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Does a tow-bar increase the risk of neck injury in rear-end collisions?

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ABSTRACT

Introduction: Does a tow-bar increase the risk of neck injury in the struck car in a rear-end collision? The rear part of a modern car has collision zones that are rendered nonoperational when the car is equipped with a tow-bar. Past crash tests have shown that a car's acceleration was higher in a car equipped with a tow-bar and also that a dummy placed in a car with a tow-bar had higher peak acceleration in the lower neck area. *Method:* This study aimed to investigate the association between the risk of neck injury in drivers and passengers, and the presence of a registered tow-bar on the struck car in a rear-end collision. We performed a merger of police reports, the National Hospital Discharge Registry, and the National Registry of Motor Vehicles in Denmark. We identified 9370 drivers and passengers of whom 1519 were diagnosed with neck injury within the first year after the collision. We found a statistically insignificant 5% decrease in the risk of neck injury in the occupants of the struck car when a tow-bar was fitted compared to not fitted (hazard ratio = 0.95; 95% confidence level = 0.85–1.05; p = 0.32). The result was controlled for gender, age, and the seat of the occupant. Several other collision and car characteristics and demographic information on the drivers and passengers were evaluated as confounders but were not statistically significant. *Conclusions:* The present study may serve as valuable input for a meta-analysis on the effect of a tow-bar because negative results are necessary in order to avoid publication bias.

1. Introduction

Does a tow-bar increase the risk of neck injury in a rear-end collision? The question has become relevant because the rear part of modern vehicles is designed with a collision zone with the purpose of capturing some of the force in rear-end collisions, thereby reducing the struck car's acceleration. A collision zone will also reduce the acceleration of occupants in the struck car, thus decreasing the likelihood of neck injury. When a car has a tow-bar, this mounted construct will absorb the power of the struck car, which will never reach the collision zone, and therefore the acceleration will be larger in the cabin, implying a higher risk of neck injury including whiplash. Some tow-bars can be partly removed from the back of a car when not in use. In this situation, the hook itself is removed, but the fastening to the car is still present. Depending on the make of car, this fastening can be located within, below, or in front of the collision zone, thus inducing noise in the effect of the tow-bar.

If the tow-bar increases the risk of neck injury then it could also be associated with a higher rate of fatality. The number of deaths due to rear-end collisions in Europe was 2000 in 2010 (The European Commission, 2012) of which some potentially could have been avoided had tow-bars been mounted in a safer way.

1.1. Previous studies on the risk due to a tow-bar

The key evidence on the effect of a tow-bar can be found in a paper by Krafft, Kullgren, Tingvall, Boström, and Fredriksson (2000). Their study addressed whether a tow-bar could change the stiffness of the car and subsequently the crash pulse. The study comprised both laboratory crash tests and data on real-life rear impacts with and without a tow-bar reported as claims to an insurance company.

The laboratory analysis of tow-bar effects was done through crash tests involving two Volvo 240s with and without a tow-bar being hit by a Volvo 240 with an impact speed of 25 km/h. The results showed that the car acceleration was higher in the tow-bar equipped car with a peak of 9.6 g compared with 8.0 g in the car without a tow-bar. The mean acceleration was similar, 3.0 g, in the two cars. The car equipped with a tow-bar recorded a higher change in velocity of 15.1 km/h compared with 14.1 km/h in the car without a tow-bar. A dummy placed in the car with a tow-bar had a 33% higher peak acceleration of 8.9 g in the lower neck region, whereas a dummy in the car without a tow-bar experienced a peak acceleration of only 6.7 g.

Next, all real-life rear-end collisions between 1990 and 1993 reported to the insurance company (Folksam, Sweden) involving three car types, Volvo 240, Volvo 700, and Saab 900, were selected (struck

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cars). A total of 75 car crashes where at least one occupant had been diagnosed with long-term neck injury as a consequence were identified. Long-term consequences were classified by a medical specialist in the insurance company as a result of a preliminary assessment after one year or after three to five years. The 75 car crashes representing long-term consequences were compared with a control group of 426 rear-end car crashes representing the general distribution of tow-bars on struck cars of the three car types. Information on tow-bars was obtained from the National Swedish Vehicle Registry. Krafft and colleagues found that there was 22% greater risk of long-term consequences in a car with a tow-bar than in one without. This result was found to be statistically significant ($p = .001$). The authors studied the short-term consequences of minor neck injuries as well, but a comparison of 233 car crashes involving at least one occupant reporting a minor neck injury and the abovementioned control group gave a statistically insignificant result.

Another study by Krafft mentioned the tow-bar as well (Krafft, 2002). However, this paper used the same data as in Krafft et al. (2000) on real-life rear impacts reported as claims to an insurance company.

A third study by Linder and colleagues also provided data on the effects of a tow-bar but touched only peripherally upon the risk of a tow-bar in rear-end collisions (Linder, Olsen, Eriksson, Svensson, & Carlsson, 2012). Their data on rear-end crashes and injury severity originated from claims to an insurance company. Only new cars less than three years old of the types Saab 9-3 and Saab 9-5 and the period from 1993 to 2007 were included. Information on tow-bar status was obtained from questionnaires sent out by the authors to the owners of the cars in cases of high impact severity. Short-term neck injury was defined as lasting for less than one week, whereas medium- to long-term injury was defined as lasting for more than one week. An analysis of 699 drivers did not show a statistically significant effect for the presence of a tow-bar on the distribution of no injuries, short-term injuries, or medium- to long-term injuries (Linder et al., 2012; from the data of Table A-II: $p = 0.30$). The authors mentioned a very slight tendency for females to have more long-term injuries with a tow-bar than without a tow-bar, but this was not statistically significant ($p = 0.56$).

Carroll et al. (2008) and Holm et al. (2008) briefly addressed the tow-bar in their best evidence synthesis and concluded that a tow-bar is a risk factor for neck injury with reference to Krafft and colleagues. A study by Hynes and Dickey (2008) concluded that vehicles with tow-bars are stiffer and have shorter times to peak acceleration, and it referred to Krafft et al. (2000). Worsfold (2014) cited Carroll et al. (who again cited Krafft et al.). Finally, the recent study by Nishimura, Simms, and Wood (2015) ended up asking for more evidence on the effect of the tow-bar on vehicle stiffness.

The idea of this study originates from several requests to the last author from lawyers who subsequently used the Swedish results as an argument for higher compensation in cases of whiplash injury because of the presence of a tow-bar.

New cars have much better collision zones than the Volvo 240. But a tow-bar mounted on a new car will still destroy the beneficial effect of the collision zones, thus increasing the risk of neck injury in the cabin. Our hypothesis is that the risk of neck injury for the driver and passengers in the struck car in a rear-end collision is greater when the struck car is fitted with a tow-bar.

1.2. Study aim

This study aimed to investigate the association between the risk of neck injury in car occupants and the presence of a registered tow-bar on the struck car in a rear-end collision.

2. Materials and methods

We conducted a registry-based study nested within the general population of Denmark (approximately 5.1 million inhabitants). We included all drivers and passengers in the struck cars of all models in rear-end collisions registered by police in the 10-year period from 2003 to 2012.

2.1. Registry data in Denmark

In Denmark, every individual has a unique civil registration number, given to all Danes at birth. This 10-digit number is used in most administrative registers, permitting the linkage of individual records – for example, hospital records – with records of police-recorded car crashes. Here, we further utilized the fact that the registration plate of a car involved in a rear-end collision could be used to link the identities of persons in the cars with technical information on the presence of a tow-bar on the struck car. We also obtained information from other public registries besides information on the tow-bar, with the aim of achieving an adjusted estimate of the risk of neck injury with and without a tow-bar.

2.2. Socio-economic information

The core of the Danish administrative registries is the Central Person Registry (CPR), which registers every demographic action (death, emigration/migration, and within-country moves) of all Danes holding a valid personal identifier, which at the same time is a social security number. From the CPR, we obtained information on sex and age (divided into categories: 0–17 years of age, 18–29, 30–39, 40–19, 50–59, 60–69, 70 and older). The police reports were linked to the National Hospital Discharge Registry, which comprises discharge dates and diagnoses from both hospitals and emergency wards. Furthermore, we linked to the socio-economic databases at Statistics Denmark, which provide the household income and the highest attained educational level per individual on a yearly basis (October 1 each year). We chose to divide the household income by quintiles by year and we used the most recent information from the year before the accident. Educational level was divided into nine categories (primary; upper secondary; vocational education; short-cycle higher education; vocational bachelors', bachelors', masters', and PhD programs; and a missing category).

2.3. Technical information on the struck car

Technical information on the struck car was obtained from police reports and the National Registry of Motor Vehicles. From the latter, we obtained information about the presence of tow-bars which were registered during the first registration of new cars, and in those cases where the owner installed and chose to register a tow-bar. The Registry of Motor Vehicles also included car weights (in five categories: 500–999, 1000–1499, 1500–1999, 2000 kg or more, missing weight), and the first registration year of the car (seven categories: 1966–1989, 1990–1994, 1995–1999, 2000–2004, 2005–2009, 2010–2015, missing). The police reports comprised information on accident type. The accident type was divided into three categories according to the Danish classification [hit directly from the back ("140"), hit from the back when turning right ("311"), or hit from the back when turning left ("321")]. We chose to include all three types of accident in our main analysis. It is unique to Denmark that the police report the accident type. Finally, the police reports could distinguish between the persons involved as either drivers or passengers. The calendar year of the accident was treated in two-year categories.

2.4. Definition of neck injury and whiplash

We obtained diagnoses from the Hospital Discharge Registry with information on whether the drivers and passengers had been in the emergency ward, admitted to hospital, or both. We identified all persons in the study population with a neck injury (International Classification of Disease version 2010: ICD-10) code DS13.4*. DS13.4* could be

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