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Comparison of fatal motor vehicle accidents at passive and active railway level crossings in Finland

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ABSTRACT

The study compares accidents at passive and active railway level crossings, and both immediate and background risk factors are considered. Passive railway level crossings have no warning devices, although there might be a static warning sign. Active level crossings are equipped with automatic devices warning road users of approaching trains. The data covers all fatal motor vehicle accidents at level crossings in Finland during the years 1991 to 2011 (n = 142). All these accidents have previously been investigated in detail by Road Accident Investigation Teams.

Most of the accidents took place at passive level crossings. Compared to active level crossings, and related to the number of fatal accidents, passive level crossings have become proportionally more risky during the study period. Almost all the immediate risk factors in the accidents were of the human error type. Observation errors on the part of the road user were typical at passive level crossings, and risk taking at active level crossings. The environment did not support safe crossing in most of the accidents at passive level crossings. The speed limits of both the road and rail were high, visibility was insufficient, and the level crossing was often situated uphill.

Active warning devices are effective in preventing accidents due to road user errors. Equipping the most dangerous passive level crossings with warning devices – low cost or conventional – would increase safety. Alternatively, some level crossings could be removed altogether. A minimum requirement is that the environmental factors at passive level crossings support safe crossing.

1. Introduction

There are more than 300 fatalities every year in accidents at railway level crossings in the EU member states. This accounts for more than one fourth of all rail fatalities (excluding suicides) and 1% of all road deaths [1]. Despite this, road traffic safety, measured by the number of fatalities, has improved in most European countries in the last years. So has railway safety, measured by the number of fatal train collisions and derailment per train-kilometre. However, the annual rate of serious accidents (four or more fatalities) per train-kilometre at level crossings remained unchanged during 1990–2009 in Europe [2]. Evans [3] studied fatal accidents at railway level crossings in Great Britain during 1946–2009. The annual number of fatal accidents and fatalities fell by about 65% in the first half of the study period, but remained more or less constant during the latter half. Silla and Kallberg [4] studied railway safety in Finland from 1958 to 2008 and found a safety improvement in all subcategories. The annual number of fatalities per million train-kilometres reduced as follows: passengers 4.4%, railway employees 8.3%, road users at level crossings 5.0%, and others (mainly trespassers) 3.6%. However, they found that since the mid-1990s the annual number of level crossing accidents had been fairly stable. This is in concord with results found elsewhere in Europe [2,3].

Many railway level crossings are passive, which means that there are no automatic warning devices, but only a static sign (e.g. a St. Andrew's Cross). Safe crossing relies therefore wholly upon the road user. However, due to cognitive limitations, humans are vulnerable to errors. Consequently, human-related factors such as drivers' observation errors, play a major role in most traffic accidents [5]. At a passive level crossing, road users have complete responsibility to look out for rail traffic, and to decide when it is safe to cross. There is often no information provided to drivers such as at what speeds trains are travelling. The speed of an oncoming train at passive level crossings in Finland might be as much as 140 km/h. The task of crossing is considerably easier at active level crossings where road users receive a warning if a train is approaching. However, human error plays a role also in accidents at active level crossings [6].

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In 2011 there were altogether 3745 railway level crossings in Finland of which 78% were passive. This proportion is higher than in many other European countries. For example in 2011, 15% of all level crossings in Belgium were passive, in the Netherlands 26%, in France 30%, in Germany 36%, in Sweden 63%, and in the United Kingdom 75% [7]. The Finnish Transport Agency (former Finnish Rail Administration) is responsible for the management, development and maintenance of the Finnish railway network. Every year, on average 100 level crossings are being removed, and 10 passive level crossings are equipped with automatic warning devices. This is not only to increase safety, but also to allow higher speeds on railways. Speed limits above 140 km/h are not allowed on stretches with passive level crossings. [8].

Some passive level crossings in Finland (14% in 2009 according to Kallberg [9]) are equipped with a stop sign, and drivers are expected to stop before the sign and look in both directions even if a train is not presently in sight (Note: this is not required at other passive level crossings as they are only equipped with a St. Andrew's Cross). Of all level crossings, 22% are active, i.e. equipped with automatic warning devices. Most (704 in 2012, 89%) have gates, flashing lights as well as bells, but 90 (11%) are equipped with flashing lights only, mostly combined with bells. There are no manually controlled warning devices in Finland

Previous research has found that about 82% of all level crossing accidents in Finland take place at passive level crossings [10]. This percentage is high given that traffic volumes at these crossings are typically low. According to the Finnish railway level crossing inventory [9], the road traffic volume was less than 11 road vehicles per day at 72% of all passive level crossings. Nearly half of the passive level crossings had a road traffic volume of at most only one road vehicle per day. Such quiet level crossings are typically found in rural areas and are used mostly by farmers driving from one field to another. Not only traffic volumes, but also train volumes might be low at these passive level crossings. The low number of trains per day may lead vehicle drivers to gradually develop dangerous crossing habits which do not adequately acknowledge the possibility that a train is approaching [6].

Passive level crossings seem proportionally more dangerous in Finland than in other countries, e.g. Great Britain or Austria. In Great Britain, about two-thirds of all railway level crossings are passive [3], but only about 43% of all railway level crossing accidents take place at these. In Austria, 65% of all level crossings were passive in 2011, but only 57% of all level crossing accidents take place at these [11].

1.1. Aim of study

The aim of this study is to describe and compare fatal motor vehicle accidents at passive and active railway level crossings in Finland during the years 1991 to 2011. The study covers all fatal motor vehicle accidents at railway level crossings during the study period and focuses on both immediate and background risk factors in these accidents. Special focus is on environmental factors that affect a driver's safe crossing: speed limit on the road and the railway, visibility from the road to the railway, and road gradient. The study excludes level crossing accidents of pedestrians and cyclists because the environmental factors studied here have different effect on their accidents than on the accidents of motor vehicle drivers.

2. Material and methods

The data used in this study originates from a database of fatal motor vehicle accidents in Finland during 1991–2011 [12]. In Finland all fatal motor vehicle accidents, including level crossing accidents, are investigated in detail by Road Accident Investigation Teams, of which there are 20 across the country. The work is regulated by the Act on the investigation of road and cross-country traffic accidents (24/2001) and organised by the Finnish Motor Insurers' Centre. The investigation teams do not take a stand on issues of liability or compensation [13].

Each team includes expertise representing the police, medicine, vehicle technology, road maintenance and behavioural sciences. The team members collect information about the vehicles involved in an accident, the drivers and passengers in these vehicles, the accident site, and the road and weather conditions. Finally, an investigation report is produced, in which it is described how the accident happened, probable causes, associated risk factors, and safety recommendations in order to prevent similar accidents in the future. Apart from the report, which is a public document, an investigation folder and an electronic accident information register (coded database) are compiled for the benefit of research [13]. The criterion for starting an investigation is that somebody dies within 30 days as a result of the accident. Deaths due to illness or suicide are also investigated. The reason is that, despite being different from ordinary traffic accidents, they may pose a serious threat to the occupants of other vehicles involved.

The Road Accident Investigation Teams have investigated all fatal level crossing accidents since the beginning of the 1970s. However, when the investigation method was developed, the focus was on road accidents, and although the coded database includes several hundred variables on each accident, some information specific to railways or railway level crossings is not transferred from the accident report in the same way as in the case of road accidents. The original accident reports were therefore used in this study to supplement the coded data and to get information on what type of train was involved (passenger train, freight train, locomotive or track/maintenance vehicle), and whether the level crossing was equipped with any warning devices.

Altogether 142 fatal motor vehicle accidents took place at railway level crossings during the study period, leading to 176 fatalities and 46 injured. All fatalities were either drivers or passengers in the road vehicles. Four accident reports were missing and information about warning devices was therefore not available. Of the remaining 138 accidents, 109 (78%) took place at passive level crossings and 29 (22%) at active level crossings (Table 1). Of the passive level crossings, 39 (36%) were equipped with a stop sign. Of the active level crossings 24 were equipped with gates and 5 with flashing lights and bells.

There were altogether 5408 fatal motor vehicle accidents in Finland during the study period, of which 3190 were collision accidents. The level crossing accidents thus comprised 2.6% of all fatal motor vehicle accidents and 4.5% of all fatal motor vehicle collision accidents in Finland.

This study focuses on the immediate risk factors of the accidents at both passive and active level crossings. In the method handbook of the Road Accident Investigation Teams [13], an immediate risk factor is defined as follows: "An immediate risk factor, often human error, usually triggers the key event and thus actively affects the progress of events and the accident occurrence". The definition implies that the immediate risk factor is any event that immediately precedes an accident ("key event") and makes it irrevocable. Vehicle or environment related immediate risk factors are very rare. The former could include e.g. a sudden foot brake malfunction when approaching a level crossing so that the driver is not able to stop the vehicle in time. An environment related immediate risk factor is, for example, malfunction of an active warning device so that a driver is not warned about an approaching train. The Road Accident Investigation Team defines one immediate risk factor for each driver in an accident.

The study also describes and compares background factors related to the driver and the environment at the two types of railway level

Table 1
Number of fatal motor vehicle accidents at passive and active level crossings during 1991–2011 in Finland.

Type of crossing	n	%
Passive railway level crossing	109	78
Active railway level crossing	29	22
Total	138	100