



Interventions and controls to prevent emergency service vehicle incidents: A mixed methods review

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ABSTRACT

Background: Emergency service vehicle incidents (ESVI), including crashes, rollovers, and roadside struck-by incidents, are a leading cause of occupational fatality and injury among firefighters and other emergency responders. Though there are numerous strategies and interventions to prevent ESVIs, the evidence base for these strategies is limited and dispersed. The goal of this study was to gather and present a review of evidence-based ESVI interventions.

Methods: We searched five academic databases for articles published within the last decade featuring interventions to reduce or prevent ESVIs. We interviewed key informants from fire departments serving major metropolitan areas for additional interventions. Interventions from both sources were summarized and data on intervention effectiveness were reported when available.

Results: Sixty-five articles were included in the final review and 17 key informant interviews were completed. Most articles focused on vehicle engineering interventions (38%), followed by policy and administration interventions (26%), environmental engineering interventions (19%) and education or training (17%). Most key informants reported policy (49%) and training interventions (29%). Enhanced drivers' training and risk management programs were associated with 19–50% and 19–58% reductions in ESVIs, respectively.

Conclusions: Only a limited number of interventions to address ESVIs had adequate outcome data. Based on the available data, training and risk management approaches may be particularly effective approaches to reducing ESVIs.

1. Introduction

Emergency service vehicle incidents (ESVIs) include crashes, rollovers, and roadside struck-by incidents. ESVIs are the leading cause of death among emergency medical services (EMS) personnel with 2.7 fatalities per 100,000 workers annually (Maguire et al., 2002), and are the second leading cause of occupational fatality among U.S. firefighters, accounting for 390 fatalities between 1994–2014 (United States Fire Administration, 2014). ESVIs also pose a serious threat to public road users given the vehicles' large size and high-speed operations. Between 1997 and 2006, 94 of 107 fatalities resulting from collisions involving a fire service vehicle during an emergency response

were occupants of the other vehicle, pedestrians, or bicyclists (Fahy, 2008).

ESVI intervention effectiveness studies are sparse, and no systematic reviews of effective interventions to reduce ESVIs are available. While safety and regulatory agencies provide guidelines for the safe operations of emergency service vehicles (Federal Emergency Management Agency, 2012; United States Fire Administration, 2003) and best practices for roadside safety (Trench et al., 2014; International Association of Firefighters, 2010), these guidelines rarely cite evidence to support recommendations. Further, these guidelines are generally recommendations for safe practices (e.g., recommending lower vehicle speeds), as opposed to exogenous interventions that reinforce, enable,

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promote or strengthen safe practices (e.g., using in-cab devices to alert drivers to speeding). Though the evidence base for interventions targeting civilian crashes is robust, (Aeron-Thomas and Hess, 2005; Beyer Fiona and Ker, 2009; Bunn et al., 2003; Ker et al., 2003; Russell Kelly et al., 2011; Wilson et al., 2010) these interventions may not apply or be effective in occupational settings, especially in the emergency services where working conditions are highly variable and may be dangerous.

Synthesizing the evidence base for effective interventions will help inform policies and practices that may be implemented in emergency service departments by safety managers, and will also provide information to help inform future research. The objective of this review is to collect and present potentially effective interventions used in the emergency services to reduce the risk of ESVIs and the severity of those incidents as measured by fatalities, injuries, and economic costs.

2. Materials and methods

We conducted a ‘mixed methods review,’ combining a systematic literature review with key informant interviews to identify interventions to reduce ESVIs (Grant and Booth, 2009). Studies involving emergency service workers, including: firefighters, ambulance crews, and emergency service technicians (i.e., first responders) operating emergency service vehicles in an occupational setting were eligible for inclusion. Articles describing or evaluating the effects of an intervention to reduce the frequency and/or severity of ESVIs were included for review. The types of interventions and vehicle incident types considered were broadly defined to capture all possibly effective interventions and three primary intervention domains were considered:

- a) Education/Training: Interventions aimed at enhancing education and/or training of emergency vehicle workers (promotional behavior change campaigns, enhanced driver’s training/licensure, etc.).
- b) Enforcement/Policy: Administrative and policy approaches to creating safer vehicle operations, workflows and/or processes (introducing new laws, enforcement of existing policies, new standard operating procedures, and operational or procedural modifications such as changes to emergency response protocols, etc.).
- c) Engineering: Interventions that modify or add technology to vehicles or the built environment to reduce the risk of ESVIs. Such interventions included modifications to the road environment (e.g., traffic light pre-emption) and additions to emergency vehicles (e.g., vehicle data recorders).

When available, outcome measures indicating the effectiveness of interventions were reported. We defined the outcomes of interest as 1) changes in the frequency or risk of vehicle incidents (incidence counts or rates, proportions, percentages, odds ratios or relative risks), and 2) changes in the severity of vehicle incidents (reductions in fatalities, injuries or economic costs). Unless otherwise noted, the term ‘crash’ in our review encompasses any type of ESVI including on-road collisions with other vehicles as well as striking fixed objects or structures.

2.1. Literature search methods

We conducted searches of PubMed, Embase, CINAHL, PsycInfo, and Web of Science databases using MeSH headings, Emtree terms, CINAHL descriptors and targeted keyword terms such as ‘emergency vehicle,’ ‘ambulance,’ ‘first responder,’ ‘fire,’ and ‘crash prevention.’ The time-frame of interest was restricted to 2006–2017 to capture the most current articles and interventions. An initial citation screening was conducted to remove duplicated or irrelevant citations such as those focusing on commercial trucking research.

After citation screening, two independent reviewers screened the remaining titles and abstracts and excluded articles that were unrelated to the emergency services or ESVIs. Next, the reviewers obtained the

full texts of the remaining articles and independently assessed each article for inclusion eligibility. Articles were included for review if the article 1) was relevant to emergency services populations, and 2) assessed at least one intervention to reduce the incidence or severity of ESVIs. Articles were excluded if they only discussed general recommended guidelines. For example, articles that discussed or recommended reducing driving speed, but did not review exogenous mechanisms, tools or policies to promote, reinforce, or enable speed reduction, were excluded. Reviewers extracted data using a standardized data abstraction form collecting information on the study methods, participants, intervention description, and results and outcomes if reported. Disagreements in inclusion/exclusion criteria occurred in about a third of the articles reviewed, and were reconciled by a third reviewer (the lead author). Most disagreements occurred during abstract screening and were almost all on the classification of interventions.

2.2. Key informant interview methods

To supplement the literature review, we contacted key informants from a purposive sample of fire departments referenced in the reviewed articles to obtain updates on the interventions applied in their departments, attitudes and perceptions of effectiveness, and to request crash data to evaluate intervention effects. To expand the sample of key informants, we invited fire chiefs from the International Association of Fire Chiefs (IAFC) and National Fire Protection Association (NFPA) Metropolitan Fire Chiefs association to participate in the review. The Metropolitan Fire Chiefs include chiefs from fire departments with at least 350 full time career firefighters, serving large major metropolitan areas. Interviews were conducted between Fall 2016 and Spring 2017.

A semi-structured interview guide was created to gather information and data from each interviewee. Interviewers asked about policy, education and engineering interventions implemented and the perceived effectiveness of each intervention in terms of changes to crash frequency, severity and cost. Interviews were completed by the study’s lead author and research assistants and lasted 30 to 60 min each. All interviews were completed via phone calls with follow-up conducted through emails. Interview results were recorded in guided interview forms. Frequencies and percentages were calculated for categorical response variables and key themes regarding intervention effectiveness, strengths and weaknesses were abstracted from the interview forms during data analysis. We requested outcome data from the fire department representatives to verify intervention effectiveness. When sufficient data were provided, we conducted interrupted time series analyses to quantify the impact of intervention on temporal changes in crash outcomes (i.e., changes to crash frequency, severity, or costs) before and after intervention (Linden, 2015).

3. Results

3.1. Article results

The database search resulted in 7508 articles for screening. After preliminary citation screening, 416 articles remained for abstract screening (Fig. 1). After screening abstracts, 341 articles were excluded from full-text review because they did not cover an intervention to reduce ESVIs or were non-emergency related. Moreover, the excluded articles were predominantly opinion or editorial pieces on the hazards of crashes in emergency services or descriptive papers on crashes and safe driving (e.g., advice on safe driving). Seventy-five articles were deemed eligible for full-text review. An additional twelve articles (12/75, 16%) were removed after full-text review because they were descriptive articles on safe driving and/or did not review a specific intervention. We included one relevant report found by referral (Devlin, 2010) and one article found through review of citations within the final article set (Levick and Swanson, 2005).

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