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Shorter Versus Longer Shift Durations to Mitigate Fatigue and Fatigue-Related Risks in Emergency Medical Services Personnel and Related Shift Workers: A Systematic Review

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ABSTRACT

Background: This study comprehensively reviewed the literature on the impact of shorter versus longer shifts on critical and important outcomes for Emergency Medical Services (EMS) personnel and related shift worker groups. **Methods**: Six databases (e.g., PubMed/MEDLINE) were searched, including one website. This search was guided by a research question developed by an expert panel *a priori* and registered with the PROSPERO database of systematic reviews (2016:CRD42016040099). The critical outcomes of interest were patient safety and personnel safety. The important outcomes of interest were personnel performance, acute fatigue, sleep and sleep quality, retention/turnover, long-term health, burnout/stress, and cost to system. Screeners worked independently and full-text articles were assessed for relevance. Data abstracted from the retained literature were categorized as favorable, unfavorable, mixed/inconclusive, or no impact toward the shorter shift duration. This research characterized the evidence as very low, low, moderate, or high quality according to the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) methodology. **Results**: The searched yielded $n = 21{,}674$ records. Of the 480 full-text articles reviewed, 100 reported comparisons of outcomes of interest by shift duration. We identified 24 different shift duration comparisons, most commonly 8 hours versus 12 hours. No one study reported findings for all 9 outcomes. Two studies reported findings linked to both critical outcomes of patient and personnel safety, 34 reported findings for one of two critical outcomes, and 64 did not report findings for critical outcomes. Fifteen studies were grouped to compare shifts <24 hours versus shifts ≥24 hours. None of the findings for the critical outcomes of patient and personnel safety were categorized as unfavorable toward shorter duration shifts (<24 hours). Nine studies were favorable toward shifts <24 hours for at least one of the 7 important outcomes, while findings from one study were categorized as unfavorable. Evidence quality was low or very low. **Conclusions**: The quality of existing evidence on the impact of shift duration on fatigue and fatigue-related risks is low or very low. Despite these limitations, this systematic review suggests that for outcomes considered critical or important to EMS personnel, shifts <24 hours in duration are more favorable than shifts ≥24 hours. **Key words:** Shift duration; fatigue; safety; EMS

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Background

Many Emergency Medical Services (EMS) organizations schedule shifts of 24 hours in duration or longer (1, 2). Some sources suggest that 12-hour and 24-hour duration shifts are the most prevalent shift schedules worked by EMS personnel in the United States (2–6). Longer duration shifts are linked to greater sleepiness and fatigue (7, 8). Fatigue affects greater than half of EMS personnel and reports of EMS personnel falling asleep while performing critical duties are on the rise (9–12). There is reason to believe that EMS personnel that work longer duration shifts are at increased risk of fatigue and fatigue-related risks (e.g., ambulance accidents, injury, medical error, and patient adverse events) (7, 9–11, 13). Our understanding of the relationship between fatigue, fatigue-related outcomes, and shift duration is limited. There is no known comprehensive review of the evidence dedicated to explaining the relationships between shift duration and fatigue in EMS personnel.

Placing limits on shift duration has long been a standard tactic for fatigue management in high risk occupations, including airline pilots, truck drivers, and other shift worker groups (14, 15). In graduate medical education, shift duration was restricted for first-year medical residents following prospective studies that demonstrated a link between extended duration shifts and medical errors, needlestick injuries, and motor vehicle crashes on the commute home (16–18). These restrictions were recently modified, and the debate on appropriate work hours for resident physicians is ongoing. This debate is driven, in part, due to limited understanding of the evidence of the relationship between shift duration, fatigue, and fatigue-related outcomes. There are no known regulatory limits on shift duration for EMS personnel, a worker group that similarly performs complex and high-risk activities that can be negatively impacted by fatigue and one that often has few layers of support to protect from accidents and errors. A comprehensive review of the evidence is needed to inform EMS administrators and their decisions germane to mitigating the effects of fatigue.

This research sought to systematically search the literature and evaluate the certainty of evidence linking shift duration to fatigue and/or fatigue-related risks in EMS personnel or similar workers. This systematic literature review was guided by a single question: "In EMS personnel, do shift-scheduling interventions mitigate fatigue, fatigue-related risks, and/or improve sleep?" (PROSPERO 2016:CRD42016040099) (19). Due to the volume of literature and potential number of shift-scheduling interventions, we further refined this question to evaluate literature that unambiguously compared outcomes between two or more different shift durations.

Methods

This research used a systematic review study design and searched five databases and one website: PubMed/Medline, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), Scopus, PsycINFO, the Published International Literature on Traumatic Stress (PILOTS), and the publications section of the National Institute of Justice (NIJ) website. The definition of our target population was developed *a priori* by a panel of experts, and crafted in such a way that literature of diverse shift worker groups would be included: "EMS personnel or similar worker groups, defined as shift workers whose job activity requires multiple episodes of intense concentration and attention to detail per shift, with serious adverse consequences potentially resulting from lapses in concentration" (19). The details of this research methodology, study protocol, and procedures for reviewing published and unpublished literature have been published separately (20). In the following sections, the components of our search and review procedures unique to this systematic review are described.

Study Design

We assessed journal publications that described randomized controlled trials, quasi-experimental studies (21), and observational study designs (e.g., prospective cohort, cross-sectional, and analyses of secondary/administrative datasets).

Types of Interventions

We retained research that reported on critical outcomes of interest (e.g., patient safety) or important outcomes (e.g., acute fatigue) identified *a priori* (19) and stratified by different shift durations (e.g., 12 hours versus 24 hours).

Types of Outcome Measures

This research searched the literature for two critical and seven important outcomes of interest selected *a priori* by a panel of experts (19). Panelists selected outcomes based on procedures prescribed by the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) framework (19, 22). The critical outcomes of interest were patient safety and personnel safety. The important outcomes of interest were personnel performance, acute fatigue, sleep and sleep quality, retention/turnover, long-term health, burnout/stress, and cost to system.

Search Methods for Studies

A research librarian (PMW) performed searches of six databases, including five bibliographic database products and one website (20). For this systematic review, 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 multiple variables of shift scheduling (i.e., duration, rotation, rotation speed, recovery time between shifts, number of consecutive shifts, and shift placement (night/day). All searches included literature from January 1980 to September 2016. Online Supplement Appendix A provides a detailed description of the search strategies specific to this systematic review.

Data Collection and Selection of Studies

Screening

Two investigators (PJC and DJS) independently screened titles and abstracts to identify potentially relevant publications. Two investigators (PDP and DJS) adjudicated disagreements against inclusion/exclusion criteria: a) the study describes the population of interest; b) the study describes shift duration as the primary comparison of interest; and c) the title and/or abstract describes one or more outcomes of interest. We used the Kappa statistic to determine inter-rater agreement.

Full-Text Review

Nine investigators (EMT, AJK, MEM, BRC, KLF, XX, ZB, JPC, and MLR) worked independently to abstract key information from full-text articles (Online Supplement Appendix B). Co-investigators EMT, AJK, MEM, BRC, KLF, XX, ZB, JPC, and MLR verified all abstractions, and disagreements were resolved by discussion with the principal investigator (PDP). This reseasrch excluded book chapters, conference abstracts, newsletters and similar publications, and dissertations and theses. Co-investigators EMT, AJK, MEM, BRC, KLF, XX, ZB, JPC, and MLR searched bibliographies to identify relevant research.

Risk of Bias Assessment

Our team's three senior investigators (CMG, MSR, and PDP) used the Cochrane Collaboration's Risk of Bias tool for experimental studies to document perceived bias of individual studies (23). The GRADE template was used to assess risk of bias of studies with observational designs (non-experimental) (24). We resolved disagreements through discussion and consensus.

Statistical Analysis

This research classified studies based on study design (experimental/non-experimental) and by the shift comparison indicated (e.g., 8-hour versus 12-hour shifts). Studies that reported findings by multiple shift comparisons were collated into a category labeled "multiple comparisons." Three investigators (PDP, MSR, and CMG) used a categorical system adopted by Bolster and Rourke to describe the impact of shorter shift durations, compared with longer shift durations, on the critical and important outcomes as favorable, unfavorable, mixed/inconclusive, or no impact (25). Additional information regarding the protocol for assessing the findings of retained research can be found in a separate paper in this supplement (20).

Quality of Evidence

Four investigators (PDP, CMG, MSR, and ESL) used GRADE evidence profile tables to summarize key findings stratified by shift duration comparisons and to present a quality of evidence rating for each outcome of interest (24, 26).

Reporting

Findings are presented in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) (27).

RESULTS

The search strategy yielded $n = 21{,}674$ records of which $n = 44$ duplicates were removed (Figure 1). Two investigators (PJC and MLR) independently screened $n = 21{,}630$ titles and abstracts. The inter-rater agreement for inclusion/exclusion during screening was moderate (Kappa = 0.49). Following conflict adjudication, $n = 244$ records were judged potentially eligible based on title and abstract. An additional $n = 236$ studies were identified during bibliography searches and reviewed in full text format. Of the $n = 480$ total journal articles reviewed in full, $n = 100$ that reported on experimental and non-experimental studies were determined relevant and key findings abstracted into tables (See Online Supplement Appendix B). Of these $n = 100$, $n = 25$ of the studies reported in these articles were classified as experimental or quasi-experimental, and $n = 75$ classified as observational or non-experimental (See Online Supplement Table 1). There was variation in the type of shift worker studied (See Online Supplement Table 1). Half of all studies ($n = 51$) included "other healthcare shift workers," such as nurses and physicians. One third of all studies retained ($n = 30$) included "other non-healthcare shift workers," such as power plant workers, long-haul truck drivers, miners, factor workers, and others. Four studies (4%) included public safety workers such as police officers. Fifteen studies (15%) included EMS professionals, including ground-based EMS, air-medical, and fire-based EMS

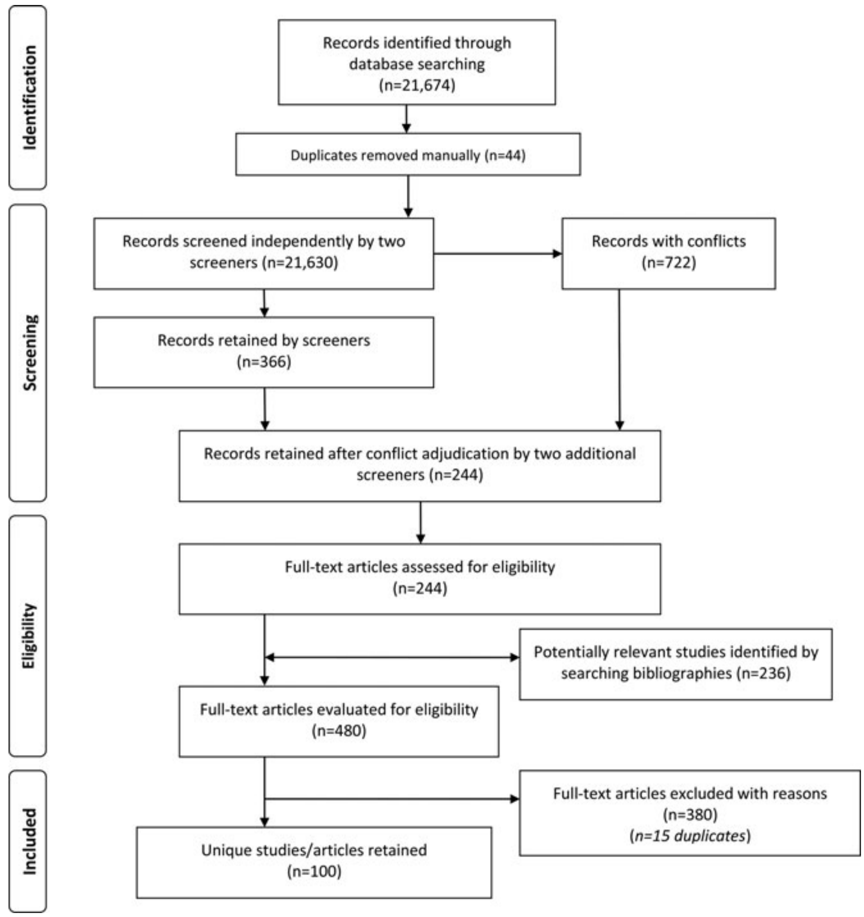

Figure 1. PRISMA 2009 Flow Diagram for PICO#2 PROSPERO 2016:CRD42016040099.

shift workers. Three hundred eighty journal articles were excluded after full-text review and reasons given for exclusion are organized in the Population, Intervention, Comparison, Outcome (PICO) format (See Online Supplement Appendix C) (28–30). Risks of bias detected in the 100 retained studies are described in the Online Supplement Appendix D. See Online Supplement Appendix E for a complementary document to Online Supplement Table 1. Online Supplement Appendix E provides additional detail of our findings stratified by the specific shift duration comparisons and study types.

This research identified 24 different shift duration comparisons (Online Supplement Table 1). Approximately 40% of all studies ($n = 38$) compared outcomes by 8 versus 12-hour shifts. One quarter of all studies ($n = 24$) compared outcomes by multiple shift durations. The remaining 38 studies compared outcomes by the following durations: 4 versus 6-hour ($n = 3$ studies), 6 versus 12-hour ($n = 1$), 6 versus 30-hour ($n = 1$), <8 versus >8-hour ($n = 2$), 8 versus 9-hour ($n = 2$), 8 versus 10-hour ($n = 1$), 8 versus 16-hour ($n = 2$), 8 versus 24-hour ($n = 3$), 8.5 versus 24-hour ($n = 1$), 9 versus 32-hour ($n = 1$), 10 versus 13-hour ($n = 2$), 10 versus 14-hour ($n = 2$), <12 versus >12-hour ($n = 1$), 12 versus 18-hour ($n = 1$), 12 versus 20-hour ($n = 1$), 12 versus 24-hour ($n = 6$), <13 versus >13-hour ($n = 1$), 14 versus 24-hour ($n = 1$), 14 versus 28-hour ($n = 1$), <16 versus ≥16-hour ($n = 2$), <24 versus ≥24-hour ($n = 1$), and 24 versus 48-hour shifts ($n = 2$).

No one study reported findings connected to all nine of the critical or important outcomes (Online Supplement Table 1). Of the 100 total studies, only two reported findings linked to both critical outcomes of patient safety and personnel safety, 34 studies reported findings for one critical outcome, and 64 did not report findings for either of the critical outcomes. Six of the 100 total studies reported findings for 5–7 important outcomes, 47 reported findings for 2–4 important outcomes, and 83 studies reported findings for at least one important outcome. Of the nine outcomes of interest, studies most often reported findings for acute fatigue.

We grouped together eight different shift comparisons and 15 experimental and non-experimental studies into a new category (shifts <24 hours versus shifts >24 hours; See Online Supplement Table 2). One of the 15 studies was a direct comparison of <24 hours versus ≥24-hour shifts, and 6 studies compared 12-hour versus 24-hour shifts. Eight studies reported outcomes stratified by 6 versus 30-hour shifts, 8 versus 24-hour, 8.5 versus 24-hour, 9 versus 32-hour, 14 versus 24-hour, and 14 versus 28-hour shifts. Three of the 15 studies grouped into the <24 versus ≥24-hour comparison reported findings for critical outcomes of patient and personnel safety (16, 31, 32). One study by Talusan et al. measured the reaction time of medical residents at the start and end of shifts in a driving simulator (32). These findings were categorized as mixed/inconclusive. Allen et al. measured the success rate of endotracheal intubations with an analysis of archived medical recordsand the findings were categorized as not impact (31). Barger et al. measured motor vehicle crashes in relation to shift duration with findings categorized as favorable toward shifts <24 hours in duration (16). Nine studies were favorable toward <24-hour shifts for at least one of the seven important outcomes, while findings from one study were categorized as unfavorable. The latter study by Yi et al. assessed psychomotor performance on a laparoscopic simulator at the end of 12-hour and 24-hour shifts (33). Findings showed no differences by shift duration for four of five psychomotor performance measures. Speed of the dominant hand was faster at the end of the longer duration shift compared to the end of the shorter duration shift. We categorized these findings as unfavorable toward the shorter duration shift for the outcome measure of personnel performance (See Online Supplement Table 1). Notably, none of the findings abstracted from any of the 15 studies linked to critical outcomes of patient and personnel safety were categorized as unfavorable toward the shorter duration (<24 hours) shifts.

Findings reported by the 38 studies comparing 8-hour versus 12-hour shifts were mixed (See Online Supplement Table 1 and Online Supplement Appendix E). Three studies reported findings judged favorable toward the shorter 8-hour shifts for the critical outcomes of patient or personnel safety. Two studies reported findings linked to indicators of personnel safety that we categorized as unfavorable toward the shorter duration 8-hour shift. For the important outcomes, six studies were favorable and 12 unfavorable toward 8-hour shifts, with one study both favorable and unfavorable for certain outcomes. Sixteen studies showed mixed/inconclusive findings for at least one important outcome.

Twelve of 24 studies (50%) grouped into the multiple comparisons category, including two with experimental designs, reported findings germane to critical outcomes of patient and personnel safety (Online Supplement Table 1 and Online Supplement Appendix E). Fifty-four percent of studies ($n = 7$) had findings that favored the shorter duration shifts, 34% ($n = 4$) were categorized as no impact, 8% ($n = 1$) was categorized as mixed/inconclusive, and no study that reported on critical outcomes reported findings categorized as unfavorable towards shorter duration shifts. Eighty-three percent of studies ($n = 20$) reported findings linked to at least one important outcome of interest. Thirty-three percent of studies ($n = 8$) reported on two or more important outcomes and only 16.7% ($n = 4$ studies) reported findings for three or more important outcomes. One study reported findings categorized as unfavorable toward shorter duration shifts (34). Amendola et al. studied two police departments in an experimental study and measured the impact of shorter (8-hour) versus longer duration shifts (10-hour and 12-hour) on overtime costs to the employer (34). Findings show a significantly greater number of overtime hours among officers on the 8-hour shifts (5.75 hours) than officers on the 10-hour (0.97) or 12-hour shifts (1.89). This study categorized these findings as unfavorable toward the shorter duration shift specifically for the important outcome of cost to system. The categorization of other findings linked to important outcomes was mostly favorable toward shorter duration shifts (Online Supplement Table 1).

Quality of Evidence

Our analysis of quality is presented in GRADE evidence profile tables and accessible in Online Supplement Table 3. We determined that, regardless of the shift hour comparison, most of the 25 experimental studies provided inadequate descriptions of randomization procedures, limited information about allocation concealment, and uncertainty with respect to safeguarding against threats to internal validity. Most studies evaluated reported use of observational study designs (e.g., cross-sectional, cohort, etc.). We discovered inconsistency in findings for important outcomes. Most studies focused on non-EMS personnel and provided indirect evidence. We also downgraded the assessment of the quality of evidence for imprecision. For most outcomes, the quality of evidence was rated low to very low.

Discussion

Summary of Main Results

There is considerable research comparing fatigue-related outcomes by different shift durations. More than one-third of all studies reported outcomes of interest by the 8 versus 12-hour duration, and one-quarter compared outcomes by multiple shift durations. The analysis of the ratio of favorable versus unfavorable findings in the 8-hour versus 12-hour comparison led to the conclusion no clear advantage of one shift duration over the other. The pattern analysis of studies with multiple shift hour comparisons similarly suggested that shorter duration shifts are not consistently favorable over longer duration shifts across all comparisons. Few studies compared critical or important outcomes by extended shift durations common in EMS organizations (i.e., 12-hour, 24-hour, and 48-hour shifts). Fifteen studies were grouped to compare shifts <24 hours versus ≥24 hours, which are commonly utilized in EMS systems. Our study examined patterns of outcome data in this comparison and determined that for the three studies reporting data for critical outcomes of patient and personnel safety, one study was favorable toward the shorter duration shift for personnel safety, while the other two were classified as no impact and mixed/inconclusive for patient and personnel safety, respectively. Additionally, nine studies reported findings judged favorable toward shifts <24 hours for one or more important outcomes (e.g., personnel performance). The quality of evidence reviewed, regardless of shift hour comparison, was adjudicated as low or very low for most studies.

Inclusion / Exclusion of Prior Research

We included journal articles that reported on studies involving any type of shift worker (i.e., clinician, truck driver, pilot, etc.) and unambiguously compared outcomes by shifts of two or more different shift durations. All other articles were excluded, including book chapters, newsletters, and similar documents.

Quality of Evidence

Overall, this study determined the research examined in this systematic review presented a high risk of bias. The research assessments of evidence quality varied by outcome and by shift hour comparison but were considered either low or very low.

Agreement and Disagreement With Other Systematic Reviews

Our systematic review is similar to reviews by Bae and Fabry; Neil-Sztramko et al.; Uehli et al.; Estabrooks et al.; and Short et al. (35–39). This work is similar because it included/retained many of the same studies, was searching for similar outcomes of interest, or was inclusive of multiple types of shift worker groups. This work is different from prior work because some of the studies retained in these prior reviews were ultimately excluded from this analysis. The most common reason for exclusion from this review was that the comparison of interest was not reported; a common reason for exclusion in systematic reviews with focused research questions (30).

This systematic review differs from prior systematic reviews by Reed et al.; Leroyer et al., Harris et al.; Baldwin et al.; Fletcher et al.; Mansukhani et al.; Fletcher et al.; Fletcher et al.; Moonesinghe et al.; Jamal et al.; and Levine et al. (40–50). Many previous reviews retained studies that reported findings stratified by shift scheduling systems/patterns, or reported on studies that examined outcomes before and then after implementation of a new shift schedule. We excluded studies retained in these previous systematic reviews that reported findings stratified by different shift scheduling systems/patterns (e.g., a night float system versus a more traditional physician shift schedule/pattern/rotation), or reported on findings before/after implementation of a new shift system and did not report findings stratified by specific durations (51–55). A number of systematic reviews describe shift work schedules, patterns, and other aspects of shift work for select shift worker populations (e.g., maritime/shipping, healthcare professionals, and others) (44–20, 56–59). This review was inclusive of all shift worker groups. A review by de Cordova et al. involved a mixed-methods review of literature/research that examined "off-shift" work hours and patterns (e.g., out-of-hours, after-hours, off-peak hours, weekends) (60). This review did not focus on "off-shift" work. The present review differed from the systematic review by Driscoll et al. because select observational designs (i.e., cross-sectional studies) were excluded in the prior review (61). In contrast, cross-sectional studies, case-reports, and other designs were reported that lack a concurrent referent group.

Many of the reviews previously cited examine shift systems, patterns, or rotations isolated to a specific shift worker (e.g., nurse, physician). The systematic review makes a meaningful contribution to the literature with a focused assessment of studies that compared a minimum of one shift duration to another among EMS workers or related occupational groups.

Operational Context

Our research found few studies that compared shift durations common in EMS (e.g., several studies included maritime workers or train drivers and compared 4- versus 6-hour shifts) (62–64). We downgraded these studies for indirectness using the GRADE methodology and grouped like studies with relatively similar durations to allow for a synthesis of multiple studies. Our approach created three stratums of shift duration comparisons: <24 hours versus ≥24 hours, 8 hours versus 12 hours, and a combination of other shift comparisons (labeled as multiple comparisons).

Our study focused on studies that compared shifts <24 hours to shifts ≥24 hours. This scheduling decision is commonly considered in the EMS operational setting. Remaining awake for just 19 consecutive hours results in cognitive performance impairment similar to that observed with a blood alcohol concentration (BAC) of 0.05, with 24 hours of continuous wakefulness equivalent to a BAC of 0.10 (65). Without on-shift rest, a 24-hour work shift would lead to significant neurocognitive impairment for most individuals. The findings showed a preponderance of literature demonstrating that shifts of 24 or more hours in duration, compared to shifts <24 hours, are associated with worse personnel safety, personnel performance, acute fatigue, sleep and sleep quality, retention/turnover, and long-term health. This finding has important implications for EMS systems as many use shift schedules incorporating individual shifts of 24 hours (1, 2).

Shifts of 8 hours and 12 hours in duration are utilized in EMS systems. This research identified 38 studies that reported this comparison. The analysis revealed no consensus in findings among these studies, with a generally even split in favorable and unfavorable findings for the outcomes of interest (Online Supplement Table 1, Appendix B and E). Specific to patient and personnel safety, neither shift type consistently revealed itself as the safer option.

Evaluation of the remaining shift comparisons provide some perspective into the question of whether shorter versus longer shifts should be preferred. A greater proportion of these studies showed favorable findings for shorter duration shifts when considering the outcomes of personnel safety, personnel performance, acute fatigue, retention/turnover, and long-term health (See Online Appendices B and E).

LIMITATIONS

The literature collected for this systematic review was isolated to selected databases, websites, and a search strategy specific to this study (20). Other databases and sources may maintain literature and research that could be relevant to our PICO question.

The judgment of screeners to include or exclude a record based on title/abstract may differ from others. The decisions of the screeners were examined against decisions by the principal investigator PDP with a random sample of $n = 50$ titles and abstracts selected from the initial pool of screened records. Findings from this assessment of 50 revealed 100% agreement among PDP, CMG, and JPC on decisions to include/exclude based on title and/or abstract alone.

The judgments on the favorability of findings reported in retained studies may differ from those of others reviewing the same literature. The GRADE framework guided the judgment of evidence quality. For judgments of favorability and of evidence quality, we used the decision rule that two of the three senior investigators must agree to issue a final decision. Similar to other systematic reviews, we used discussion to address disagreements (25, 37, 46).

Finally, the findings are limited by indirectness of the populations studied. Indirectness is a common problem for guideline developers (66). All 100 studies retained in this systematic review met the criteria for inclusion (including EMS personnel or similar shift workers); however, the bulk of the evidence did not directly compare outcomes of interest when applied to EMS personnel. Fifteen of the 100 studies retained in this systematic review included EMS personnel (4 studies related to shifts < or > 24 hours). The remaining 85 studies involved other types of shift workers. This research addressed this issue by downgrading the quality of evidence per guidance from the GRADE methodology.

CONCLUSION

The research reviewed had numerous methodological limitations, which contributed to low or very low judgments of evidence quality for most outcomes. Despite limitations, the findings from this systematic review suggest that for outcomes considered critical or important to EMS, shifts <24 hours in duration are more favorable than shifts ≥24 hours. The need for additional research of EMS shift scheduling is compelling.

References

1. Ward MJ. Saving more lives? JEMS. 2014;39(2):46–53. PMID:24660358
2. Mears G, Armstrong B, Fernandez AR, Mann NC, McGinnis K, Mears CR, Sanddal ND, Sanddal TL, Shofer FS. National EMS Assessment. [Internet]. 2011. Available from: http://www.ems.gov/pdf/2011/National_EMS_Assessment_Final_Draft_12202011.pdf.
3. Patterson PD, Suffoletto BP, Kupas DF, Weaver MD, Hostler D. Sleep quality and fatigue among prehospital providers. Prehosp Emerg Care. 2010;14(2):187–93. https://doi.org/10.3109/10903120903524971 PMID:20199233
4. Patterson PD, Weaver MD, Frank RC, Warner CW, Martin-Gill C, Guyette FX, Fairbanks RJ, Hubble MW, Songer TJ, Callaway CW, et al. Association between poor sleep, fatigue, and safety outcomes in emergency medical services providers. Prehosp Emerg Care. 2012;16(1):86–97. https://doi.org/10.3109/10903127.2011.616261 PMID:22023164
5. Patterson PD, Buysse DJ, Weaver MD, Callaway CW, Yealy DM. Rcovery between work shifts among emergency medical services clinicians. Prehosp Emerg Care. 2015;19(3):365–75. https://doi.org/10.3109/10903127.2014.995847 PMID: 25658148
6. Patterson PD, Buysse DJ, Weaver MD, Suffoletto BP, McManigle KL, Callaway CW, Yealy DM. Emergency healthcare worker sleep, fatigue, and alertness behavior survey (SFAB): development and content validation of a survey tool. Accid Anal Prev. 2014;73:399–411. https://doi.org/10.1016/j.aap.2014.09.028 PMID:25449415
7. Caruso CC. Negative impacts of shiftwork and long work hours. Rehabil Nurs. 2014;39(1):16–25. https://doi.org/10.1002/rnj.107 PMID:23780784
8. Patterson PD, Buysse DJ, Weaver MD, Doman JM, Moore CG, Suffoletto BP, McManigle KL, Callaway CW, Yealy DM. Real-time fatigue reduction in emergency care clinicians: the SleepTrackTXT randomized trial. Am J Ind Med. 2015;58(10):1098–1113. https://doi.org/10.1002/ajim.22503 PMID:26305869

9. Staff E. Medic falls asleep at wheel, crashes ambulance: the ambulance was reportedly completely destroyed in the incident. [Internet]. 2013 [cited 2016 February 15]. Available from: https://www.ems1.com/ambulances-emergency-vehicles/articles/1414503-Medic-falls-asleep-at-wheel-crashes-ambulance/.
10. Blau R. Bronx woman critically injured in ambulance crash after surviving seven-hour brain surgery; family alleges she was not strapped in properly. [Internet]. 2015 [cited 2016 February 15]. Available from: http://www.nydailynews.com/new-york/bronx-woman-brain-dead-ambulance-crash-article-1.2143628.
11. Stevens T. EMT injured after ambulance driver falls asleep on I-81. [Internet]. 2015 [cited 2016 February 15]. Available from: http://www.roanoke.com/news/crime/roanoke_county/emt-injured-after-ambulance-driver-falls-asleep-on-i/article_56113003-88c0-5d00-9dfb-37847bc865b6.html.
12. Patterson PD, Weaver MD, Hostler D. EMS provider wellness. In: Cone D, Brice JH, Delbridge T, Myers B, editors. *Emergency medical services: clinical practice and systems oversight*. Vol. 2. Chichester, West Sussex; Hoboken: Wiley; 2015. P. 211–16.
13. Patterson PD, Weaver MD, Hostler D, Guyette FX, Callaway CW, Yealy DM. The shift length, fatigue, and safety conundrum in EMS. Prehosp Emerg Care. 2012;16(4):572–76. https://doi.org/10.3109/10903127.2012.704491 PMID: 22823487
14. Gander P, Hartley L, Powell D, Cabon P, Hitchcock E, Mills A, Popkin S. Fatigue risk management: Organizational factors at the regulatory and industry/company level. Accid Anal Prev. 2011;43(2):573–90. https://doi.org/10.1016/j.aap.2009.11.007 PMID:21130218
15. Jones CB, Dorrian J, Rajaratnam SM, Dawson D. Working hours regulations and fatigue in transportation: a comparative analysis. Safety Science. 2005;43(4):225–52. https://doi.org/10.1016/j.ssci.2005.06.001]
16. Barger LK, Cade BE, Ayas NT, Cronin JW, Rosner B, Speizer FE, Czeisler CA. Extended work shifts and the risk of motor vehicle crashes among interns. N Engl J Med. 2005;352(2):125–34. https://doi.org/10.1056/NEJMoa041401 PMID:15647575
17. Ayas NT, Barger LK, Cade BE, Hashimoto DM, Rosner B, Cronin JW, Speizer FE, Czeisler CA. Extended work duration and the risk of self-reported percutaneous injuries in interns. JAMA. 2006;296(9):1055–62. https://doi.org/10.1001/jama.296.9.1055 PMID:16954484
18. Barger LK, Ayas NT, Cade BE, Cronin JW, Rosner B, Speizer FE, Czeisler CA. Impact of extended-duration shifts on medical errors, adverse events, and attentional failures. PLoS Med. 2006;12:e487. https://doi.org/10.1371/journal.pmed.0030487]
19. Patterson PD, Higgins JS, Lang ES, Runyon MS, Barger LK, Studnek JR, Moore CG, Robinson K, Gainor D, Infinger A, et al. Evidence-based guidelines for fatigue risk management in EMS: formulating research questions and selecting outcomes. Prehosp Emerg Care. 2017;21(2):149–56. https://doi.org/10.1080/10903127.2016.1241329 PMID: 27858581
20. Patterson PD, Higgins JS, Weiss PM, Lang ES, Martin-Gill C. Systematic review methodology for the fatigue in emergency medical services project. Prehosp Emerg Care. 2018;22(S1):9–16.
21. Shadish WR, Cook TD, Campbell DT. Experimental and quasi-experimental designs for generalized causal inference. Boston, MA: Houghton Mifflin; 2002.
22. Guyatt GH, Oxman AD, Kunz R, Atkins D, Brozek J, Vist G, Alderson P, Glasziou P, Falck-Ytter Y, Schunemann HJ. GRADE guidelines: 2. Framing the question and deciding on important outcomes. J Clin Epidemiol. 2011;64(4):395–400. https://doi.org/10.1016/j.jclinepi.2010.09.012 PMID:21194891
23. Higgins JPT, Green S (eds). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. The Cochrane Collaboration, 2011. Available from http://handbook.cochrane.org.
24. Guyatt GH, Oxman AD, Vist G, Kunz R, Brozek J, Alonso-Coello P, Montori V, Akl EA, Djulbegovic B, Falck-Ytter Y, et al. GRADE guidelines: 4. Rating the quality of evidence.study limitations (risk of bias). J Clin Epidemiol. 2011;64(4):407–15. https://doi.org/10.1016/j.jclinepi.2010.07.017 PMID:21247734
25. Bolster L, Rourke L. The effect of restricting residents' duty hours on patient safety, resident well-being, and resident education: an updated systematic review. J Grad Med Educ. 2015;7(3):349–63. https://doi.org/10.4300/JGME-D-14-00612.1 PMID:26457139
26. Guyatt GH, Oxman AD, Akl EA, Kunz R, Vist G, Brozek J, Norris S, Falck-Yitter Y, Glasziou P, DeBeer H, et al. GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. J Clin Epidemiol. 2011;64(4):383–94. https://doi.org/10.1016/j.jclinepi.2010.04.026 PMID:21195583
27. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA-Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. J Clin Epidemiol. 2009;62(10):1006–10. https://doi.org/10.1016/j.jclinepi.2009.06.005 PMID:19631508
28. Huang X, Lin J, Demner-Fushman D. Evaluation of PICO as a knowledge representation for clinical questions. AMIA Annu Symp Proc. 2006:359–63. PMID:17238363
29. Thabane L, Thomas T, Ye C, Paul J. Posing the research question: not so simple. Can J Anaesth. 2009;56(1):71–9. https://doi.org/10.1007/s12630-008-9007-4 PMID:19247780
30. Edinger T, Cohen AM. A large-scale analysis of the reasons given for excluding articles that are retrieved by literature search during systematic review. AMIA Annu Symp Proc. 2013:379–87. PMID:24551345</bib
31. Allen TL, Delbridge TR, Stevens MH, Nicholas D. Intubation success rates by air ambulance personnel during 12-versus 24-hour shifts: does fatigue make a difference? Prehosp Emerg Care. 2001;5(4):340–3. https://doi.org/10.1080/10903120190939481 PMID:11642582
32. Talusan PG, Long T, Halim A, Guliani L, Carroll N, Reach J. Effects of fatigue on driving safety: a comparison of brake reaction times in night float and postcall physicians in training. J Grad Med Educ. 2014;6(4):653–7. https://doi.org/10.4300/JGME-D-14-00006.1 PMID:26140113
33. Yi WS, Hafiz S, Sava JA. Effects of night-float and 24-h call on resident psychomotor performance. J Surg Res. 2013;184(1):49–53. https://doi.org/10.1016/j.jss.2013.03.029 PMID:23587456
34. Amendola KL, Weisburd D, Hamilton EE, Jones G, Slipka M. An experimental study of compressed work schedules in policing: advantages and disadvantages of various shift lengths. J Exp Criminol. 2011;7(4):407–42. https://doi.org/10.1007/s11292-011-9135-7]
35. Bae SH, Fabry D. Assessing the relationships between nurse work hours/overtime and nurse and patient outcomes: systematic literature review. Nurs Outlook. 2014;62(2):138–56. https://doi.org/10.1016/j.outlook.2013.10.009 PMID: 24345613
36. Neil-Sztramko SE, Pahwa M, Demers PA, Gotay CC. Health-related interventions among night shift workers: a critical review of the literature. Scand J Work Environ Health. 2014;40(6):543–56. https://doi.org/10.5271/sjweh.3445 PMID:24980289
37. Uehli K, Mehta AJ, Miedinger D, Hug K, Schindler C, Holsboer-Trachsler E, Leuppi JD, Kunzli N. Sleep problems and work injuries: a systematic review and meta-analysis. Sleep Med Rev. 2014;18(1):61–73. https://doi.org/10.1016/j.smrv.2013.01.004 PMID:23702220

38. Estabrooks CA, Cummings GG, Olivo SA, Squires JE, Giblin C, Simpson N. Effects of shift length on quality of patient care and health provider outcomes: systematic review. Qual Saf Health Care. 2009;18(3):181–8. https://doi.org/10.1136/qshc.2007.024232 PMID:19467999
39. Short MA, Agostini A, Lushington K, Dorrian J. A systematic review of the sleep, sleepiness, and performance implications of limited wake shift work schedules. Scand J Work Environ Health. 2015;41(5):425–40. https://doi.org/10.5271/sjweh.3509 PMID:26103467
40. Reed DA, Fletcher KE, Arora VM. Systematic review: association of shift length, protected sleep time, and night float with patient care, residents' health, and education. *Ann Intern Med*. 2010;153(12):829–42. https://doi.org/10.7326/0003-4819-153-12-201012210-00010 PMID:21173417
41. Leroyer E, Romieu V, Mediouni Z, Becour B, Descatha A. Extended-duration hospital shifts, medical errors and patient mortality. Br J Hosp Med (Lond). 2014;75(2):96–101. https://doi.org/10.12968/hmed.2014.75.2.96 PMID:24521805
42. Harris JD, Staheli G, LeClere L, Andersone D, McCormick F. What effects have resident work-hour changes had on education, quality of life, and safety? A systematic review. Clin Orthop Relat Res. 2015;473(5):1600–8. https://doi.org/10.1007/s11999-014-3968-0 PMID:25269530
43. Baldwin K, Namdari S, Donegan D, Kamath AF, Mehta S. Early effects of resident work-hour restrictions on patient safety: a systematic review and plea for improved studies. J Bone Joint Surg Am. 2011;93(2):e5. https://doi.org/10.2106/JBJS.J.00367 PMID:21248206
44. Fletcher KE, Underwood Wr, Davis SQ, Mangrulkar RS, McMahon LFJ, Saint S. Effects of work hour reduction on residents' lives: a systematic review. JAMA. 2005;294(9):1088–100. https://doi.org/10.1001/jama.294.9.1088 PMID:16145030
45. Mansukhani MP, Kolla BP, Surani S, Varon J, Ramar K. Sleep deprivation in resident physicians, work hour limitations, and related outcomes: a systematic review of the literature. Postgrad Med. 2012;124(4):241–9. https://doi.org/10.3810/pgm.2012.07.2583 PMID:22913912
46. Fletcher KE, Davis SQ, Underwood WR, Mangrulkar RS, McMahon LFJ, Saint S. Systematic review: effects of resident work hours on patient safety. Ann Intern Med. 2004;141(11):851–57. https://doi.org/10.7326/0003-4819-141-11-200412070-00009 PMID:15583227
47. Fletcher KE, Reed DA, Arora VM. Patient safety, resident education and resident well-being following implementation of the 2003 ACGME duty hour rules. J Gen Intern Med. 2011;26(8):907–19. https://doi.org/10.1007/s11606-011-1657-1 PMID:21369772
48. Moonesinghe SR, Lowery J, Shahi N, Millen A, Beard JD. Impact of reduction in working hours for doctors in training on postgraduate medical education and patients' outcomes: systematic review. BMJ. 2011;342:d1580. https://doi.org/10.1136/bmj.d1580 PMID:21427046
49. Jamal MH, Doi SA, Rousseau M, Edwards M, Rao C, Barendregt JJ, Snell L, Meterissian S. Systematic review and meta-analysis of the effect of North American working hours restrictions on mortality and morbidity in surgical patients. Br J Surg. 2012;99(3):336–344. https://doi.org/10.1002/bjs.8657 PMID:22241280
50. Levine AC, Adusumilli J, Landrigan CP. Effects of reducing or eliminating resident work shifts over 16 hours: A systematic review. Sleep. 2010;33(8):1043–53. https://doi.org/10.1093/sleep/33.8.1043 PMID:20815185
51. Hendey GW, Barth BE, Soliz T. Overnight and postcall errors in medication orders. Acad Emerg Med. 2005;12(7):629–34. https://doi.org/10.1111/j.1553-2712.2005.tb00919.x PMID:15995095
52. Chow KM, Szeto CC, Chan MH, Lui SF. Near-miss errors in laboratory blood test requests by interns. QJM. 2005;98(10):753–6. https://doi.org/10.1093/qjmed/hci116 PMID:16126739
53. Bhavsar J, Montgomery D, Li J, Kline-Rogers E, Saab F, Motivala A, Froehlich JB, Parekh V, Del Valle J, Eagle KA. Impact of duty hours restrictions on quality of care and clinical outcomes. Am J Med. 2007;120(11):968–74. https://doi.org/10.1016/j.amjmed.2007.07.026 PMID:17976424
54. Landrigan CP, Rothschild JM, Cronin JW, Kaushal R, Burdick E, Katz JT, Lilly CM, Stone PH, Lockley SW, Bates DW, et al. Effect of reducing interns' work hours on serious medical errors in intensive care units. N Engl J Med. 2004;351(18):1838–48. https://doi.org/10.1056/NEJMoa041406 PMID:15509817
55. Laine C, Goldman L, Soukup JR, Hayes JG. The impact of a regulation restricting medical house staff working hours on the quality of patient care. JAMA. 1993;269(3):374–8. https://doi.org/10.1001/jama.1993.03500030072035 PMID:8418344
56. Colquhoun WP. Hours of work at sea: watchkeeping schedules, circadian rhythms and efficiency. Ergonomics. 1985;28(4):637–53. https://doi.org/10.1080/00140138508963178 PMID:4018013
57. Oldenburg M, Hogan B, Jensen HJ. Systematic review of maritime field studies about stress and strain in seafaring. Int Arch Occup Environ Health. 2013;86(1):1–15. https://doi.org/10.1007/s00420-012-0801-5 PMID:22915144
58. Main LC, Chambers TP. Factors affecting maritime pilots' health and well-being: a systematic review. Int Marit Health. 2015;66(4):220–32. https://doi.org/10.5603/IMH.2015.0043 PMID:26726893
59. Poissonnet CM, Veron M. Health effects of work schedules in healthcare professions. J Clin Nurs. 2000;9(1):13–23. https://doi.org/10.1046/j.1365-2702.2000.00321.x PMID:11022488
60. de Cordova PB, Phibbs CS, Bartel AP, Stone PW. Twenty-four/seven: a mixed-method systematic review of the off-shift literature. J Adv Nurs. 2012;68(7):1454–68. https://doi.org/10.1111/j.1365-2648.2012.05976.x PMID:22905343
61. Driscoll TR, Grunstein RR, Rogers NL. A systematic review of the neurobehavioural and physiological effects of shiftwork systems. Sleep Med Rev. 2007;11(3):179–94. https://doi.org/10.1016/j.smrv.2006.11.001 PMID:17418596
62. Harma M, Partinen M, Repo R, Sorsa M, Siivonen P. Effects of 6/6 and 4/8 watch systems on sleepiness among bridge officers. Chronobiol Intl. 2008;25(2):413–23. https://doi.org/10.1080/07420520802106769 PMID:18484371
63. Lutzhoft M, Dahlgren A, Kircher A, Thorslund B, Gillberg M. Fatigue at sea in Swedish shipping-a field study. Am J Ind Med. 2010;53(7):733–40. PMID:20187001
64. Kazemi Z, Mazloumi A, Nasl Saraji G, Barideh S. Fatigue and workload in short and long-haul train driving. Work. 2016;54(2):425–33. https://doi.org/10.3233/WOR-162328 PMID:27286082
65. Dawson D, Reid K. Fatigue, alcohol and performance impairment. Nature. 1997;388(6639):235. https://doi.org/10.1038/40775 PMID:9230429
66. Guyatt GH, Oxman AD, Kunz R, Woodcock J, Brozek J, Helfand M, Alonso-Coello P, Falck-Yitter Y, Jaeschke R, Vist G. GRADE guidelines: 8. Rating the quality of evidence—indirectness. J Clin Epidemiol. 2011;64(12):1303–10. https://doi.org/10.1016/j.jclinepi.2011.04.014 PMID:21802903