Association between matched chronotype and poor mental health among shift workers: a systematic review and meta-analysis

Beixi Li ,[1] Gengze Liao,[1] Priscilla Ming Yi Lee,[1,2] Anke Huss,[3] Yuen Ting Julie Ma,[1] Joey Wing-Yan Chan,[4] Yun Kwok Wing,[4] Lap Ah Tse [1,5]

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[1]JC School of Public Health and Primary Care, The Chinese University, Hong Kong SAR, People's Republic of China
[2]Department of Clinical Medicine-Department of Clinical Epidemiology, Aarhus Universitet, Aarhus, Denmark
[3]Department of Population Health Sciences, Utrecht University, Utrecht, Netherlands
[4]Department of Psychiatry, The Chinese University, Hong Kong SAR, People's Republic of China
[5]Shenzhen Municipal Key Laboratory for Health Risk Analysis, Shenzhen Research Institute of the Chinese University of Hong Kong, Shenzhen, People's Republic of China

Correspondence to
Professor Lap Ah Tse, JC School of Public Health and Primary Care, The Chinese University of Hong Kong, Hong Kong SAR, People's Republic of China; shelly@cuhk.edu.hk

BL and GL contributed equally.

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ABSTRACT

Background Nearly 0.7 billion workers are involved in the shift work system, leading to concerns about its potential impacts on the large-scale population mental health. This study aimed to synthesise evidence of the associations between matched chronotype and the risk of poor mental health among shift workers.

Methods Six computerised databases were searched from inception to September 2022. Observational studies were selected if they reported any association between common mental health parameters and chronotype scores/types of shift workers. The Preferred Reporting Items for Systematic Reviews and Meta-analyses checklist was followed. We extracted adjusted risk estimates to calculate pooled effect sizes and explore sources of heterogeneity. The study was registered in PROSPERO: CRD42022357437.

Results Fourteen studies including 49 909 workers were identified. Ever shift workers had a higher risk of poor mental health than the day workers (pooled OR 1.15, 95% CI 1.03 to 1.28; I^2=14%, p=0.29), with the evening chronotype ever shift workers having a 1.47 times higher risk than those who worked during the day (pooled OR 1.47, 95% CI 1.13 to 1.91; I^2=42%, p=0.16). Sensitivity analysis excluding studies with the highest risk of bias of each group demonstrated consistent findings.

Conclusions Evening chronotype ever shift workers have poorer mental health than shift workers with other chronotypes. Chronotype remains unrecognised in the contemporary rostering system, making it a hidden contributor to occupational mental health. Work-related physical and mental stresses may be prevented/mitigated with further investigation on optimising shift work schedule combined with individual chronotype preference.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Four systematic reviews and meta-analysis were previously conducted to examine the relationship between shift work and mental health, and revealed that workers who had ever worked with shifts were at higher risks of depression and/or psychological distress than those who had never been involved in the shift work schedule.

WHAT THIS STUDY ADDS

⇒ Our results demonstrated that the mental well-being of evening chronotype ever shift workers was worse than shift workers with other chronotypes.
⇒ Additionally, ever night shift workers were not demonstrated higher risks of poor mental health than those of the day workers.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The global healthcare system is facing an enormous mental health challenge more than ever before as the COVID-19 pandemic elevated the risk of mental illnesses in the public, making this research a key area for the occupational population.
⇒ As shift-work-related poor mental health conditions continue to prevail, optimising shift work schedule with individual chronotype deserves a further investigation to mitigate the external mental stresses.

INTRODUCTION

Shift work becomes popular due to the increasing demands of services from the 24/7 modern society. Despite the COVID-19 pandemic, certain industries continue to operate round the clock.[1] Worldwide, approximately 10%–20% of the working population is engaged in the shift work system, resulting in nearly 0.7 billion workers involving in different types of day and night shift.[2 3] Shift work, especially night-time work, has been recognised as an important occupational hazard linking with diverse negative health effects including poor mental health, such as depression and anxiety.[4–7] These mental disorders are associated with sleep disorders,[8] absenteeism[9] and occupational injuries[10] and these were commonly reported mental health related problems among shift workers, which are noticeable for workers involving in night shift schedule.[11]

Four systematic reviews with meta-analysis were previously conducted to examine the relationship between shift work and mental health.[4–7] Zhao *et al* identified 33 observational studies published between 2002 and 2016 and summarised that shift workers regardless of their shift types (OR 1.32, 95% CI 1.01 to 1.73; I^2=63%) were at a higher risk of depression and/or psychological distress than those not doing shift work.[4] Lee *et al* (OR 1.43, 95% CI 1.24 to 1.64; I^2=78.0%) and Angerer *et al*

(OR 1.42, 95% CI 0.92 to 2.19; I^2=74.4%) synthesised studies specifically on the night shift workers.[5 6] Compared with the unspecified types of shift workers reported by Zhao *et al*,[4] both studies found a relatively higher depression risk among the night shift workers.[5 6] To further elaborate sex differences in mental health problems, Torquati *et al* synthesised evidence, particularly from the subgroup of female shift workers, and demonstrated that the female shift workers were more likely to experience depressive symptoms than the non-shift female workers (OR 1.73, 95% CI 1.39 to 2.14).[7]

The available evidence does not answer the question whether the hazardous effects of night shift work on mental health could be mitigated by an optimised shift work schedule. Recent research observed that workers with the evening chronotype had better tolerance (ie, frequent night shifts are better tolerated by extreme evening chronotypes) to the hazardous effects of night shift schedule than the morning type, which provides rooms to improve worker's health through individualised shift work schedule according to chronobiological trait.[12] James *et al* summarised the chronobiological aspects of night shift work and indicated that the disruption of circadian rhythms due to misalignment may be the critical mechanism underlying the development of mental health problems.[13] On the other hand, a meta-analysis by pooling 36 studies from inception to 2016 showed that evening chronotype was significantly associated with depressive symptoms (z=−0.20, 95% CI −0.18 to –0.23),[14] but with no information related to shift work. Currently, no systematic review and meta-analysis has summarised the chances of shift workers with matched chronotypes developing poor mental health. Hence, the aim of this study was to synthesise the current evidence on the associations between different individual chronotype and mental health problems among shift workers.

METHODS

We followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses[15] and Meta-analysis of Observational Studies in Epidemiology[16] reporting guidelines. This study was registered with PROSPERO: CRD42022357437.

Search strategy

Six major databases, EMBASE, MEDLINE, APA PsycINFO, CINAHL, Web of Science and PubMed, were searched using the title, abstract and keywords fields combining "shift work", "chronotype" and "mental health" terms with publication from inception to September 2022. References cited in the targeted articles were also searched manually. All searched literature was imported into Covidence[17] and duplicates were removed automatically. Two authors screened each study independently and selected the final eligible papers in consensus.

Study selection

The inclusion criteria were: (1) Observational studies published or accepted for publication in peer-reviewed journals. (2) Chronotype measured with a validated questionnaire or question (eg, Question 19 from Morningness-Eveningness Questionnaire).[18] Studies that used the Munich Chronotype Questionnaire[19] and the self-reported preferred midpoint of sleep were considered eligible. (3) In assessing mental health, a validated psychometric scale was used, by self-report, or the diagnosis was provided by a clinician. (4) Sufficient statistical information was provided to calculate the effect size. (5) Shift workers.

Studies were excluded if the full version of the article could not be obtained, without validated psychometric measurements, or chronotypes were assessed with biomarkers of circadian function (eg, salivary melatonin concentrations) or genetic markers (eg, CLOCK gene) as the current study did not cover these topics.

Data extraction

Two authors independently extracted data. Key information extracted was the first author, year of publication, country, study design, sample size, age, gender, shift work pattern, chronotype measure, psychiatric measure and point estimates and their 95% CIs. Present data from each study was initially recorded in Microsoft Excel datasheet.

Risk of bias assessment

The quality of included studies was assessed by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies.[20] It contains 22 items with 34 subitems for cohort studies and with 32 subitems for cross-sectional studies. Referencing published research that assessed study quality by STROBE statement,[21] we classified the quality of primary studies as 'good (fulfilled ≥80% of total items)', 'fair (fulfilled 80%–50% of total items)' or 'poor (fulfilled <50% of total items)' by the total scores of ≥27, 17–27 and <17 for cohort studies or ≥26, 16–26 and <16 for cross-sectional studies, respectively.

Statistical analysis

All analyses were conducted using RStudio (V.4.2.3) software. The R-Cran 'meta' package was used to compute effect sizes of differences in chronotype and mental health on shift workers. Standardised mean difference (SMD), OR and meta-correlation (COR) were called to perform the fixed-effect and random effect model studies based on heterogeneity. The association between chronotype and work patterns, mental health assessment, work patterns, and chronotype and mental health assessment of shift workers were examined, respectively.

The Q and I^2 statistics were used to evaluate the heterogeneity among studies.[22] Random-effect models were used to pool the SMD, OR or correlation if the I^2 index for the heterogeneity test was larger than 50% or $p<0.05$, otherwise, a fixed effect model was performed. Publication bias was evaluated with both funnel plot and Egger's regression asymmetry test and using sensitivity analysis. In addition, subgroup analysis was performed by work pattern (ever shift vs ever night shift, rotating vs daytime) and chronotype (eveningness vs morningness). All statistical tests were based on the two-sided 5% level of significance.

RESULTS

Study selection

We identified 579 studies initially, and 572 were excluded for duplication or unmet aims of our study. Thus, 27 studies were left for full paper assessment. Of them, seven studies were of irrelevant outcomes, three studies did not measure individual chronotype, the study subjects of two studies did not meet the study requirement and two studies lacked information for the calculation of effect sizes. Finally, 14 articles were included (figure 1) with 3 cohort studies[8 23 24] and 11 cross-sectional studies.[25–35] We separately extracted gender-specific data from the Behrens *et al* study (at 10-year follow-up) as the study did not provide a combined OR of males and females.[23] Therefore, a total of 15 independent samples were included in this study.

Shift work definition and study quality

Shift work definition and work schedules were shown in online supplemental table 1. Two studies did not define shift work but

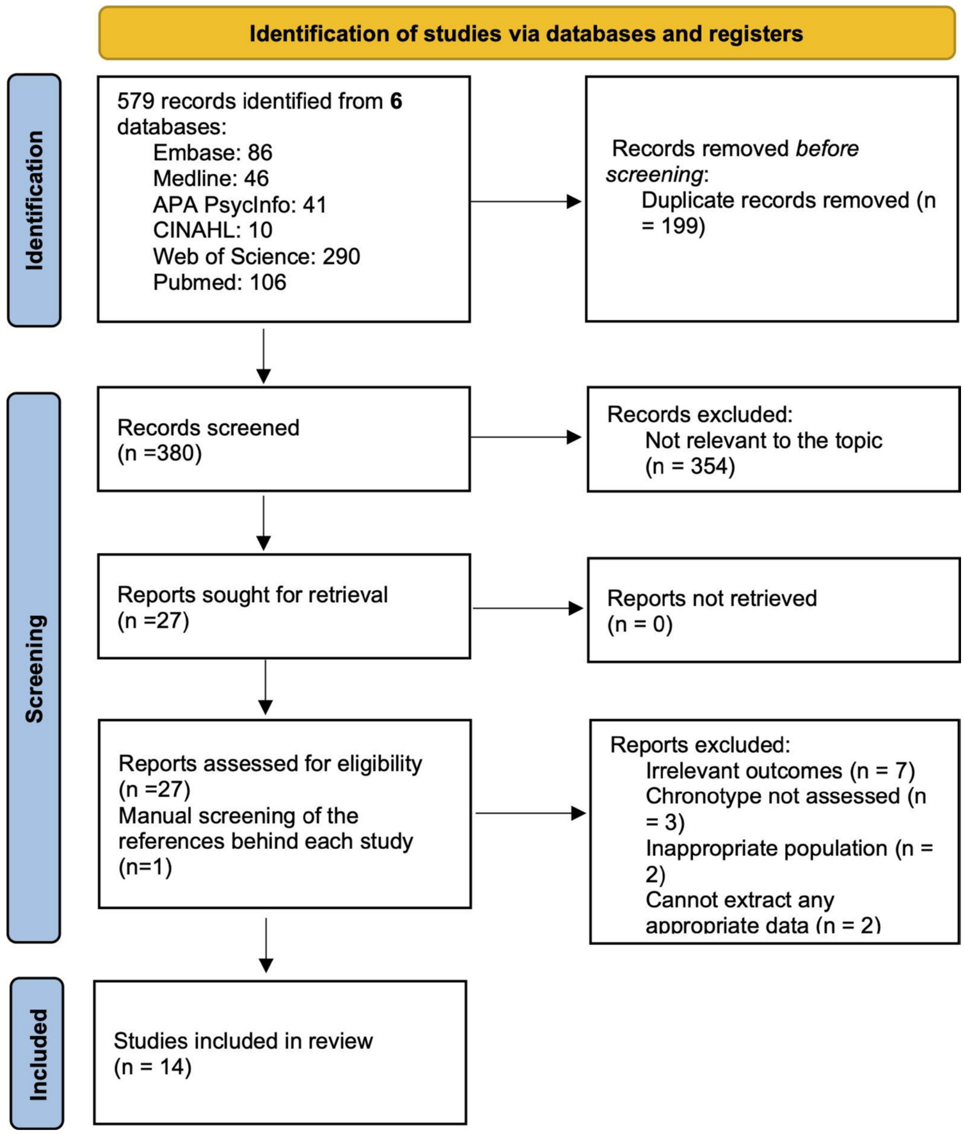

Figure 1 Flow chart of included studies.

gave the work schedules.[27 28] Rotating (regular/irregular) shift work was the most common shift pattern. For the distinct job nature, extreme shift work type exists, like firefighters in Korea work on a 24 hours shift schedule.[25 35] Overall, one cohort study was considered high quality,[23] six rated as fair[8 24 25 32 33 35] and seven studies were considered poor quality (online supplemental table 2).[26–31 34] The quality assessment scores of each included study were not significantly different between the two reviewers (BL and GL).

Study characteristics

The main characteristics of the study were presented in online supplemental table 3. Of the 49 909 workers, 33 198 (66.5%) were shift workers and 16 711 (33.5%) were day workers, with more female workers than male workers in both groups. Six studies recruited day workers as the reference group,[8 23 25 27 31 33] and the rest studies did not. The age of participants ranged from 20 to over 60 years old. Included studies were published between 1989 and 2021, with nine of them published in recent 5 years (2017–2021).[8 23–25 27–29 33 34] None of them recruited participants after the start of COVID-19 pandemic.[1] Of the 14 studies, 7 were done in Asia (China, India, Iran, Japan and Korea),[25 27 28 31 33 34] 5 in Europe (Finland, Germany, Greece, Italy and Norway),[8 23 26 30 32] 1 in the USA[24] and 1 in Australia.[29]

Chronotype was classified as the morning type, the intermediate type and the evening type. Poor mental health outcomes included in the pertinent studies were depressive symptoms/depression, anxiety, mood disorders and general mental health. The Behrens *et al* study and Vetter *et al* study used intake of an antidepressant, and/or physician/clinician diagnosis as an indicator of depression.[23 24]

The association between chronotype and mental health among shift workers was shown in table 1. There were 16 073 participants assessed to be one of the morning, intermediate or evening chronotype.[8 23 25 26 28 29 31 33–35] Of them, 10 493 (65.3%) were classified as intermediate type, which refers to the individuals whose optimal timing of rest and activity were not extreme and conform to the usual day light cycle. In the shift work group, the number of individuals with evening chronotype (1608, 17.2%) was like those with morning type (1540, 16.4%). In the day work group, morning type individuals (1597, 23.8%) were 11% more than the evening type individuals (835, 12.4%).

Table 1 The association between chronotype and mental health among workers of selected studies

Author ID, country, sample size (n, %)	Shift/day worker chronotype	Shift/day worker mental health	Main results
Cohort study			
Behrens, 2021a Germany N=295 Shift: 75 (25.4) Day: 220 (74.6)[23]	Midpoint of sleep Frequency (n, %) Shift workers Early: 12 (16.0) Intermediate: 53 (70.7) Late: 9 (12.0) Day workers Early: 29 (13.2) Intermediate: 154 (70.0) Late: 35 (15.9)	Shift workers Mental health scores (median, Q1, Q3) CES-D: 4 (3, 8) Frequency (n, %) Antidepressant medication: 5 (6.7) CES-D≥17/antidepressant medication: 8 (10.7) Day Mental health scores (median, Q1, Q3) CES-D: 4.1 (2, 8) Frequency (n, %) Antidepressant medication: 5 (2.3) CES-D≥17/antidepressant medication: 10 (4.6)	*Adjusted relative risk, 95% CI Shift workers CES-D≥17 and/or antidepressant medication Morning type Ever shift work: 0.56 (0.10 to 3.01) Ever night work: 0.97 (0.14 to 6.83) Intermediate type Ever shift work: 1.05 (0.25 to 4.40) Ever night work: 1.85 (0.49 to 7.03) Evening type Ever shift work: 4.14 (0.27 to 63.7) Ever night work: n/e
Behrens, 2021b Germany N=191 Shift: 23 (12.0) Day: 168 (88.0)[23]	Midpoint of sleep Frequency (n, %) Shift workers Early: 5 (21.7) Intermediate: 12 (52.2) Late: 5 (21.7) Day workers Early: 29 (17.3) Intermediate: 111 (66.1) Late: 26 (15.5)	Shift workers CES-D scores (median Q1, Q3): 7 (3.2, 11) Frequency (n, %) Antidepressant medication: 2 (8.7) CES-D≥17/antidepressant medication: 3 (13.0) Day workers CES-D score (median Q1, Q3): 6 (3, 10) Frequency (n, %) Antidepressant medication: 10 (6.0) CES-D≥17/antidepressant medication: 26 (15.5)	*Adjusted relative risk, 95% CI Shift workers CES-D≥17 and/or antidepressant medication Morning type Ever shift work: 0.97 (0.32 to 2.93) Ever night work: 0.64 (0.17 to 2.41) Intermediate type Ever shift work: 0.59 (0.08 to 4.22) Ever night work: 1.02 (0.13 to 7.89) Evening type: n/e
Cheng, 2021 Finland N=10 637 Shift: 5 416 (50.9) Day: 4 973 (46.8) Fix night: 248 (2.3)[8]	MEQ question Frequency (n, %) Shift workers Evening: 1 158 (22.2) Intermediate: 3 387 (64.9) Morning: 671 (12.9) Day workers Evening: 724 (14.6) Intermediate: 3 141 (63.2) Morning: 1 108 (22.3) Fixed night workers Evening: 69 (27.8) Intermediate: 146 (58.9) Morning: 33 (13.3)	Frequency (n, %) Shift workers Ever shift (GHQ-12≥4): 1134 (43.0) Day workers Daywork (GHQ-12≥4): 1054 (21.2) Fixed night workers Fixed night workers (GHQ-12≥4): 54 (21.8)	†Adjusted OR, 95% CI Definite morning Shift work without night: 0.98 (0.68 to 1.41) Shift work with night: 0.95 (0.65 to 1.38) Fixed night: 1.56 (0.60 to 4.07) Somewhat morning Shift work without night: 0.98 (0.72 to 1.35) Shift work with night: 0.98 (0.72 to 1.35) Fixed night: 0.87 (0.39 to 1.93) Somewhat evening Shift work without night: 1.35 (1.00 to 1.83) Shift work with night: 1.11 (0.83 to1.47) Fixed night: 1.91 (1.09 to 3.34) Definite evening Shift work without night: 1.02 (0.67 to 1.56) Shift work with night: 1.75 (1.18 to 2.60) Fixed night: 2.05 (1.06 to 3.98)
Vetter, 2018 USA N=32 470 Shift: 22 769 (70.1) Day: 9 701 (29.9)[24]	MEQ question Whole group (n, %) Evening: 3 136 (9.7) Intermediate: 17 073 (52.6) Morning: 12 261 (37.8)	Frequency (whole group, n, %) Shift Self-report depression: 1776 (70.5) Day Self-report depression: 742 (29.5)	‡Chronotype| incident depression, 95% CI Intermediate: reference Age adjusted (all participants) Evening: 1.13 (1.00 to 1.29) Morning: 0.86 (0.79 to 0.93) Female-never night Evening: 1.00 (0.78 to1.29) Morning: 0.73 (0.26 to 0.85)
Cross-sectional study			
Choi, 2020 Korea N=276 24-Shift: 60 (30.2) Day: 139 (69.8) 3-Shift: 77 (35.6)[25]	MEQ score (SD) 24-Shift: 50.5 (9.9) Day: 49.3 (8.0) 24 hours shift workers (n, %) Evening: 11 (18.3) Intermediate: 35 (58.3) Morning: 14 (23.3) 3-shift workers (n, %) Evening: 25 (32.5) Intermediate: 50 (64.9) Morning: 2 (2.6) Day workers (n, %) Evening: 23 (16.5) Intermediate: 100 (71.9) Morning: 16 (11.5)	24 hours shift workers: ① n, %; ② mean (SD) ① HADS-D (≥8): 25 (41.7) ① HADS-A (≥8): 14 (23.3) ② HADS-D score: 7.9 (4.4) ② HADS-A score: 5.4 (3.6) 3-shift workers Frequency (n, %) ① HADS-D (≥8): 41 (53.2) ① HADS-A (≥8): 31 (40.3) ② HADS-D score: 7.6 (3.4) ② HADS-A score: 7.0 (4.1) Day workers ① HADS-D (≥8): 41 (29.5) ① HADS-A (≥8): 37 (26.6) ② HADS-D score: 6.3 (3.6) ② HADS-A score: 5.3 (3.6)	Shift workers(β/SE) §HADS-D|MEQ score: –0.08 (0.026), p<0.01 §HADS-A|3-shift: 1.64 (0.498), p<0.01 Correlation coefficients 24 hours shift MEQ|HADS-D: –0.18, MEQ|HADS-A: –0.15 3-Shift Correlation coefficients MEQ|HADS-D: –0.17, MEQ|HADS-A: –0.07 Day workers Correlation coefficients MEQ|HADS-D: –0.23, p<0.05 MEQ|HADS-A: –0.11

Continued

Table 1 Continued

Author ID, country, sample size (n, %)	Shift/day worker chronotype	Shift/day worker mental health	Main results
Costa, 1989 Italy N=24 Shift: 24 (100.0)[26]	CTQ score (SD): 60.3 (15.9) Frequency (n, %) Moderately evening: 7 (29.2) Intermediate: 10 (41.6) Morning: 7 (29.2)	Score mean (SD) MAS score: 17.2 (8.0)	MAS score by chronotype Moderately evening: 16.9 (7.8) Morning: 17.4 (7.1)
Hosseini, 2019 Iran N=202 Shift: 90 (44.6) Day: 112 (55.4)[27]	MEQ score (SD) Shift workers: 44.9 (5.1) Day workers: 45.3 (4.8)	Frequency (n, %) Shift Anxiety: 72 (80.9) Day Anxiety: 64 (57.1)	na
Hu, 2018 China N=1 100 Shift: 1 100 (100.0)[28]	MEQ score (SD) Shift workers: 54.0 (7.2) Frequency (n, %) Evening: 78 (6.6) Intermediate: 780 (65.6) Morning: 331 (27.8)	Depression Shift (Mean, SD) SDS score: 50.3 (11.1) Frequency (n, %) Normal: 637 (53.6); minor: 426 (35.8) Intermediate: 114 (9.6); severe: 12 (1.0)	SDS score by chronotype Evening: 2.7 (0.5), Morning: 2.4 (0.6) Intermediate: 2.5 (0.5) Correlation coefficients MEQ|Depression: –0.14, p<0.01 ¶Regression coefficients MEQ|Depression: –0.16 (–0.24, –0.08)
Khan, 2020 Australia N=134 Shift: 134 (100.0)[29]	Frequency (n, %) Evening: 15 (11.0) Intermediate: 76 (57.0) Morning: 43 (32.0)	Shift (mean, SD) BDI-SF score: 6.9 (6.5)	BDI-SF scores by chronotype Evening: 13.3 (9.2) Intermediate: 6.4 (5.7) Morning: 5.6 (5.5)
Korompeli, 2013 Greece N=364 Shift: 221 (60.7) Day: 143 (39.3)[30]	CSM score (SD) Total: 35.3 (6.5) Shift workers: na Day workers: na	Shift CAQ: na, SAQ: na Day CAQ: na, SAQ: na	**Regression coefficients CAQ| Shift work (β/SE): 0.90 (0.83) SAQ| shift work (β/SE): 0.34 (0.61) Morning| shift work (β/SE): –0.78 (0.87) Correlation coefficients Morning|CAQ: –0.16, Morning|SAQ: –0.12
Nag, 2004 India N=136 Shift: 97 (72.9) Day: 39 (27.1)[31]	CSM frequency (n, %) Evening: 3 (2.2) Intermediate: 69 (50.7) Morning: 64 (47.1) CSM score (SD) Shift workers: 40.7 (5.6) Day workers: 42.5 (3.9)	Shift (mean, SD) Cognitive anxiety score: 2.2 (1.2) Somatic anxiety score: 2.6 (1.4) Day (mean, SD) Cognitive anxiety score: 2.0 (0.9) Somatic anxiety score: 1.9 (0.9)	na
Saksvik-Lehouillier, 2012 Norway N=642 Shift: 642 (100.0)[32]	DTS score (SD) Shift workers: 17.9 (3.3) Day workers: na	Shift (mean, SD) HADS-D score: 2.5 (2.8) HADS-A score: 4.4 (3.6)	Correlation DTS|HADS-D: –0.05, DTS|HADS-A: –0.09 ††Regression coefficients HADS-D|MEQ (β/SE): 0.00 (0.3) HADS-A|MEQ (β/SE): –0.06 (0.4), p<0.05
Togo, 2017 Japan N=2 669 Shift: 1 556 (58.3) Day: 1 113 (41.7)[33]	MEQ score (SD) Shift workers: 52.4 (7.5) Day workers: 55.7 (6.7) Frequency (n, %) Shift workers Evening: 120 (7.7) Intermediate: 1111 (71.4) Morning: 325 (20.9) Day workers Evening: 19 (1.7) Intermediate: 710 (63.8) Morning: 384 (34.5)	Shift CES-D score (mean, SD): 14.1 (7.8) CES-D score (≥16, n, %): 351 (31.6) Day CES-D score (mean, SD) : 13.5 (7.5) CES-D score (≥16, n, %): 550 (35.4)	‡‡Shift worker Regression coefficients β(SE), 95% CI CES-D|MEQ: –0.135 (0.030), CI (–0.193 to –0.076) Linear relationship CES-D|MEQ: r=–0.199, p<0.01 Day worker Regression coefficients: β(SE), 95% CI CES-D|MEQ: –0.209 (0.036), CI (–0.279 to –0.139) Linear relationship CES-D|MEQ: r=–0.232, p<0.01
Yoo, 2017 Korea N=257 Shift: 257 (100.0)[34]	Frequency (n, %) Evening: 65 (25.3) Intermediate: 181 (70.4) Morning: 11 (4.3)	Shift (mean, SD) BDI score: 13.6 (7.7)	MEQ|BDI score Evening: 14.9 (6.5) Intermediate: 13.2 (8.0) Morning: 13.5 (9.3)
Yun, 2015 Korea N=515 Shift: 409 (97.4) Day: 106 (20.6)[35]	Frequency (n, %) Shift workers Evening: 43 (10.5) Intermediate: 300 (73.3) Morning: 66 (16.1) Day workers Evening: 8 (7.5) Intermediate: 67 (63.2) Morning: 31 (29.2)	All participants Morning (mean, SD) SRI score: 13.5 (18.0), BDI score: 3.4 (3.9) Intermediate (mean, SD) SRI score: 22.4 (48.5), BDI score: 4.1 (5.3) Evening (mean, SD) SRI score: 28.6 (26.7), BDI score: 7.0 (7.5)	CSM|BDI score Evening: 7.0 (7.5) Intermediate: 4.1 (5.3) Morning: 3.4 (3.9)

Continued

Table 1 Continued

Author ID, country, sample size (n, %)	Shift/day worker chronotype	Shift/day worker mental health	Main results

*Adjusted for age (years) at follow-up, years of school education and monthly household equivalent income (continuous).
†Adjusted for job demands and working hours.
‡Adjusted for menopausal status, marriage, living situation, census-tract based household income, retirement status, smoking status, physical activity, BMI, sleep duration, predicted vitamin D levels, alcohol consumption, cancer, myocardial infarction, type 2 diabetes.
§Model variables included demographics (age, sex), individual chronotype (MEQ score), habitual factors (alcohol consumption, smoking and caffeine consumption) and shift type.
¶Adjusted for gender, marital status, BMI, education, age, working years occupation, fitness level, daily smoking, alcoholism, use of sleep medication, sleep pattern.
**Adjusted for sex, age, family status, profession, family member, chronic diseases, shift, second paid job, work experience (years), mean±SD.
††Adjusted for age, children at home, percentage of full position, nights worked last year, sleepiness/fatigue T1, hardiness, morningness, flexibility, languidity.
‡‡Adjusted by age, sex, years of experience as a rotating shift worker, the number of night shifts during the previous 1 month, position, marital status, drinking habits, smoking habits, physical activity level and sleep duration on days off.
BDI, Beck Depression Inventory; BMI, body mass index; CAQ, Cognitive Anxiety Questionnaire; CES-D, The Centre for Epidemiologic Study Depression Scale; CSM, The Composite Scale of Morningness ; CTQ, Circadian type questionnaire; DTS, Diurnal type scale; GHQ-12, General Health Questionnaire; HADS, Hospital Anxiety and Depression Scale; MAS, Manifest anxiety scale; MEQ, Morningness-Eveningness Questionnaire; na, not available; SAQ, Somatic Anxiety Questionnaire; SDS, self-rating depression scale; SF-8, Short Form-8; SRI, Stress Response Inventory.

Meta-analysis and subgroup analysis

The meta-analyses included 13 studies, the Vetter *et al* study was excluded for we could not extract available effect sizes[24]; adjusted OR between chronotype and mental health were derived from two studies.[8 23] Other meta-analysis scenarios (online supplemental table 3) were correlation between poor mental health and chronotype (online supplemental figure 1.1)[25 28 30 32 33]; the mental health assessment scores of the evening type and morning type shift workers (online supplemental figure 1.2)[26 28 34 35]; chronotype scores of shift workers and day workers (online supplemental figure 1.3-1.3.1−1.3.2)[25 27 31 33]; the number of evening chronotype shift workers and day workers (online supplemental figure 1.4-1.4.1−1.4.2)[8 23 25 33]; the mental health scores of the shift workers and day workers (online supplemental figure 1.5).[25 31 33]

The association between shift workers with different chronotype and mental health

Figure 2A shows that the ever shift workers had a slightly higher risk of poor mental health than the day workers (pooled OR 1.15, 95% CI 1.03 to 1.28; I^2=14%, p=0.29). Moreover, the evening chronotype individuals who had ever worked shifts had 1.47 times higher risk of poor mental health than those who worked during the day (pooled OR 1.47, 95% CI 1.13 to 1.91; I^2=42%, p=0.16). However, the higher risk of poor mental health did not appear when comparing the ever night shift workers with the day workers (pooled OR 1.18, 95% CI 0.98 to 1.41; I^2=21%, p=0.25, figure 2B).

Online supplemental figure 1.1 shows the pooled association of individual chronotype score/type and the specific mental health outcomes in shift workers. Both depression and anxiety were positively correlated with eveningness (depression: COR −0.14, 95% CI −0.21 to –0.07; I^2=63%, p=0.03; Anxiety: COR −0.11, 95% CI −0.17 to –0.05; I^2=0%, p=0.79).

In online supplemental figure 1.2, evening type shift workers had poorer mental health (ie, higher mental health assessment score) than that of the morning type shift workers (SMD 0.55, 95% CI 0.37 to 0.74; I^2=36%, p=0.18).

Chronotype and work patterns and mental health assessment

Four studies reported the mean chronotype scores of shift workers and day workers.[24 26 30 32] Compared with the ever shift workers, day workers had higher chronotype scores (SMD −0.30, 95% CI −0.48 to –0.11; I^2=70%, p=0.02; online supplemental figure 1.3), indicating that day workers were more likely to have the early (ie, morning) preference of the sleep-wake activities, that is, go to sleep early and wake up early. To examine whether the high heterogeneity of the chronotype scores occurred among studies with variations of exposure assessment on the shift work patterns, we conducted subgroup analyses according to the shift work patterns described by individual studies, by (1) excluding a study with 24 hours every other day schedule (online supplemental figure 1.3.1) and (2) included studies with a rotating shift schedule (online supplemental figure 1.3.2), and the heterogeneity of both subgroups became moderate across studies (I^2=58%, p=0.07).

SENSITIVITY ANALYSIS AND PUBLICATION BIAS

Sensitivity analysis excluding studies with the highest risk of bias of each group demonstrated consistent meta-analysis findings (eg, online supplemental figure 1.6 left).

We conducted Egger's test, 'metabias' and visualise funnel plot for studies to examine the potential publication bias. We observed no evidence of publication bias with inspection of the linear regression test of funnel plot asymmetry (eg, online supplemental figure 1.6 right. Test result: t=2.22, d_f=2, p=0.16).

DISCUSSION

The present review included various professions working in shifts or during daytime. They were recruited from eleven countries, covering four continents before the start of COVID-19 pandemic. Compared with the day workers, those with ever night shift work were not associated with an increased risk of poor mental health, nevertheless, a higher risk of poor mental health was observed in workers who had ever worked with shifts, particularly those with evening chronotype.

The extent to which shift workers can adapt to shift work arrangements may be dependent on the preference of sleep-wake activity cycles and adaptability to the changing environment. Chronotype is introduced to describe this preference for sleep-wake cycle and daily activity times. Recent research revealed that chronotype, which is closely linked to genetic variables in people,[36] plays an important role in disease onset, and can be changed by imposing environmental factors (eg, light treatment).[37] Individuals with evening chronotype who exhibit late sleep time can extend their sleep into the day and may consequently create adverse health effects due to circadian disturbance.

Few studies have evaluated shift work, chronotype, and common mental health issues simultaneously so far. In this systematic review, ever shift workers with evening type were found to have a higher risk of developing depressive mood/anxiety compared with morning type ever shift workers and day workers.[8 23] Change in circadian preference predicts sustained

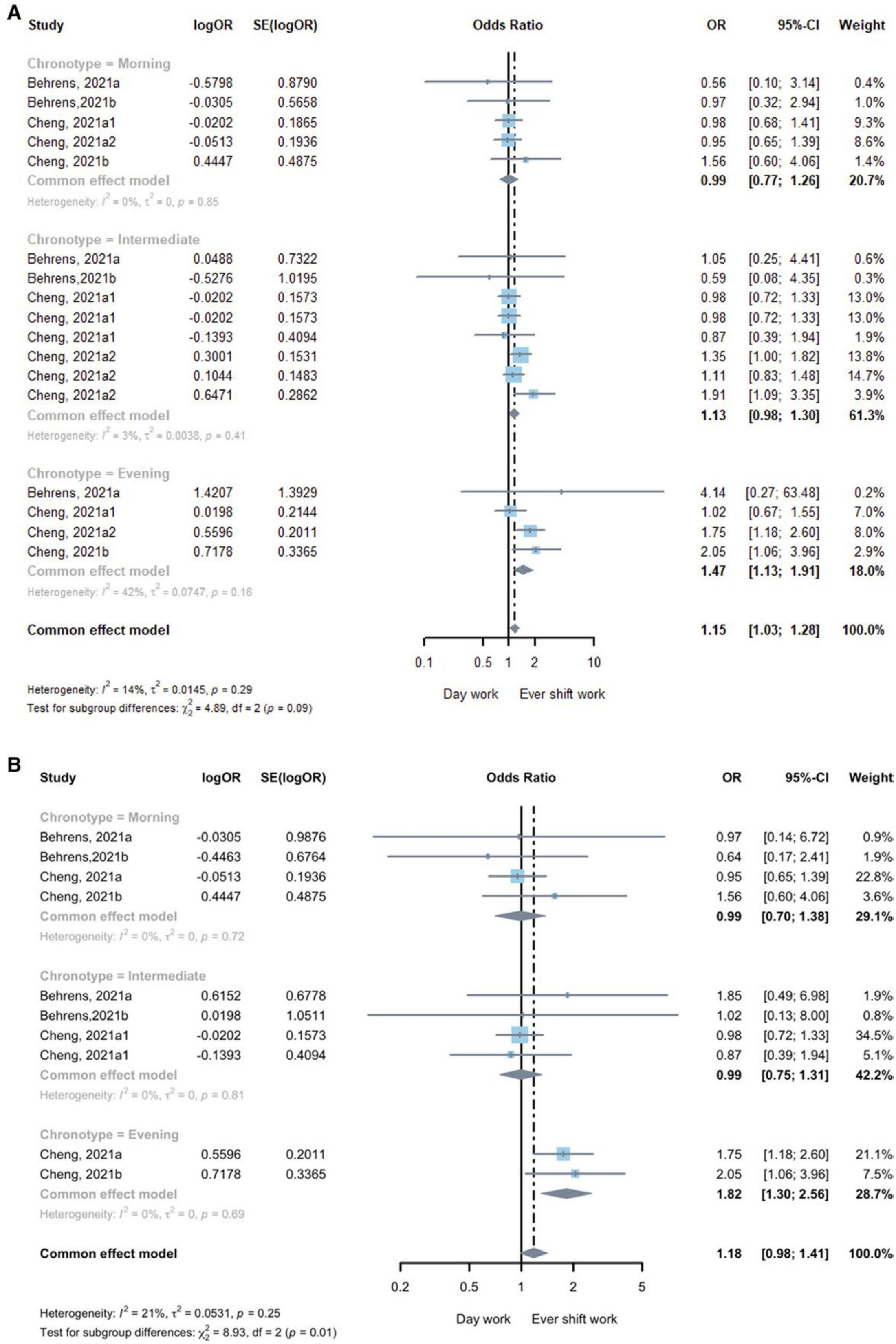

Figure 2 (A) The association between ever shift work and poor mental health by different chronotype (ever shift worker vs day worker) Behrens, 2021a:[23] Participants were male shift workers. Behrens, 2021b: Participants were female shift workers. Cheng, 2021a1: Participants were shift workers who did not work night shifts. Cheng, 2021a2: Participants were shift workers with night shifts. Cheng, 2021b: Participants were fixed night workers. (B) The association between ever night shift work and poor mental health by different chronotype (ever night shift worker vs day worker) Behrens, 2021a:[23] Participants were male ever night shift workers. Behrens, 2021b: Participants were female ever night shift workers. Cheng, 2021a: Participants were ever night shift workers (definite morning or definite evening chronotype). Cheng, 2021a1: Participants were shift workers with night shifts (somewhat morning or somewhat evening chronotype). Cheng, 2021b: Participants were fixed night workers.

treatment outcomes in patients with unipolar depression and evening preference.[8] In addition, evening type on fast rotating schedules may have higher risk of depressive symptoms and occurrence of shift work disorders (SWD),[25] while morning type decreased the odds of SWD onset.[38] Although our meta-analysis also showed that morningness was inversely correlated with poor mental health in shift workers, Yoo and Kim reported that individual morningness-eveningness were not decisive factors for depressive symptoms.[34] This may be explained by different occupational stress involved in various shift work. For example, shift nurses have severe stress due to time pressure, excessive responsibility and workload but low stress on job insecurity. However, factory shift workers may experience more stress on job insecurity while have less pressure on responsibility.[39]

A study suggested that chronotype may provide opportunities for shift workers to align external demands with internal rhythms, thereby minimising potential adverse health effects.[12] Vetter *et al* tailored a real-life chronotype-adjusted shift schedule among the rotating shift workers (ie, abolish morning shifts for late chronotypes, nights for early ones). As a result, shift workers suffered less social jetlag after shift work and slept longer.[12] Despite not having sleep quality data, our meta-analysis indicated that poor mental health was more likely to happen in evening chronotype shift workers than in other chronotype shift workers. Morning type shift workers were not observed at higher risk of poor mental health even when doing night shift work. For consistent evidence, more simulated studies need to be conducted.

The results of our meta-analyses were in line with the previous reviews showing that evening type was associated with poor mental health in the general population.[40] Moreover, regarding job arrangement pattern factors, we also demonstrated that evening type was more prevalent among shift workers. However, it is unclear whether this phenomenon was a passive choice for shift workers to adapt to shift work arrangement.

Age and gender are endogenous factors that influence chronotype and mental health, however, due to a lack of information on gender and age of shift workers and day workers in each included study, our meta-analysis did not support a subgroup analysis of either kind. Moreover, the number of studies comparing different depressive symptoms, or the potential moderating effects of shift work patterns in this systematic review were too few to draw conclusions regarding the quantity of original research and their respective effect sizes, so it is hard to draw causal relationship on the directionality of the relationship.

This is the first meta-analysis to synthesise the association between different individual chronotype and the risk of poor mental health among shift workers. However, our review contains several limitations. First, high heterogeneity across studies in meta-analyses was observed in several groups. This may result from differences in participants, shift work pattern, ethnicity, study designs, report methods and variation in results as limited studies reported the same mental health outcomes. Second, most studies did not recruit or report data on reference group (day workers), so there was a lack of comparison of adverse outcomes between shift workers and day workers. Third, the reverse causality between mental health and chronotype as well as mental health and shift work could not be evaluated from included cross-sectional studies. The limited number of cohort studies may also fail to reveal plausible association due to lack of power. Fourth, we did not have enough information on gender, age, occupation, shift work duration to do subgroup meta-analysis. Fifth, the inconsistency exposure assessments of shift work in each study limited the ability to compare between studies and limited the chances to explore potential moderating effects of specific occupations.

We have several suggestions for future studies. First, prospective study with large sample size and assessments involving control groups for age, gender, shift work patterns and specific occupational group. Moreover, the psychosocial impact of COVID-19 is greatly underestimated, which makes further research necessary. Second, sleep condition which is suggested to be involved in chronotype variation and good mental health needs to be evaluated. Third, exogenous factor such as exposure to light need to be assessed as it is considered an emerging determinant of chronotype. Evidence also showed that light intervention could improve mood in mental disorder patients with evening chronotype.[37] Fourth, whether matching certain chronotype to shift work could improve poor mental health remains uncertain. Mental health effects of matched and mismatched chronotypes with shift work should be explored.

CONCLUSION

Most shift workers are working against the natural circadian rhythm and biological preference of sleep and activities, placing them at higher risks of developing diseases. Chronotype remains unrecognised in the contemporary rostering system, making it a hidden contributor to poor mental health, especially for workers with evening chronotypes. Considering the current study, it is unclear whether matching chronotype to shift work patterns could benefit shift workers' mental health. Further research on a wider scale is needed to confirm these findings.

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ORCID iDs
Beixi Li http://orcid.org/0000-0002-7582-4640
Lap Ah Tse http://orcid.org/0000-0003-0355-6218

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