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Original article

A systematic review of the effect of various interventions on reducing fatigue and sleepiness while driving

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ABSTRACT

Purpose: To identify and appraise the published studies assessing interventions accounting for reducing fatigue and sleepiness while driving.
Methods: This systematic review searched the following electronic databases: Medline, Science direct, Scopus, EMBASE, PsycINFO, Transport Database, Cochrane, BIOSIS, ISI Web of Knowledge, specialist road injuries journals and the Australian Transport and Road Index database. Additional searches included websites of relevant organizations, reference lists of included studies, and issues of major injury journals published within the past 15 years. Studies were included if they investigated interventions/exposures accounting for reducing fatigue and sleepiness as the outcome, measured any potential interventions for mitigation of sleepiness and were written in English. Meta-analysis was not attempted because of the heterogeneity of the included studies.
Results: Of 63 studies identified, 18 met the inclusion criteria. Based on results of our review, many interventions in the world have been used to reduce drowsiness while driving such as behavioral (talking to passengers, face washing, listening to the radio, no alcohol use, limiting the driving behavior at the time of 12 p.m. – 6 a.m. etc), educational interventions and also changes in the environment (such as rumble strips, chevrons, variable message signs, etc). Meta-analysis on the effect of all these interventions was impossible due to the high heterogeneity in methodology, effect size and interventions reported in the assessed studies.
Conclusion: Results of present review showed various interventions in different parts of the world have been used to decrease drowsy driving. Although these interventions can be used in countries with high incidence of road traffic accidents, precise effect of each intervention is still unknown. Further studies are required for comparison of the efficiency of each intervention and localization of each intervention according to the traffic patterns of each country.

Introduction

Road traffic accidents (RTAs) are amongst the most common accidents causing death every year.[1,2] Due to their importance, the WHO designated "Safe Roads" as the theme of the World Health Day 2004 and addressed the decrease in RTAs by 2020 as its 21st objective.[3] Based on the study of the global burden of diseases, it is estimated that RTAs have ranked eighth in the world in 2010 in terms of Years of Lives Lost (YLL) due to premature death or disability.[4] Drowsiness and fatigue are introduced as the main risk factors for occurrence of traffic accidents and deaths. Considering the raised mortality statistics due to RTAs worldwide despite the decrease in some countries, the General Assembly of the United Nations (UN) passed a global plan for the decade of action (from 2011 to 2020) for road safety and requested all members to take steps to lower RTAs through implementing preventive measures.[5]

Sleepiness results from the sleep component of the circadian cycle of sleep and wakefulness, restriction of sleep, and/or interruption or fragmentation of sleep.[6] Sleepiness causes auto crashes

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because it impairs performance and can ultimately lead to the inability to resist falling asleep at the wheel.[7] Although sleeping is the most effective way to reduce sleepiness, in some situation continuing to driving is unavoidable and it seems we need some interventions to deal with drowsy driving.

Drivers, particularly professional drivers are at high risk of sleepiness due to a combination of several factors including shift work and obstructive sleep apnea/hypopnea syndrome (OSAHS). Previous studies shown that driver fatigue is a significant cause of traffic accidents and is believed to account for 20%–30% of all vehicle accidents.[8] Many experts agree that this is a conservative estimate and the actual contribution of fatigue to RTAs may be much higher. In addition to having potentially catastrophic personal consequences, fatigue-related accidents have a substantial financial burden, particularly in accident that occurs at night and also in situations in which driving hours are very long and varied.[9]

According to the study which conducted by MacLean and his colleagues,[10] 29%–55% of drivers report feeling drowsy while driving, 11%–31% report having fallen asleep at the wheel, and 4%–12% report having had a crash due to sleepiness. Drowsiness is the second most important factor, after alcohol, in the occurrence of single and multiple vehicle accidents and yields a significant human and financial cost. Accidents caused by driver fatigue, or more precisely, driver lapses of attention caused by sleep deprivation, are often particularly severe as the drowsy driver may not take evasive action to avoid the severity of a potential collision.[11]

Several factors can account for fatigue and drowsy driving. Different physiological and psychophysiological processes can be linked to fluctuations of activation, arousal, alertness and vigilance. Based on existing evidences, among factors that influence RTAs the role of human factors is very dominant. Human factors in vehicle collisions include all factors related to drivers and other road users that may contribute to a collision such as: driver behavior, visual and auditory acuity, decision-making ability, and reaction speed. In fact, due to the complex and systemic nature of human function precise extraction or isolating of all factors contributing in a traffic crash is very difficult in a single study. Indeed, in order to reach a better understanding and isolating causal role of fatigue or sleepiness, as human factors contributing in road crashes, we need to conduct experimental studies, but implementation of such studies have ethical issues.[12]

As mentioned earlier, drowsy driving is a serious problem that leads to thousands of automobile crashes each year. Due to the impact of sleepiness and fatigue in the incidence of RTAs, a study on the intervention programs to deal with this issue can be effective in reducing the incidence of these events. To address this need, the authors decided to conduct a systematic review on effectiveness of interventions to reduce drowsy driving with two objectives: (1) identify effective interventions to reduce sleepiness while driving and (2) determine the true effect size of each intervention that has influence on reducing drowsiness while driving.

Materials and methods

We sought to identify all the epidemiological studies which examined the effect of different interventions to reduce accidents related to fatigue and drowsiness. The question addressed in this systematic review was designed based on PICOs rules (In our study PICO were as follows: participants = drivers, intervention or exposure = any intervention or exposure to reduce drowsiness, comparison group = drivers without the defined exposure/intervention in the study, outcome = decrease of road crashes related to drowsy driving). The question selected was: what interventions are being used to reduce fatigue or sleepiness while driving? Studies were included in the review if they evaluated the effect of one or more interventions in drivers to reduce sleepiness while driving.

The review criteria therefore included all observational or interventional studies that investigated the effect of one or more interventions on decreasing sleepiness while driving. We excluded case reports, studies using more 'proximal' outcome measures, such as performance on a simulator, and studies of fatigue in road user groups that potentially have different characteristics from car drivers, such as truck drivers or motorcyclists.

Search strategy and selection criteria

We followed a standard protocol for doing systematic review: a computerized search was undertaken of Medline (1980–2015), Science direct (1980–2015), Scopus (1980–2015), EMBASE (1980–2015), PsycLIT (1990–2015), transport and road websites (to 2015). The Cochrane Library, BIOSIS and ISI Web of Knowledge were also searched in February 2015. Reference lists of identified articles were also examined, and proceedings of relevant conferences were hand-searched for further studies. The websites of institutions involved in research and policy in the areas of road safety, injury prevention and sleep were searched and publication lists were obtained where possible. The review was not restricted to published or peer-reviewed literature and there were no restrictions regarding date of studies.

Electronic databases were searched using following keywords: sleepiness and accidents, fatigue and accidents, drowsiness and accidents, driver fatigue, sleepiness, and their synonyms. Other combined key words used to find appropriate papers in two major databases (Medline and EMBASE) were summarized as follows:

A: ("drowsy driving" OR "Sleep Stage" OR "Stage, Sleep" OR "Stages, Sleep") AND ("Road accident" OR "Traffic Accidents" OR "Accident, Traffic" OR "Traffic Accident")
B: ("Drowsiness" OR "Drowsiness") AND ("Road accident" OR "Traffic Accidents" OR "Accident, Traffic" OR "Traffic Accident")
C: ("drowsy driving" OR "Sleep Stage" OR "Stage, Sleep" OR "Stages, Sleep" OR "Drowsiness" OR "Drowsiness") AND ("Road accident" OR "Traffic Accidents" OR "Accident, Traffic" OR "Traffic Accident")
D: "Drowsy Driving" AND "Road accident"
E: ("fatigue alertness" OR "sleepiness alertness") AND "Road accident"
F: ("Fatigue management" OR "sleepiness management") AND "Road accident"
G: ("Sleep" OR "forced desynchrony") AND "Road accident"
H: ("driver behavior" OR "driving simulator" OR "road engineering measures") AND "Road accident"

The search strategy was developed to maximize sensitivity of article identification. Searching process was carried out by two reviewers independently, and disagreements between them were resolved by consensus.

Since there is no single objectively defined measure of fatigue, we accepted a range of commonly used measures of drowsiness and fatigue and their likely determinants, including: sleepiness at the time of fatigue measurement, usual daytime sleepiness, acute deviation of the lines on the road, Stanford Sleepiness Scale, Swedish Occupational Fatigue Inventory (SOFI), status blinking eyes, reaction time during sleep, Electro Dermal Activity, the effective time delay physiological measure of eye closure, Karolinska Sleepiness Scale, CAS Fatigue score, reaction time, right rate and awareness about fatigue and sleepiness. For further information, definition of these measurement scales was summarized in Table 1.[11,13–22]

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