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Sleep of healthcare workers during the COVID-19 pandemic and the role of atypical work schedules: a scoping review

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Abstract

The COVID-19 pandemic has negatively impacted the well-being of healthcare workers (HCWs). HCWs are highly exposed to shift work and their work schedules have been subject to increasing unpredictability since the start of the pandemic. This review aims to: 1) map the studies providing information about factors associated with sleep characteristics in HCWs working in the context of the COVID-19 pandemic during the first and second waves and 2) examine the state of the evidence base in terms of the availability of information on the influence of atypical work schedules. A literature search was performed in PubMed. Studies containing information about factors (demographic; psychological; occupational; COVID-19-specific; work schedule; lifestyle, medical, or other) associated with various sleep characteristics among HCWs working in the context of the COVID-19 pandemic were included. Particular attention was paid to the availability of information on the role of atypical work schedules on HCW sleep. Fifty-seven articles met the inclusion criteria. Most studies were reports of quantitative cross-sectional surveys using self-report measures. Associations between female sex, frontline HCW status, psychological factors, and poorer sleep were observed. Six studies included a measure of shift work in their analyses, five of which reported an association between shift work status and sleep. A wide range of factors were

investigated, with female sex, frontline HCW status, and psychological factors repeatedly demonstrating associations with poorer sleep. Sleep was predominantly measured in terms of self-reported sleep quality or insomnia symptoms. Few studies investigated the influence of atypical work schedules on HCW sleep in the context of the COVID-19 pandemic. Research on this topic is lacking in terms of reliable and consistent measurements of sleep outcomes, longitudinal data, as well as knowledge about the influence of covariates such atypical work schedules, comorbidity, and medical history on HCW sleep.

1. Introduction

One of the occupational groups whose members experience very high levels of sleep problems are healthcare workers (HCWs). Prior to the COVID-19 pandemic, an estimated 42.7% of healthcare support workers and 38.1% of healthcare practitioners and technical workers reported short sleep duration, compared with 36.5% in the general population (Shockey and Wheaton, 2017). The incidence of sleep disorders was also elevated, with reported estimates of 3.3% prevalence among HCWs compared with 1.6% for the general population (Kim et al., 2018). Since onset of the COVID-19 pandemic, this situation seems to have further deteriorated (Pappa et al., 2021). In a meta-analysis, Cénat et al. (Cénat et al., 2020) reported a significantly higher prevalence of insomnia symptoms in HCWs [k = 6, 36.52, 95% CI (32.99 - 40.20)] relative to the general population [k = 8, 16.45, 95% CI (8.39 - 29.74)], (z = 2.69, $p < 0.05$). The estimated pooled prevalence rates for sleep problems among HCWs has ranged from 36 to 45% (Muller et al., 2020; Pappa et al., 2020; Jahrami et al., 2021b; Xia et al., 2021). This is of concern, as sleep-related impairment may affect the ability of HCWs to perform critical tasks related to patient care (Trockel et al., 2020).

Atypical work schedules refer to a range of irregular work schedule configurations including overtime and shift work (Barthe et al., 2011). Working shifts

that impose non-standard sleep/wake times may cause shorter duration of sleep, sleep fragmentation, and sleepiness due to a conflict between the required sleep-wake cycle and the individual's endogenous circadian system (Boivin et al., 2012; Wright Jr et al., 2013; Boivin and Boudreau, 2014). HCWs are one of the groups with the highest exposure to shift work, with estimates as high as 40% in the European Union and 35% in Canada (Rydz et al., 2020; Vanttola et al., 2020). HCWs have experienced considerable changes to their work schedules since the start of the COVID-19 pandemic including longer hours, more shift work, and general alterations in staff scheduling to minimize interactions between different staff members (Walton et al., 2020; Hoedl et al., 2021; Mehta et al., 2021). Studies have demonstrated that sleep loss results in more occupational injuries (e.g. injuries sustained while moving patients) and errors (e.g. medication administration) among HCWs working atypical shifts than those working regular shifts (Rogers et al., 2004; Caruso and Hitchcock, 2010; Weaver et al., 2015; Booker et al., 2018). Shift work status is thus a key factor to consider when examining sleep characteristics for HCWs in the context of the COVID-19 pandemic.

In the wake of the COVID-19 pandemic, much research on sleep problems in HCWs has rapidly emerged. Previous studies have quantified the prevalence of sleep problems and provided important summaries of risk factors for poorer sleep among

HCWs such as frontline HCW status and lack of social support (Bhat and Chokroverty, 2021; Pappa et al., 2021). Yet no previous review has systematically synthesized the risk factors associated with sleep problems in health care workers. More specifically, the extent to which existing research studies account for the role of atypical work schedules in determining the associations between potential risk factors and sleep characteristics remains to be seen. Thus, the first aim of this scoping review was to assess the extent and nature of the research investigating factors associated with sleep characteristics in HCWs working in the context of the COVID-19 pandemic. The second aim of the review was to closely examine these studies based on the state of existing knowledge about the potential impact of atypical work schedules on sleep among HCWs.

2. Material and methods

This scoping review followed the methodological framework for scoping reviews (Arksey and O'Malley, 2005) and the organization of the manuscript was guided by the PRISMA Extension for Scoping Reviews (PRISMA-ScR) checklist (Tricco et al., 2018) (see Appendix 1). Scoping review methodology was used as the most suitable method for reviewing a large body of heterogeneous literature not amenable to a more precise systematic review. The project was approved by the research ethics boards of the Douglas Mental Health University Institute and that of the funding agency.

2.1. Search strategy

A keyword search was conducted on February 12, 2021, using PubMed, and updated soon after, on February 26, 2021. The search strategy was developed and categorized around three concepts, 'COVID-19', 'health care worker', and 'sleep'. Variations for each key word were combined with the 'OR' operation to maximize results, for example, 'SARS-CoV-2', 'frontline health worker', 'insomnia'. Search terms are presented in greater detail in appendix 2.

2.2. Eligibility criteria

Eligibility criteria for the selection of articles in the present review included original research studies published in English or French that reported on factors associated with sleep among HCWs who were working in the context of the COVID-19 pandemic. Only studies in which data collection took place during either the first or second waves of infection, were included. In the present review the first wave referred to the period from February 1st, 2020 to July 31st, 2020; and the second wave referred to the period from August 1st 2020 to February 26th, 2021. (Looi, 2020; Vahidy et al., 2020; Fan et al., 2021; Iftimie et al., 2021; Saito et al., 2021). No geographic restrictions were imposed.

Both quantitative and qualitative studies were considered. The studies of interest included samples of HCWs over 18 years of age where the majority of participants were in direct contact with persons seeking healthcare. Only studies that reported on factors potentially influencing sleep among HCWs, defined in terms of a series of characteristics including poor sleep quality, symptoms of insomnia, increased sleep latency (difficulty initiating sleep), and sleep problems or sleep dysfunction/disturbances/disruptions, were included in the present review. Studies that were measuring factors associated with burnout or fatigue only (not sleep) were excluded from the review.

Studies reporting quantitative data were required to demonstrate a statistical relationship between the factor being tested and a measure of sleep. Where qualitative data were reported, the influence of the factor on sleep had to be clearly identifiable. Study protocols or feasibility studies were not included. Articles were excluded if they were theses or dissertations, did not provide an abstract, conference presentations, or books or book chapters. Review articles were not included in the current synthesis, although the reference lists of review articles whose topic was closely related to that of the present review were screened for titles that may not have been captured by the keyword search.

2.3. Screening procedure

After removal of duplicates, the PubMed search generated a total of 417 results. The reference lists of all relevant review articles were then screened, and a further 12 records retrieved, producing a total of 429 records for review. A calibration exercise was conducted before title and abstract screening in order to refine the eligibility criteria. Two raters (NP and MF) separately evaluated the titles and abstracts of ten studies for inclusion or exclusion. Inter-rater agreement was then compared. This process was repeated until sufficient inter-rater agreement was achieved (80%). At this point, the article titles and abstracts were screened for eligibility according to the established inclusion criteria. Disagreements were resolved by discussion and, where necessary, a third party (DBB) was consulted. For articles meeting the inclusion criteria, the full texts were retrieved, resulting in a total of 125 articles for full-text review. The same calibration exercise that was conducted before title and abstract screening was conducted prior to beginning full text screening. The full text screening resulted in a total of 57 articles for the final synthesis. A flow chart detailing the study selection process is provided in Figure 1 (below).

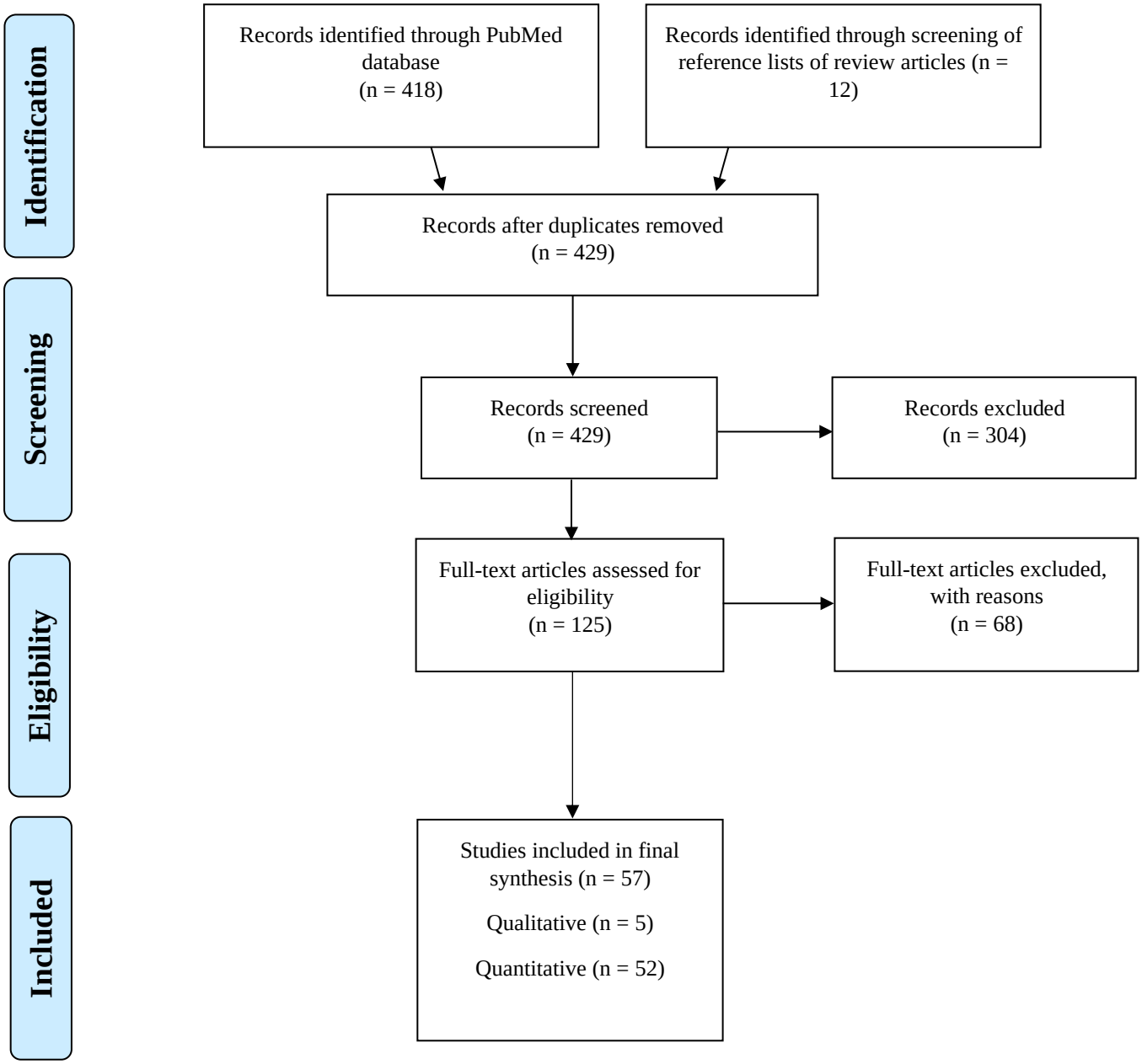

Figure 1 Flow diagram of database searches and study selection illustrating factors associated with sleep

2.4. Data extraction

A data extraction sheet was developed that included: author(s), year, journal, article title, study objectives, country, participants/setting, data collection period, method, data analysis, factors measured, and main findings. All factors whose association with sleep was investigated across studies were categorized as: demographic; psychological; occupational; COVID-19-specific; work schedule; and lifestyle, medical, other. These categories were developed in consultation with the research team. For studies, particularly qualitative studies that did not explicitly describe data according to one of these categories, influencing factors were abstracted by the first author and assigned to a category. A calibration exercise was conducted to ensure sufficient inter-rater agreement (80%) on the designation of certain concepts to each category.

3. Results

3.1 Description of study samples and contexts

Fifty-seven studies (52 quantitative and five qualitative), met the inclusion criteria. All quantitative studies were descriptive in nature and consisted of cross-sectional surveys except for a single study where sleep was measured at baseline and at one-month follow-up using the PSQI (Zhao et al., 2020). In four of the five qualitative studies, data were

collected using semi-structured interviews carried out either in person, or virtually (e.g., using Skype) (Cui et al., 2020; Sun et al., 2020b; Whelehan et al., 2021b; Yıldırım et al., 2021a), whereas one study did not describe how the data were collected (Fan et al., 2020b). Some proportion of the sample in all studies included workers in direct contact with COVID-19 patients, although the exact percentage of individuals who were working under these conditions was not always specified. Some study samples consisted of nurses/physicians only. Other studies conducted investigations of sleep in specific samples such as anesthesiologists (Jain et al., 2020b) or non-consultant hospital doctors working in a surgery department (Whelehan et al., 2021a). Some studies comprised a mixture of several different types of HCWs (e.g., doctors, pharmacists, paramedics, emergency department attendants, medical technicians) (Al Ammari et al., 2020; Giardino et al., 2020b; Gupta et al., 2020b; Khanal et al., 2020a; Que et al., 2020a; Robles et al., 2020a; Sagaon-Teyssier et al., 2020a; Sharma et al., 2020; Van Roekel et al., 2020a; Wang et al., 2020a; Zhang et al., 2020a; He et al., 2021; Huffman et al., 2021). Twenty-three of the 57 studies took place in China, twelve of which occurred in the context of emergency department setting at the outbreak of the virus. Data collection for all studies took place in 2020. The most recent data collection period was between July and October 2020 (Abdellah et al., 2021) .

3.2. Measurement of sleep characteristics

Most studies used self-report instruments to measure sleep in terms of insomnia symptoms and/or sleep quality. As expected, there was heterogeneity in the measures of sleep utilized across studies. The Insomnia Severity Index (ISI) was the sleep measure most frequently adopted (Morin et al., 2011), followed by the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989). Other measures of sleep included the Visual Analogue Sleep Scale (Snyder-Halpern and Verran, 1987; Verran and Snyder-Halpern, 1988) and the Athens Insomnia Scale (AIS) (Soldatos et al., 2003). A full list of instruments and sleep measures with corresponding cut-off scores (where specified) is presented in Table 1.

Measures of sleep	Authors	Presentation of cut-off score for insomnia or poor sleep (where provided)
Insomnia Severity Index (Morin et al., 2011)	Al Ammari et al. (Al Ammari et al., 2020)	Insomnia ≥ 8
	Cai et al. (Cai et al., 2020a)	Insomnia ≥ 10
	Cai et al. (Cai et al., 2020b)	Insomnia ≥ 8
	Elkholy et al. (Elkholy et al., 2020b)	Insomnia ≥ 8
	Giardino et al. (Giardino et al., 2020a)	Insomnia ≥ 8
	Gu et al. (Gu et al., 2020)	Insomnia ≥ 8
	Herrero San Martin et al. (San Martin et al., 2020)	Insomnia ≥ 9
	Jain et al. (Jain et al., 2020b)	Insomnia ≥ 8
	Khanal et al. (Khanal et al., 2020a)	Insomnia ≥ 8
	Lai et al. (Lai et al., 2020b)	Insomnia ≥ 8
	Manh Than et al. (Than et al., 2020)	Insomnia ≥ 15
	Que et al. (Que et al., 2020a)	Insomnia ≥ 15
	Sagaon-Teyssier et al.(Sagaon-Teyssier et al., 2020b)	n/s
	Sahin et al. (Şahin et al., 2020b)	Insomnia ≥ 8
	Sharma et al. (Sharma et al., 2020)	n/s
	Wańkowicz et al. (Wańkowicz et al., 2020a)	Insomnia ≥ 8

	Wang et al. (Wang et al., 2020a)	Insomnia ≥ 8
	Yang et al. (Yang et al., 2021)	Insomnia ≥ 8
	Zhang et al. (Zhang et al., 2020a)	Insomnia ≥ 8
	Zhang et al. (Zhang et al., 2020c)	Insomnia ≥ 8
	Zhou et al. (Zhou et al., 2020a)	Insomnia ≥ 8
Pittsburgh Sleep Quality Index (Buysse et al., 1989)	Abdellah et al. (Abdellah et al., 2021)	Poor sleep quality > 5
	Giardino et al. (Giardino et al., 2020b)	Poor sleep quality > 5
	He et al. (He et al., 2020)	Sleep disturbance > 7
	Herrero San Martin et al. (Herrero San Martin et al., 2020)	Poor sleep quality > 7
	Huang et al. (Huang et al., 2020b)	n/s
	Jaharami et al. (Jahrami et al., 2021a)	Poor sleep quality ≥ 5
	Korkmaz et al. (Korkmaz et al., 2020b)	Sleep disturbance > 5
	Olagunju et al. (Olagunju et al., 2021a)	Poor sleep quality > 5
	Saracoglu et al. (Saracoglu et al., 2020a)	n/s
	Simonetti et al. (Simonetti et al., 2021b)	n/s
	Stojanov et al. (Stojanov et al., 2021)	n/s

	Tu et al. (Tu et al., 2020b)	Poor sleep quality ≥ 7
	Wang et al. (Wang et al., 2020d)	Sleep disturbance > 7
	Xiao et al. (Xiao et al., 2020)	n/s
	Yi et al. (Yi et al., 2020b)	Poor sleep quality ≥ 5
	Zhang et al. (Zhang et al., 2021)	n/s
	Zhao et al. (Zhao et al., 2020)	Poor sleep quality > 5
	Zhou et al.(Zhou et al., 2020b)	Poor sleep quality ≥ 7
Visual Analogue Sleep Scale (Snyder-Halpern and Verran, 1987; Verran and Snyder-Halpern, 1988)	Karabulut et al. (Karabulut et al., 2021a)	n/s
Athens Insomnia Scale (Soldatos et al., 2003)	Diomidous et al.(Diomidous, 2020)	n/s
	Shen et al. (Shen et al., 2021b)	Insomnia ≥ 4
	Tselebis et al. (Tselebis et al., 2020a)	No insomnia < 6
	Zhan et al. (Zhan et al., 2020b)	No insomnia < 6
Research Diagnostic Criteria (RDC) for insomnia disorder (Edinger et al., 2004)	McCall et al. (McCall et al., 2021)	Insomnia diagnosed if there was: 1) adequate sleep opportunity <u>and</u> 2) ≥ 1 of the following: problems falling asleep, or staying asleep, or waking too early, or poor quality sleep <u>and</u> 3) ≥ 1 of the following:

		fatigue, attention/memory problems, social/vocational problems, mood problems, daytime sleepiness, problems with motivation or energy, accident proneness, headaches/GI symptoms, worries about sleep Chronic insomnia if above criteria are met ≥ 1 month
Hamilton Rating Scale (Ramos-Brieva and Cordero-Villafafila, 1988)	Herrero San Martin et al. (San Martin et al., 2020)	n/s
Two-item version of the Sleep Condition Indicator (SCI-02) (Luik et al., 2019)	Barua et al. (Barua et al., 2020)	Insomnia: ≤ 2
The Jenkins Sleep Scale (Jenkins et al., 1988)	Diomidous et al. (Diomidous, 2020)	n/s
Sleep Quality Scale (SQS) single item measure of sleep quality (Snyder et al., 2018)	Gupta et al. (Gupta et al., 2020b) Khamis et al. (Khamis et al., 2020a)	Poor sleep ≤ 3 n/s
Subscales of Sleep-50 Questionnaire addressing diagnostic criteria for sleep disorders (Spoormaker et al., 2005)	Diomidous et al. (Diomidous, 2020)	n/s
Employee well-being measure for sleep problems (Adriaenssens et al., 2012)	Van Roekel et al. (van Roekel et al., 2020b)	n/s
Self-Rating Sleeping Situation Scaling (SRSS) (Li, 2000)	Yang et al. (Yang et al., 2021)	Sleep disorder ≥ 23
Other	Arafa et al. (Arafa et al., 2021)	"Inadequate sleeping" < 6 h/day n/s

	Huffman et al.(Huffman et al., 2020)	
	Robles et al. (Robles et al., 2020b)	n/s

Table 1 Measures of sleep characteristics adopted in included studies

In studies that used the ISI, scores were presented in a variety of ways. Most frequently, a global score ranging from 0-28 was interpreted using the following criteria: ISI scores of 0–7 indicating absence of insomnia, 8–14 indicating sub-threshold insomnia symptoms, 15–21 indicating moderate insomnia, and 22–28 indicating severe insomnia. In studies that used the PSQI, the cut-off score for poor sleep varied from > 5 to > 7, with one study using >10 as the cut-off (Zheng et al., 2021b).

3.2. Factors associated with sleep

A wide range of variables were measured in terms of their association with the sleep of HCWs. An overview of the included articles as well as a summary of the factors in each study for which a relationship with a sleep characteristic was measured using a test of association (correlation or regression analysis) is presented in Table 2 (below). Female sex, psychological factors, and job position were the factors that demonstrated the most prominent associations with sleep characteristics across studies. These specific results are reported in greater detail in this section.

Qualitative

Author	Design	Data collection (time period)	Country and setting	Type of healthcare worker (n)	Factors	Mention of atypical work schedules (✓/✗)
Cui et al. (Cui et al., 2020)	Content analysis	Semi-structured face to face interviews (Apr-May 2020)	China, Hubei Hospitals	Nurses recruited from hospitals in Jiangsu province who voluntarily travelled to Hubei to provide support (n = 12)	A-typical work schedules Checking notifications on phone about COVID-19 news, fear of missing notifications about COVID-19	✓
Fan et al. (Fan et al., 2020a)	Thematic analysis	Interview (n/s)	China	Nurses (n = 44), transdisciplinary and non-transdisciplinary	Heavy workload, lack of training	✗
Sun et al. (Sun et al., 2020a)	Colaizzi's phenomenological method	Interview, face-to-face or telephone interviews (Jan-Feb 2020)	China Hospital	Nurses (frontline) (n = 20)	Psychological pressure Long hours, workload Extra tasks related to COVID (training, information reporting, disinfection, and isolation) Lack of time to sleep	✗

Whelehan et al. (Whelehan et al., 2021a)	Thematic analysis	Semi-structured interviews (Mar- May 2020)	Ireland Department of surgery tertiary hospital	Non-consultant hospital doctors (n = 14)	Work load, new rota work models Dehydration related to PPE, focus on COVID-19	✗
Yildrim et al. (Yıldırım et al., 2021b)	Phenomenological analysis	Semi-structured interviews via Skype (May-Aug 2020)	Turkey hospitals and COVID-19 units	Nurses (n = 21)	Long shifts	✗

Quantitative

Author	Design	Data collection (time period) and sleep measure	Country and setting	Type of healthcare worker (n)	Factors	Adjustment for atypical work schedules (✓/✗)
Abdellah et al. (Abdellah et al., 2021)	Univariate, multivariate	Cross-sectional survey (Jul-Oct 2020) PSQI	Egypt and Saudi Arabia Medical centres	Doctors (n = 344)	Sex, age, marital status Anxiety features*, depression features* Work hours COVID-19 history	✗

Al Ammari et al. (Al Ammari et al., 2020)	Multivariate analysis	Cross-sectional web-based survey (May-Jun 2020) ISI	Saudi Arabia, Health centres	HCWS (n = 720), doctors, nurses, pharmacists	Sex, age Work experience*, work position*	✗
Arafa et al. (Arafa et al., 2021)	Univariate and multivariate	Cross-sectional, questionnaire (Apr 2020) Average daily sleeping hours (< 6, 6-9, or > 9 h/day) <6 h/day was "inadequate sleeping"	Egypt & Saudi Arabia Hospitals	HCWS (n = 426), doctors, nurses, other	Sex, age, country Living with older adults*, emotional support from family*, emotional support from society *, emotional support from hospital* Work position, department; work experience Working hours*, emergency shifts, night shifts* Consumption of COVID news (≥ 2 p/day)*	✓
Barua et al. (Barua et al., 2020)	Univariate and multivariate	Cross-sectional, online questionnaire	Bangladesh Clinical settings	Frontline doctors (n = 370)	Sex Asthmatic status*	✓

		(Apr-May 2020) Two-item version of the Sleep Condition Indicator (SCI-02)			Workplace resources*, place of work Shifting duty* Living in COVID-19 infected area*	
Cai et al. (Cai et al., 2020a)	Univariate and multivariate	Cross sectional case control, online questionnaire (Feb 2020) ISI	China Hospitals	HCWs doctors, nurses, medical technicians, respiratory therapists, emergency room attendants (n = 2,346), frontline (n = 1173) and non-frontline (n = 1173)	Work position*	✗
Cai et al. (Cai et al., 2020b)	Univariate and multivariate	Cross-sectional case control, online questionnaire (Feb 2020) ISI	China Hospital	Nurses (n = 1,330), frontline, non-frontline, Fangcang shelter hospital workers	Sex, age, marital status, living situation Uncertainty of fighting against pandemic* Work position*, work experience, adequate cohabitants with suspicious symptoms, PPE, sufficient protection conditions and confidence Change in physical	✗

					condition*, value of online psychological information*	
Diomidous et al. (Diomidous, 2020)	Correlational	Cross-sectional, questionnaire (Feb- Apr 2020) The Jenkins sleep Scale; Athens Insomnia Scale; Sub scales of Sleep-50-Questionnaire investigating sleep disorders according to diagnostic parameters of DSM-IV	Greece, Athens Public hospitals	Doctors and nurses (n = 204)	Physical activity	✗
Elkholy et al. (Elkholy et al., 2020a)	Univariate and multivariate	Cross sectional survey (Apr-May 2020) ISI	Egypt Hospitals	Doctors, nurses, non-specialized nurses (n = 502)	Age*	✗

Giardino et al. (Giardino et al., 2020b)	Univariate and multivariate	Cross-sectional online survey (June 2020) PSQI, ISI	Argentina	Doctors, trainee doctors, nurses, and other (technicians, phlebotomists etc.) (n = 1059)	Age*, sex*, living status Work sector, work position*, workplace location Contact w COVID patients* Sleep medication (pre pandemic)*, sleep medication (post pandemic)*	✗
Gu et al. (Gu et al., 2020)	Univariate and multivariate	Cross-sectional online survey (February 2020) ISI	China Fangcang shelter hospitals (set up specially to treat COVID patients)	Doctors and nurses (n = 522), Fangcang shelter hospital workers	Work position*, work experience*	✗
Gupta et al. (Gupta et al., 2020b)	Univariate, multivariate & correlation	Cross-sectional online survey (May 2020) Single-item sleep quality scale (SQS)	India Public and private hospitals	Doctors, nurses, dentists, paramedic staff (n = 368)	Age, sex, marital status, education Anxiety* Work position PPE availability	✗

He et al. (He et al., 2021)	Univariate, multivariate, correlational	Cross-sectional web based survey (Feb – May 2020) PSQI	China	Doctors, nurses, public health doctors, health related administrators (n = 403)	Perceived effect of COVID-19 on daily life*, expressions of concern through social media* Consumption of COVID-19 news*, worried about spreading COVID-19 to family members, family members' concern about being infected, possibility of being cured when infected	✗
Herrero San Martin et al. (San Martin et al., 2020)	Univariate & multivariate	Hospital based questionnaire (Mar-Apr 2020) ISI, PSQI	Spain, Madrid Hospital	Doctors, nurses, nursing assistants, porters, cleaning staff (n = 100)	Age* Work position Shift work*	✗
Huang et al. (Huang et al., 2020b)	Univariate & multivariate	Online questionnaire (n/s) PSQI	China Fangcang hospitals	Nurses in (n = 966), Fangcang shelter hospital workers	Sex Stress perception* Work experience*, no. of patients* Family's support* Patient's trust*	✗
Jaharami et al.	Univariate & multivariate	Cross-sectional	Bahrain	Frontline and non-frontline,	Age, sex, marital status	✗

(Jahrami et al., 2021a)		online survey (Apr-Jul 2020) PSQI		doctors, nurses, and allied healthcare professionals (n = 257)	Work position	
Jain et al. (Jain et al., 2020b)	Univariate and multivariate	Cross-sectional (May 2020) ISI	India Hospital	Anaesthesiologists (n = 512)	Age, sex, marital status Loneliness, anxiety Work position, salary deduction Increased work hours* COVID related stress, fear of COVID-19, family exposure risk, availability of PPE, exposure to COVID-19 Food and accommodation issues	✗
Karabulut et al. (Karabulut et al., 2021a)	Univariate and correlation	Cross-sectional (Apr-Jul 2020) Visual analogue sleep scale	Turkey Hospital	Healthcare professionals working in intensive care units (n = 210)	Perceived stress, state anxiety*, trait anxiety	✗
Khamis et al. (Khamis et al., 2020a)	Univariate & multivariate	Cross-sectional, web-based survey (Apr 2020)	Oman Range of health care facilities	Doctors & nurses from several health care facilities, including primary health centres, polyclinics, and	Anxiety*, stress*, well-being*	✗

		Sleep quality scale		secondary and tertiary care hospitals (n = 402)		
Khanal et al. (Khanal et al., 2020a)	Univariate & multivariate	Cross-sectional, online questionnaire (Apr-May 2020) ISI	Nepal A range of health facilities	Nurses, doctors, pharmacists, diagnostic personnel, paramedics and public health practitioners (n = 475)	Age, ethnicity (Janajati)*, education History of medication Work position, work experience* Working overtime Stigma about COVID-19 Affected district, awareness about government incentive	✗
Korkmaz et al. (Korkmaz et al., 2020a)	Correlational	Cross-sectional, psychiatric interviews (n/s) PSQI	Turkey Outpatient clinics or emergency departments	Nurses, assistant healthcare staff, and doctors (n = 140)	Age Problem-solving skills*, anxiety* Quality of life	✗
Lai et al. (Lai et al., 2020a)	Univariate & multivariate	Cross-sectional, hospital based survey (Jan-Feb 2020) ISI	China, Hubei Hospitals	Nurses and doctors (n = 1830)	Work position*	✗

Liu et al. (Liu et al., 2020)	Correlation, univariate, multivariate	Cross-sectional, online questionnaire (Feb – Mar 2020) ISI	China	Nurses, doctors, medical technicians (n = 606)	Sex, age*, marital status, education degree*, annual income Somatic disease Resilience, strength*, hardiness* Work position, working hours p/d*	✗
Manh Than et al. (Than et al., 2020)	Univariate, multivariate	Cross-sectional survey (Mar-Apr 2020) ISI	Vietnam Hospitals	Nurses, doctors, technicians, pharmacists (n = 173)	Age Work experience* Designated COVID-19 hospital, concern contracting COVID at work*, concerns about infection prevention control (IPC) at hospital*, concerned about long-term quarantine/serving at the hospital*	✗
McCall et al. (McCall et al., 2021)	Univariate	Cross-sectional survey by email (May 2020) Research Diagnostic	U.S.A., Georgia Hospitals and clinics	Practicing doctors, advance practice providers, medical residents, and nurses (n = 573)	Sex, age* Pre-COVID-19 insomnia disorder status Work position, amount of	✓

		Criteria for insomnia disorder			training, increase in workload, clinical work load hours* Shift work Exposure to COVID-19 Insomnia before COVID-19	
Olagunju et al. (Olagunju et al., 2021b)	Correlation	Cross-sectional questionnaire (June – Aug 2020) PSQI	Nigeria Hospital	Healthcare workers (permanent staff) (n = 303)	Psychological distress*	✗
Que et al. (Que et al., 2020a)	Univariate, multivariate	Cross-sectional online survey (Feb 2020) ISI	China	Medical residents, doctors, nurses, technicians, and public health practitioners (n = 2285)	Sex, ethnicity, annual household income, region in China Work position* Attention to negative pandemic information (frequency), attention to type of pandemic information (negative)*, negative feedback (reports?) from families or friends who join frontline work*, personal	✗

					COVID status (suspected or confirmed case), willingness to join frontline work if had choice* Regular exercise, smoking, drinking*	
Robles et al. (Robles et al., 2020a)	Univariate, multivariate	Cross-sectional online survey (Apr-May 2020) Question about need for more rest time	Mexico	Nurses, psychologists, medical specialists, GPs or specialist residents, undergraduate students, social workers, paramedics (n = 5938)	Sex*, age* Domestic violence victim status* Work position Personal COVID status*, friends and relatives COVID status* Mourning the death of friends or loved ones due to COVID-19*, caring for a person vulnerable to COVID-19 over the age of 65 or with a chronic disease Caring for one's own children Need to rest*	✗

Sagaon-Teyssier et al. (Sagaon-Teyssier et al., 2020a)	Univariate, multivariate	Cross-sectional self-administered questionnaire (Apr 2020) ISI	Mali NGO community-based HIV care centers	Doctors, pharmacy doctors, midwives, nurses, community healthcare worker, psychosocial counselors, and other workers (n = 135)	Sex* Perceived health status PHQ-9, GAD-7 Work position*, moral transgression, betrayal* COVID-19 awareness index, PPE, healthcare supply No. of economically dependent family members Center characteristics, equipment in centres, drug stock-outs, HR availability	✗
Şahin et al. (Şahin et al., 2020a)	Univariate, multivariate	Cross-sectional online questionnaire (Apr-May 2020) ISI	Turkey	Doctors, nurses, other (n = 939)	Sex* History of psychiatric illness* Work position* Taking the COVID test*	✗
Saracoglu et al. (Saracoglu et al., 2020b)	Univariate, correlation	Cross-sectional survey written questionnaire (n/s)	Turkey Hospital	Nurses, anesthesiologists, nurse anesthetists and staff working	Age* Work experience*	✗

		PSQI		in the wards (n = 208)	Fear of COVID*	
Sharma et al. (Sharma et al., 2020)	Univariate	Cross-sectional online survey questionnaire (n/s) ISI	Indiadepartment of Obstetrics and Gynaecology	Doctors and nurses, or those indirectly involved, such as attendants, helpers, laboratory technicians, or house-keeping staff (n = 184)	Avoidant coping style*, anxiety, stress	✗
Shen et al. (Shen et al., 2021b)	Correlation	Cross-sectional online questionnaire (Mar 2020) Athens Insomnia Scale	China Hospital	Nurses (frontline) (n = 643)	Anxiety*, stress*	✗
Simonetti et al. (Simonetti et al., 2021b)	Correlation, multivariate	Cross-sectional questionnaire (Feb – Apr 2020) PSQI	Italy Hospitals	Nurses (n =1005)	Sex* Anxiety*, self-efficacy* Department*	✗
Stojanov et al. (2020)	Univariate, multivariate, correlation	Cross-sectional online web-based study (n/s) PSQI	Serbia Clinical Center including temporary hospitals	Healthcare workers (n = 201)	Sex*,education, married with children Mental health*, depression*, anxiety* Health related quality of life*	✗

Tselebis et al. (Tselebis et al., 2020a)	Univariate, multivariate, correlation	Cross-sectional self-reported questionnaire (May 2020) Athens Insomnia Scale	Greece Hospital	Nurses (n = 150)	Age Stress*, family support scale Work experience*	✗
Tu et al. (Tu et al., 2020a)	Multivariate	Cross-sectional survey (Feb 2020) PSQI	China Wuhan Hospital	Conscripted frontline nurses (n = 100)	Age, education level, status as only child, marital status, have children PHQ-9*, GAD–7 Work experience;	✗
van Roekel et al. (Van Roekel et al., 2020a)	Univariate, multivariate	Cross-sectional online survey (May – Jun 2020) Three employee well-being measures: sleep problems; mental exhaustion; physical exhaustion	Netherlands Hospitals, nursing homes, homecare, mental health care, disability care and other	Healthcare workers (n = 7208)	Sex*, age, living alone Leadership role Sufficient protective equipment*	✗
Wang et al. (Wang et al., 2020a)	Univariate, multivariate, correlation	Cross-sectional electronic questionnaires (February 2020)	China Hospitals	Nurses, doctors, auxiliary staff (n = 1049)	Sex, education level* Anxiety* depression* stress	✗

					Work position, work experience*, department Exposure to COVID-19*	
Wang et al. (Wang et al., 2020d)	Univariate, multivariate	Cross-sectional self-reported questionnaire (Jan – Feb 2020) PSQI	China Wuhan Children's healthcare center	Doctors, nurses (n = 123)	Status as only child* Anxiety, depression* Work position Contact with COVID patients*	✗
Wańkowicz et al. (Wańkowicz et al., 2020a)	Univariate, multivariate	Cross-sectional survey (May 2020) ISI	Poland Hospitals	Healthcare workers (n = 441)	Work position*	✗
Xiao et al. (Xiao et al., 2020)	Correlation, multivariate	Cross-sectional (Jan-Feb 2020) Self-reported questionnaires PSQI	China Hospitals	Nurses & doctors (n = 180)	Social support, anxiety*, self-efficacy*, stress*	✗
Yang et al. (Yang et al., 2021)	Univariate, multivariate	Cross-sectional questionnaire (March 2020) ISI	China Wuhan Fangcang shelter hospitals and seven general hospitals	Nurses & doctors (n = 1036)	Emotional self-efficacy* Working days in Wuhan, working hours per day in an isolation area*, frequency of time spent in a	✗

					medical area time/week Exposure to COVID-19*, perceived peer exposure, peer diagnosis	
Yi et al. (Yi et al., 2020b)	Univariate, multivariate	Cross-sectional (Apr - May 2020) Online questionnaire PSQI	China Hospitals including designated hospitals treating COVID patients	Medical staff (n = 171)	Age, sex, education*, marital status, geographic location Mental problems before the outbreak, depression (PHQ-9), anxiety (GAD-7), stress, post-traumatic stress symptoms, occupational pressure* Occupation, working hours per day, professional title, department, hospital category Military personnel or not, anti-epidemic experience	✗

Zhan et al. (Zhan et al., 2020b)	Univariate	Cross-sectional online questionnaire (March 2020) Athens Insomnia Scale	China Wuhan Hospitals	Frontline nurses (n = 1,794)	Sex*, age Chronic disease status Professional psychological assistance* Experience with negative events* Perceived stress* Work experience* Night shift frequency* Treating COVID patients*, personal protection training, occupational exposure to COVID-19, fear of COVID-19* Midday nap duration*, fatigue* Frequency of exercise	✓
Zhang et al. (Zhang	Univariate, multivariate	Cross-sectional questionnaire	China Hospitals	Hospital staff including nurses, doctors, hospital administration,	Sex, age, education	✗

et al., 2020a)		(Jan-Feb 2020) ISI		other medical staff (n = 1563)	level*, living situation Work position*, work experience, department* Exposure to COVID-19, personal COVID-19 status, COVID status of people living with you, sufficient infection prevention training, strict self-protection for COVID-19, current protection can prevent getting infected, worried about being infected*, perception of psychological support from news or social media regarding COVID-19*, hours each day spent on reading information about the COVID-19 outbreak in past week; uncertainty regarding disease control*	

Zhang et al. (Zhang et al., 2021)	Correlation, multivariate	Cross-sectional online survey (May 2020) PSQI	China Hospitals	Nurses (n = 323)	Cognitive fusion*, cognitive reappraisal, mental health problems* Occupational stressors*	✗
Zhang et al. (Zhang et al., 2020c)	Univariate, multivariate	Cross-sectional survey (Feb-Mar) ISI	China, n /s	Medical health workers (n = 927)	Sex, age, marital status, living area*, education, living with family Disease status* Anxiety, depression, somatization, obsessive-compulsive symptoms, phobic anxiety Risk of contact with COVID patients in hospitals*	✗
Zhao et al.(Zhao et al., 2020)	Multivariate	Longitudinal, sleep measured at baseline and at one month follow-up, self-administered questionnaire (Jan-Feb 2020) PSQI	China Hospital	Doctors & nurses (n = 215)	Use of online CBT to manage sleep disorders* Work experience*, work experience related to other infectious diseases, such as epidemic virus infections (SARS-CoV	✓

					and MERS-CoV) Number of nightshift days per month before screening for 2019-nCoV (before study period) Exposure to COVID-19 (number of work days in the department handling febrile patients during the month)*, subjective psychological stress related to 2019-nCoV infection*	
Zheng et al. (Zheng et al., 2021b)	Univariate, multivariate	Cross-sectional online questionnaire (March 2020) PSQI	China Hospitals	Nurses, doctors, technicians (n = 207)	Age, sex*, educational level Working experience*, work position*, type of hospital, work position Shift work* Supporting Wuhan*	✓
Zhou et al.(Zhou et al., 2020a)	Univariate, multivariate	Cross-sectional online questionnaire	China Hospital	Frontline hospital staff (n = 606)	Age*, sex, education,	✗

		(Feb - Mar 2020) ISI			marital status, family income BMI* Work experience, working hours* Experienced SARS	
Zhou et al. (Zhou et al., 2020b)	Univariate, multivariate	Cross-sectional online survey (Feb 2020) PSQI	China Isolation unit/hospitals, or fever clinics	Doctors & nurses (n = 1931)	Age*, sex, education, marital status, living status (living with family) Family support Work position* work experience Familiarity with COVID-19 exposure to COVID (contact with confirmed cases in daily work) Smoking status, alcohol consumption Ever attending a crisis response*, less familiarity with crisis response less knowledge*, working in outer response team in Wuhan*	✗

Mixed-methods						
Huffman et al. (Huffman et al., 2021)	Qualitative & quantitative, (univariate)	Cross-sectional Survey distributed in a large academic institution for departmental distribution Survey questions on sleep (n/s) (Apr 2020)	U.S.A. University School of Medicine encompassing nine campuses and seventeen hospitals	Attending doctor, fellow, resident, or administrator in University Indiana school of medicine & individual health system hospitals (n = 720)	Concerns related to PPE	✗

*factors that demonstrated a statistically significant association with a sleep outcome ($p < 0.05$)

✓ atypical work schedules (e.g. shift work, night shift frequency) was controlled for in the test of factors associated with sleep characteristics

✗ atypical work schedules (e.g. shift work, night shift frequency) was not controlled for in the test of factors associated with sleep characteristics

Table 2 Overview of included studies (n = 57)

3.2.1. Female sex

Nine studies identified a significant association between female sex and poorer sleep (Giardino et al., 2020b; Robles et al., 2020a; Sagaon-Teyssier et al., 2020a; Şahin et al., 2020a; Van Roekel et al., 2020a; Zhan et al., 2020b; McCall et al., 2021; Simonetti et al., 2021b; Stojanov et al., 2021). Some studies reported stronger associations, for instance, in a sample of HCWs in Argentina (n = 1059), the odds of reporting a PSQI

score greater than 5 were 6.4 times higher for females than for males, 95% CI (4.46 - 9.20) and the odds of reporting an ISI score greater than 7 were 4.31 times higher for females than males (Giardino et al., 2020b). Yet, in other studies, the strength of the associations were much weaker (Zhan et al., 2020a; Simonetti et al., 2021b).

3.2.2. Psychological factors

The influence of psychological factors such as stress, as well as symptoms of anxiety and depression, on sleep was investigated in many of the studies reviewed. These variables were most often assessed using correlation analysis. Four studies reported a significant association between depressive symptoms and sleep (Tu et al., 2020a; Wang et al., 2020a; Wang et al., 2020d; Stojanov et al., 2021). Relationships between anxiety symptoms and sleep were identified in both small (Gupta et al., 2020b; Khamis et al., 2020a; Korkmaz et al., 2020a; Xiao et al., 2020; Abdellah et al., 2021; Karabulut et al., 2021a; Shen et al., 2021b; Stojanov et al., 2021) and larger study samples (Wang et al., 2020b; Simonetti et al., 2021a). Associations between stress and sleep were reported in four studies (Huang et al., 2020b; Khamis et al., 2020a; Tselebis et al., 2020a; Xiao et al., 2020; Shen et al., 2021b). The influence of social support on sleep was also assessed. Results of a path analysis conducted by Xiao et al. (Xiao et al., 2020) indicated that social support provided to medical staff reduced their anxiety and stress levels, and positively

affected self-efficacy but did not directly affect sleep (n = 180). A similar pattern was observed in Tselebis et al. (Tselebis et al., 2020a) where family support among nursing staff did not directly influence rates of sleep disturbance but followed an indirect pathway via stress (n = 150). In a sample of 2,285 healthcare workers, Que et al. (Que et al., 2020a) found that those who reported an unwillingness to join frontline work, if given the choice, were at greater risk of reporting symptoms of insomnia (OR = 3.39, 95% CI, 1.86 - 6.17). In a sample of 323 nurses, cognitive fusion, defined as a process of constructing thoughts towards stressors and not being able to distinguish between thoughts and facts (Gross and John, 2003; Hayes et al., 2009), was positively associated with sleep difficulty ($\beta = 0.148$, $p = .022$) (Zhang et al., 2021). A range of other psychological factors affecting HCWs such as status of receiving professional psychological assistance, experience with negative events (Zhan et al., 2020b), and history of psychiatric illness (Şahin et al., 2020a) also demonstrated associations with sleep characteristics.

3.2.3. Job position

Six of the eight studies that tested frontline HCW status as a risk factor found statistically significant associations between frontline HCW status and sleep characteristics in both medium (Jahrami et al., 2020; Wańkowicz et al., 2020b) and larger sample sizes (Al Ammari et al., 2020; Cai et al., 2020a; Cai et al., 2020b; Que et al., 2020a) with some

studies reporting strong associations (Cai et al., 2020a; Que et al., 2020a). Sixteen studies in the review investigated associations between some measure of work experience or seniority, and sleep. A pattern indicating a relationship between greater work experience and poorer sleep was observed; seven studies with widely ranging sample sizes reporting significant associations (Gu et al., 2020; Huang et al., 2020b; Khanal et al., 2020a; Than et al., 2020; Tselebis et al., 2020a; Zhan et al., 2020b; Zheng et al., 2021b). Various types of jobs were investigated as predictors of sleep (e.g., doctor vs. other; resident vs. consultant). While heterogeneity among these associations was reported, three studies found that being a nurse was associated with poorer sleep. In multivariate regression models adjusted for age and sex, Zhou et al. (2020b) (Zhou et al., 2020b) found that being a nurse was associated with poorer sleep (n =1931), and Gu et al., (2020) (Gu et al., 2020) observed that the odds ratio for higher scores on the ISI was 3.03 (95% CI, 1.97 – 5.32) in nurses, as compared with doctors (n = 522). Based on a logistic regression model conducted by Giardino et al. (Giardino et al., 2020b) being a non-doctor predicted a higher score on the PSQI (n = 1095), although the analysis did not control for sex. In models adjusted for age and sex, Zhang et al. (Zhang et al., 2020a) reported that, compared with other medical staff, being a doctor was associated with less risk of insomnia symptoms (n = 1,563).

3.3 Assessment of the role of atypical work schedules

3.3.1. Shift work

Among the 52 quantitative studies, only six included some measurement of shift work status. Four of these studies used binary (yes/no) measures of shift work status (Barua et al., 2020; San Martin et al., 2020; Arafa et al., 2021; McCall et al., 2021). Zhan et al. (Zhan et al., 2020b) assessed shift work in terms of frequency of night shifts per week. Zhao et al. (Zhao et al., 2020) assessed the number of night shift days per month before HCWs started screening for COVID-19 in patients. In a cross-sectional survey conducted by Zheng et al. (Zheng et al., 2021b) participants were asked whether they were working shifts as usual, working more night shifts, or more day shifts. Only five studies that investigated other factors as predictors of sleep characteristics adjusted for shift work status in their multivariate analyses. No study sample consisted exclusively of HCWs working atypical work schedules.

Associations between shift work and poorer sleep were reported in both univariate (Arafa et al., 2021; Zheng et al., 2021a) and multivariate analyses (Barua et al., 2020; San Martin et al., 2020; Zhan et al., 2020b; Zheng et al., 2021b). Arafa et al., (2021) found that in models adjusted for age, sex, profession, and country; individuals working nights shifts were 1.81 times more likely to sleep less than six hours per day than those

who were not working night shifts (95% CI, 1.17 - 2.80, n = 426)(Arafa et al., 2021). In their investigation of the factors associated with sleep among frontline HCWs (n = 100), Herrero San Martin et al. (San Martin et al., 2020) found that, after conducting univariate analyses on a range of variables, only shift work retained a significant association on the risk of obtaining worse scores on the ISI in the multivariate analysis. The same study also assessed parasomnias such as sleep terrors and confusional arousals and found that being a shift worker was associated with higher frequency of reporting such sleep-related symptoms (OR = 2.40, 95% CI, 1.06 -5.42; p = 0.034), although other sleep disorders were not assessed. In a univariate analysis conducted among 207 healthcare workers, Zheng et al. (2021), (Zheng et al., 2021b) found that working more night shifts was associated with poorer sleep quality (OR = 2.94, 95% CI, 1.37 - 6.31, p = 0.01). This association was retained after controlling for confounding factors, while results of the multivariate logistic regression analysis indicated that HCWs working more night shifts were 3.10 times more likely to report poorer sleep quality than those not working night shifts (95% CI, 1.31 –7.34). In a multinomial logistic regression analysis, Barua et al. (2020), (Barua et al., 2020) observed that shift work was associated with the odds of moderate sleep disturbances (2.21, 95 % CI, 1.24 - 3.94), but was not significantly associated with the odds of reporting insomnia (n = 370). McCall et al. (2021), (McCall

et al., 2021) conducted a study on rates and predictive factors for short-term insomnia disorder in a sample of 573 HCWs before and during the COVID-19 pandemic. Results for the overall sample suggested that the presence of shift work was not a significant risk factor for new cases of insomnia disorder during the pandemic. However, this analysis did not measure whether a change in the intensity of shift work over the course of the pandemic had an impact on sleep. One study did measure shift work status before the pandemic (Zhao et al., 2020), reporting that the number of night shifts worked per month (before starting screening for COVID-19) was not associated with sleep quality at baseline or at one month follow-up (n = 215). However once again, the change in intensity of shift work since the start of the pandemic and its association with sleep was not assessed. Among the qualitative findings, a sample of nurses who volunteered to work in Hubei Province during the COVID-19 pandemic, described how the new shift schedules requiring night shifts disturbed their sleep (Cui et al., 2020) .

3.3.2. Longer working hours

Working hours were measured in eight of the quantitative studies (Jain et al., 2020a; Khanal et al., 2020b; Liu et al., 2020; McCall et al., 2020; Yi et al., 2020a; Zhou et al., 2020a; Abdellah et al., 2021; Arafa et al., 2021). Four of these studies found that extended working hours were associated with poorer sleep. Arafa et al. (2021) found that

working more than six hours per day was associated with inadequate sleep (n = 426)(Arafa et al., 2021). Jain et al., (Jain et al., 2020b) reported that HCWs with an increase in working hours were 3.16 (95% CI, 1.48 - 6.74) times more likely to report an ISI score greater than or equal to eight compared with HCWs not subject to increased working hours (n = 512). Analyses conducted by Liu et al. (Liu et al., 2020) and Zhou et al. (2020a), reported that greater working hours were associated with a higher score on the ISI (n = 606 in both studies).

4. Discussion

In this scoping review, the state of research activity investigating factors associated with sleep in HCWs during the first and start of the second waves of the COVID-19 pandemic was assessed. Fifty-seven studies were included in the final synthesis. A comprehensive overview of risk factors for poor sleep, as investigated in relevant studies, was provided. This may be useful in providing clinicians with a visualization of available information on this subject and its development. The paper also evaluated the extent to which the impact of atypical work schedules was considered in research investigating sleep among HCWs during the pandemic and, in so doing, identified a number of knowledge gaps in this area. The review of the literature revealed certain methodological issues regarding

the measurement of sleep characteristics across the studies reviewed. A summary of the findings of this scoping review are summarized in appendix 3.

4.1. Methodological issues

Most studies assessed sleep in terms of sleep quality or insomnia symptoms, with the PSQI and the ISI the instruments most frequently adopted. Fifteen different instruments were used to measure sleep in the various studies. The choice of sleep measure may have an important impact on the generalizability and application of findings (Moul et al., 2004). There was a lack of consistency regarding the reporting of results. Some studies adopted the same measure of sleep (e.g. ISI) but their scores differed in terms of interpretation (different cut-off points) or presentation (insomnia vs. insomnia symptoms) (Al Ammari et al., 2020; Cai et al., 2020b). This variation in the measurement of sleep and interpretation of sleep scores makes it difficult for clinicians to precisely distinguish risk factors for moderate sleep disruption from factors suggesting more severe cases of insomnia, which has implications for assessment and intervention. Nearly all studies assessed sleep using self-report measures. Although self-report measures are useful in assessing patient perceptions of sleep, other physiological and neurophysiological measures of sleep, such as actigraphy and polysomnography, have also demonstrated effectiveness (Girschik et al., 2012; Sadeh, 2015). Future studies on the sleep of HCWs

may consider using measures such as these in addition to self-report measures. All but one quantitative study consisted of cross-sectional data and, as such, any conclusions drawn from these cross-sectional studies regarding risk factors for sleep among HCWs would be somewhat limited. Longitudinal data are needed to assert causal factors for sleep disturbances in this population. A small amount of longitudinal studies have been conducted since the present literature search was conducted (Abdalla et al., 2021; Jordan et al., 2021; Rossi et al., 2021; Topriceanu et al., 2021). Just two of these studies (Abdalla et al., 2021; Rossi et al., 2021) assessed predictors of poorer sleep over time, with similar risk factors to those identified in cross-sectional studies (e.g., frontline healthcare worker status, more working hours) being reported. However, in contrast to the findings of cross-sectional studies, Rossi et al. (2021) reported that male sex was associated with an increase in insomnia symptoms. More longitudinal studies are needed to ascertain possible sex differences in the sleep of HCWs over time. Several studies failed to control for variables such as sleep medication status, sleep history, and comorbidity in assessing associations between the factors investigated and sleep. For instance, only one study adjusted for pre-existing insomnia status (before the pandemic) in their analyses (McCall et al., 2021). Sleep problems are also common in chronic conditions such as diabetes (Khalil et al., 2020). These and several other variables

reported in many of the studies may have confounded associations between the factors investigated and sleep, such as the failure to control for hypertension or anti-depressant medications. Moreover, many studies did not control for important lifestyle factors such as alcohol consumption, smoking, exercise, Body Mass Index (BMI), and hypertension when assessing predictors of sleep (Rod et al., 2020; Romero Starke et al., 2020; Zhang et al., 2020b).

4.2. Emergent risk factors

As previously mentioned, most of the studies reviewed here were quantitative descriptive studies consisting of cross-sectional survey data, yet there was considerable heterogeneity across studies in terms of the methodologies, scales, and statistical analyses adopted. Thus, it was not possible to combine results, infer causality, or make conclusions about which factors have a greater influence on sleep than others. However, a number of overall patterns of association could be observed among the studies reviewed. It appears that female sex and frontline HCW status were the factors most consistently related to poorer sleep during the COVID-19 pandemic. These findings are consistent with existing studies which assert that women and frontline HCWs have been disproportionately vulnerable to mental health problems since the start of the COVID-19 pandemic (Cabarkapa et al., 2020; De Kock et al., 2021; Liu et al., 2021). Other sex differences such as COVID-19

mortality risk may also explain differences in sleep, though the increased mortality risk for males does not speak to our findings (Peckham et al., 2020). In addition to biological factors, gender issues are likely involved. Indeed, women remain more responsible for domestic tasks than men, increased child supervision due to stay-at-home orders and additional tasks related to COVID-19 such as increased household sanitization may have added to the domestic workload of women and subsequently impacted health outcomes such as sleep (Bigalke et al., 2020). Women represent almost 70% of the global healthcare workforce (Boniol et al., 2019) and may be a subgroup of HCWs in need of extra support during the pandemic. Numerous studies have also observed a relationship between psychological factors and sleep in HCWs. While the inferences that may be made based on these cross-sectional findings are limited, the results draw some attention to social support as a potentially important variable in disentangling the complex interrelationships between psychological factors and sleep among HCWs in the context of a pandemic. This is important information for sleep clinicians insofar that it highlights the importance of a biopsychosocial approach in assessing and treating health conditions that may be associated with sleep. The influence of other novel psychological phenomena, such as anxiety syndrome features associated with COVID-19, have yet to be fully understood. In the present review, there was some evidence to suggest that greater work

experience or seniority was associated with poorer sleep among HCWs, although some studies also found inverse associations. Results of some previous studies provide some support for an association between greater work experience and less stress (Lam et al., 1999; Casu and Giaquinto, 2018); however overall, this finding is largely consistent with the findings of more recent research, where similarly heterogeneous associations between seniority and sleep (Sigursteinsdóttir et al., 2020) and seniority and stress-related outcomes (e.g. psychological distress and burnout) (Vargas et al., 2014; Gómez-Urquiza et al., 2017) were observed in HCWs.

Age has been demonstrated as an important factor driving differences in COVID-19 mortality (O'Driscoll et al., 2021), which may have implications on sleep. However, a consistent pattern of association between age and sleep characteristics was not observed in the studies included in the present review. The relationship between these factors may also be partly obscured by the relationship between age and shiftwork, a relationship that requires further clarification (Ritonja et al., 2019). However, given that shift work status was not measured in the majority of studies, it is unclear how accounting for this factor would affect the relationship between work experience/seniority and shift work. Staff shortages induced by the COVID-19 pandemic have also led to increased responsibility and work scheduling changes among HCWs. More knowledge is needed to ascertain

whether there is an association between work experience and sleep to identify subpopulations of HCWs who are potentially in need of extra support. As the pandemic progresses, further development of the findings presented here will be necessary to further clarify the factors influencing sleep and the general well-being of HCWs.

4.3. Atypical work schedules and gaps in knowledge

Five studies in the present review found that shift work status independently predicted poorer sleep in HCWs. Herrero San Martin et al. (San Martin et al., 2020) identified shift work as the only independent predictor of sleep in a multivariate analysis. These findings add to a considerable body of evidence asserting that shift work is a major risk factor for poorer sleep. While many studies discussed the increase in shift work during the COVID-19 pandemic, this review demonstrated that very few of the quantitative studies accounted for atypical work schedules in their statistical analyses, which may detract from the interpretive value of certain findings. For instance, despite the increased prevalence of shift work among nurses and frontline HCWs compared with other HCWs, some studies did not control for shift work status when assessing sleep characteristics for these groups (Al Ammari et al., 2020; Cai et al., 2020a; Cai et al., 2020b; Gu et al., 2020; Que et al., 2020a; Wang et al., 2020d; Wańkowicz et al., 2020a; Zhou et al., 2020b; Jahrami et al., 2021a). Overall, study samples did not distinguish between shift

workers and non-shift workers. Even among studies in which the analyses did account for shift work status, the change in intensity or frequency of shift work, pre- versus post-pandemic, was not measured. As well, measures of shift work status in studies included in the present review did not provide enough detail to decipher whether participants had been carrying out shift work before the pandemic and, if so, for how long. Moreover, individual variation in tolerance to shift work was not accounted for in the present analyses (Ritonja et al., 2019; Höller et al., 2021). Additionally, studies in which shift work was measured did not provide information related to recovery time between shifts. Quality recovery time may have been exceptionally challenging for HCWs during the pandemic due to stressful work environments as well as extra domestic duties created by stay-at-home orders. More detailed information about shift work recovery and chronicity would help distinguish shift work disorder from normal sleep complaints due to episodic or occasional atypical shifts. Such information about the history and chronicity of shift work would be of use to clinicians in terms of diagnosis, risk assessment, and treatment for HCWs with sleep problems. A recently published study did identify a cross sectional association between shift work and insomnia symptoms (Aslan and Dinç, 2021), however, just as with the studies included in the present review, shift work frequency or chronicity was not accounted for in measurement of the shift work variable.

The observed associations between extended working hours and poorer sleep in HCWs, as reported in the studies presented, provide some evidence of a relationship among these factors. Working hours was measured in only eight studies, which was surprising given the considerable increase in working hours for HCWs since the start of the pandemic. Only one study examined how the work schedules of HCWs had *changed* over the course of the pandemic (Jain et al., 2020a). The work schedules of HCWs have been subject to substantial change since the start of the pandemic (Mehta et al., 2021), yet the impact of these changes on the sleep of HCWs has yet to be thoroughly investigated. Changes in work schedule may result in greater unpredictability and a reduced sense of control for the HCW. There have been some media reports of increased mandatory overtime since the start of the pandemic; though precise statistics describing this phenomena, and how it varies from country to country, are lacking. Perceived control is a key element in determining how an individual responds to stress at work [141]. HCWs' perceived control over their work schedule may influence the relationship between stress and sleep. Future research on sleep among HCWs should take this into consideration.

4.4. Limitations

Certain limitations in the present scoping review must be acknowledged. The literature search was conducted in one database only (PubMed). Given the rapid advancement of COVID-19-related research, the authors chose to restrict the search to PubMed as one of the most extensive databases available in order to capture the greatest number of relevant titles in the shortest space of time. Despite a thorough search of this database, some relevant studies may have been overlooked (e.g., studies published in languages other than English or French). Despite efforts to calibrate the data-charting process, the categories used to organize the variables measured in the review were developed by the present authors and, as such, may be subject to disagreement from authors of articles in the review regarding the categorization or interpretation of their data. It should also be noted that the data reported on studies included in the current review were collected in the very early stages of the pandemic (first and start of the second waves of infection), therefore the associated findings cannot be generalized to other waves of the pandemic. The fear and uncertainty attributed to the novelty of the virus at that time may have accounted for a greater impact of psychological symptoms and their sequelae (such as sleep) than would occur at the present time. Since the collection of the data in the studies included in this review, there is more information about the COVID-19 virus and vaccinations have become available in some contexts. Future syntheses of research on

this topic should make efforts to understand the distinct challenges for HCWs at each wave of infection and to distinguish the associated impact on HCW well-being at each stage.

5. Conclusion

This paper provides a systematic overview of the literature describing the factors associated with sleep among HCWs in the context of the COVID-19 pandemic during the first and start of the second waves. There is a clear need for longitudinal data to ascertain how certain risk factors impact the sleep of HCWs over time, especially those factors unique to the context of the current pandemic. Additionally, efforts toward greater consistency regarding the measurement of sleep as an outcome (e.g. list of accepted measures, consensus on cut-off scores) would facilitate better appraisal and interpretation of knowledge on this topic. Existing research on factors associated with sleep in HCWs mainly consists of cross-sectional studies using self-reported measures of sleep quality or insomnia symptoms. Some evidence has indicated that female sex and frontline HCW status may be associated with poorer self-reported sleep, while other findings suggest that being a nurse or having more work experience may be associated with more sleep problems. Not surprisingly, psychological factors such as stress or symptoms of anxiety and depression appear to be related to quality of sleep among HCWs. Social support may

also indirectly influence sleep through its effect on other psychological variables. Few studies have assessed the influence of atypical work schedules on sleep. The six studies in this review that measured atypical work schedules did so by asking participants about their status or frequency of shift work. There was a lack of information about changing shift schedules, history of shift work, and recovery between shifts. Given the notable changes in work schedules induced by the COVID-19 pandemic, more research is needed to obtain additional information about the influence of atypical work schedules on the sleep of HCWs.

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Declaration of conflicting interests

The authors declare that there is no conflict of interest

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6. Appendices

Appendix 1 Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	**ITEM**	**PRISMA-ScR CHECKLIST ITEM**	**REPORTED ON PAGE #**
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach	4-6

Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	6
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	--
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	7-8
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	7
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Appendices; appendix 2
Selection of sources of evidence †	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	7-10

Data charting process ‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	11
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	7-8
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	--
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	11
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	10
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	14-18, 19-41
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	--

Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	14-18, 19-41
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	11-13, 18, 41-47
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	48-54
Limitations	20	Discuss the limitations of the scoping review process.	55
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	56-57
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	57

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where sources of evidence (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion,

and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with information sources (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.
§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco A.C., Lillie E., Zarin W., O'Brien K.K., Colquhoun H., Levac D., et al.

PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann

Intern Med, 2018. **169**(7): p. 467–473. doi: 10.7326/M18-0850.

Appendix 2 keyword search strategy using PubMed

#1	All Fields (COVID OR COVID-19 OR coronavirus OR SARS-CoV-2 OR 2019-nCoV)
#2	All fields (health worker* OR health care worker* OR frontline health care worker* OR frontline health worker* OR doctor* OR nurse*)
#3	All fields (sleep OR sleep quality OR sleep problem* OR insomnia OR fatigue OR sleep disturbances)
#4	#1 AND #2 AND #3

Appendix 3 Review of the research on the factors associated with COVID-19 HCW sleep: main findings

1) Factors demonstrating patterns of association with sleep characteristics	Female sex (Giardino et al., 2020a; McCall et al., 2020; Robles et al., 2020b; Sagaon-Teyssier et al., 2020b; Şahin et al., 2020b; Stojanov et al., 2020; van Roekel et al., 2020b; Zhan et al., 2020a; Simonetti et al., 2021a) Frontline HCW status (Al Ammari et al., 2020; Cai et al., 2020a; Cai et al., 2020b; Lai et al., 2020b; Que et al., 2020b; Wańkowicz et al., 2020b; Shen et al., 2021a) <u>Psychological factors</u> - stress (Huang et al., 2020a; Khamis et al., 2020b; Tselebis et al., 2020b; Wang et al., 2020b; Xiao et al., 2020; Zhan et al., 2020a; Shen et al., 2021a) - anxiety symptoms (Gupta et al., 2020a; Khamis et al., 2020b; Korkmaz et al., 2020b; Stojanov et al., 2020; Wang et al., 2020b; Xiao et al., 2020; Karabulut et al., 2021b; Shen et al., 2021a; Simonetti et al., 2021a)

	- depression symptoms (Lai et al., 2020b; Stojanov et al., 2020; Tu et al., 2020b; Wang et al., 2020b; Wang et al., 2020c) - social support (Tselebis et al., 2020b; Xiao et al., 2020)
2) Methodological issues	Inconsistent measurements of sleep as an outcome Over-reliance on self-report measures of sleep Lack of longitudinal data
3) Gaps in knowledge	Paucity of information about the impact of shift work and pre-existing health status on HCW sleep