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# Effects of Napping During Shift Work on Sleepiness and Performance in Emergency Medical Services Personnel and Similar Shift Workers: A Systematic Review and Meta-Analysis

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Abstract

**Background**: Scheduled napping during work shifts may be an effective way to mitigate fatigue-related risk. This study aimed to critically review and synthesize existing literature on the impact of scheduled naps on fatigue-related outcomes for EMS personnel and similar shift worker groups. **Methods**: A systematic literature review was performed of the impact of a scheduled nap during shift work on EMS personnel or similar shift workers. The primary (critical) outcome of interest was EMS personnel safety. Secondary (important) outcomes were patient safety; personnel performance; acute states of fatigue, alertness, and sleepiness; indicators of sleep duration and/or quality; employee retention/turnover; indicators of long-term health; and cost to the system. Meta-analyses were performed to evaluate the impact of napping on a measure of personnel performance (the psychomotor vigilance test [PVT]) and measures of acute fatigue. **Results**: Of 4,660 unique records identified, 13 experimental studies were determined relevant and summarized. The effect of napping on reaction time measured at the end of shift was small and non-significant (SMD 0.12, 95% CI −0.13 to 0.36; p = 0.34). Napping during work did not change reaction time from the beginning to the end of the shift (SMD −0.01, 95% CI −25.0 to 0.24; p = 0.96). Naps had a moderate, significant effect on sleepiness measured at the end of shift (SMD 0.40, 95% CI 0.09 to 0.72; p = 0.01). The difference in sleepiness from the start to the end of shift was moderate and statistically significant (SMD 0.41, 95% CI 0.09 to 0.72; p = 0.01). **Conclusions**: Reviewed literature indicated that scheduled naps at work improved performance and decreased fatigue in shift workers. Further research is required to identify the optimal timing and duration of scheduled naps to maximize the beneficial outcomes. **Key words:** napping; fatigue; shift work; emergency medical services

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Supplemental data for this article can be accessed on the publisher's website.

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## Background

Greater than half of Emergency Medical Services (EMS) personnel report fatigue and poor sleep quality (1–3). Naps improve alertness, vigilance, and cognitive performance in laboratory and field studies (4, 5). In nightshift workers, naps can augment the sleep obtained during daytime hours, often shortened due

to circadian timing. Prior research shows that EMS personnel use naps during shifts to achieve adequate sleep (6, 7). Guyette et al. reported that air-medical EMS clinicians earn a mean 6.8 hours of sleep during 24-hour shifts and 1-hour of sleep during 12-hour shifts (6). A case study shows a paramedic sleeping nearly six hours on average on 24-hour shifts and 0.3 hours on 8-hour shifts (7).

Naps are common among shift workers with 55% reporting to have taken at least one nap in the last month (8). Moreover, napping during a work shift is a countermeasure that may help mitigate fatigue and fatigue-related risks for EMS personnel (9). Naps have been shown to improve performance, mood and alertness better than caffeine (10, 11). A nap as short as 10-minutes reduced sleepiness and fatigue and improved vigor and cognitive performance (12). Although allowing EMS personnel to sleep on-the-job is not without controversy and operational challenges, scheduled naps during shifts may benefit safety, performance, and other outcomes relevant to EMS personnel, administrators, and the public they serve.

The benefits of napping during EMS shiftwork are not widely known to EMS administrators and managers. Although a review of the evidence on napping was previously conducted, it was limited by small heterogeneous studies (13). A more focused summary of the evidence exploring the effects of intra-shift napping on EMS or similar shift workers would benefit EMS administration and their decisions germane to fatigue risk management. This research systematically reviewed the literature to assess the effects of a nap (i.e., a brief scheduled interval of sleep) during shift work as a strategy for EMS personnel and similar worker groups to impact patient and personnel safety, mitigate fatigue, and improve sleep. This review was guided by the research question: "In EMS personnel, does the use of sleep or rest strategies and/or interventions mitigate fatigue, fatigue-related risks, and/or improve sleep?" (PROSPERO 2016:CRD42016040107) (14).

# METHODS

This study was a systematic review of literature relevant to napping during shift work indexed in multiple databases. This study has described the details of the databases searched, the methodology and study protocol, and procedures for reviewing literature in a separate publication (15). The components unique to this systematic review are described in the following sections.

## Study Design

The selection of literature was limited to experimental study designs (i.e., randomized controlled trials and quasi-experimental studies such as before and after designs) (16).

## Types of Participants

Experimental research involving persons 18 years of age and older classified as EMS personnel or similar shift worker groups were included (14). Studies were excluded that did not include shift workers. Disagreements were addressed through discussion between co-investigators CMG, LKB, and PDP.

## Types of Interventions

The retained studies that tested the impact of a nap during shift work as a component of one or more study arms. Although the duration, timing and conditions of the naps were different across studies, all allowed for sleep during the work shift. Studies were excluded that did not report on the effects of naps as a method to mitigate fatigue, involved naps before or after a work period, and evaluated the impact of a break period not involving sleep.

## Types of Outcome Measures

The primary (critical) outcome of interest was EMS personnel safety (e.g. incidence of needle sticks or vehicle accidents) (14). The secondary (important) outcomes of interest were: patient safety (e.g. medication errors or procedural complications), personnel performance; acute fatigue, alertness, and sleepiness; indicators of sleep (e.g., sleep duration and quality); employee retention/turnover; indicators of long-term health (e.g., cardiovascular disease); and cost to the system. All outcomes were assessed as defined by the individual study.

## Search Methods for Studies

A research librarian (PMW) searched 5 bibliographic database products and one website. For the systematic review described here, the search incorporated multiple terms covering each of three concepts: emergency medical services and other critical shift-based occupations; fatigue, sleep, and sleep disorders; and napping and rest breaks. All searches included literature from January 1980 to September 2016. An explanation provides the methods of the search strategies, all sources searched, the search terms incorporated, and the description of search vocabulary in a separate paper in this supplement (15). See Online Supplement Appendix A for search strategy details specific to this systematic review.

## Data Collection and Selection of Studies

### Screening

Co-investigators (PJC and EMT) independently screened titles and abstracts to identify potentially relevant publications. Two additional co-investigators

(PDP and DJS) adjudicated disagreements based on the following inclusion criteria: a) the study describes the population of interest; b) the study describes use of a nap period as the primary intervention of interest; and c) the title and/or abstract describes one or more outcomes of interest. The Kappa statistic was used to determine inter-rater agreement during screening.

### Full-Text Review

Five investigators (EMT, JPC, KLF, AAD, and MEM) worked independently to abstract key information from full-text articles. Co-investigators verified data abstractions and disagreements were handled by discussion with principal investigator PDP. Several co-investigators (EMT, JPC, KLF, AAD, and MEM) searched bibliographies to identify additional relevant research.

## Risk of Bias Assessment

The team's three senior co-investigators (CMG, LKB, and PDP) used the Cochrane Collaboration's risk of bias tool for experimental studies to document perceived bias of individual studies (17). The Cochrane tool appraised the risk of bias across six domains. Disagreements between reviewers were handled by discussion.

## Statistical Analysis

Three investigators (CMG, LKB, and PDP) used a system for categorizing findings in systematic reviews to describe the impact of a nap intervention on critical and important outcomes as favorable, unfavorable, mixed/inconclusive, or no impact (18). Additional details of the system for categorizing findings are available in a separate publication (15).

When 2 or more studies used an experimental study design and reported results for a specific outcome, these data were pooled for purposes of a meta-analysis (15) This was possible for the impact of nap on the psychomotor vigilance test (PVT) and acute fatigue (i.e., sleepiness). RevMan software (version 5.3, Copenhagen, Denmark) was used to calculate the standardized mean difference (SMD) and 95% confidence intervals (CIs) of a pooled main effect.

### Quality of Evidence

Four investigators (CMG, LKB, PDP, and ESL) used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework to summarize and rate the quality of retained research (evidence) (19). The GRADE evidence profile table contains key information about the quality of evidence germane to outcomes rated as critical and important (20). Key information includes: number of studies per outcome; judgments about underlying quality of evidence (e.g., risk of bias, indirectness); statistical results; and a quality rating (very low, low, moderate, or high).

### Reporting

Findings were presented from this systematic review as prescribed by the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement (21).

# Results

The search strategy yielded $n = 4{,}656$ unique records (Figure 1). Two investigators (EMT and JPC) independently screened $n = 4{,}656$ titles and abstracts. The interrater agreement for inclusion/exclusion was substantial (Kappa = 0.78). Seventy-six records were judged potentially eligible based on title and abstract. Seventeen studies were identified during bibliography searches as potentially relevant and reviewed in full-text format. Thirteen experimental studies were determined relevant and key findings abstracted in tables (See Online Supplement Appendix B). Eighty studies were excluded with reasons given, organized in the Population, Intervention, Comparison, Outcome (PICO) format (See Online Supplement Appendix C) (22–24).

Within the retained studies, naps were implemented in various ways. In all cases, a nap opportunity was afforded to study participants. In all cases, the nap period included the opportunity to sleep. In some cases, the nap opportunity was scheduled for a particular time in the shift. The reviewed research and specific nap interventions are described in Table 1.

## Impact of Scheduled Naps on Personnel Safety Outcomes

One experimental study assessed personnel safety by determining the fraction of time during simulated driving at or below a study-defined cut point of alertness (25). The authors reported no aggregate differences in driving performance. Napping had no impact on the outcome.

## Impact of Scheduled Naps on Personnel Performance Outcomes

The impact of scheduled naps on personnel performance was judged favorable for eight of 11 studies that measured personnel performance (Table 2) (25–32). Two studies were judged as no impact and one as mixed/

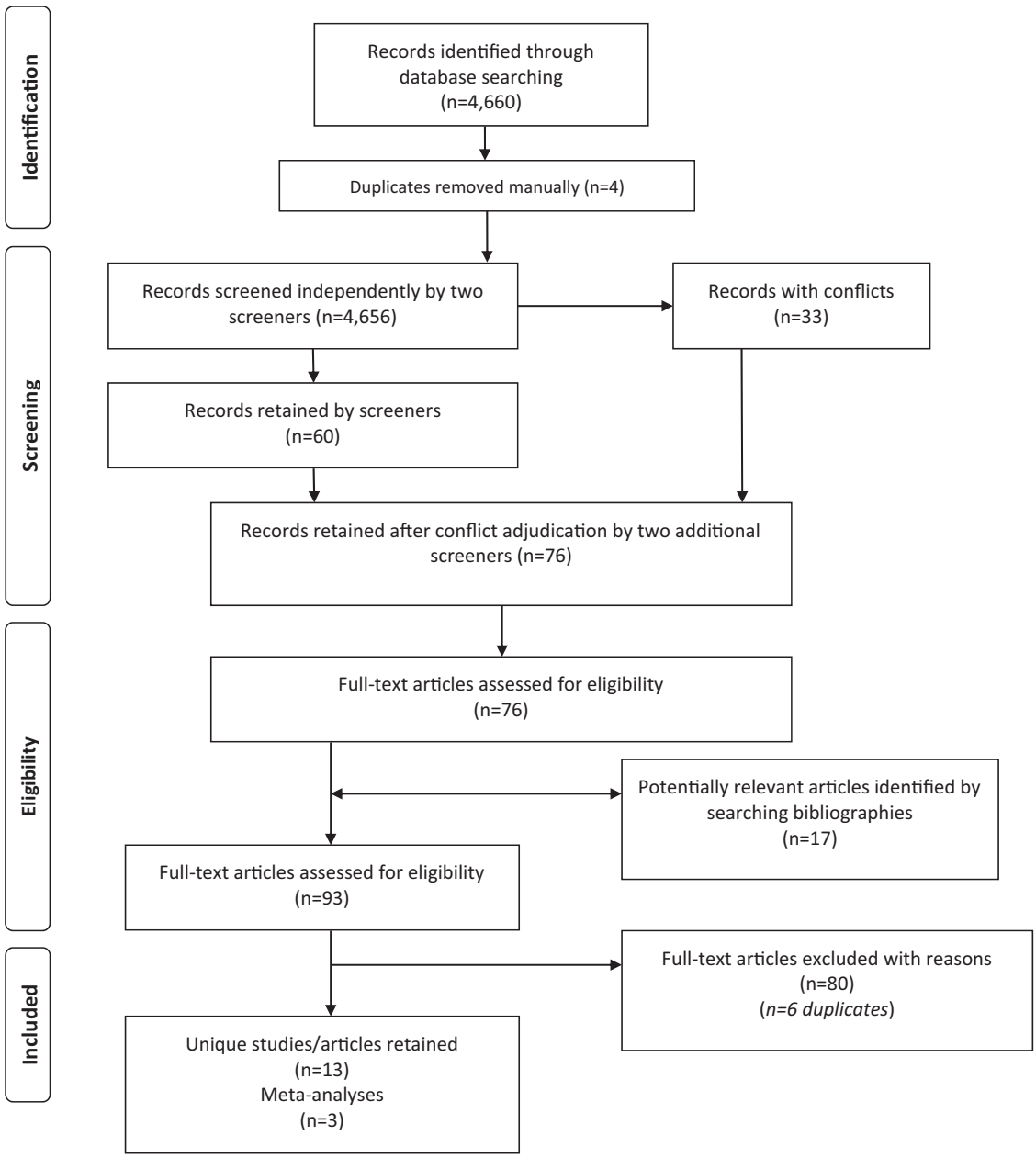


FIGURE 1. PRISMA flow diagram for PICO#4 PROSPERO 2016: CRD42016040107.

inconclusive for personnel performance. Pooled analysis was performed for three experimental studies that measured reaction time at the start and end of shift (27, 29, 31). Purnell et al. used the 10-minute Mackworth Clock Vigilance Task (29). Signal et al. used the 10-minute psychomotor vigilance task (31). Sallinen et al. used the two-choice visual reaction time test of the National Institute for Occupational Safety and Health fatigue battery (27). The effect of naps on reaction time measured at the end of shift was small, and the difference between the nap and no–nap condition was non-significant (SMD 0.12, 95% CI −0.13 to 0.36; p = 0.34; Figure 2a). This study detected a moderate level of heterogeneity (Chi(2) = 3.94; df = 2; p = 0.14; $I^2$ = 49%). The effect of napping on the difference in reaction time from the start to the end of shift was small (SMD −0.01, 95% CI −25.0 to 0.24; Figure 2b). The effect was non-significant (p = 0.96). There was a moderate level of heterogeneity (Chi(2) = 6.06; df = 2; p = 0.05; $I^2$ = 67%).

## Impact of Scheduled Naps on Acute Fatigue Outcomes

Eleven studies evaluated the impact of napping on measures of acute fatigue (25, 27–29, 31–37). The impact of napping on acute fatigue (sleepiness) was judged favorable for five of 11 studies, mixed/inconclusive for three studies, and no impact for three studies (Table 2).

TABLE 1. Detailed information regarding napping intervention in retained studies

| Author, Year | Study Design | Nap protocol | Nap achieved [data collection method] |
|---|---|---|---|
| Amin et al. (26) RefID-152 PMID-22914520 | Non-randomized controlled trial | A 20-minute nap opportunity versus 20-minute break (investigators chatted with control group residents during 20-minute break to prevent them from napping). | Mean nap duration was 8.4 ± 3.0 minutes [electroencephalogram (EEG)]. |
| Sallinen et al. (27) RefID-3575 PMID-9844850 | Non-randomized cross-over | A 50 or 30-minute nap opportunity at 01.00 (early) or 04.00 hours (late). | Timing / total sleep period / mean nap duration [polysomnography (PSG)]. Early / 50 minutes / 38.1 ± 12.1 minutes Early / 30 minutes / 24.5 ± 6.7 minutes Late / 50 minutes / 46.6 ± 2.1 minutes Late / 30 minutes / 27.5 ± 1.9 minutes |
| Smith et al. (28) RefID-3851 PMID-n/a | Randomized cross-over | A 30-minute nap opportunity between 02:00 and 03:00. | Mean nap duration was 13.44 ± 8.96 minutes [EEG]. |
| Smith-Coggins et al. (25) RefID-3852 PMID-17052562 | Randomized controlled trial | A 40-minute nap opportunity at 03:00. | Mean nap duration was 24.8 ± 11.1 minutes (90% of subjects napped) [PSG]. |
| Matsumoto et al. (33) RefID-2621 PMID-8206058 | Quasi-experimental | A 2-hour nap opportunity during the night shift. Nap allowed in the control group without a defined nap period. | Mean nap duration not defined. No difference in total sleep time between nap and no nap period groups [subjective measurement]. |
| Purnell et al. (29) RefID-3297 PMID-12220318 | Cross-over | A 20-minute nap opportunity between 01:00 and 03:00 on two night shifts. | Half of the engineers (50%) taking a nap during the first night shift reported that they had not fallen asleep during the nap and 42% reported not having fallen asleep during the nap taken on the second night shift. Mean nap duration for subjects that reported sleeping during the nap was 19 ± 11.62 minutes on the first night shift and 21 ± 14.49 minutes on the second night shift [subjective measurement]. |
| Bonnefond et al. (34) RefID-455 PMID-11681794 | Quasi-experimental | A 1-hour nap opportunity between 23:30 and 03:30. | Mean nap duration was approximately 31.5 minutes (based on monthly questionnaires; approximately 79% of rest periods had sleep) [subjective measurement]. |
| Gillberg et al. (37) RefID-1457 PMID-8795796 | Counter-balanced experiment | A 30-minute nap opportunity during night shift. | Mean nap duration was 18.7 ± 2.8 minutes [PSG]. |
| Chang et al. (30) RefID-660 PMID-25683536 | Randomized controlled trial | A 30-minute nap opportunity between 02:00 and 03:00. | No information on mean nap duration [subjective measurement]. |
| Signal et al. (31) RefID-3772 PMID-19250171 | Cross-over design | A 40-minute nap opportunity approximately 2 hours into an early (22:30–06:00) or late (23:30–06:30) night shift. | Mean nap duration was 19 minutes (early shift) or 20 minutes (late shift) [EEG]. |
| Takahashi et al. (35) RefID-4037 PMID-15204275 | Quasi-experimental | A 15-minute nap opportunity during a post-lunch rest period. | No information on mean nap duration [actigraphy]. |
| Tempesta et al. (36) RefID-4093 PIMD-24016171 | Quasi-experimental | No Information on duration of nap opportunity. | No information on mean nap duration [actigraphy]. |
| Howard et al. (32) RefID-1821 PMID-n/a | Randomized cross-over | A 30-minute nap opportunity at start of night shift (19:45) or during overnight shift (04:00). | Mean nap duration during evening nap was 4.88 ± 8.28 minutes (38% of subjects napped). Mean nap duration during early morning nap was 23.5 ± 5.48 minutes (100% of subjects napped) [PSG]. |

TABLE 2. Synthesis of findings of individual studies comparing Napping/Sleeping during shift work to No Napping/Sleeping during shift work in relation to outcomes rated critical or important

| Experimental Study Designs | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Critical Outcomes | Important Outcomes | | | | | | |
| Author, Year | RefID PMID | Study Design | Personnel Safety | Patient Safety* | Personnel Performance† | Acute Fatigue‡ | Sleep and Sleep Quality§ | Retention / Turnover‖ | Long-Term Health# | Cost to System |
| Amin et al. (26) | RefID-152 PMID-22914520 | Non-randomized controlled trial | — | — | Favorable | — | — | — | — | — |
| Sallinen et al. (27) | RefID-3575 PMID-9844850 | Non-randomized cross-over | — | — | Favorable | Favorable | Unfavorable | — | — | — |
| Smith et al. (28) | RefID-3851 PMID-N/A | Randomized cross-over | — | — | Favorable | Favorable | No Impact | — | — | — |
| Smith-Coggins et al. (25) | RefID-3852 PMID-17052562 | Randomized controlled trial | No Impact | — | Favorable | Favorable | No Impact | — | — | — |
| Matsumoto et al. (33) | RefID-2621 PMID-8206058 | Quasi-experimental | — | — | — | Mixed/ Inconclusive | Mixed/ Inconclusive | — | — | — |
| Purnell et al. (29) | RefID-3297 PMID-12220318 | Cross-over | — | — | Favorable | No Impact | No Impact | — | — | — |
| Bonnefond et al. (34) | RefID-455 PMID-11681794 | Quasi-experimental | — | — | — | Mixed/ Inconclusive | No Impact | — | — | — |
| Gillberg et al. (37) | RefID-1457 PMID-8795796 | Counter-balanced experiment | — | — | No Impact | No Impact | — | — | — | — |
| Chang et al. (30) | RefID-660 PMID-25683536 | Randomized controlled trial | — | — | Favorable | — | — | — | — | — |
| Signal et al. (31) | RefID-3772 PMID-19250171 | Cross-over design | — | — | Favorable | Favorable | No Impact | — | — | — |
| Takahashi et al. (35) | RefID 4037 PMID-15204275 | Quasi-experimental | — | — | No Impact | Favorable | No Impact | — | — | — |
| Tempesta et al. (36) | RefID-4093 PIMD-24016171 | Quasi-experimental | — | — | Mixed/ Inconclusive | Mixed/ Inconclusive | No Impact | — | — | — |
| Howard et al. (32) | RefID-1821 PMID-n/a | Randomized cross-over | — | — | Favorable | No Impact | — | — | — | — |

Note: Findings are classified as favorable for use of napping during shift work, unfavorable, mixed/inconclusive, or no impact. *Includes quality of care. †Includes external subjective ratings of the study subject's performance including perceived satisfaction with the subject's performance. ‡Includes acute states of fatigue, sleepiness, alertness. §includes sleep latency, total sleep time, recovery, and related measures. ‖Includes job satisfaction and measures of preference for a particular shift pattern. #General wellness or well-being measures included.

Purnell et al. measured sleepiness with a visual analog scale (29). Sallinen et al. measured sleepiness with the Karolinska Sleepiness Scale (KSS) (27). Naps had a moderate, significant effect on sleepiness measured at the end of shift (SMD 0.40, 95% CI 0.09 to 0.72; p = 0.01; Figure 2c). The researchers detected no evidence of heterogeneity (Chi (2) = 0.20; df = 1; p = 0.66; $I^2$ = 0%). The difference in sleepiness from the start to the end of shift between the nap and no–nap condition was moderate (SMD 0.41, 95% CI 0.09 to 0.72; Figure 2d), the effect was statistically significant (p = 0.01) and there was a low level of heterogeneity (Chi (2) = 1.35; df = 1; p = 0.25; $I^2$ = 26%).

## Impact of Scheduled Naps on Indicators of Sleep and Sleep Quality

Nine experimental studies assessed indicators of sleep and/or sleep quality and judged unfavorable ($n$ = 1), mixed/inconclusive ($n$ = 1), or no impact ($n$ = 7; Table 2) (25, 27–29, 31, 33–36). Sallinen et al. determined that subjects felt they slept better in the control (no–nap) condition (27). Matsumoto et al. compared self-reported sleep times prior to, during, and following scheduled shifts stratified by day/night shift work (33). Matsumoto and colleagues reported that day sleep was affected when a nap was taken on night

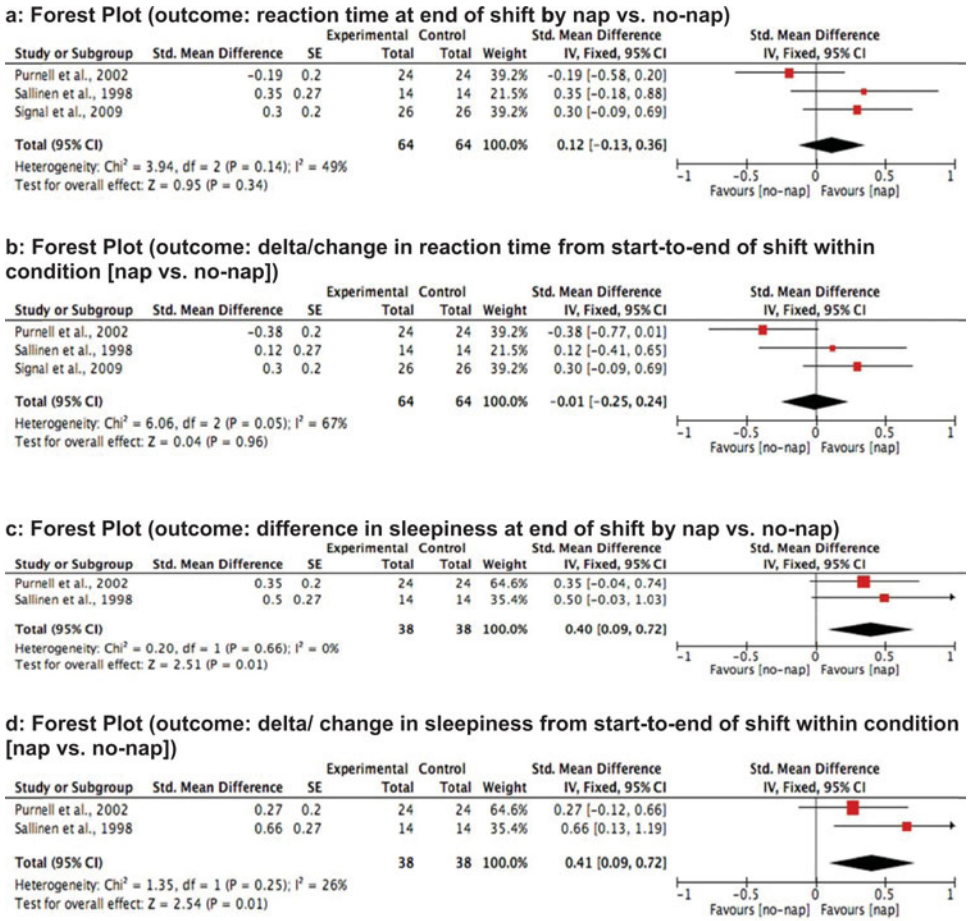


FIGURE 2. Figure 2a-2d: Forest Plots (2a: outcome: reaction time at end of shift by nap vs. no-nap), (2b: outcome: delta/change in reaction time from start-to-end of shift within condition [nap vs. no-nap]), (2c: outcome: difference in sleepiness at end of shift by nap vs. no-nap), (2d: outcome: delta/change in sleepiness from start-to-end of shift within condition [nap vs. no-nap]). Notes: The aforementioned figures report the standardized mean difference (SMD) for reaction time and acute fatigue (using sleepiness measures) for the control compared to the intervention (mean outcome under the control condition minus the mean outcome under the nap condition). The SMD is the estimated intervention effect of each study relative to the variability in the study and also known as Cohen's d measurement of effect size. The effect size is not tied to a specific scale or scales used in the pooled analysis. An SMD of zero implies the intervention and control condition (placebo) are equal. An SMD greater than zero indicates that the napping group had a lower mean value than the control group (treatment condition leads to better/faster reaction time and lower sleepiness). Common delineations or cut-points for interpretation include: 0.2 = small; 0.5 = medium/moderate; 0.8 or greater as large. The SMD is non-significant if the corresponding 95% confidence interval is wide and overlaps 0. RevMan software (V.5.3) was used to generate SMDs for reaction time and sleepiness and for producing forest plots. For the Purnell et al. study, reaction time data (means and standard errors) were abstracted from Table 1 of the manuscript for the start and end of the 1st shift for both the control condition and the nap condition (29). The use of data from the 1st shift was appropriate as the participants would be more naïve to the intervention compared to the participants in the 2nd shift. Signal and colleagues generated reaction time with use of the 10-minute psychomotor vigilance test (PVT) (31). Raw means and SDs were not reported in the manuscript. These data were obtained from Signal upon request specific to the "early night shift" start of shift and end of shift PVT measures (31). Data for reaction time (means and SDs) for the Sallinen et al. study were abstracted from Table 2 of the manuscript specific to the early 30 arm (27). Data from these three studies was combined and the specific study arms from each study given the similarities in timing of the napping intervention and nap duration across studies. The studies all used crossover designs with each participant having measurements during intervention and control periods. For purposes of Figure 2a, the difference in mean reaction time taken at the end of the shift between the control condition and nap condition was calculated. When standard deviations (SDs) were not provided, the study used the following formula to generate SDs [SD = SE * SQRT(N)]. The standard deviation with person difference between the intervention and control periods was calculated assuming the correlation within person was 0.5 (SD for the difference = $\sqrt{(SD^2_{\text{intervention}} + SD^2_{\text{control}} - 2*0.5*SD_{\text{intervention}}*SD_{\text{control}})}$. Figure 2b shows the calculation of the change (delta) in reaction time from the start-to-end of shift within each condition (the nap and no-nap groups). The difference in the change was then calculated by subtracting the intervention change from the control condition change. The SD for the within shift change were approximated assuming the correlation within shift for the same individual was 0.5 (SD for the within shift change = $\sqrt{(SD^2_{\text{before shift}} + SD^2_{\text{after shift}} - 2*0.5*SD_{\text{before shift}}*SD_{\text{after shift}})}$. This study applied the same approach when calculating the SD for the control versus intervention changes due the crossover nature of the study designs (SD for the difference in deltas = $\sqrt{(SD^2_{\text{intervention within shift delta}} + SD^2_{\text{control within shift delta}} - 2*0.5*SD_{\text{intervention within shift delta}}*SD_{\text{control within shift delta}})}$. Figure 2c shows the abstracted data from Sallinen et al. and Purnell et al. (27, 29). For the Purnell et al. study, the current research abstracted data from Table 1, for the measurement of subjective ratings of sleepiness measured with a visual analog scale (scored 0–100), where higher scores indicate worsening sleepiness (29). For the Sallinen et al. study, the current research abstracted data from Table 2, where authors reported results of the Karolinska Sleepiness Scale (KSS), with scores ranging from 1–9 where higher scores imply worsening sleepiness (27). For purposes of Figure 2d, this study used the aforementioned calculation for the delta/change within sleepiness from start to end of shift by nap vs. no-nap condition.

shift, however, there was no difference in the night sleep totals between the nap versus no nap group and findings were overall judged to be mixed/inconclusive (33). Smith et al. showed no difference in sleep hours prior to work between the nap and no-nap conditions (28). Smith-Coggins et al. detected no differences in total sleep time between conditions (25). Purnell et al. detected no difference in sleep duration following night shift work with use of actigraphy and sleep diaries (29). Bonnefond et al. detected no differences in the main sleep duration over a 12-month period after instituting a nap period during shift work (34). Signal et al. showed that a nap during the night shift did not affect timing, duration, or efficiency of sleep at home after the night shift (31). Takahashi et al. used a sleep diary and actigraphs to measure sleep latency, sleep onset, sleep offset, total sleep time, time awake after sleep onset, and mean activity during sleep (35). The authors detected no differences in sleep measures between the nap and no nap conditions (35). Tempesta et al. detected no differences in actigraph-measured total sleep time between the wake group and nap group (36). Findings of Sallinen et al. were unfavorable (27). Findings of Smith et al., Smith-Coggins et al., Purnell et al., Bonnefond et al., Signal et al., Takahashi et al., and Tempesta et al. (25, 28, 29, 31, 34–36) were categorized as no impact. Findings by Matsumoto et al. were categorized as mixed/inconclusive (33).

### Impact of Scheduled Naps on Indicators of Patient Safety, Retention/Turnover, Long-Term Health, and Cost to the System

None of the retained studies evaluated the impact of napping on these measures.

### Quality of Evidence

Most studies were judged to have serious risk of bias. The biases for individual studies are presented in the Cochrane Collaboration's risk of bias tool for experimental studies and appear in Online Supplement Appendix D. Common biases across studies, stratified by outcome, are presented in the GRADE Evidence Profile Table (See Online Supplement Table 3). The most common biases detected are those inherent in operational field studies, including lack of randomization, allocation concealment and blinding. Given these biases, the researchers downgraded the certainty in the evidence, which contributed to the very low quality rating shown in the GRADE Evidence Profile Table.

## DISCUSSION

### Summary of Main Results

There is favorable evidence from experimental studies to suggest that brief scheduled naps during shift work mitigate fatigue in shift workers, with the greatest impact apparent for acute fatigue (sleepiness) and personnel performance. The findings show a small, non-significant effect of short duration scheduled naps on personnel performance (reaction time) during the night shift (Figures 2a and 2b). The effect of naps on acute fatigue was modest and statistically significant (Figures 2c and 2d). These findings suggest that short duration naps are a promising strategy for fatigue risk management. The lack of research assessing the impact of scheduled naps on patient safety, retention/turnover, indicators of long-term health, or cost to the system highlights the need for more research.

The optimal duration of on-duty naps cannot be answered by the systematic review. Naps were not implemented in the same manner in the reviewed research (Table 1). The duration of time allowed for naps on shift varied from 15 minutes (35) to 120 minutes (33). The acceptability of naps also varied greatly with 38% to 100% actually sleeping during the nap opportunity, sometimes depending on the timing of the nap (32). Mean sleep duration during nap opportunities varied between studies as well from a low of 8.4 minutes (26) to a high of 46.6 minutes (27). It is possible that the duration of naps influenced the outcomes examined; however, with the vast diversity in nap duration, circadian placement of nap and implementation methodology present in the limited literature available, the researchers were not able to explore this aspect of napping. Future research on heterogeneous nap durations is warranted.

Because EMS personnel often work extended duration shifts (e.g., ≥ 24 hours), there are many other aspects of napping that need further research. In the reviewed studies, the scheduled napping opportunities were protected for the participants. In the EMS environment, such nap opportunities might be unprotected by necessity, such that the EMS clinician's nap might be interrupted by an emergency call. Those workers without scheduled nap opportunities may nap anyway, intentionally or unintentionally, complicating experimental studies and operational policies.

This study judged the quality of evidence for all outcomes as very low (Online Supplement Table 3). Most studies were judged to have a serious risk of bias due to crossover study designs. Many did not incorporate randomization and blinding was not possible or feasible. The researchers downgraded for small sample sizes, inconsistency (wide confidence intervals in meta-analyses for select outcomes), indirectness of evidence involving shift workers other than EMS personnel, and

imprecision of select outcomes (e.g., use of diverse outcomes across studies with uncertain reliability).

## Agreement and Disagreement with other Systematic Reviews

Ruggiero and Redeker performed a narrative review of the evidence on napping while incorporating elements of a systematic review (e.g., exploring literature from multiple repositories) (13). While the current study's systematic review and meta-analysis was isolated to shift workers (14), Ruggiero and Redeker included studies involving healthy volunteers or non-shift worker study participants (13) (e.g., Sagaspe et al., 2007; 38). The current study's analysis was aimed to more directly evaluate outcomes on participants that are most like EMS personnel. Still, the findings of Rugiero and Redeker agree with this study, as they identified that most investigations found night shift napping led to decreased sleepiness and improved sleep-related performance (13). Similarly, they did not find any studies, even in non-shift worker participants that evaluated the effects of naps on safety outcomes. This review and meta-analyses advance prior findings that specifically examine the impact of intra-shift napping on shift worker performance and sleepiness.

## Limitations

The collection of relevant literature to select databases was limited. Other databases may index literature and research relevant to the PICO question. The decision to include or exclude a study was based on pre-specified criteria, yet the decisions are ultimately subjective. The researchers examined the judgment of screeners to include or exclude a title/abstract by having the principal investigator (PDP) review and adjudicate a random sample of $n = 50$ titles and abstracts of the $n = 4{,}656$ reviewed by screeners PJC and EMT. Principal investigator (PDP) completed the review with no knowledge of prior judgments by screeners. Findings from this comparison revealed 100% agreement between investigators PDP, PJC, and EMT.

There are limitations with the meta-analysis of reaction time (a personnel performance measure) and sleepiness (an acute fatigue outcome measure). Only three of 13 studies reported performance measure data in a format that could be pooled for meta-analysis. Two of 13 studies reported data germane to the acute fatigue outcome (i.e., sleepiness), which was pooled to determine an overall effect of napping versus no-nap during night shift work. One study by Signal et al. reported reaction time data in graphical format (28). The team's principal investigator (PDP) requested and received the raw means and standard deviations from the study's lead author (Signal).

All the studies reviewed were collected data in operational settings. In these field studies, confounding from other fatigue countermeasures (e.g., caffeine), prior wakefulness or work conditions were not controlled. This lack of standardization may contribute to the variability seen in the results. Data on long-term outcomes, including employee retention (at an EMS agency) or social/biological outcomes (e.g., long-term health measures, social interaction measures) are lacking. Future research should evaluate the impact of naps on long-term as well as short-term outcomes.

Although the judgments of evidence quality were guided by the GRADE framework and formulated based on consensus between co-investigators (19, 20), others reviewing the same evidence may evaluate the evidence differently.

## Conclusions

In this systematic review, evidence supported napping during shiftwork. However, the effect of scheduled naps on select outcomes was not consistent across studies and some studies showed no impact or mixed/inconclusive findings. The quality of evidence was judged very low, mostly due to a lack of randomized clinical trials conducted in operational shift workers. This systematic review identifies gaps in research involving EMS personnel and similar worker groups on the efficacy of intra-shift naps as a fatigue risk management strategy. In order to improve the health and safety of EMS personnel and the patients under their care, further research evaluating the timing, duration, feasibility and acceptability of napping interventions with multiple health and safety outcomes is warranted. Cost benefit analyses of napping interventions and dissemination strategies are also necessary to maximize the implementation of successful napping countermeasure strategies.

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