdown started. 44% of respondents stated that they were sleeping the same number of hours they did before social isolation. However, 56% reported some change in sleep hours, breaking down into those who are sleeping more hours than usual (26%) and people sleeping less hours than usual (31%). 54.6% of those who are sleeping less perceive a lot of family stress, while of those who are sleeping the same number of hours, 19.1% perceive a lot of stress, and of those who are sleeping more hours a day, 26.2% perceive a lot of family stress. 67% of people felt a change in their sleep routine.
Bezerra et al., 2020 ¹⁴⁹	Cross-sectional	Brazil	16,440 individuals	Unvalidated measure	Insomnia risk was associated with high suicide risk.
Caballero-Dominguez et al., 2020 ¹⁹	Cross-sectional	Colombia	700 individuals	AIS	The increase in digital media use before going to bed mildly affected sleep latency, bedtime and wake time, but not sleep quality. In the second week of the lockdown, sleep-wake rhythms markedly changed, with people going to bed and waking up later, and spending more time in bed, but, paradoxically reporting a lower sleep quality. The increase in subjective sleep duration was associated with poorer sleep
Cellini et al., 2020 ¹³	Cross-sectional	Italy	1,310 individuals	PSQI	

quality, in particular in workers and with the increased use of digital media.

Chakraborty & Chatterjee, 2020 ¹⁵⁰	Cross-sectional	India	507 individuals	Unvalidated measure	Near one-third of the respondents reported having disturbed sleep-wake cycle in the past 2 weeks. Only a minority of the respondents was taking sleeping pills for the past 2 weeks.
Demir, 2020 ⁴	Cross-sectional	Turkey	100 individuals	Unvalidated measure	Male subjects reported a higher incidence of change in their waking hours, and an increased need for sleep during daytime. There is a high prevalence of anxiety and impaired sleep in the adult Turkish population during the COVID-19 pandemic.
Di Renzo et al., 2020 ¹²	Cross-sectional	Italy	3,533 individuals	Unvalidated measure	Sleep hours have increased during the lockdown. The individuals >30 years old, married residents, urban residents, individuals with bachelor's degrees, medical professionals, individuals with higher income, individuals who communicated through the internet many times a day and the ones who did not frequently exercised were more likely to have sleep problems.
Fu et al., 2020 ⁴⁸	Cross-sectional	China	1,242 individuals	AIS	
Gualano et al., 2020 ⁶	Cross-sectional	Italy	1,515 individuals	Items from PHQ-2 ISI	Participants experiencing poor sleep were 40.5% before lockdown and 52.4% during lockdown.
Guo et al., 2020 ²⁰	Cross-sectional	China	2,441 individuals	PSQI	Direct exposure to COVID-19 elevated the risk for insomnia. A problem-focused coping style seems to relieve individuals' post-traumatic stress, depression, and insomnia symptoms, and the emotion-focused coping style seems to exacerbate mental health symptoms.

Hartley et al., 2020 ²¹	Cross-sectional	France	1,777 individuals	Unvalidated measure	There is a strong association between the decrease in the sleep time estimated by the patients and the feeling of a deterioration in the quality of sleep during confinement, while an increase in the duration of sleep is on the contrary a protective factor. The participants with sleep quality worsening also complained of a decrease in sleep duration, which is accompanied by a later bedtime and earlier waking up. Irregular scheduling and complaints of poor sleep were associated.
Huang & Zhao, 2020 ¹⁵¹	Cross-sectional	China	7,236 individuals	PSQI	Nearly one in four HCW have sleep problems, which was significantly higher than other occupations.
Huang & Zhao, 2020 ²³	Cross-sectional	China	7,236 individuals	PSQI	The prevalence of sleep quality of the public was 18.2%. Compared with other occupational group, HCW were more likely to have poor sleep quality. HCW were at high risk for poor sleep quality.
Huang & Zhao, 2020 ¹⁵²	Cross-sectional	China	7,236 individuals	PSQI	Nearly one in four HCW have sleep problems, which was significantly higher than another occupational group. The prevalence of sleep quality was 18.2%. Compared with other occupation, HCW have the highest rate of poor sleep quality.
Huckins et al., 2020 ¹⁵³	Longitudinal	USA	217 school students	Passive sensing features duration.	In the combined sensing and mental health model, the addition of depression and anxiety to the sensing model showed a strong inferential link between anxiety and COVID-19 news, while depression was marginally significant. In the combined model, the number of unlocks, sleep duration and distance traveled were again not significant.
Jacobson et al., 2020 ¹⁵⁴	Longitudinal	USA	9,717,876 mental health search queries on Google	Search queries on Google	The implementation of stay-at-home orders are associated with a significant flattening of the curve for searches for sleep disturbances.
Kaparounaki et al., 2020 ¹⁴	Cross-sectional	Greece	1,000 students	Unvalidated measure	Participants reported that their quantity of sleep increased in 66.3%, but quality worsened in 43.0%.
Li et al., 2020 ¹⁵⁵	Cross-sectional	Taiwan	1,970 individuals	Unvalidated measure	A high level of worry about COVID-19 was significantly associated with sleep disturbance. Changes in social interaction due to COVID-19 were associated to sleep disturbance. Lower perceived social support and specific support against COVID-

					19 were both independent predictors for sleep disturbance and suicidal thoughts. The higher the academic/occupational interference by COVID-19, the higher the predicted sleep disturbance. Poorer self-reported physical health was significantly associated with sleep disturbance. Younger age was potentially associated with sleep disturbance.
Lin et al., 2020 ²¹	Longitudinal	China	5461 individuals	ISI	Fear of contracting COVID-19 was correlated with insomnia. Age, gender, and area of residence (Hubei province or other provinces) was correlated with insomnia.
Liu et al., 2020 ¹⁵⁶	Intervention	China	51 patients confirmed COVID-19 admitted to hospital	Items from SRSS	Progressive muscle relaxation had a positive effect on improving sleep quality in patients with COVID-19.
Liu et al., 2020 ¹⁵⁷	Cross-sectional	China	285 individuals	4 items of the PSQI	Participants with worse sleep quality had higher PTSS prevalence.
Lopez-Bueno et al., 2020 ¹⁵⁸	Cross-sectional	Spain	2,741 individuals	Unvalidated measure	The prevalence of short sleep decreased during confinement.
Losada-Baltar et al., 2020 ¹⁵⁹	Cross-sectional	Spain	1,310 individuals	Unvalidated measure	Higher exposure to news about COVID-19, lower quality of sleep and higher loneliness were associated with higher distress.
Marelli et al., 2020 ⁸	Cross-sectional	Italy	400 university students & administration staff	PSQI ISI MEQ	During lockdown sleep quality and insomnia worsened, and there was a later shift in sleep timing.
Moore et al., 2020 ¹⁵	Cross-sectional	Canada	1,472 individuals	Unvalidated measure	Children and youth slept more during the initial COVID-19 virus outbreak compared with before the restrictions. Girls engaged in more social media use and slept more than boys.
Neill et al., 2020 ¹⁶⁰	Cross-sectional	Australia	4,462 individuals	Unvalidated measure	During the initial COVID-19 outbreak, less sleep was associated with higher alcohol.
Roy et al., 2020 ¹⁶¹	Cross-sectional	India	662 individuals	Unvalidated measure	Approximately, 12 % of the participants had sleeping difficulty due to being worried about the pandemic in the past week. Approximately 28 % of people reporting sleep difficulties.

Shi et al., 2020 ²²	Cross-sectional	China	56,932 individuals	Items from PHQ-9 ISI ASDS	There as a high prevalence of insomnia among patients with COVID-19 (71.0%)
Stanton et al., 2020 ⁹	Cross-sectional	Australia	1,491 individuals	Unvalidated measure	40.7% reported a negative change in their sleep quality since the onset of the COVID-19 pandemic.
Tan et al., 2020 ⁴⁶	Cross-sectional	China	673 full-time employees	ISI Items from: IES-R DASS-21	The respondents reported a low prevalence of insomnia (2.3%).
Ustun, 2020 ¹⁶²	Cross-sectional	Turkey	1,115 individuals	Unvalidated measure	Sleep problems were associated with depression.
Varshney et al., 2020 ¹⁶³	Cross-sectional	India	653 individuals	Unvalidated measure	Approximately one third of respondents had significant psychological impact, defined as fears, worries, and impairment in sleep
Xiao et al., 2020 ²⁶	Cross-sectional	China	170 individuals self-isolated after a mild infection	PSQI	Isolated individuals reported high anxiety and stress, and poor sleep quality.
Yang et al., 2020 ¹⁸	Longitudinal	China	764 chronic insomnia patients	PSQI	During the isolation period, in chronic insomnia patients the average score of PSQI was much higher than the baseline score, indicating worsening sleep quality. During the epidemic, the sleep latency, sleep duration, sleep efficiency and daytime function of PSQI were affected.
Yuan et al., 2020 ¹⁰	Cross-sectional	China	939 individuals	PSQI	The 18–24-year age group had the lowest global sleep quality scores, and sleep quality deteriorated for two weeks as COVID-19 epidemic progressed.
Zachary et al., 2020 ¹⁶⁴	Cross-sectional	USA	173 individuals	SIT-Q	There was a significant relationship between predictor variables hours of sleep per night and physical activity time on reported weight gain. Those who got fewer hours of sleep were more than likely to gain weight.
Zhang et al., 2020 ⁴⁰	Longitudinal	China	66 college students	PSQI	19.9% of participants reported sleep dissatisfaction.

Zhao et al., 2020 ¹¹	Cross-sectional	China	1,630 individuals	PSQI	People's anxiety significantly mediated the relationship between perceived stress and sleep quality. People's self-esteem moderated the indirect effect of perceived stress on sleep quality through its moderation of the effect of perceived stress on anxiety, indicating the mediation effect of anxiety was stronger at low levels of self-esteem than at high levels of self-esteem. The direct effect of perceived stress on sleep quality was moderated by self-esteem.
Ebola					
<u>Adult studies</u>					
Mohammed et al., 2015 ³⁴	Cross-sectional	Africa	117 patient/contacts	Reported	The most frequently occurring psychological distress among all respondents included “Lost much sleep over worry” (33.3 %). Soldiers with combat experience reported more somatic and sleep problems at pre-deployment than those without previous combat experience. It should be noted, that although the overall rates of mental health problems were low, relatively more soldiers during the deployment reported sleep problems (12%), and these numbers are somewhat closer to the 20–30% reported in combat zones.
Sipos et al., 2018 ³⁵	Cross-sectional	USA	251 U.S soldiers pre deployment 173 U.S soldiers during deployment	ISI	

Table S3a. Summary of studies on sleep and social isolation

Authors & year	Type of study	Country	Sample size (n)	Social construct	Sleep measures	Summary findings
Social isolation						
<i>Adolescent Studies</i>						
Fernandez-Mendoza et al., 2016 ¹⁶⁵	Cross-sectional	USA	397	Pediatric Behavior Scale (PBS)	PSG Self-reported version of Pediatric Sleep Questionnaire MEQ	Adolescents with insomnia symptoms who slept objectively ≥ 7 h had elevated scores in aggression and inappropriate social behavior, elevated scores in perseverative thinking and social isolation as compared to controls, while adolescents with insomnia symptoms who slept objectively ≤ 7 h did not.
<i>Adults studies</i>						
Butt et al., 2015 ⁷⁷	Longitudinal	USA	11	Unvalidated measure	Automated wireless system (headband)	Higher levels of social exposure (both previous and following days) are correlated with greater amounts of SWNREM sleep. SWNREM+REM % is correlated to following day sociability across subjects but not to previous day sociability.
Cellini et al., 2020 ¹³	Cross-sectional	Italy	1,310	None	PSQI	During the lockdown, people increased the usage of digital media near bedtime, but this change did not affect sleep habits. During home confinement, sleep timing markedly changed, with people going to bed and waking up later, and spending more time in bed, but, paradoxically, reporting a lower sleep quality.
Pressman et al., 2005 ⁶⁸	Cross-sectional	USA	83	Social Networks in Adult Life Questionnaire	PSQI	Elevated levels of loneliness throughout the semester and small social networks were independently associated with poorer antibody response to one component of the vaccine. Those with both high levels of

loneliness and a small social network had the lowest antibody response.

Roy et al., 2020 ¹⁶⁶	Cross-sectional	India	662	None	Unvalidated measure	Sleep difficulties, paranoia about acquiring COVID-19 infection and distress related social media were reported. Participants reported sleeping difficulty due to being worried about the pandemic in the past week.
Tang et al., 2020 ¹⁶⁷	Cross-sectional	China	2,485	Unvalidated measure	Unvalidated measure	Subjectively, short sleep duration was the second most significant risk factor for psychological distress. Sleep durations was a mediator between exposures and mental health problems. Shorter sleep durations were associated with mental health consequences.
Xiao et al., 2020 ²⁶	Cross-sectional	China	170	PSCI-16	PSQI	The social capital of the participants who self-isolated during the COVID-19 epidemic improved sleep quality, which was reduced by anxiety and stress. Anxiety levels correlated with stress levels, which reduced sleep quality.
<i>Older adult studies</i>						
Grimby & Wiklund, 1994 ¹⁶⁸	Cross-sectional	Sweden	565	NHP	Items from NHP	No correlation with sleep was found.
Goodman-Casanova et al., 2020 ¹⁶⁹	Longitudinal	Spain	93	Interview using telephone-based survey	Unvalidated measure	The individuals living alone reported less well-being, more anxiety and more sleeping problems than those living with others.
Kumar, 2013 ¹⁷⁰	Cross-sectional	Nepal	400	Unvalidated measure	Unvalidated measure	Disturbed sleep pattern increased with age. Living exclusively with spouse was associated with normal sleep pattern because of security and good status in family,

absence of which led to disturbed sleep pattern.

Luo et al., 2013 ¹⁷¹	Cross-sectional	China	1,086	Clinical face-to-face interview	PSQI	Age, less education, living alone, anxiety, number of chronic disease and arthritis were risk factors of poor sleep quality.
Riedel et al., 2012 ⁷³	Cross-sectional	Germany	2,873	The social integration index	Unvalidated measure	In low-income and socially isolated participants, neighborhood unemployment odds of reporting insomnia were particularly elevated. Low education and social isolation were more than two times more prevalent among insomniacs than among non-insomniacs.
Stephoe et al., 2008 ¹⁷²	Cross-sectional	UK	827	Unvalidated measure	JSS	Financial strain, social isolation, low emotional support, negative social interactions, and psychological distress were related to reported sleep problems.
Yu et al., 2018 ³³	Longitudinal	Taiwan	639	Unvalidated measure	PSQI Item from CES-D	Higher PSQI score was associated to a high level of social isolation and loneliness at baseline.
Zohre & Ali, 2018 ⁵⁹	Cross-sectional	Iran	80	UCLA Loneliness Scale	Petersburg's sleep quality index	There was an inverse relationship between social isolation and quality of sleep of the subjects. The elderly with high social isolation had a lower quality of sleep.

Table S3b. Summary of studies on sleep and loneliness

Authors & year	Type of study	Country	Sample size (n)	Social construct	Sleep measures	Summary findings
Loneliness						
Children Studies						
Becker, 2014 ¹⁷³	Cross-sectional	USA	175	SPPC	Items from UCLA-LS Items from SSRS Items from PSS-Fa	Sleep problems were significantly associated with increased loneliness and poorer friendship satisfaction.
Harris, 2013 ⁴⁹	Longitudinal	UK	209	LLSCA	PSQI	Lonely adolescents had more trouble sleeping, took longer to get to sleep, and had more disturbed sleep. High level of loneliness made a contribution to sleep dysfunction that is independent of the effects of depression and earlier health problems.
Adolescents studies						
Doane et al., 2014 ⁴⁷	Longitudinal	USA	82	UCLA	Actigraphy Unvalidated measure	Loneliness was a significant moderator of the associations between daily stress and sleep duration and latency, such that lonely individuals had shorter sleep durations and sleep latencies after stressful days. There are daily dynamic associations among loneliness, daily stress, and objective measures of adolescent sleep.
Eccles et al., 2020 ¹⁷⁴	Cross-sectional	47 countries	3,305	UCLA	Unvalidated measure	Loneliness is associated with poorer self-reported health and sleep problems among young adolescents.
Mahon, 1994 ¹⁷⁵	Cross-sectional	N/A	330	UCLA	VSH	Loneliness and sleep disturbance were associated in early and middle adolescents, but not for late adolescents.

Majeno et al., 2018 ¹⁷⁶	Cross-sectional	USA	316	UCLA	Actigraphy PSQI	Loneliness partially mediated the effect of ethnic discrimination on overall sleep quality and daily disturbances, whereas loneliness and perceived stress partially mediated the effect of non-ethnic discrimination on overall sleep quality and daily disturbances.
Xu et al., 2012 ¹⁷⁷	Cross-sectional	China	5,226	UCLA	PSQI	There were significant sleep quality differences between depression, loneliness and anxiety.
<i>Adults Studies</i>						
Aanes et al., 2011 ⁵⁸	Longitudinal	Norway	7,074	Unvalidated measure	Unvalidated measure	Troubled relationships and the feeling of loneliness have negative effects on sleep at night and alertness during the day. Loneliness was a partial mediator in the analysis of daytime sleepiness and a partial mediator in the analysis of nocturnal sleep problems in the middle-aged sample. In the older sample, loneliness fully mediated the stress/nocturnal sleep problems relationship.
Allaert et al., 2004 ⁶¹	Cross-sectional	France Germany Italy UK	2,121	Survey	Survey	Individuals reported stress, loneliness and the recent death of a relative as the main causes of their insomnia.
Ben Simon et al., 2018 ¹⁷⁸	Longitudinal	USA	S1: 293 S2: 1,033 S3: 18	UCLA	PSG	Impact of lack of sleep on social isolation, but not the reverse.
Cacioppo et al., 2002 ⁵⁶	Cross-sectional	USA	64	UCLA-R	PSG	Lonely individuals evinced poorer sleep efficiency and more time awake after sleep onset than nonlonely individuals.
Cacioppo et al., 2002 ¹⁷⁹	Cross-sectional	USA	S1: 49 S2: 25	UCLA	PSQI	Lonely participants both young (Study 1) and old (Study 2) suffered lower quality sleep on multiple dimensions.
Hawkley et al., 2010 ¹⁸⁰	Longitudinal	USA	215	UCLA	Unvalidated measure	Being younger, a female, more time exposed to news about COVID-19, lower contact with relatives, higher self-

perception as a burden and lower quality of sleep were associated with higher loneliness.

Hom et al., 2017 ¹⁸¹	Cross-sectional and Longitudinal	USA	S1: 747 S2: 2,785 S3: 208 S4: 343 S5: 326 S6: 183	Unvalidated measure	ISI Items from BDI Items from SHDS	Findings underscore the strength of the association between insomnia and loneliness and suggest that depression may account for this relationship.
Kurina, 2011 ⁵⁷	Cross-sectional	USA	95	R-UCLA	ESS PSQI Actigraphy	Higher loneliness scores were associated with higher levels of sleep fragmentation. Loneliness was not associated with sleep duration. Feelings of loneliness were associated with worse overall sleep quality and daytime dysfunction. The association between loneliness and sleep quality was exacerbated among individuals exposed to violence victimization in adolescence or maltreatment in childhood.
Matthews et al., 2017 ⁷⁰	Longitudinal	UK	2,232	UCLA	PSQI	Loneliness was associated with sleep disturbance and sleep related impairment.
Peltzer et al., 2019 ⁶⁹	Cross-sectional	Indonesia	31,447	Unvalidated measure	PROMIS	Loneliness was associated with having sleeping problems and short sleep duration. Among female university students, loneliness was associated with long sleep duration.
Peltzer et al., 2017 ¹⁸²	Cross-sectional	21 countries	17,886	CES-D	Unvalidated measure	Loneliness was associated with elevations in circulating levels of cortisol and poorer sleep efficiency and quality.
Pressman et al., 2005 ⁶⁸	Cross-sectional	USA	83	UCLA	PSQI	Loneliness was associated to worse health through less sleep and lower medical adherence.
Segrin et al., 2010 ⁵²	Cross-sectional	USA	265	UCLA	Items from HPS	Higher levels of male loneliness predict lower female self-reported sleep quality. The corresponding partner effect from females to males was not significant.
Segrin et al., 2015 ⁵⁰	Cross-sectional	USA	255	UCLA	PSQI	

Sladek et al., 2015 ¹⁸³	Longitudinal	USA	71	UCLA	Actigraphy	Within-person increases in daily social connection were associated with longer time spent in bed and more actual time asleep only for adolescents with high loneliness level. Within-person increases in daily social connection were associated with a greater cortisol awakening response (CAR) the next day, regardless of trait loneliness.
Smith et al., 2012 ¹⁸⁴	Cross-sectional	Australia	97	R-UCLA	PSQI	Higher levels of perceived loneliness are associated with poorer subjective sleep quality.
Smith et al., 2014 ¹⁸⁵	Longitudinal	USA	68	UCLA	PSQI	There were positive correlations among loneliness and sleep quality.
Stickley et al., 2015 ¹⁸⁶	Cross-sectional	Russia	1,190	Unvalidated measure	Unvalidated measure	Participants who felt lonely were more likely to have poor self-rated health and have suffered from insomnia and mental ill health.
Wakefield et al., 2020 ⁵⁴	Longitudinal	UK	387	Unvalidated measure	PSQI ISI	Family identification was a negative predictor of loneliness, which in turn was a positive predictor of depression, which predicted poor sleep quality/insomnia.
Zawadzki et al., 2013 ⁷¹	Cross-sectional	USA	S1: 1,244 S2: 300 S3: 218 S4: 360	UCLA	PSQI	Rumination and trait anxiety fully mediated the associations between loneliness and depressed mood as well as poor sleep quality.
<i>Older Adults Studies</i>						
Cheng, 2015 ¹⁸⁷	Cross-sectional	China	730	UCLA-LS	PSQI	Empty nesters had a higher level of loneliness among both genders.
Cho et al., 2019 ⁶⁰	Cross-sectional	USA	2,541	Unvalidated measure	PSQI Items from CFQ	Older adults with objective social isolation had worse sleep disturbance and fatigue, mostly when they experienced subjective social isolation.
Christiansen et al., 2016 ¹⁸⁸	Cross-sectional	Denmark	8,593	Danish version of UCLA	Unvalidated measure	Poor sleep mediated the association between loneliness and adverse health conditions.
Demir et al., 2018 ¹⁸⁹	Cross-sectional	Turkey	700	UCLA-LS	PSQI	Daytime sleepiness and feelings of loneliness were risk factors that had a negative effect on sleep quality.

Devkota et al., 2019 ¹⁹⁰	Cross-sectional	Nepal	124	UCLA	Unvalidated measure	Adequate sleeping hour and good perception about the quality of sleep were associated with loneliness and depression. Even though the sleeping hour of nearly half of the respondents is <5 hours, 65.3% of respondents had a good perception of their sleep quality.
Fu, 2020 ¹⁹¹	Cross-sectional	China	2,038	Chinese version of De Jong Gierveld Loneliness Scale	ISI	Insomnia symptoms alone were not significant.
Griffin et al. 2020 ¹⁹²	Longitudinal	USA	5,067	HLS	Unvalidated measure	Loneliness predicted subsequent sleep disturbance, which in turn predicted subsequent self-reported health.
Griffin et al., 2019 ¹⁹³	Longitudinal	USA	5,067	HLS	Unvalidated measure	The relationship between loneliness and sleep disturbance is bidirectional.
Jacobs et al., 2006 ¹⁹⁴	Longitudinal	Jerusalem	290	Unvalidated measure	Unvalidated measure	Loneliness was significantly associated with poor GSS.
Jia et al., 2020 ¹⁹⁵	Cross-sectional	China	1,658	UCLA	PSQI	Deficiencies in the quantity and quality of sleep can predict some health problems.
McHugh et al., 2011 ¹⁹⁶	Cross-sectional	Ireland	505	Jong-Gierveld Scale	PSQI	Loneliness was associated with subjective sleep quality independently of depression or personality.
McHugh et al., 2013 ¹⁹⁷	Cross-sectional	Dublin	505	Jong-Gierveld Scale	PSQI	Emotional loneliness was associated to subjective sleep quality. Sleep duration may not differ between lonely and non-lonely individuals, satisfaction with sleep may differ significantly.
Segrin et al., 2011 ⁵¹	Longitudinal	USA	224	UCLA	PSQI	Loneliness is associated with greater sleep disturbances.
Shankar et al., 2020 ¹⁹⁸	Longitudinal	UK	5,698	Unvalidated measure	Unvalidated measure	High loneliness was associated with an increase in the odds of short sleep, but not long sleep at follow up.

Yu et al., 2018 ⁵⁵	Longitudinal	Taiwan	639	CES-D	PSQI	Loneliness was associated with poorer sleep quality in bivariate analysis but was not related to sleep quality after covariates had been taken into account.
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Table S3c. Summary of studies on sleep and social cohesion

Authors & year	Type of study	Country	Sample size (n)	Social construct	Sleep measures	Summary findings
Social cohesion						
<u>Children Studies</u>						
Bagley et al., 2018 ⁶²	Longitudinal	USA	210	Census tract information	Actigraphy	Higher levels of neighborhood economic deprivation were associated with fewer sleep minutes and poorer sleep efficiency. More neighborhood social fragmentation was associated with poorer sleep efficiency.
<u>Adult studies</u>						
Jin et al., 2014 ⁷⁵	Cross-sectional	China	1,632	Unvalidated measure	Chinese version of PSQI	Students with good social support had longer sleep time, higher sleep efficiency, good subjective sleep quality and shorter sleep latency.
Johnson et al., 2016 ⁶⁴	Cross-sectional	USA	5,301	Unvalidated measure	Unvalidated measure	Higher neighborhood violence and more neighborhood problems were associated with shorter sleep duration and poorer sleep quality.
Murillo et al., 2019 ⁶⁵	Cross-sectional	USA	14,538	Unvalidated measure	Unvalidated measure	For all subgroup of Latino adults, medium and high levels of neighborhood social cohesion were associated with normal sleep duration.
Win et al., 2018 ⁶⁶	Cross-sectional	Japan	12,321	Unvalidated measure	Unvalidated measure	Neighborhood social capital (NSC) was only significant in men. Each dimension of NSC was negatively associated with insufficient sleep except the feeling of fellowship.
Young et al., 2018 ⁶⁷	Cross-sectional	USA	2,464	Unvalidated measure	PSQI GSAQ	Low social cohesion was associated with increased odds of short sleep duration. No associations with having trouble falling or staying asleep and feeling well rested were found.
<u>Older adult studies</u>						

Chen-Edinboro et al., 2015 ¹⁹⁹	Longitudinal	USA	7,231	Unvalidated measure	Unvalidated measure	Higher neighborhood physical disorder and lower neighborhood social cohesion were associated with greater odds of trouble falling asleep. Greater physical disorder was associated with waking up too early in the morning. Lower social cohesion was associated with a greater odd of not feeling rested in the morning across age groups. Higher neighborhood physical disorder was associated with a greater odd of not feeling rested in individuals aged 69 years and older.
Johnson et al., 2017 ⁶³	Cross-sectional	USA	1,949	Unvalidated measure	Actigraphy	Higher levels of neighborhood social cohesion were associated with an earlier sleep midpoint. No associations between neighborhood social environment and sleep efficiency or sleep fragmentation index.

Table S3d. Summary of studies on sleep and social support

Authors & year	Type of Study	Country	Sample size (n)	Social construct	Sleep measures	Summary findings
Social support						
<i>Adults studies</i>						
Adriaenssens et al., 2012 ²⁰⁰	Cross-sectional	Belgium	248	LQWQ LQWQ-N	Unvalidated measure	Qualitative social support from the supervisor was associated with less somatic complaints and fatigue, while adequate social support from colleagues was associated with less fatigue.
Allgower et al., 2001 ²⁰¹	Cross-sectional	15 countries in Europe	5,529	Unvalidated measure	Unvalidated measure	Low social support was independently associated with sedentary behavior, irregular sleep hours. Only social support was associated with both self-reported measures of sleep quality.
Chung et al., 2017 ⁸⁰	Longitudinal	USA	1,255	Unvalidated measure	PSQI Actigraphy	Only social strain was associated with sleep efficiency, with night-to-night sleep variability. Neither social support nor social strain was associated with TST.
Jarrin et al., 2014 ²⁰²	Longitudinal	Canada	1,449	Unvalidated measure	PSQI ISI Items from FIRST	Reporting receiving social support did not moderate the link between sleep reactivity and the onset of insomnia symptoms or syndrome. Lower social stress and good social support were correlated with better sleep status and stress or support from friends, family and classmates were all related with sleep variables.
Jin et al., 2014 ⁷⁵	Cross-sectional	China	1,632	Unvalidated measure	Chinese version PSQI	Resilience and social support are two important protective factors against poor sleep. Participants with high resilience or great social support had favorable sleep.
Liu et al., 2016 ⁷⁶	Cross-sectional	China	1,471	MSPSS	PSQI	

Matsumoto et al., 2015 ⁷⁹	Cross-sectional	Japan	2,593	Unvalidated measure	Unvalidated measure	Lack of social support has a stronger association with prolonged sleep difficulties than non-modifiable or hardly modifiable consequences caused directly by the disaster. Lack of emotional support showed the strongest association with prolonged sleep difficulties.
Nakata et al., 2004 ²⁰³	Cross-sectional	Japan	1,161	Unvalidated measure	Unvalidated measure	Significant increases in the prevalence of insomnia and DMS in workers with low coworker support. There is a high prevalence of DIS and EMA in workers with low support by family/friends.
Paulsen et al., 1991 ⁸¹	Cross-sectional	USA	69	ASSIS	PSG	Regardless of whether life events and social support were positively or negatively evaluated, neither factor had a direct effect on either reported sleep quality or objective sleep.
Peltzer et al., 2017 ²⁰⁴	Cross-sectional	25 countries	17,886	Social Support Questionnaire	Unvalidated Questionnaire	Lonely students were likely to self-report poor subjective health status, sleeping problems and short sleep duration. Individuals reported higher levels of perceived social support availability. The negative relation between their average occupational stress and average sleep quality became weaker.
Pow et al., 2017 ⁷²	Longitudinal	Canada	87	ISEL	PSQI	
Segrin et al., 2011 ⁵¹	Longitudinal	USA	224	Survey	PSQI	Social support had indirect associations with all indicators of health, through loneliness.
Sinokki et al., 2010 ²⁰⁵	Cross-sectional	Finland	3,430	Unvalidated measure Job Content Questionnaire	Unvalidated Questionnaire	Low social support from supervisor and from coworkers were associated with tiredness and sleeping difficulties within the previous month. Low private life support was associated with short sleep duration and among women. Low and intermediate support from coworkers was related to

Troxel et al., 2010 ⁷⁸	Cross-sectional	USA	119	ISEL	PSQI Actigraphy	tiredness, with higher probability of short sleep duration among women and to long sleep duration among men. Higher social support was associated with lesser actigraphy assessed WASO in individuals with insomnia and controls. There were no significant main effects of social support or social support by patient group interactions for subjective sleep quality, daytime sleepiness, napping behavior or TST.
<i>Older adult studies</i>						
Bazargan et al., 1996 ²⁰⁶	Cross-sectional	USA	998	Unvalidated measure	Unvalidated measure	Emotional social support had a significant impact on sleep problems.
Cheng et al., 2015 ²⁰⁷	Cross-sectional	China	730	SSRS PSS-Fa	PSQI	Empty nesters had a higher level of loneliness among both genders. Sleep problems were associated to quality of perceived social support. Elderly individuals who reported sleep problems, prolonged SOL and non-restorative sleep presented lower scores on the ISES, compared to those who denied such problems. The individuals who denied having sleep problems perceived social support to be significantly better than those who reported such problems.
Da Costa et al., 2011 ²⁰⁸	Cross-sectional	Brazil	498	ISES	Items from NHP	The number of supportive ties was associated to better sleep quality, whereas the number of aversive ties was related to poorer sleep. The number of ambivalent ties was unrelated to sleep quality. Depression was found to mediate the link between relationship quality and sleep quality.
Kent et al., 2015 ²⁰⁹	Cross-sectional	USA	175	SRI	PSQI Items from CES-D	

Proulx-Tremblay et al., 2019 ²⁹⁴	Cross-sectional	Canada	72	SSQ6	PSQI	There was a significant association between self-reported diurnal dysfunctions and satisfaction with social support.
Stafford et al., 2017 ²¹⁰	Longitudinal	UK	2,446	Unvalidated measure	PSQI	Greater exposure to positive support and lower exposure to negative support over 15 years were associated with better sleep quality at age 68. Sleep quality was poorer for those who experienced declining positive support or increasing negative support. Those who nominated a spouse or partner as their closest person tended to have better sleep quality than those who nominated another person. Not having felt close to anyone in the last twelve months was related to poorer sleep quality. Chronic exposure to high negative support was most strongly associated with poor sleep.

Table S4a. Summary of studies on sleep and financial difficulties

Authors & year	Type of Study	Country	Sample size (n)	Construct or Exposure measure	Sleep measures	Summary findings
Financial difficulties						
<i>Children Studies</i>						
El-Sheikh et al., 2013 ⁸²	Cross-sectional	USA	276	Economic adversity	Actigraphy Items from SHS	Lower levels of mothers' perceived economic well-being predicted shorter sleep duration and greater variability in sleep onset in children.
Lundahl et al., 2013 ²¹¹	Cross-sectional	USA	122	Parent-reported financial strain	Items from CBCL	Parent-reported financial strain accounted for a significant amount of unique variance in child sleep problems, whereas child-reported worries accounted for a marginally significant amount of unique variance in child sleep problems. Persistent short sleepers came from households with high levels of financial hardship. Financial hardship could reflect lower family SES, which has been implicated in short and poor child sleep.
Magee et al., 2014 ²¹²	Longitudinal	Australia	2,926	Financial hardship	Unvalidated measure	Maternal full-time work was associated with persistent short sleep.
Östberg et al., 2006 ²¹³	Cross-sectional	Sweden	5,390	Economic stress	Unvalidated measure	Economic stress, but not social class, is a significant determinant of psychosomatic symptoms. Having difficulties falling asleep was the most commonly reported symptom weekly.
<i>Adolescents studies</i>						
Bao et al., 2016 ⁸⁹	Cross-sectional	China	997	Family economic hardship	Chinese version of PSQI	Family economic hardship had a direct effect on adolescents' sleep problems and perceived economic discrimination. High levels of perceived economic discrimination predicted sleep problems.
<i>Adults studies</i>						
Allaert et al., 2004 ⁶¹	Cross-sectional	France Germany Italy	2,121	Financial difficulties	Survey	Insomnia especially affects individuals that live alone. Insomnia is often a long-term disorder and is often intermittent rather than constantly present.

UK

Aronsson et al., 2005 ²¹⁴	Cross-sectional	Europe	778	Financial Strain	Item from GHQ-12	For multiple somatic symptoms, the inclusion of sleep disturbances increased explained variance, but this variable did not act as a mediator.
Beck et al., 2010 ⁸⁵	Cross-sectional	France	10 000	Financial difficulties	Unvalidated measure	Individuals feeling in financial difficulty and the unemployed are more likely to suffer from sleep disorders.
Bernal-Solano et al., 2019 ²¹⁵	Cross-sectional	Spain	205	Home foreclosure	Unvalidated measure	The second most prevalent indicator of health deterioration was sleep patterns, commonly associated with mental health symptoms. Financial strain was related to daytime dysfunction and was unrelated to poor sleep quality and sleep quantity. The indirect effect of financial strain on poor sleep quality and daytime dysfunction was significant, while the indirect effect on sleep quantity was not.
Campbell et al., 2015 ²¹⁶	Cross-sectional	Belgium	215	Financial strain	PSQI Item from IDAS	During infancy, financial difficulty and multiple hardships were inversely associated with night sleep. Housing disrepair was inversely associated with total 24-hour sleep. The number of suboptimal sleep practices in infancy is associated with the number of suboptimal sleep practices in toddlerhood. This relationship increased with food insecurity and multiple hardships.
Duh-Leong et al., 2020 ⁹⁰	Longitudinal	USA	451	Material hardship	BISQ	Financial hardship differed based on poor sleep health, including poor sleep quality, short sleep duration, problems falling asleep, problems staying awake in the daytime, and use of sleep medication. High financial hardship was associated with all the sleep health outcomes, with dose-response relationships. Those experiencing medium and high financial hardship were more likely to have problems staying awake.
Duncan et al., 2017 ²¹⁷	Cross-sectional	France	580	Financial hardship	PSQI	

El-Sheikh et al., 2015 ¹²¹	Longitudinal	USA	211	Income-to-needs ratio Perceived economic well-being	Actigraphy PSQI	Lower SES was directly associated with worse sleep. Income-to-needs ratio was the SES variable most robustly associated with multiple sleep parameter.
Griffith, 2015 ²¹⁸	Cross-sectional	USA	4, 567	Financial difficulties	Unvalidated measure	Postdeployment trouble sleeping were associated with increased financial difficulties. Soldiers who reported sleeping problems were twice as likely to report increased financial difficulties as soldiers without such conditions.
Hall et al., 2009 ⁸⁴	Cross-sectional	USA	368	Financial strain	PSQI PSG	Financial strain was a significant correlate of sleep quality and continuity. African American and Caucasian participants who endorsed financial strain had increased subjective sleep complaints and lower sleep efficiency compared to their counterparts who reported no financial strain.
Kalousová et al., 2019 ¹¹¹	Cross-sectional	USA	730	Material hardship	Unvalidated measure	There is no strong evidence of associations between housing instability and sleep. The associations between housing instability, sleep insecurity, and negative sleep outcomes could be explained by other physical and mental health conditions.
Kidwai et Ahmed, 2013 ²¹⁹	Cross-sectional	Pakistan	1,488	Financial problems	Unvalidated measure	The strongest predictor of insomnia was psychological distress followed by health problems, exposure to adverse events and financial problems. Among those who reported insomnia, one out of three persons was taking a sleep aid and the majority was taking benzodiazepines.
Lallukka et al., 2010 ²²⁰	Cross-sectional	Finland	8,960	Economic difficulties	Item from JSQ	Both childhood and current economic difficulties were associated with complaints of insomnia.
Lallukka et al., 2012 ²²¹	Longitudinal	UK Finland	Finnish cohort: 6,328 UK cohort: 5,002	Economic difficulties	Item from JSQ	Persistent frequent economic difficulties were associated with sleep problems. There were similar associations between persistent and increasing difficulties, with sleep problems both among those who did and among those who did not report childhood economic difficulties. Childhood

economic difficulties were reported by around one fifth or one quarter of participants, and only partly overlapped with current economic difficulties.

Meadows & Arber, 2012 ²²²	Longitudinal	UK	4,424 couples	Satisfaction with income	Unvalidated measure	Individuals who are unemployed or retired and those dissatisfied with their income are more likely to have sleep maintenance problems. Women tend to have higher odds of sleep maintenance problems. Among older couples, education and satisfaction with income are associated with greater sleep problems.
Matthews et al., 2019 ⁸⁷	Longitudinal	USA	1,203	Financial stress	Actigraphy Unvalidated measure	Sleep differences between whites and blacks or Hispanics were mediated by health problems and financial hardship. Financial hardship was an important mediator for all sleep characteristics for specific racial/ethnic comparisons and reduced the direct effect to no significance for the Hispanic/white differences in WASO and sleep duration, and for the black/white differences in sleep quality.
Maume et al., 2018 ²²³	Cross-sectional	23 countries in Europe	14,143	Financial stress	Unvalidated measure	Both the average woman and man sleep better when living in gender-equal countries. Having a stressful job was associated with an increase in the log odds of restless sleep, but the positive effect was significant and of similar magnitude for women and men alike.
Mauramo et al. 2012 ²²⁴	Longitudinal	Finland	5,563	Economic difficulties	Unvalidated measure	Childhood economic difficulties, education, occupational class, income and housing tenure were not associated with sleeping pill and sedative medication, whereas women with current economic difficulties showed a higher risk of medication. Men with rented housing had a higher risk of

sleeping pill and sedative medication. Men with frequent current economic difficulties had a lower risk of sleeping pill and sedative medication.

Peltz et al., 2020 ²²⁵	Cross-sectional	USA	792	Financial strain	PSQI	For students who reported higher levels of financial strain, increased work hours were associated with more sleep disturbance.
Perales & Plage, 2017 ¹¹²	Cross-sectional	Australia	9,181	Financial strain	Unvalidated measure	Individuals experiencing material deprivation, a lack of financial prosperity and a worsening in financial circumstances sleep less than those who do not. There are no differences in sleep duration of individuals who qualify as income poor and those who do not.
Slopen & William, 2014 ²²⁶	Cross-sectional	USA	2,983	Financial stress; employment stressors	Unvalidated measure	Higher stressor scores for financial strain, community disadvantage and childhood adversity were associated with shorter sleep duration. For sleep difficulties, everyday discrimination, regardless of attribution, was associated with more sleep problems, whereas major experiences of discrimination were not.
Sonnega et al., 2019 ⁸⁶	Qualitative study	USA	70	Financial strain	Unvalidated measure	When participants talked about reasons for sleep deficits and sleep disparities, economic, safety, and future insecurity were the dominant themes.
Steptoe et al., 2008 ²²⁷	Cross-sectional	UK	736	Financial strain	JSS	Sleep problems were commonly reported by participants experiencing high financial strain.
Warth et al., 2019 ⁸⁸	Cross-sectional	Germany	7,985	Over-indebtedness	Unvalidated measure	Compared to the general population, over-indebted individuals had a higher risk of problems related to sleep onset.
Zheng et al., 2012 ⁹¹	Longitudinal	USA	285	Financial strain	PSG	Characteristics associated with having greater differences in the measures of Night 1 vs. Nights 2 or 3 included financial strain.

Older adult studies

Chen, 2019 ²²⁸	Longitudinal	USA	1,693	Economic hardship	Unvalidated measure	Poverty, both present exposure and for 5 or more years of exposure, was associated with a higher likelihood of long sleep duration and difficulty falling asleep.
Gamaldo et al., 2014 ²²⁹	Longitudinal	USA	450	Financial strain	PSQI	Sleep quality was related to a number of demographics, mental health, and physical health variables. Lower income and current and childhood financial strain were related to worse sleep quality.
Hall et al., 2008 ⁸³	Cross-sectional	USA	75	Financial strain	PSQI PSG	Participants experiencing ongoing financial strain took longer to fall asleep and spent more time awake after sleep onset.

Table S4b. Summary of studies on sleep and job insecurity

Authors & year	Type of Study	Country	Sample size (n)	Type of job insecurity	Sleep measures	Summary findings
Job insecurity						
<i>Adolescents study</i>						
Lee & Park, 2019 ⁹⁸	Longitudinal	Korea	1,228	Employment insecurity	Unvalidated measure	Relatively shorter hours of sleep in all groups exposed to prolonged precarious employment may be attributable to the negative subjective experiences associated with employment insecurity.
<i>Adults studies</i>						
Antillón et al., 2014 ¹¹³	Longitudinal	USA	121,628	Seasonal unemployment	Survey	Higher state unemployment rates are associated with more sleep time, even controlling for the powerful mediating effects of the respondent's own employment status and household income.
Bernhard-Oettel et al., 2019 ²³⁰	Longitudinal	Swedish	9,214	Job insecurity	KSQ	Individuals who experienced more job insecurity than they generally did over time reported lower procedural justice, which was positively associated with sleep difficulties.
Bosmans et al., 2018 ¹²⁰	Longitudinal	Netherlands	560	Employment status post-disaster recovery	Items from Symptom Checklist-90-R	Unemployed residents suffered from sleeping difficulties in the first week post-event, but also in the long term.
Caroli & Godard, 2016 ²³¹	Cross-sectional	22 European countries	4,749	Job insecurity	Unvalidated measure	34% of participants are suffering from overall fatigue and 18% from insomnia or sleep difficulties.
Domenighetti et al., 2000 ²³²	Cross-sectional	Switzerland	2,024	Job insecurity	Unvalidated measure	Sleeplessness was reported by 34.6 % of individuals with a low perceived level of job insecurity, 40.8 % of individuals with a middle perceived level of job insecurity and

						47.9 % of individuals with a high perceived level of job insecurity.
Ferrie et al., 1998 ²³³	Longitudinal	UK	10,308	Job insecurity	Unvalidated measure	At termination only the higher percentage of PSA respondents sleeping 9 or more hours is significant. A significantly greater percentage of PSA men than controls were found to be sleeping 9 or more hours.
Ferrie et al., 1998 ²³⁴	Longitudinal	UK	7,419	Job insecurity	Unvalidated measure	Compared to the control group a significantly greater percentage of men anticipating exposure to agency status were found to be sleeping <5 hrs/ night, while a significantly greater percentage of those exposed to change were found to be sleeping 9 hrs or more.
Greubel & Kecklund, 2011 ¹⁰⁴	Cross-sectional	Switzerland	1,523	Job insecurity	KSQ	Extensive organizational changes had a small negative impact on sleep and sleepiness. Anticipation of organizational changes increased sleep disturbances.
Haynes et al., 2020 ²³⁵	Cross-sectional	USA	191	Unemployment Job insecurity	DSI-SD	Hindrance stressors increased the odds of insomnia above and beyond challenge stressors and other demographics associated with insomnia, including Hispanic ethnicity and lower education level.
Kaspersen et al., 2016 ²³⁶	Longitudinal	Norway	36,249	Time to unemployment	Unvalidated measure	Having insomnia was a factor associated with an increased risk of unemployment.
Khubchandani & Price, 2017 ¹⁰¹	Cross-sectional	USA	17,441	Job insecurity	Unvalidated measure	Individuals who were job insecure had higher odds of: sleeping less than 6 h on an average day and bed days of greater than 2 weeks.
Kim et al., 2020 ¹²²	Longitudinal	South Korean	29,251	Work stress	Unvalidated measure	Sleep duration taken at the baseline was associated with the onset of case-level anxiety. Compared with the average amount of seven to 9 hours of sleep per day, both shorter (≤ 7 hours per day) and longer (> 9 hours per day) sleep durations were not

						efficacious in decreasing incident case-level anxiety symptoms.
Kristiansen et al., 2011 ⁹⁹	Cross-sectional	Scania, Sweden	12,093	Worries about losing their job	Unvalidated measure	With regard to sleep problems not attributed to any external source, independent main effects were found for worries about losing the job.
Lee, Won-Wook et al., 2013 ²³⁷	Cross-sectional	South Korea	7,071	Job insecurity	Unvalidated measure	The permanent employees with moderate or high job insecurity, compared to those with low, both reported having fatigue and sleeping problems.
Magnusson et al., 2020 ²³⁸	Longitudinal	UK	3,917	Job insecurity	JSS	Job insecurity was associated with sleep disturbances and psychological distress, but only psychological distress mediated the relationship between job insecurity and CHD. Approximately 21% of the combined sample reported sleep disturbance in the past 12 months and employment insecurity increased the odds of reporting insomnia or general sleep difficulties in the past 12 months. Each unit increase in employment insecurity elevated the odds of sleep disturbance by approximately 47 %. Employment insecurity was unrelated to sleep disturbance in four European countries: Malta, Poland, Portugal and Romania.
Mai et al., 2019 ²³⁹	Cross-sectional	31 European countries	24,553	Employment insecurity	Unvalidated measure	Precarious working contracts per se do not give rise to sleeping troubles. Rather, working in precarious contracts are associated with subjective feelings of precarity, which in turn is linked to sleep disturbance. Although working in larger firms is uncorrelated with subjective precarity, workers in those firms are more likely to report sleep disturbance. Highly educated workers and those with
Mai et al., 2019 ¹⁰²	Cross-sectional	31 European countries	28,145	Job insecurity	Unvalidated measure	

Matoba et al., 2003 ²⁴⁰	Longitudinal	Japan	263	Unemployment	Unvalidated measure	longer tenures reported lowered levels of subjective precarity, but increased levels of sleep troubles than their respective counterparts. No significant differences were noted in the prevalence rates of good sleep and resting, except for in the female subgroups.
Palmer et al., 2017 ¹⁰⁶	Cross-sectional	England	8,067	Job insecurity	Unvalidated measure	Potential occupational determinants of sleep disturbance included unemployment, shift working, lack of control and support at work, job insecurity, job dissatisfaction and several of its determinants.
Salas-Nicás et al., 2020 ²⁴⁰	Cross-sectional	Spain	1,807	Job loss insecurity Working conditions insecurity	Items from Copenhagen Psychosocial Questionnaire	Salary insecurity is the only perceived job insecurity indicator that was associated with two sleeping problems measures. Recent workforce reduction was associated with three sleeping problems, while having a temporary contract or not having an employment contract were not associated with workers' sleeping problems. Challenge job demands and job insecurity were not related to sleep quality. Even though the direct across-wave relationship between job insecurity and sleep quality was not significant, the lagged pathway from job insecurity at T1 to sleep quality at T3 was significant. The level of perceived job insecurity was low.
Van Laethem et al., 2019 ²⁴²	Longitudinal	Finland	920	Job insecurity	KSQ PSQI	

Virtanen et al., 2008 ¹⁰⁸	Longitudinal	Finland	10,103	Changes in unemployment	Unvalidated measure	The pattern of changes in sleep was similar to that in men, i.e. the upward career stood out as the one with increased sleep duration while decreasing sleep duration was associated with the downward employment trajectory and chronic unemployment.
Virtanen et al., 2011 ²⁴³	Longitudinal	Sweden	1,071	Job insecurity	Unvalidated measure	The steepest increase in suboptimal sleep quality as a result of insecurity was seen among employees not exposed to temporary employment.

Table S4c. Summary of studies on sleep and economic crises

Authors & year	Type of Study	Country	Sample size (n)	Economic measure	Sleep measures	Summary findings
Economic crisis						
<i>Adult Studies</i>						
Ásgeirsdóttir et al., 2013 ¹¹⁵	Longitudinal	Iceland	9,807	Economic crisis of 2008 in Iceland	Unvalidated measure	<p>The crisis reduced certain health-promoting behaviors, but increased others increased like getting the recommended amount of sleep. Recommended sleep increased during the crisis, but reverted back to its pre-crisis level during the recovery</p> <p>Later-midlife cohorts following the Great Recession were more burdened by sleep problems than a cohort of similarly aged individuals prior to the recession. Accumulation of a greater number of economic burdens is significantly associated with a greater level of sleep problems.</p> <p>For both men and women, sleep time decreases when the economy is doing relatively better. A 5 % increase in unemployment rate is associated with three more hours of sleep per week. Total prescriptions for all therapeutic groups (including sleep aids) have increased over the study timeframe. There is a small spike in the number of total prescriptions following September 2008.</p>
Ásgeirsdóttir et al., 2016 ²⁴⁴	Longitudinal	Iceland	9,807	Economic crisis of 2008 in Iceland	Unvalidated measure	
Bierman, 2020 ²⁴⁵	Longitudinal	USA	12,129	Economic burden	Unvalidated measure	
Brochu et al., 2012 ¹¹⁴	Longitudinal	Canada	28,380	Context of recession	Unvalidated measure	
Cascade et al., 2009 ¹¹⁶	Longitudinal	USA	N/A	Economic slowdown in 2008	Unvalidated measure	

Dregan & Armstrong, 2009 ¹¹⁹	Longitudinal	UK	1st wave: 7785 2nd wave: 21,834	Economic downturn	Item from GHQ-30	Unlike many illnesses which may take years to develop, sleep loss through worry is likely to be a fairly immediate response to financial worries – and such sleep loss may in itself be contributory to (as well as being caused by) other illnesses. Fatigue in men and daytime sleepiness and snoring in women remained unchanged during the economic recession. Recession and quality of sleep were associated among Finnish unemployed subjects, most of whom were blue-collar workers. Their self-perceived insomnia and fatigue increased, and they slept worse during than before the recession. The unemployed subjects reported more insomnia than the continuously employed subjects.
Hyypä et al., 1997 ¹⁰⁹	Longitudinal	Finland	1,405	Economic recession in Finland of the 1990's	SHQ	Young men (20-40 years old), female foreign workers and men in permanent contract were more likely to experience sleep problems.
Malard et al., 2017 ¹¹⁸	Longitudinal	France	5,600	2008 economic crisis	Unvalidated measure	Psychosomatic symptoms and insomnia were remembered as extremely common among workers.
Mattei et al., 2015 ²⁴⁶	Qualitative	Italy	8	Economic crisis	Unvalidated measure	Being unemployed predicted higher insomnia. Higher perceived personal impact of the crisis predicted increased insomnia.
Navarro-Carrillo et al., 2019 ¹⁰⁵	Cross-sectional	Spain	442	Perceived Impact of the Economic Crisis	Item from GHQ-28	There was an increase in sleep disturbances and daytime sleepiness among public employees facing job
Nena et al., 2014 ¹¹⁰	Longitudinal	Greece	Phase 1: 226 Phase 2: 224	Greek financial crisis	Greek version of ESS	

Pataka et al., 2013 ¹¹⁷	Longitudinal	Greece	2008: 463 2009: 465 2011: 127	Financial crisis	Unvalidated measure	insecurity three years after the beginning of the financial crisis in Greece. The economic crisis itself may cause depression, anxiety, which may cause sleeping problems or make the existing problems worse. Using a sample of workers from the 2005 and 2010 Canadian General Social Surveys, on average, individuals reacted to increases in wage rates by sleeping less: a ten percent increase in wages led, in 2005, to about a 11–12 min decrease in sleeping per week, and in 2010 to a reduction of 18 min by males (no response by females). The prevalence of sleeping < 6 hours/day increased in both couple and lone mothers from both the manual and non-manual social classes who were in paid employment.
Sedigh et al., 2017 ²⁴⁷	Longitudinal	Canada	2005: 6,455 2010: 4,668	Context of economic growth vs economic recession	Unvalidated measure	
Trujillo-Alemán et al., 2019 ²⁴⁸	Cross-sectional	Spain	2,982	Financial crisis in Spain	Unvalidated measure	

Table 4Sd. Summary of studies on sleep and food insecurity

Authors & year	Type of Study	Country	Sample size (n)	Type of food insecurity	Sleep measures	Summary findings
Food insecurity						
<i>Children Study</i>						
Na et al., 2020 ²⁴⁹	Cross-sectional	USA	362	Food insecurity status	BISQ	There is a lack of association of household and adult food insecurity with child sleep outcomes.
<i>Adolescents studies</i>						
Becerra et al., 2018 ⁹⁵	Cross-sectional	USA	282	Food insecurity	BQ	A higher prevalence of reporting feeling tired, fatigued, or sleepy during daytime was associated with not being able to afford balanced meal compared to those who could.
Robson et al., 2017 ²⁵⁰	Cross-sectional	USA	495,509	Food insecurity	Unvalidated measure	12.8% of the adolescents reported food insecurity, which was significantly associated with insufficient sleep. Most participants (81%) reported sleeping only 5-8 hours each night, less than the recommended hours of sleep for their age group (9 or more hours), but there was no difference by food security status.
Shanafelt et al., 2016 ²⁵¹	Cross-sectional	USA	791	Food insecurity	Unvalidated measure	
<i>Adults studies</i>						
Bigand et al., 2020 ²⁵²	Cross-sectional	USA	207	Food insecurity	PROMIS	Sleep quality did not independently predict food insecurity.
Covington et al., 2019 ⁹⁷	Cross-sectional	USA	130	Household characteristics	BISQ	In low-income families, food, housing, and energy insecurity were all associated with poor sleep outcomes in toddlers
Ding et al., 2015 ²⁵³	Longitudinal	USA	15,961	Food insecurity	Survey	Among women, participants who were very low FS were associated with

El Zein et al., 2019 ⁹³	Cross-sectional	USA	855	Food insecurity	PSQI	sleeping less. Men food insecurity was associated with prolonged sleep latency. Food-insecure students reported poorer sleep quality compared to food-secure students, a finding that remained significant after controlling for sociodemographic correlates of food insecurity.
Grandner et al., 2013 ²⁵⁴	Cross-sectional	USA	4,081	Food insecurity	Unvalidated measure	Lower food security was associated with increased prevalence of all measured sleep symptoms.
Haskett et al., 2020 ²⁵⁵	Cross-sectional	USA	1,330	Food insecurity	Unvalidated measure	Food insecurity in the prior month was associated with fewer hours of sleep compared to students who were food secure. There was a significant dose–response relationship between increasing household food insecurity severity level and poor sleep quality. Sleep quality was associated with all covariates except SES and household size.
Jordan et al., 2016 ²⁵⁶	Cross-sectional	Mexico	11,356	Household food insecurity	Unvalidated measure	Sleep problems could be an important omitted factor and soft drinks may affect child behaviour problems through sleep disruption for food-insecure children.
King, 2017 ²⁵⁷	Cross-sectional	USA	2,829	Food insecurity	Unvalidated measure	Housing insecurity and food insecurity were associated with frequent insufficient sleep among US adults in 12 states.
Liu et al., 2014 ²⁵⁸	Cross-sectional	USA	68,111	Housing insecurity and food insecurity	Unvalidated measure	

Martinez et al., 2019 ²⁵⁹	Cross-sectional	USA	8,705	Food insecurity	Unvalidated measure	Students experiencing food insecurity reported fewer days of sleep sufficiency, which was also related to an increase in BMI and poor overall health. Food insecurity was associated with higher BMI and poor health, while diet quality, physical activity, and sleep sufficiency were important mediators.
Muirhead et al., 2009 ²⁶⁰	Cross-sectional	Canada	1,049	Food insecurity status	Unvalidated measure	A significantly higher percentage of food-insecure persons also reported having their speech, sleep or work adversely affected by their oral health condition.
Nagata et al., 2019 ²⁶¹	Cross-sectional	USA	14,786	Food insecurity status	Unvalidated measure	Food insecurity in young adulthood is associated with sleep outcomes such as trouble falling and staying asleep.
Nanama et al., 2012 ²⁶²	Qualitative study	Burkina Faso	33	Food insecurity status	Interview	Respondents discussed hunger and its physical effects including sleep loss (15 respondents).
Narcisse et al., 2018 ⁹⁴	Cross-sectional	USA	23,058	Food insecurity status	Unvalidated measure	There is a positive association between food insecurity and sleep quality across racial/ethnic groups with obesity.
Plattner et al., 2010 ²⁶³	Cross-sectional	Namibia	10	Shortage of food	Unvalidated measure	The lack of a job and the constant shortage of food caused feelings of helplessness, nagging thoughts, and difficulty to sleep.
Troxel et al., 2019 ⁹²	Longitudinal	USA	785	10-item adult food security survey module	Actigraphy	Higher FI was associated with shorter sleep duration, poorer sleep efficiency, and poorer subjective sleep quality.
Zekeri, 2007 ²⁶⁴	Longitudinal	USA	100	Food insecurity	Items from CESD	In a sample of low SES Female-Headed Families in Five of Alabama's Black Belt Counties, the prevalence of feeling restless was 49.6 %.

Table S5. Summary of studies on sleep and natural disasters

Authors & year	Type of Study	Country	Sample size (n)	Type of Natural disaster	Sleep measures	Summary findings
Natural disasters						
<i>Children Studies</i>						
Deonandan et al., 2019 ²⁶⁵	Cross-sectional	Sri Lanka	63	Tsunami	Reported sleep problems	Older children were more likely to report having sleep problems. Sleep problems were associated with having had a close friend or relative die or become injured in either the war or tsunami. Village-based children were more likely than those in the refugee camps to have sleep problems. The LFSC variables showed significant correlations with the child's degree of emotional upset as judged by the interviewer, and with mother-reported problems in sleep and somatic complaints.
Dollinger et al., 1984 ²⁶⁸	Cross-sectional	USA	38	Lightning-strike	Survey	Sleep-related difficulties, such as nightmares and inability to fall asleep, were one of the main signs of the children's emotional distress resulting from the disaster.
Dollinger et al., 1985 ²⁶⁶	Cross-sectional	USA	38	Lightning-strike	Unvalidated measure	A number of children experienced significant sleep and somatic problems. Any combination type predicted young survivor probable PTSD, with prediction accuracies ranging between 66%-80%. The combination of earthquake experience, everyday functioning, somatic symptoms and
Dollinger et al., 1986 ²⁶⁷	Cross-sectional	USA	38	Lightning-strike	Interview	
Ge et al., 2019 ²⁶⁹	Longitudinal	China	2099	Earthquake	Survey	

sleeping correctly predicted 683 out of 802 cases of probable PTSD.

Mondal et al., 2013 ²⁷⁰	Cross-sectional	India	3154	Earthquake	Reported measures	43 children, aged below 8 years, collectively had symptoms like sleeplessness or nightmares.
Ollendick & Hofmann, 1982 ²⁷¹	Cross-sectional	USA	54	Flood	Unvalidated measure	Children had problems in miscellaneous areas such as sleep difficulty.
Seroka et al., 1986 ²⁷²	Intervention	USA	1459	Tornado	Survey	Both samples have high frequencies for storm fears and sleep-related problems. The junior and senior high students had such cognitive problems as remembering and daydreaming. A number of problems with frequencies over the 20 % threshold level appeared in both the junior high and the senior high survey samples. These problems related primarily to sleep.
Usami et al., 2013 ²⁷³	Cross-sectional	Japan	11 639	Earthquake and Tsunami	Unvalidated measure	Children with house damage and/or evacuation experiences slept for a significantly shorter time than children without these experiences. Sleep duration was related with gender, school grade, house damage, evacuation experience.

Adolescents studies

Brown et al., 2011 ²⁷⁴	Cross-sectional and Longitudinal	New Orleans	202	Hurricane Katrina	Unvalidated measure	There is a cross-sectional relationship between sleep disturbance and fear of sleeping alone with PTS symptom severity. Longitudinal analysis indicated that general sleep disturbance at 24 months (T1) was predictive of
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Author(s) and Year	Study Design	Country	Sample Size	Event	Outcome Measure	Findings
Fan et al., 2017 ²⁷⁵	Longitudinal	China	1573	Earthquake	PSQI	<p>PTS symptoms severity at 30 months (T2).</p> <p>The response rates for the major outcome measures across all waves of follow-up were acceptable: > 65% for depression and sleep problems. Twelve months after the earthquake, 48.90% of participants reported sleeping less than 7 hours per night, 27.68% disclosed difficulties initiating sleep, 8.82% experienced problems staying sleep, 22.60% felt their sleep quality was poor, and 40.01% had difficulties functioning during daytime hours. Sleep problems were stable from 18 months to 30 months following the earthquake.</p> <p>There was a bidirectional relationship between sleep problems and anxiety symptoms. Short sleep duration predicted symptoms of PD, GAD, and ScP, and was predicted by GAD; difficulty falling asleep predicted GAD symptoms, whereas PD symptoms increased difficulty falling asleep; poor sleep quality predicted ScP symptoms and was predicted by symptoms of GAD and ScP; difficulty maintaining sleep was not associated with any subtype of anxiety symptoms in any direction; SAD and SP were not associated with any specific sleep problems in any direction.</p>
Geng et al., 2013 ²⁷⁶	Longitudinal	China	1573	Earthquake	PSQI	
Geng et al., 2018 ²⁷⁷	Longitudinal	China	1573	Earthquake	PSQI	

Hardin et al., 1992 ²⁷⁸	Longitudinal	USA	195	Hurricane Hugo	Unvalidated measure	Among the five most frequently identified negative coping strategies was sleeping. It is noteworthy that students identified sleeping as both a positive and a negative coping strategy.
Hayashi et al., 2020 ²⁷⁹	Cross-sectional	Japan	2808	Earthquake	Unvalidated measure	Psychological distress was correlated with poor sleep satisfaction due to the earthquake and Fukushima Daiichi nuclear accident. On the 20-month survey, weekday sleep duration was shorter and sleep-wake pattern delayed in children who had experienced home damage
Iwadare et al., 2014 ²⁸⁰	Longitudinal	Japan	1919	Earthquake and Tsunami	Unvalidated measure	compared to children with no such experience. Children who had experienced bereavement reported a shorter mean sleep duration on the 20-month survey compared to children reporting no bereavement experience. The daily prevalence of insomnia increased among both adults and minors in Tokyo after the Great East Japan Earthquake.
Sugiura et al., 2013 ²⁸¹	Longitudinal	Japan	5053	Earthquake	Survey	More than a quarter of the sample showed sleep problems of some kind, with 23.1% sleeping fewer than 7 h per night, 32.5% having difficulty falling asleep, 24.2% having difficulty remaining asleep, 25.3% having poor sleep quality, 17.4% having nightmares and 44.6% having difficulty functioning during daytime hours. Older participants were at higher risk of sleep issues than younger children.
Tang et al., 2018 ²⁸²	Longitudinal	China	6132	Earthquake	PSQI	

Tang et al., 2018 ²⁸³	Cross-sectional	China	5563	Earthquake	PSQI	SI was found to be prevalent among young survivors of the Ya'an earthquake in China, and SI was more prevalent among survivors who were girls, older and only-children. Multiple sleep problems were associated with SI frequency, including poor sleep quality, shorter sleep duration, trouble falling asleep, nightmares and daytime dysfunction.
Zhou et al., 2014 ²⁸⁴	Longitudinal	China	350	Earthquake	Child Behavior Problems Questionnaire	Hyperarousal symptoms was found to have a significant effect on sleep problems from 1 year to 1.5 years but not from 1.5 years to 2 years after the earthquake.
Zhou et al., 2017 ²⁸⁵	Longitudinal	China	591	Earthquake	Survey	Trauma exposure, fear, and PTSD 1 year after the earthquake each had a stable relationship with sleep problems 1 year and 1.5 years after trauma. This indicated that the association between trauma exposure and sleep problems was stable over time between 1 year and 1.5 years after earthquake.

Adults studies

Abrahams et al., 1976 ²⁸⁶	Longitudinal	Australia	1202	Flood	Interview	The consumption of sleeping tablets and psychotropic drugs rose.
Adeola, 2009 ²⁸⁷	Longitudinal	USA	1510	Hurricane Katrina	Survey	African Americans had higher levels of psychosocial problems including trouble sleeping than their White counterparts.

Bayleyegn et al., 2006 ²⁸⁸	Cross-sectional	USA	593	Hurricane Ivan	Interview	Common findings in both counties included post-hurricane sleep disturbances. Responders sleeping 5 or fewer hours per night on average were 4 times more likely to report seeking medical treatment from an injury related to a slip, trip or fall; 3 times more likely to report seeking medical treatment for exposure to a chemical; and 2 times more likely to report seeking medical treatment for exposure to flood waters, for sun burn, and for heat stress.
Bergan et al., 2015 ²⁸⁹	Cross-sectional	USA	2695	Hurricane Katrina and Rita	Survey	Seven responders reported problems with intrusive thoughts that disrupted their sleep, difficulty either going to sleep or staying asleep, or having night terrors or disturbing dreams for a short period of time after they returned from their tour of duty.
Clukey, 2010 ²⁹⁰	Longitudinal	USA	8	Hurricane Katrina and Rita	Survey	Correlations were found between local food concerns, sleep difficulties with higher EE, with more women than men concerned about local food contamination due to radiation effects.
Fujitani et al., 2016 ²⁹¹	Cross-sectional	Japan	34	Earthquake and Fukushima nuclear radiation disaster	GHQ	The most common short-term effect they reported was the inability to sleep. During Charley, management sent out all of the staff to all available shelters and there was no backup, which made it almost impossible to sleep or even rest with all the people in there.
Geisz-Everson et al., 2012 ²⁹²	Longitudinal	USA	10	Hurricane Katrina	Interview	
Mash et al., 2013 ²⁹³	Cross-sectional	USA	4323	Hurricane	Unvalidated measure	

Hicks et al., 1991 ²⁹⁴	Cross-sectional	USA	72	Earthquake	Survey	Short-sleepers were more assertive and self-controlled than long-sleepers.
Hlodversdottir et al., 2016 ²⁹⁵	Longitudinal	South Iceland	1096	Volcanic eruption	Survey	The exposed participants in 2013 were more likely to experience insomnia, sleep difficulties and having two or more physical symptoms, compared with 2010.
Hong et al., 2017 ²⁹⁶	Cross-sectional	Korea	600	Typhoon	Survey	Sleeping disorders were identified in 6.8% surveyed in Paju and 17.4% in Jeju. Sleeping disorders were frequently identified in both Paju and Jeju following the 2 typhoons.
Khazaie et al., 2019 ²⁹⁷	Cross-sectional	Iran	778	Earthquake	PSQI ISI	About 4% of the sample had a very poor sleep quality and severe insomnia, over 100% belonged to the cluster of poor sleep quality and moderate insomnia, and over 22% had a relatively poor sleep quality and mild insomnia.
Khazaie et al., 2019 ²⁹⁸	Cross-sectional	Iran	999	Earthquake	PSQI ISI DBAS	Issues such as physical injury caused by the disaster, house demolition, and job loss contribute to sleep problems and severity of insomnia.
Konno et al., 2013 ²⁹⁹	Longitudinal	Japan	2016	Earthquake and Tsunami	Unvalidated measure	Sleep quality was poorer in the general population.
Kwanbunjan et al., 2006 ³⁰⁰	Cross-sectional	Thailand	250	Tsunami	Survey	Complaints of health problems increased after the disaster, including sleep disturbances. Suppressed emotional needs manifested as physical symptoms, such as sleeplessness.
Kwasnik et al., 2020 ³⁰¹	Intervention	USA	117	Hurricane Irma	Survey	42 % reported sleepiness.

Labarda & Chan, 2018 ³⁰²	Cross-sectional	Philippines	223 and 138	Typhoon	PSQI ISI	Insomnia was associated with both posttraumatic stress and general psychological distress, whereas sleep quality was associated with posttraumatic stress, but not with general psychological distress. Approximately 18 months after the storm, the prevalence rates for insomnia were reported at 36.3%. Over half of the survivors reported poor overall sleep quality.
Labra et al., 2017 ³⁰³	Longitudinal	Chile	18	Earthquake	Interview	The problem most frequently reported was sleep disorders. There was a significant increase of sleep problems pertaining to insomnia. The most frequent complaints were difficulty with sleep induction, awakenings during the night, and sleepiness during the day.
Lazaratou et al., 2018 ³⁰⁴	Cross-sectional	Greece	170	Earthquake	AIS	Higher STAI, CES-D, and IES-R scores were associated with greater likelihood of having insomnia six months after the earthquake.
Matsumoto et al., 2015 ⁷⁹	Cross-sectional	Japan	2593	Earthquake	Unvalidated measure	The prevalence of prolonged sleep difficulties observed was much lower than in previous studies. More than 43% reported sleep problems at some point in the previous 2 weeks and 13.9% reported sleep problems on more than half of the days in the past 2 weeks.
McKibben et al., 2010 ³⁰⁵	Cross-sectional	USA	4323	Hurricane	Unvalidated measure	Those with sleep disturbance were 5.91 times more likely to report 7 days of impaired/limited day-to-day function in the past month.

Mellman et al., 1995 ³⁰⁶	Longitudinal	USA	54	Hurricane Andrew	PSQI PSG	Subjective sleep complaints are common after a natural disaster and are most prominent among those with psychiatric morbidity.
Messias & Lacy, 2007 ³⁰⁷	Cross-sectional	USA	93	Hurricane Katrina	Interview	Latino survivors and evacuees have a higher prevalence of sleep disturbances and somatization. SS prevalence was calculated as the proportion of those having any of 8 predetermined symptoms including back pain, neck stiffness, sleep difficulty, dizziness, heart palpitations, poor appetite, or stomachache. SS prevalence was 29.1%.
Midorikawa-Inomata et al., 2020 ³⁰⁸	Cross-sectional	Japan	2593	Earthquake and Tsunami	Survey	When nCPAP device users are forced to sleep without using the device, they are likely to inflict adverse effects on evacuees sleeping within their vicinity, particularly by their snoring, leading them to become hyper vigilant to their surroundings, which further decreases the quality of their sleep.
Mito et al., 2013 ³⁰⁹	Cross-sectional	Japan	1047	Earthquake and Tsunami	Unvalidated measure	In both sexes, PRs decreased remarkably after adjustments for satisfaction of sleep and participation in recreation and community activity.
Nagai et al., 2017 ³¹⁰	Cross-sectional	Japan	33 350	Earthquake	Unvalidated measure	Insomnia showed early significant improvement.
Ohta et al., 2003 ³¹¹	Longitudinal	Japan	248	Volcanic eruption	Unvalidated measure	Post-disaster newly-started drinking was significantly associated with being male, less than 65 years old, sleep dissatisfaction and psychological distress.
Orui et al., 2017 ³¹²	Longitudinal	Japan	66 501	Earthquake	Survey	

Pagel et al., 1995 ³¹³	Cross-sectional	Hawai	265	Hurricane Iniki	Unvalidated measure	Women reported a significantly higher level of stress association with dreaming.
Pistoia et al., 2018 ³¹⁴	Intervention	Italy	107	Earthquake	ISI	There was a general increase of a tendency toward sleep problems in earthquake victims. All sleep complaints except for awakenings during the night and final awakening, were statistically more frequent in subjects with PTSD.
Psarros et al., 2017 ³¹⁵	Cross-sectional	Greece	92	Wildfire	AIS	Awakenings after sleep onset, were more frequent in participants with PTSD. The awakenings did not differ significantly from subjects not suffering from PTSD. Female gender, PTSD, older age, and ‘fear of imminent death’, were independently associated with insomnia.
Krakow et al., 2004 ³¹⁶	Cross-sectional	New Mexico	78	Cerro Grande Fire	DDNSI ISI FOSQ Sleep breathing tests	A large portion of individuals with sleep complaints met minimum diagnostic criteria for chronic nightmare disorder, psychophysiological insomnia, and sleep-disordered breathing. Posttraumatic sleep disturbances in treatment-seeking fire evacuees were characterized by a profile that matched the conventional diagnosis of “psychiatric insomnia.”

Psarros et al., 2015 ³¹⁷	Cross-sectional	Greece	92	Wildfire	AIS	<p>All sleep complaints except for awakening during the night and final awakening were more frequent in subjects with PTSD. The percentage of nightmares reported was significantly greater in patients with PTSD compared to participants with no PTSD, but the awakenings did not differ significantly from patients not suffering from PTSD. Surveillance information showing an increase in new prescriptions for sleep-aids dispensed among females in High River was disseminated widely to health care workers through professional networks and the media. Sleep deprivation was the most frequent diagnosis. Women of middle age or older with sleep deprivation were more than twice the number of men of the same age. People with sleep deprivation before the disaster might be included, but the first day of diagnosis peaked at 31 on Day 14.</p> <p>Cyclones had numerous psychosocial impacts on the population including sleep disorder.</p> <p>Poor sleep is a potential modifiable risk factor for challenges with psychological functioning in context of a tropical storm.</p> <p>Disturbed sleep decreased significantly in all participants after a 1 week yoga camp for tsunami survivors.</p>
Sahni et al., 2016 ³¹⁸	Longitudinal	Canada	Estimated total of 100,000 people	Flood	Unvalidated measure	
Suda et al., 2019 ³¹⁹	Cross-sectional	Japan	10 464	Earthquake and tsunami	Survey	
Tasdik et al., 2020 ³²⁰	Cross-sectional	Bangladesh	20	Climate Risk	Unvalidated measure	
Tavernier et al., 2019 ³²¹	Cross-sectional	Caribbean island of Dominica	174	Tropical storm Erika	Survey MEQ	
Telles et al., 2007 ³²²	Intervention	India	47	Tsunami	VAS	

Tempesta et al., 2012 ³²³	Longitudinal	Italy	3574	Earthquake	PSQI	<p>Even after a period of two years, people exposed to a catastrophic disaster continue to suffer from a reduced sleep quality. Sleep quality deterioration was more pronounced in the elderly. Participants in both groups showed significant improvements in stress-related symptoms, including sleep. Survivors presented with increased risk of PTSD hyperarousal symptoms, sleep-related problems, PTSD-related sleep disturbances compared to the unexposed group.</p> <p>Characteristics of disaster work, e.g. low quality of sleep, may be an important contributor to PTSD symptoms and subjective health complaints in volunteers.</p> <p>The majority of the sample said that they experienced sleep disorders, with insomnia and nightmares being the most prominent causes. Although sleep disorders did not differ between married and unmarried subjects, the former had significantly more nightmares. All age groups experienced the same sleep problems.</p> <p>Sleep quality was related to the time course of perceived stress as measured at many time points beginning before Ike through 1 y after. Good sleepers fared considerably better than poor sleepers.</p>
Thordardottir et al., 2014 ³²⁴	Intervention	South Iceland	66	Earthquake	IQL	
Thordardottir et al., 2015 ³²⁵	Cross-sectional	Iceland	643	Avalanche	PSQI-A	
Thormar et al., 2014 ³²⁶	Longitudinal	Indonesia	506	Earthquake	SCL-90R	
Varela et al., 2008 ³²⁷	Cross-sectional	Greece	305	Earthquake	Survey	
Wu et al., 2015 ³²⁸	Longitudinal	USA	296	Hurricane Ike	PSQI	

Yokoyama et al., 2014 ³²⁹	Cross-sectional	Japan	1 640	Earthquake	Survey	The factor that most strongly influenced subjective well-being, low mood, worsened sleep state, and intense fatigue was work hours per day at the dispatch destination.
Yoshida et al., 2016 ³³⁰	Cross-sectional	Japan	542	Earthquake	Survey	The proportion of residents who expressed satisfaction with their sleep patterns and health among people with K6 score above the cutoff was lower than among people with K6 score below the cut-off.
Zhang et al., 2020 ³³¹	Cross-sectional	Japan	56 774	Earthquake	Japanese version AIS-SJ	Participants who experienced unemployment and a decreased income had a higher PR of sleep dissatisfaction.
Zhen et al., 2018 ³³²	Cross-sectional	China	187	Flood	Unvalidated measure	The flood victims' traumatic exposure could lead to sleep problems by increasing their feelings of fear.

Older adults studies

Inoue & Yamaoka, 2017 ³³³	Longitudinal	Japan	879	Earthquake and Tsunami	Survey	Health problems were more likely to be present among the elderly population. One dimension of social support, having emotional support, was associated with a lower prevalence of health problems. Elderly people who have persons who listen attentively to their concerns or follow them up closely might experience less concerns and have easier access to appropriate health services. Receiving long-term care services was positively associated with having health problems.
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Ishiki et al., 2016 ³³⁴	Longitudinal	Japan	2 149	Earthquake	Unvalidated measure	<p>K6 and AIS scores improved based on the comparison between the data at 24 and 42 months. The effects and influence of the disaster on the survivors is quite different and varied. Financial hardship predicted higher risks of short sleep duration, sleep insufficiency, poor sleep quality, and insomnia symptoms. Home destruction was associated with more sleep medication use. Health care disruption was linked to poor sleep quality. Social support in the form of instrumental support was linked to lower risks of all sleep problems whereas emotional support was tied to lower risk of poor sleep quality. The material impacts of damage caused by the disaster (financial hardship, home destruction, and health care disruption) emerged as salient predictors of sustained sleep problems.</p> <p>The prevalence of sleep difficulties was 15.0%. Females, those who lived on public livelihood assistance, those who did not have anyone to whom to report an emergency, and those who did not have interaction with neighbors were more likely to report sleep difficulties. Sleep was believed to recover as a result of decreased aftershocks, reduced disruption in the environment including basic infrastructure, and increased sleep pressure caused by poor sleep quality during the first night.</p>
Li et al., 2018 ³³⁵	Longitudinal	Japan	3 547	Earthquake and Tsunami	Unvalidated measure	
Matsumoto et al., 2014 ³³⁶	Cross-sectional	Japan	4 176	Earthquake and Tsunami	Survey	
Mizuno & Okamoto-Mizuno, 2014 ³³⁷	Longitudinal	Japan	8	Earthquake	Actigraphy Sleep logs Unvalidated measure	

Sompom et al., 2012 ³³⁸	Cross-sectional	Thailand	237	Flood	Survey	Sleep disturbance is common and has been reported among elderly people. Approximately more than half of the elderly participants reported having sleep disturbance due to frequent visits to the bathroom among their roommates and feeling of numbness and pain during their sleep.
Tachibana et al., 2014 ³³⁹	Longitudinal	Japan	1731	Earthquake	Survey	Presence of psychological impact immediately after the earthquake and decrease in sleep hours were associated with higher scores on the K10.
Wu et al., 2015 ³⁴⁰	Cross-sectional	China	1183	Flood	Survey	Older age, singlehood, poor sleep patterns, chronic diseases, being hospitalized in the past year, living alone, being female and being sick in the past two weeks were significantly associated with poor HRQoL.
Yabe et al., 2018 ³⁴¹	Longitudinal	Japan	2 295	Earthquake	AIS	Improvements in sleep disturbance could prevent the onset of LBP. Continuing sleep disturbances were significantly associated with the continuation of LBP.

Table S6. Summary of studies on sleep and terrorist attacks

Authors & year	Type of Study	Country	Sample size (n)	Type of Terrorism	Sleep measures	Summary findings
<i>Children Studies</i>						
Klein et al., 2009 ³⁴²	Cross-sectional	USA	104	September 11 attacks	Parents reported child behavioral and emotional responses	Sleep changes were frequent, on September 11th and after, at times causing great disruption to families' lives, but also allowing parents to make and carry out plans on that day when infants and toddlers slept unexpectedly for hours.
<i>Adolescents Studies</i>						
Grønli et al., 2017 ³⁴³	Cross-sectional	Norway	42	Mass shooting	Actigraphy BIS ESS Reported symptoms of OSA Survey	The prevalence of insomnia, excessive daytime sleepiness, symptoms of obstructive sleep apnea, and frequent nightmares, were all higher in the survivors than in the controls.
Mijanovich et al., 2010 ³⁴⁴	Cross-sectional	USA	1998-1999 : N = 5282 2001-2002 : N = 5120	September 11 attacks	Survey	Pre-sleep worry among adolescents remained elevated for many months after the event relative to pre-disaster levels, though pre sleep worry steadily declined over the 6 months following September 11. These elevated levels of pre-sleep worry occurred in the context of familial, school, and neighborhood environments of youth that were significantly more supportive in

important respects relative to the pre-9/11 survey period.

Adults studies

Adams et al., 2004 ³⁴⁵	Cross-sectional	USA	1762	September 11 attacks	Survey	Reporting sleep problems was significantly associated with receipt of formal help.
Applewhite & Dickins, 1997 ³⁴⁶	Cross-sectional + intervention	USA	52	Car-bomb explosion	Reported psychosocial disturbances.	Sleep disturbance was reported by 19% of the sample.
Bleich et al., 2015 ³⁴⁷	Longitudinal	Israel	444	Terrorist attacks in Israel	Reported by participants	There was a tendency toward more sleeplessness.
Bulkeley & Kagan, 2018 ³⁴⁸	Cross-sectional	USA	21	September 11 attacks	Unvalidated measure	The 9/11 attacks affected what they dreamed about, but not the way they dreamed.
Cyhlarova et al., 2020 ³⁴⁹	Cross-sectional	Tunisia Paris Brussels	529	2015–2016 terrorist attacks in Tunisia, Paris and Brussels	Survey	Nine respondents reported sleep problems, nightmares and flashbacks. Thirteen people were prescribed sleep and/or antidepressant medication. Overall PTSD symptoms during the day predicted shorter subjective sleep duration and worse sleep quality that night. For sleep duration, this appears to be largely driven by daytime numbing.
Dietch et al., 2019 ³⁵⁰	Longitudinal	USA	202	September 11 attacks	Unvalidated measure	Women, younger adults, non-whites, Hispanics, persons reporting being unemployed or disabled, depression, or at least one day in the past month of worry, poor physical or mental health, or not getting enough sleep
Ford et al., 2006 ³⁵¹	Cross-sectional	USA	4640	September 11 attacks	Interview	

						were at risk for reporting 9/11-related psychological problems.
Fortenbaugh et al., 2020 ³⁵²	Longitudinal	USA	397	September 11 attacks	PSQI	A positive history of mTBI was highly associated with current sleep disorders and pain, with only 1.5% of veterans with a history of mTBI not reporting concurrent issues with sleep or pain.
Giosan et al., 2015 ³⁵³	Cross-sectional	USA	2453	September 11 attacks	Unvalidated measure	Sleep disturbance severity was significantly higher amongst individuals with PTSD. Insomnia was associated with both traditional and social media use. Associations between social media and insomnia were independent of traditional media use. Media use in the immediate aftermath of attacks was significantly associated with insomnia a month after the event. Particular types of social media were more strongly associated with insomnia than traditional media formats.
Goodwin et al., 2018 ³⁵⁴	Cross-sectional	France	1878	November 2015 Paris attacks	Bergen insomnia scale	13 % (n = 8) experienced sleep disturbance. Descriptors: Reports of intrusive dreams, nightmares, sleep disturbance. 13 % reported sleep disturbance upon return from New York City.
Kinsel & Thomasgard, 2008 ³⁵⁵	Longitudinal	USA	61	September 11 attacks	Reported	Female respondents reported more frequent monthly nightmares than did male respondents. An increase in nightmare frequency was
Nielsen et al., 2006 ³⁵⁶	Longitudinal	Canada	23 990	September 11 attacks	Estimation of the numbers of dreams and nightmares recalled in a typical month	

						observed post-September 11 only for male respondents.
Smith et al., 2019 ³⁵⁷	Cross-sectional	USA	54	September 11 attacks	Reported in the interviews	Research participants reported a range of long-term psychosocial issues including posttraumatic stress disorder (PTSD), anxiety, depression, insomnia, relationship breakdowns and impact on family support systems, and addictive and risk-taking behaviors.
Smith et al., 2019 ³⁵⁸	Cross-sectional	USA	54	September 11 attacks	Reported in the interviews	Participants highlight the importance of developing good sleeping habits. Psychological distress and general sleep-related experiences were correlated in a positive direction. Both sleep-related experiences and psychological distress were significantly correlated with baseline levels of themselves over a three-year lag. Those who were exposed through media, and were distressed by it, had elevated levels of general sleep experiences following this distress.
Soffer-Dudek & Shahar, 2010 ³⁵⁹	Longitudinal	Israel	91	Operation Oferet Yetzuka	ISES	GSEs were related to dissociative experiences and to poor sleep quality, over and above nocturnal awakenings due to alarms. In the context of exposure to terrorism, GSEs are related to poor sleep quality.
Soffer-Dudek et al., 2016 ³⁶⁰	Longitudinal	Israel	53	Operation Oferet Yetzuka	ISES PSQI	

Stein et al., 2004 ³⁶¹	Longitudinal	USA	395	September 11 attacks	Survey	<p>Adults with persistent distress were most likely to report that as a result of terrorism they had used alcohol, medications, or drugs to relax, sleep, or feel better in the month before the Wave 2 interview.</p> <p>Altogether 267 of 281 survivors reported contact with health services at T2, including 254 with ≥ 1 types of primary care services; and 192 with mental health services. Mental health service utilization was associated with female gender, injuries, PTSD, mental distress, somatic symptoms, and sleep problems. PTSD was a stronger determinant of subjective sleep complaints than self-reported blast exposure. Prior blast exposure or TBI alone, in the absence of current chronic concussive symptoms, does not adversely affect sleep quality, insomnia, disruptive sleep disturbances, or objective sleep measures beyond the effects of PTSD. Neither blast exposure nor PTSD was associated with detectable changes in objective measures of sleep continuity and NREM sleep. REM fragmentation was the only REM sleep parameter that differed across the four groups of veterans.</p>
Stene & Dyb, 2015 ³⁶²	Longitudinal	Norway	281	Terrorist attacks in Norway.	Interview	
Stocker et al., 2016 ³⁶³	Intervention	USA	71	September 11 attacks	PSG ISI PSQI PSQI-A ESS	

Table S6. Summary of studies on sleep and acute war events

Authors & year	Type of Study	Country	Sample size (n)	Type of War	Sleep measures	Summary findings
<i>Children Studies</i>						
Barath, 2002 ³⁶⁴	Cross-sectional	Kosovo	813 School-age children 41 Parents 31 Teachers	Ethnic conflict in former Yugoslavia in 1999	SCSI	18% of participants experienced sleeplessness (18%).
Lavie et al., 1993 ³⁶⁵	Longitudinal	Israel	First study : 61 Second study : 55	Scud missile attacks during the Gulf War	Unvalidated measure Actigraphy	Comparison of sleep quality measures obtained during the War with those of age- and sex-matched children monitored a year before the war did not reveal any significant differences apart from the immediate response to the attack. Practical, Narrative, and Social Dreams could fill a protective function, as war trauma did not negatively impact psychosocial well-being among children who reported these dreams. The TRT was not able to increase more beneficial or reduce dysfunctional dream characteristics.
Qouta et al., 2016 ³⁶⁶	Longitudinal	Gaza	257	Gaza War	Dream characteristics	
<i>Adults studies</i>						
Aloni et al., 2019 ³⁶⁷	Longitudinal	Israel	200	Yom Kippur War	Unvalidated measure	Interpersonal trauma was shown to be a unique experience resulting in sleep disruptions over time, leading to cognitive impairment. This highlights the importance of viewing trauma survivors at high-risk for sleep disruptions. The longitudinal effects of sleep disruptions were directly related to cognitive impairment but not to telomeres.

Askenasy & Lewin, 1996 ³⁶⁸	Longitudinal	Israel	1045	Gulf War	Survey	In the first survey, subject distribution according to sleep quality was 49% (normal), 38% (acute insomniacs) and 13% (chronic insomniacs). Acute insomniacs were further subdivided in accordance with the quality of their insomnia: mild, moderate or severe. The number of self-reported normal sleepers had increased significantly; the major improvement occurred in the subgroup of severe insomnia.
Ben-Zur & Zeidner, 1991 ³⁶⁹	Cross-sectional	Israel	500	Missile attack during the "Desert Storm" operation in the Gulf War	PSSA	Ss in the crisis sample showed higher insomnia levels than did a norm group of students tested during normal times.
Kashani et al., 2010 ³⁷⁰	Cross-sectional	USA	270	War time	Actigraphy PSQI ESS Unvalidated measure	Stress levels were dramatically elevated in this nurse population. This is underscored by the low amount of time spent on themselves per week and the few hours of sleep obtained at night. Nurses reported an average of 5.5 hours of sleep/night, 8.8 h/wk taken for self, and 3.8 h/wk for exercise. Actigraphy data showed an average of 6.0 hours of sleep/night.
Kim, 2017 ³⁷¹	Longitudinal	Korea	2230	Korean War	Survey	Depression, loneliness, and sleep disorder are closely related and fear is a different type of emotion related to essential brain development periods. Significant differences between patients and controls were found in REM
Lavie et al., 1979 ³⁷²	Longitudinal	Israel	11	1973 Yom Kippur War	PSG	latency, REM percentage and length of the third REM period. Total sleep time was shorter and sleep efficiency indices

Lobel et al., 1993 ³⁷³	Cross-sectional	Israel	66	Gulf war	WRQ	<p>lower in patients than in controls. The hypnograms demonstrate the different types of sleep disturbances and indicate that most mid-sleep awakenings in patient 10 clustered around REM periods or at expected times of REM periods. A similar temporal pattern of mid-sleep awakenings was observed in patient 11.</p> <p>Those who usually use emotion-oriented coping most frequently, experienced sleep disturbances. Combat exposure is associated with particular aspects of insomnia, namely waking several times, trouble staying asleep and the composite sleep score. 41% of those who had been to Iraq or Afghanistan reported sleep problems. Those who had initially reported any insomnia had significantly higher overall scores for PTSD severity at follow-up than did service members without such a complaint. Insomnia is a particularly frequent, severe, and persistent complaint in service members returning from deployment. 97% of combat veterans with PTSD report nightmares. The frequency of nightmares and sleep disturbances increases with trauma and PTSD severity in this population. 81% of those with non-combat related PTSD reported nightmares; and 84% of those with trauma exposure but no PTSD reported nightmares.</p>
McCarren et al., 1994 ³⁷⁴	Cross-sectional	Vietnam	2825	Military service in Vietnam, Laos, or Cambodia	JSS	
McLay et al., 2010 ³⁷⁵	Longitudinal	USA	1887	Military deployments to Iraq and Afghanistan	Unvalidated measure	
Shore et al., 2009 ³⁷⁶	Longitudinal	Vietnam	305	Vietnam war	M-PTSD	

Table S7. Summary of studies on sleep and anthropogenic disasters

Authors & year	Type of Study	Country	Sample size (n)	Type of anthropogenic disasters	Sleep measures	Summary findings
<i>Children Studies</i>						
Dirkzwager et al., 2006 ³⁷⁶	Longitudinal	The Netherlands	4486	Societal hazards (Fireworks depot explosion)	ICPC	Children who experienced the disaster at a younger age presented more sleep and social problems compared with their controls.
Itagaki et al., 2018 ³⁷⁷	Longitudinal	Japan	13 272	Hazardous materials Radioactive materials (Nuclear disaster)	Fukushima Health Management Survey	Shorter sleep time was associated with a higher risk of mental health in 4-6-year-olds. Oversleeping was associated with a high risk of mental health in 7-15-year-olds.
<i>Adolescents studies</i>						
Jeon et al., 2018 ³⁷⁸	Longitudinal	Korea	75	Transportation -- Sea travel Ferry accident	AIS	Female adolescents tend to share feelings of loss after trauma with family, friends, and therapists, and think highly of recommendations from these resources. Male adolescents tend to think that their mental health is a function of their will or attitude, and rarely express their feelings. Even though the male adolescent subjects' resilience significantly decreased at months 6 and 12 compared to month 1, they reported that their posttraumatic stress symptoms had improved. All symptoms decreased to their lowest level at month 1 (subacute phase), lower than on day 2 (acute phase), then increased again at months 6 and

12 (chronic phase). During this period, the survivors were protected from secondary trauma by preventing exposure to media, funerals, and memorial ceremonies, which minimized their acute stress responses, abnormal grief reactions, and guilty feelings.

Lee et al., 2018 ³⁷⁹	Cross-sectional	South Korea	21	Transportation -- Sea travel (Sewol Ferry Disaster)	Reported in the interviews	The psychiatric symptoms reported by the subjects during the interview included insomnia and nightmares.
<i>Adults studies</i>						
Adler, 1943 ³⁸⁰	Longitudinal	USA	46	Societal hazards (Cocoanut Grove fire disaster)	Reported insomnia	Nightmares occurred in one third of the patients while they were in the hospital, but nightmares persisting after discharge occurred only in patients with anxiety neurosis. Residents whose households were directly affected by flooding were more likely to report poor sleep quality. It was observed that renters, as opposed to home owners, were almost 3 times more likely to suffer from sleep problems and symptoms of probable PTSD.
Alderman et al., 2013 ³⁸¹	Cross-sectional	Australia	960	Societal hazards (The Brisbane river flood)	GSQS	The most frequently reported post-traumatic stress symptoms included trouble falling or staying asleep. Respondents reported overall high severity of depressive symptoms, insomnia symptoms and trauma-related sleep disturbances, as well as
Belleville et al., 2019 ³⁸²	Cross-sectional	Canada	379 (55 were interviewed)	Societal hazards (Wildfires)	ISI PSQI PSQI-A	

						poor sleep quality. Significant factors associated with post-traumatic stress symptom severity included trauma-related sleep disturbances and insomnia symptoms.
Grievink et al., 2017 ³⁸³	Longitudinal	The Netherlands	1567	Societal hazards (Fireworks depot explosion)	GSKS	The prevalence of severe sleeping problems decreased from 3 weeks to 18 months after the disaster for the affected residents. Residents whose house was completely destroyed by the disaster responded more strongly to SLEs reported 18–20 months following the disaster than residents who reported less extreme disaster exposure. These differences in stress responsiveness were not apparent almost 4 years following the disaster. Sleeping problems were included in important perpetuating factors for physical symptoms among survivors and mediated the association between traumatic stress and physical symptoms.
Smid et al., 2012 ³⁸⁴	Longitudinal	The Netherlands	1076	Societal hazards (Fireworks depot explosion)	SCL-90-R	Compared with reference values in the general Dutch population, high scores were found for sleeping problems. Subjective health symptoms were present nearly twice as often and severe sleep problems about three times as often among participants as
Van den Berg et al., 2008 ³⁸⁵	Longitudinal	The Netherlands	1567	Societal hazards (Fireworks depot explosion)	GSKS	
Van Kamp et al., 2006 ³⁸⁶	Longitudinal	The Netherlands	3792	Societal hazards (Fireworks depot explosion)	GSKS	

De Soir et al., 2015 ³⁸⁷	Longitudinal	Belgium	T1: 1027 T2: 579	Societal hazard (Ghislenghien disaster (July 30th, 2004) Gaz explosion)	Survey	<p>in the reference population. More than 50% reported symptoms of serious sleeping problems. People who experienced a shocking event reported more sleep symptoms and used more tranquilizers.</p> <p>The direct witnesses who had seen human damage had significantly higher prevalence rates of sleeping disturbances both at T1 and T2.</p> <p>All disaster-related experiences were associated with insomnia, except death of a family member or colleague. Most of these types of traumatic exposure were associated with the risk of insomnia in a time-independent way. Social discrimination/slurs was associated with all three types of insomnia and was also influenced by other experiences, such as life-threatening danger, property loss, and colleague death.</p> <p>Among cleanup workers, arrival at Chernobyl in 1986 (vs. later) was associated with sleep problems, somatization, and symptoms of agoraphobia. 24 years after the Chernobyl accident, cleanup workers from Estonia experienced higher levels of emotional distress (as manifested by trouble sleeping and fatigue) than unexposed men of the same age.</p>
Ikeda et al., 2019 ³⁸⁸	Longitudinal	Japan	1403	Hazardous materials Radioactive materials (Nuclear disaster)	AIS	
Laidra et al., 2015 ³⁸⁹	Cross-sectional	Ukraine (Chernobyl)	1320	Hazardous materials Radioactive materials (Nuclear disaster)	EST-Q2	

Oe et al., 2016 390	Longitudinal	Japan	12 371	Hazardous materials Radioactive materials (The Fukushima Daiichi Nuclear Power Plant accident)	Unvalidated measure	The overall proportion of subjective sleep insufficiency was 35.8%. The proportions of subjective sleep insufficiency were 16.7% in the resistant group, 32.7% in the mild distress group, 48.8% in the moderate distress group and 64.6% in the severe distress group. Subjective sleep insufficiency were associated with psychological distress trajectories. The crash generated a major impact on the passengers' sleeping habits. Thirty-five of the passengers experienced difficulty sleeping for up to one month after the crash. The very first night many had problems falling asleep due to pain or other difficulties, such as shortness of breath. Disturbed sleep due to waking up often or very early because of discomfort was a negative effect that stretched past the first couple of days. Reliving the crash through sleep was common. A great variety of dreams were described: violent, strange and diverse nightmares as well as flashbacks to the crash. Family and relatives were often portrayed in dreams, sometimes causing passengers to wake up crying.
Doohan & Saveman, 2014 391	Cross-sectional	Sweden	56	Transportation -- Road (Major bus crash)	Reported in the interviews	
Dooley & Gunn, 1995 392	Cross-sectional	Belgium	75	Transportation -- Sea travel (Ferry Herald of Free Enterprise)	Unvalidated measure	The commonest symptoms suffered were sleep disturbance, loss of concentration and increased anger.

capsized and partly sank)

Jang et al., 2017 393	Intervention	Korea	109	Transportation -- Sea travel (Sewol ferry sank into the southern coast of South Korea)	ISI PSG	Within the BF, beta power was significantly lower in individuals with high insomnia than those with low insomnia. The differences in beta activity were significant between the normal sleep and the severe insomnia group. Frontal beta activity decreased continuously with increasing symptom severity in the four sub-groups of insomnia. Significant correlations in the BF were presented between PTSD symptom severity scores and insomnia severity scores, PTSD and complicated grief scores and insomnia score and frontal beta power.
Lee et al., 2017 394	Cross-sectional	South Korea	16	Transportation -- Sea travel (Sinking)	Survey	More than half of teachers reported sleep disturbances. Recurrent distressing dreams/nightmares were reported in 18% of participants. Subjective sleep quality assessed within 2 months of rescue and clean-up work at the crash site predicted several physical health outcomes.
Irish et al., 2013 395	Longitudinal	USA	159	Transportation -- Aviation (Plane crash)	PSQI	Subjective sleep quality complaints in the immediate aftermath of trauma and at 1-year follow-up did not significantly affect NK cell number or function.

Johannesson et al., 2006 ³⁹⁶	Cross-sectional	Italie and Sweden	184 Italian and 63 Swedish	Transportation – Aviation (Milano/Linate Plane crash)	Survey	Within the Italian population, it was more common to use medication for sleeping problems, a pattern that was similar both in the acute phase and 18 months later. The most severe symptoms reported by the subjects were extreme fatigue, non-restorative sleep, concentration-problems, memory-problems, and muscle and joint pains.
Van Hoof et al., 2003 ³⁹⁷	Cross-sectional	Amsterdam	19	Transportation -- Aviation	Unvalidated measure	
Raphael et al., 1984 ³⁹⁸ .	Longitudinal	Australia	95	Transportation -- Rail (Granville rail disaster)	Survey	Specific questioning about problems in the month after the disaster showed that about 25 % had symptoms of anxiety, depression, and insomnia which they considered more than usual.

Appendix 3: Supplementary References

Supplementary References

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