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Observational study of child restraining practice on Norwegian high-speed roads: Restraint misuse poses a major threat to child passenger safety

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ABSTRACT

Objective: Restraint misuse and other occupant safety errors are the major cause of fatal and, severe injuries among child passengers in motor vehicle collisions. The main objectives of the present, study were to provide estimates of restraining practice among children younger than 16 years, traveling on Norwegian high-speed roads, and to uncover the high-risk groups associated with, restraint misuse and other safety errors.
Methods: A cross-sectional observational study was performed in conjunction with regular traffic, control posts on high-speed roads. The seating and restraining of child occupants younger than 16, years were observed, the interior environment of the vehicles was examined, and a structured, interview of the driver was conducted according to a specific protocol.
Results: In total, 1260 child occupants aged 0–15 years were included in the study. Misuse of restraints, was observed in 38% of cases, with this being severe or critical in 24%. The presence of restraint, misuse varied significantly with age ($p < 0.001$), with the frequency being highest among child, occupants in the age group 4–7 years. The most common error in this group was improperly routed, seat belts. The highest frequency of severe and critical errors was observed among child occupants in, the age group 0–3 years. The most common errors were loose or improperly routed harness straps and, incorrect installations of the child restraint system. Moreover, 24% of the children were seated in, vehicles with heavy, unsecured objects in the passenger compartment and/or the trunk that were, likely to move into the compartment upon impact and cause injury. No totally unrestrained children, were observed.
Conclusions: This study provides a detailed description of the characteristics of restraint misuse and, the occupant's exposure to unsecured objects. Future education and awareness campaigns should, focus on children aged <8 years. The main challenges are to ensure correct routing and tightness of, harness straps and seat belts, correct installation of child restraints, and avoidance of premature, graduation from child restraints to seat belts only. Information campaigns should also advocate the use, of chest clips and address the potential risks of hard, heavy objects in the passenger compartment and, the importance of the placement and strapping of heavy objects in the trunk.

1. Introduction

Traffic-related child injuries and mortality in Western countries have reduced markedly over the past decade (European Transport Safety Council, 2005, 2008). Major improvements in automobile design, such as increased strength of the passenger compartment, front-end crumple zones, and installation of airbags (Farmer, 2005), are important factors explaining the decline in severe injuries and death among occupants of any age. Safety equipment such as child restraint systems (CRSs) and seat belts (SBs) is recommended as best practice for the protection of child occupants (Amundsen, 2004; Durbin et al., 2003; Durbin, 2011; European Transport Safety Council, 2005; Koppel & Charlton, 2009; Nance et al., 2010). Recent findings suggest that the crash-protection effectiveness of modern CRSs have reduced injuries by approximately 70% (Brown et al., 2010; Decina and Lococo, 2005; Koppel and Charlton, 2009). Until now, the use of size-appropriate CRSs has been the main

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focus of educational efforts and legislative requirements; however, increased attention is now being paid to CRS misuse being commonly accompanied by dramatically reduced effectiveness (Brown et al., 2010; Decina and Lococo, 2005; Koppel and Charlton, 2009; Skjerven-Martinsen et al., 2011).

In Norway, the most common type of motor vehicle (MV) collision (MVC) that results in severe injuries and child fatalities is a frontal impact collision on a high-speed road with speed limitation ≥70 km/h, but without a central reservation separating opposing lanes of traffic (Skjerven-Martinsen et al., 2011; Statistics Norway, 2013). An in-depth evaluation of MVCs has revealed safety errors (i.e., SB misuse or the placement of unsecured objects) in 93% of severely or fatally injured child occupants (Skjerven-Martinsen et al., 2011). The current public awareness of the hazards of restraint misuse appears to be low, and so a further reduction in the child fatality rate from MVCs should be achievable.

The main objectives of the present study were to provide estimates of restraining practice among children younger than 16 years traveling in MVs on Norwegian high-speed roads, and to uncover the high-risk groups associated with restraint misuse and other safety errors.

2. Methods

2.1. Setting

An observational, cross-sectional, multisite study design was chosen for this study on child-restraint use in passenger MVs on high-speed rural, two-lane roads with 80 km/h speed limits and without a central reservation of opposing traffic. The study was carried out in four counties in the southeastern region of Norway (2.8 million inhabitants).

2.1.1. Data collection

Data were collected prospectively between April 2011 and August 2011 during roadside MV inspections carried out in six different locations, all of which are heavily used high-speed roads carrying weekend and public holiday traffic. The study was performed in conjunction with regular traffic control posts set up by the police. All MVs with at least one child occupant younger than 16 years were routed to our investigation teams and asked for consent to participate.

The investigation team first observed the seating and restraining of the child occupants. A structured interview of the driver was then conducted followed by a detailed examination of the interior environment, including the restraint installation. In order to ensure that most MVs were included in the study, five to six investigation teams (experienced MVC investigators and CRS fitting specialists) were involved simultaneously.

2.1.2. Data sources and measurements

The length of the journey, MV age, occupant safety equipment (i.e. airbags), SB use by all occupants, and family relationships of the passengers and driver were registered. In addition, the number of children in each MV and their individual ages, heights, weights, and locations in the MV were registered using a standardized data-collection template. The use of a chest clip designed to keep the harness strap (HS) correctly against the child's shoulders was also checked.

Specifically, the inspection team evaluated the following factors:

- Whether the CRS was size-appropriate and correctly oriented and installed.
- The age of the CRS and whether installation guidelines or user manuals were present.
- The position, tension, and routing of the SB/HS and whether there were any buckles.
- Presence of any unsecured objects in the passenger compartment or trunk.

The fitting of the harness straps and installation of the CRS were first controlled without removing the child or the CRS from the vehicle, by a visual control of the attachment status and a rigorous pull on straps and belts. If any installation error was suspected by this primary check-up, the CRSs were removed from the vehicle and re-checked before being properly readjusted for the child. The investigation teams compiled a detailed, separate form for each child occupant. Restraint use was coded as correct if the CRS was installed and used according to the manufacturers' specifications, and otherwise coded as incorrect. Both the type of error and the number of errors per child were noted. CRS installation using the ISOFIX system, which is the international standard for CRS attachment points in modern MVs, was registered.

In the present study, "restraint misuse" was defined as any incorrect use of a CRS or SB (e.g., improper routing or twisting of the SB or HS), presence of CRS installation errors, and/or the use of restraints inappropriate for the child's size. The term "safety error" included both restraint misuse and the presence of unsecured, heavy luggage in the passenger compartment or trunk.

All types of restraint misuse were noted in detail and graded as follows: grade 1, minor errors; grade 2, severe errors; and grade 3, critical errors. This grading system was created in order to classify the severity of the restraint misuse based on the likelihood of potential injury resulting from a hypothetical high-energy MVC. In the case of multiple safety errors, categorization was based on the most severe error present. The rating assessments were based on the severity rating approach described by Brown et al. (2010) and Decina and Lococo (2005) as well as expert opinion within the research group (Skjerven-Martinsen et al., 2011).

The Abbreviated Injury Scale (AIS) (Association for the Advancement of Automotive Medicine, 1998) is represented by a severity score ranging from 1 to 6, where a score of 1–3 represents a minor injury, 3 or 4 represents a severe injury, and 5 or 6 represents a critical and/or currently untreale injury. A grade-1 error corresponds to what in our opinion may generate a minor injury (score of <3 on the AIS) in a high-speed MVC, while a grade-2 error corresponds to an AIS score of 3 or 4 (severe injury) or the need for prehospital and/or hospital treatment in order to prevent severe injury or death. A grade-3 error corresponds to an AIS score of 5 or 6, which is a critical/currently untreatable injury or a cascade of mechanisms leading to a possibly fatal injury.

The European legislation mandates the use of CRSs for children with a height of <135 cm and/or a body weight of <36 kg traveling in a passenger MV or light van. Furthermore, child occupants younger than 3 years are not allowed in an MV with no SBs installed. Rearward orientation is mandatory up to 9 kg and prohibited in front of an active airbag (EUR-lex, 2003; Lovdata, 2003). The number of child occupants not restrained in accordance with these regulations was evaluated.

The child occupants were categorized into four age cohorts: 0–3, 4–7, 8–11, and 12–15 years. The MVs were also categorized according to age: <5, 5–14, and >14 years. The different types of CRS were categorized according to the National Highway Traffic Safety Administration categorization: (National Highway Traffic Safety Administration, 2011) (1) infant car seat, (2) rearward-facing child seat, (3) forward-facing child seat with a harness, (4) high-back, belt-positioning booster seat (BPB), and (5) backless BPB and