Train Crashes - Consequences for Passengers

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“If one refuses to look back, and not dare to look ahead, one has to watch out!”

Tage Danielsson

The train was seen as a terrible beast with its snorting locomotive, rushing through the dark woods. A highly apparent heir to the trolls and giants that had just begun to withdraw” (1864).

The Swedish railway history
(Kullander, 1994)
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ABSTRACT

Background: Globally, and in Sweden, passenger railway transport is steadily increasing. Sweden has been relatively free from severe train crashes in the last decades, but the railway infrastructure is alarmingly worn and overburdened, which may be one reason for an increasing number of reported mishaps. Worldwide, major train crashes/disasters are a frequent cause of mass casualty incidents. Several shortcomings, especially within the crash and post-crash phases cause severe consequences for the passengers.

Aim: To investigate the consequences of train crashes on passengers, focusing on factors of importance in the crash and post-crash phases. The specific aims are: (I) to identify the historical development and magnitude of passenger train disasters globally on various continents and countries, (II, III) to identify injury panorama and injury objects in two train crashes, (IV) to explore survivor’s experiences from a train crash, and (V) to explore their experiences of journalists and media coverage.

Methods: Study I is a register study based on 529 railway disasters worldwide, whereas studies II-V are case studies from the two latest severe train crashes in Sweden (Nosaby and Kimstad). These studies are based on 73 and 21 passengers respectively. Studies I-III is essentially quantitative where descriptive statistics (I, III), multivariate analysis (III), and content analysis (II, III) are used. Studies II and III are also supplemented by semi-structured interviews. Studies IV and V are qualitative and the interviews (n=14, n=30) have been analyzed with qualitative content analysis. Study IV is also supplemented with quantitative data.

Results: The number of railway disasters, fatalities, and non-fatally injured passengers has increased throughout the last hundred years - particularly during the last four decades (1970–2009) when 88% of all disasters occurred (I). Passengers in the first overturned carriage suffered most severe and lethal injuries (III). Internal structures such as tables, chairs, internal walls, as well as luggage, other passengers (II, III), glass (II), and wood pellets (III) induced many of the injuries. Those who traveled facing forward with a table in front of them, in carriages that did not overturn, were more likely to sustain injuries to their abdomen/pelvis than those without a table (III). Passengers who traveled rear facing had higher rates of whiplash injuries. Surviving a train crash was experienced as “living in a mode of existential threat”. The long term consequences however were diverse for different persons (IV). All experienced that they had cheated death, but some became “shackled by history”, whereas others overcame the “haunting of unforgettable memories.” The centrality of others and the importance of reconstructing the turn of events were important when “dealing with the unthinkable”. The media coverage were experienced as positive in the recovery process and the journalists were also perceived as helpful (V). By some the journalist’s nevertheless were also perceived as harmful or negligible, and the subsequent media coverage as either uncomfortable or insignificant.

Conclusion: Despite extensive crash avoidance systems severe railway crashes still occur. Improved interior safety, as has been implemented in the automobile and aviation industries, would have an important reduction in injuries and facilitate evacuation. Being surrounded by family, friends, fellow passengers and participating in crash investigations, and experiencing descriptive media coverage were some crucial factors when dealing with the traumatic event and should be promoted.

Key words: Accident, crash, disaster, experiences, injuries, injury inducing objects, media coverage, railway, safety
SAMMANFATTNING (summary in Swedish)


Syfte: Att analysera konsekvenserna för passagerare med speciell inriktning på faktorer av betydelse i krasch och post-krasch faserna. Delsyftena är: (i) att identifiera den historiska omfattningen och utvecklingen av tågkatastrofer i olika världsdelar och länder, (ii) att identifiera skadepanorama och skadebringande objekt från två svenska tågkrascher, (iii) utforska överlevandens erfarenheter av en tågkrasch, och (iv) att utforska deras erfarenheter av journalister och media.


Konklusion: Trots omfattande åtgärder för att förebygga tågkrascher inträffar fortfarande katastrofala krascher runt om i världen. Förbättrat inre säkerhet, så som i vägfordon och flygplan, skulle ha en betydande potential att minska skadorna och underlätta vid evakuering. Att vara omgiven av närstående eller andra passagerare, samt att medverka i utredningar och ta del av faktabaserad media kan för vissa vara viktiga faktorer vid bearbetning av händelsen och bör därför främjas.

Nyckelord: Olycka, krasch, katasstrof, upplevelser, skador, media, järnväg, säkerhet, tåg, skadebringande objekt
## ABBREVIATIONS AND EXPLANATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Explanation</th>
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<tr>
<td><strong>Injury event, crash, or incident</strong></td>
<td>These terms are used interchangeably throughout the thesis</td>
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<tr>
<td><strong>Passengers</strong></td>
<td>This term is used for people on the train, including train crew members</td>
</tr>
<tr>
<td><strong>Train/rail</strong></td>
<td>These terms are used interchangeably throughout the thesis</td>
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<tr>
<td><strong>ATC</strong></td>
<td>Automatic Train Control</td>
</tr>
<tr>
<td><strong>ERTMS</strong></td>
<td>European Rail Traffic Management System</td>
</tr>
<tr>
<td><strong>AIS</strong></td>
<td>Abbreviated Injury Scale</td>
</tr>
<tr>
<td><strong>MAIS</strong></td>
<td>Maximum Abbreviated Injury Scale</td>
</tr>
<tr>
<td><strong>TGV</strong></td>
<td>Train Grande Vitesse (high speed train)</td>
</tr>
<tr>
<td><strong>PTSD</strong></td>
<td>Posttraumatic Stress Disorder</td>
</tr>
<tr>
<td><strong>km/h</strong></td>
<td>Kilometers per hour</td>
</tr>
<tr>
<td><strong>mph</strong></td>
<td>Miles per hour</td>
</tr>
<tr>
<td><strong>CRED</strong></td>
<td>Centre for Research on the Epidemiology of Disasters</td>
</tr>
<tr>
<td><strong>EM-DAT</strong></td>
<td>Emergency Events Database</td>
</tr>
<tr>
<td><strong>PCA</strong></td>
<td>Principal Component Analysis</td>
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<tr>
<td><strong>PLS-DA</strong></td>
<td>Partial Least Square Discriminant Analysis</td>
</tr>
<tr>
<td><strong>MSB</strong></td>
<td>Swedish Civil Contingencies Agency</td>
</tr>
<tr>
<td><strong>EU</strong></td>
<td>European Commission</td>
</tr>
<tr>
<td><strong>SPAD</strong></td>
<td>Signal Passed At Danger</td>
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LIST OF PUBLICATIONS

This thesis is based on the following studies that will be referred by their Roman numerals in the text:


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INTRODUCTION

In late 2006, a collaboration project was initiated between the National Board of Health and Welfare’s Centre for Research and Development - Disaster Medicine, in Umeå, and the Swedish Civil Contingencies Agency (MSB) with the aim of developing prehospital care for passengers at major train crashes. The train sector proved to be complex and fragmented with several actors involved and different responsibilities appeared to fall between the cracks. Several knowledge gaps and lack of safety measure implementation were also found within the crash and post-crash phases. Clarity crystallized when comparing how the automobile and aviation industries deal with similar safety issues.

Indeed, traveling by train is relatively safe; however, much more can be done to reduce the consequences for passengers, both physically and psychologically. The focus of the thesis, thus, investigates possible mitigation measures that would reduce these harmful consequences in future crashes.
BACKGROUND

The history of train travel

Railway has a long history with passenger railway traffic. It has its roots in England where the first passenger railway line was opened in 1825 (Kirby, 2002). Industrialism and technological breakthroughs accelerated the impact of the railway by, for example, enabling the transportation of heavy goods over long distances in a faster and more economical way. Technological developments have had a tremendous impact on the railway, and three different methods of powering can be identified throughout history. Steam was the first and most common method until the 1950s. Thereafter, the diesel engine became popular but since the 1970s, more countries nonetheless have electrified their railways (Kullander, 1994; Ohlin, 1997). The most recent development encompasses a new method consisting of magnetic levitation as propulsion. This so called Maglev train (see Figure 1) is currently available to a limited extent in Japan, China, and Germany, and this type of train will most likely continue to operate in the future as technology is further developed (Railway Technical Research Institute, 2012).

Figure 1. The commercial speed of the Maglev train in Shanghai, China is 430km/h (267mph). Photo: Hervé Aubert, International Union of Railways.

The development has also led to a continuous rise in train speeds. The first steam trains reached approximately 50 km/h (31 mph) and since then speeds have constantly increased (Kullander, 1994). When the electrified high-speed Train Grande Vitesse (TGV) was introduced in France in 1979 it averaged 213 km/h (132 mph). Later, the TGV reached 574.8 kilometers per hour
(357.2 mph). Yet, the Maglev train, propelled by magnetic force, has the highest recorded speed after reaching an impressive 581 km/h (361 mph) in 2003 (Railway Gazette International, 2007). The increased speed even enables the railway traffic to compete with domestic aviation.

Based on the profound development of trains as well as environmental considerations, many countries are investing in high-speed lines. In fact, one of the main transport infrastructure initiatives in Europe during the late 1990s was increased development of high-speed trains (De Rus & Nombela, 2007), and the development has continued. A parallel process has been a continual deregulation of the railway sector in EU member states, meaning changes in the regulatory structure and a gradual privatization of the former state monopolies. Today cross-border rail traffic in Europe is mainly hampered by differing technical standards and services; and a lack of effective coordination between countries. Thus, the European commission has stated that a major argument for reforms and for a deregulation process is the establishment of a more common European railway transportation market (Alexandersson & Hultén, 2008). However, it is important to remember that the railway sector differs from, for example, road and air transportation in that regard, and that various historical and political reasons have influenced differing technical specifications of rail transportation from country to country. Accordingly, a process for creating cross-country operability is developing, the European Rail Traffic Management System (ERTMS). This system aims to create a European standard of railway infrastructure and will improve the overall safety (Midya et al., 2008). Yet, such a process will take time.

In Sweden, there is a long history of state-owned railway since the Parliament decided on a general nationalization of private railway tracks in 1939. Gradually, the sector nevertheless has transformed. For instance, cars and buses became more common in the 1960s; resulting in the closure of nearly half of the railway tracks. However, a growing awareness of environmental issues has later contributed to a renewed interest in train travel by Swedes. Moreover, the introduction of the train set X2000 in 1990, reaching a maximum speed of 200 km/h (124 mph), contributed to an immediate upsurge in passenger traffic (Kullander, 1994; Ohlin, 1997). According to Alexandersson & Hultén (2008) the transportation volume increased more than 40% between 1990 and 2003, and it has continued to increase since (Trafikanalys, 2012).

The Swedish deregulation process started in 1988 when the railway sector was nearly synonymous with Swedish State Railways (SJ); yet, in 1988 the monopoly was broken and a new authority responsible for the train infrastructure, the Swedish Rail Administration was formed (Alexandersson
& Hultén, 2008). The Swedish State Railways has since been divided into several specialized companies, some state-owned, some privatized: SJ (passenger), Green Cargo (freight), Euromaint (technical maintenance of rail carriages), Train Tech Engineering (engineering and technical services), Unigrid (IT business), Jernhusen (properties) and Trafficare (cleaning and switching). Thereafter, the competition “for the tracks” has continued and now public procurement by competitive tendering dominates the passenger rail market (Alexandersson & Hultén, 2008). As a result, one can conclude that many actors with different areas of responsibility characterize the Swedish railway sector. Accordingly, the railway sector is highly fragmented and it is challenging to get an overview of the many actors involved. The consequences of such a development are not yet fully known, but today the railway infrastructure is alarmingly worn and overburdened (Swedish Transport Administration, 2011a), which may be one reason for an increasing number of reported mishaps during the last years (Swedish Accident Investigation Authority, 2011abc). As recent as February 2012, a passenger train collided with a truck at a level crossing in Åkersberga Sweden, but fortunately only four people were injured (Carpo, 2012). However, it is an indication that it is not a question of if a severe train crash will occur, but rather when it will happen again. It further raises the questions of what factors are important for passenger safety and recovery after train crashes.

Haddon´s matrix as analytical framework

In this thesis I use Haddon´s Matrix (Haddon, 1980; Haddon & Baker, 1981), originally created for road traffic trauma (Table 1) to determine influencing factors on the passengers in the railway sector. Thus, it has been the basis for the entirety thesis. It provides a compelling framework for understanding the origins of the negative consequences for the passenger’s and for identifying multiple countermeasures to address those problems in the context of the railway.

Haddon identified several factors that contribute to injury events and injuries: (i) human, (ii) vehicle/equipment, (iii) physical environment, and (iv) socioeconomic environment. These factors contribute in three phases: (i) pre-event, (ii) event, and (iii) post-event (Haddon, 1972; Haddon, 1980).
The upcoming literature review has been designed according to Haddon’s structure to determine influencing factors on the passengers in train crashes. The pre-crash phase includes factors that influence the probability of an injury event taking place. The crash phase is about factors that affect the amount of crash energy reaching passengers. The post-crash phase deals with mitigation of incurred injuries; for example, using the best possible rescue procedures and rehabilitation care. Human factors deal with individuals and their characteristics, both for drivers and passengers in the carriages. Vehicle and equipment factors deal with train construction, crashworthiness, interior design, and equipment. Physical environment includes the environment surrounding the train, such as weather conditions, level crossings etc. Socio-economic environment is the category in which society in general affects the railway structure through, e.g., national laws.

Through the use of the Haddon matrix, casual or associated factors that contribute to the problem can be pinpointed. However, not all casual factors are key determinants. Interpreting a casual pathway requires the controllable factors be identified to provide a basis for injury preventive interactions.

**Ten strategies for reducing human losses**
Mitigation of injuries can then be based on Haddon’s (1970, 1995) ten injury mitigation strategies. The strategy aims at reducing energy from reaching humans at levels that exceed the injury threshold, to strengthen the human body, and to reduce acute and long term consequences (emergency/acute care and rehabilitation) when an injury does occur (Table 2). The discussion in this thesis is, therefore, structured according to reasonable preventive measures based on the thinking represented by Haddon’s ten injury prevention strategies in their logical sequence.

### Table 1. Haddon’s matrix.

<table>
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<tr>
<th></th>
<th>Human</th>
<th>Vehicle/equipment</th>
<th>Physical environment</th>
<th>Socioeconomic environment</th>
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<td><strong>Pre-crash</strong></td>
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<tr>
<td><strong>Crash</strong></td>
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<td><strong>Post-crash</strong></td>
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</table>
Table 2. Haddon’s ten injury reducing strategies in their logical sequence.

<table>
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<tr>
<th>Haddon´s ten injury preventing strategies</th>
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<tbody>
<tr>
<td>1. Prevent the marshalling of the form of energy in the first place</td>
</tr>
<tr>
<td>2. Reduce the amount of energy marshalled</td>
</tr>
<tr>
<td>3. Prevent the release of energy</td>
</tr>
<tr>
<td>4. Modify the rate of spatial distribution of release of the energy from its source</td>
</tr>
<tr>
<td>5. Separate, in space or time, the energy being released from the susceptible structure</td>
</tr>
<tr>
<td>6. Separation by “barrier”</td>
</tr>
<tr>
<td>7. Modify appropriately contact surfaces (softening)</td>
</tr>
<tr>
<td>8. Strengthen the human resistance</td>
</tr>
<tr>
<td>9. Prevent aggravation of occurred injury event – emergency care</td>
</tr>
<tr>
<td>10. Restoration and rehabilitation of those injured</td>
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Train crashes understood through Haddon’s matrix

Pre- Crash
The Human factor has proved to be the direct cause of several train crashes. Many studies have been carried out within this factor and contain aspects of the human factor through investigations of crash causes and user-friendly instruments and tools. The term is often used to denote the human tendency to misunderstand, make miscalculations, and mistakes.

The 1999 crash in Ladbroke Grove, Great Britain is one example where the human factor was the direct cause when there was a failure to stop at red signal; so called Signal Passed At Danger (SPAD) (Lawton & Ward, 2005). Kecklund et al. (2001) have also pointed out problems between the interaction by the driver and Automatic Train Control (ATC). Stress, low motivation combined with lack of information, and dilapidated automatic monitoring technology are some contributing factors. Fatigue problems (Chang & Ju, 2008; Dorrian et al., 2011; Kecklund et al., 2001) and inattentiveness (Edkins & Pollock, 1997) are other causes for human faults. Speed limit violation by the drivers, as in Amagasaki, Japan, in 2005, caused a train to derail in a curve killing 107 passengers and injuring another 549 (Nagata et al., 2006).
Miscalculations or infringements by car drivers at level crossings are another common cause for crashes (Evans, 2011). Edkins and Pollock (1997) also found that inadequate maintenance can cause severe consequences. Lawson and Ward (2005), nevertheless, warn against putting too much blame on human error and thereby miss other important factors. The human factor must, therefore, be seen in context.

Train crashes caused by carriage and equipment failure must be avoided by for example timely inspections and maintenance, and are included in the vehicle/equipment factor. The 1998 train crash in Eschede, Germany (Figure 2) occurred when the Intercity Express (ICE) traveling at 200 km/h collided with a bridge (Oestern et al. 2000) after wheel failure. The train crash in Skotterud, Norway, 2010 (Thurfjell, 2010) is another example. Non user-friendly instruments, tools and inadequate equipment designs (e.g., driver safety systems) inside the train are other causes for train crashes because the risk for human mistakes is increased (Edkins & Pollock, 1997).

Physical environment factors can also be reasons for crashes. In the early days, trains sometimes collided with cows, but it did not create any severe injury events. Bridge collapses were other hazards (Shaw, 1978). Improved materials and performance of railway tracks have reduced the number of crashes caused by, e.g., the weather or climate, which cause heat distortions of tracks, ice formations, problems induced by snow (Shaw, 1978; Semmens, 1994; Kichenside, 1997).

Figure 2. The German high-speed train derails at 125 miles/hour (200 km/h), resulting in 101 deaths and 103 injured. Photo: IngoWagner/DPA/Scanpix
However, the rail disaster with the highest death count in history occurred in Sri Lanka, 2004, and was caused by the tsunami following an Indian Ocean earthquake. More than 1,700 people died when the wave swept in and overturned the carriages (Steele, 2004).

Existing level-crossings have been improved (c.f. Millegran et al., 2009; Yan, 2010) and the construction of new ones has been minimized. Despite this, the number of European level crossing crashes between 1990 and 2009 remained the same in relation to the number of passenger kilometers traveled (Evans, 2011). This makes level crossing crashes a high priority issue. For example, in 1999 a passenger train collided with a tractor-semitrailer at a grade crossing in Bourbonnais, Illinois. U.S. The locomotive and 11 of the 14 Amtrak cars derailed. The accident resulted in 11 deaths and 122 people being transported to local hospitals (National Transportation Safety Board, 2002). Davey et al., (2008) suggest that the crossings design and location should be reviewed as they are often unsuitable for large vehicles. Reliable safety systems also need to be in place to reduce human mistakes, and have been improved immensely over the years. Broadly, modern signaling has taken the place of flag or hand signals (Kichenside, 1997); this means that information about, e.g., clearance and the maximum permitted speed are now specified in the driver’s cab. If drivers fail to react to a signal the train automatically brakes.

Within the socioeconomic environment, surroundings are put into a larger context. Train crashes are seldom tied to a single casual factor, but could be the result of systematic failure (Lawton & Ward, 2005). Among several important developments in this area is the introduction of a standard time. When trains began to run across time zones according to a schedule, several crashes were caused because of the lack of a common time (Shaw, 1978). Numerous improvements have then been developed for traffic control over the years, but the latest is the implementation of the European Rail Traffic Management System (ERTMS). This will make rail transport safer and more competitive, and guarantees a common standard that enables trains to cross national borders (Midya et al., 2008).

Unfavorable company policies regarding e.g. work schedules may cause fatigue, stress and low motivation (Kecklund et al., 2001), may contribute to crashes. Chang and Ju (2008) showed, that long shifts and too high working pressure was part of this problem. Improved railway safety requires good working conditions for all employees according to Dorrian et al. (2011). Edkins and Pollock (1997) show many human failures can be symptoms of latent defects within the organization. Organizational impact has been linked to numerous incidents, which demonstrates that, for example, improved
resource management and organizational climate is a critical part for safety improvements (Baysari et al., 2008; Sanne, 2008, Santos-Reyes & Beard, 2006).

There is also a wider causal perspective; questioning the impact on railway safety through privatization. Nevertheless, there is no evidence that the 1994 privatization in Great Britain (Evans, 2007) or in Japan in 1987 (Evans, 2010), have increased the risk for train crashes. Elvik (2006) even found that deregulation was associated with improved rail safety. However, more research is needed on the effect of privatization and safety.

Crash

*Human* factors in the crash phase refer to passenger movements in a crash and their injuries. In a crash, energy will be transferred to the body by the deceleration of the train. Modern trains run at increasingly high speeds, increasing the kinetic energy that must be handled. Passengers sustain injuries by intrusion when the carriage bodies break down and when passengers are thrown as projectiles inside the carriages or hit by flying objects like luggage.

*Vehicle/equipment* factors refer to train carriage crashworthiness and interior design. The improvements in train construction and crashworthiness have been remarkable over the years. During the 19th century the carriages were made of wood and simply disintegrated when the train decelerated in a crash. A crash in France in 1933 demonstrated this reality. In thick fog, a locomotive struck a slow moving wooden passenger express from behind and crashed through the carriages entire length; killing 230 and injuring 300 people (Kichenside, 1997), in phenomenon called “telescoping.” Crashes during this time were further complicated by fire (Shaw, 1978). New stable metal train carriages were introduced and by the 1950s they had mostly replaced wooden carriages worldwide. The change accordingly minimized the telescoping problem but created another dangerous phenomenon, “overriding,” casting a shadow over railroad crash safety for decades. As an example, three morning trains collided in Clapham, England in 1988. One train carriage overrode the other and crashed down on the passengers below, which cost 35 passenger their lives and injured nearly 70 (Semmens, 1994). Deformation zones on train carriages were encouraged and crash zones have been investigated as possible answers to the “overriding” problem. Corrugated metal plates, which hooked the carriages together in the event of a crash, were fitted to the end of each rail carriage. These designs decreased the risk of vertical movement that could develop into overriding. The train crash in Germany in 1998 (Figure 2), on the other hand, highlighted another dangerous crash phenomenon called “jack-knifing” or “lateral buckling”. Upon impact, the train carriages derailed and collided into each other’s sides. The weak side walls collapsed inwards
One approach to counter this phenomenon was to make the couplings between carriages stronger and more stable to prevent carriages from buckling either sideways or vertically.

Changes in the design of the train exterior, to provide passenger protection, continue to evolve; as seen in numerous articles in engineering (e.g., Kirk et al., 1999; Tyrell & Perlman, 2003, Gao & Tian, 2007; Scholes & Lewis, 1993; Xue et al., 2005). Both simulated and experimental crash tests are commonly used to evaluate the design change effectiveness. Simons and Kirkpatrick (1999), for example, used a finite element model to estimate the probability of surviving a crash by showing the number of expected deaths. Omino et al. (2002) also estimated passenger movement patterns during a crash to find injury prevention countermeasures using computer simulations. Crash zones (Tyrell & Perlman, 2003) and structural modifications (Gao & Tian, 2007) have improved the crash-worthiness of train carriages, however, they cannot withstand the high energies produced in today’s high-speed train crashes. The front carriages often take the brunt of the impact. Thus, sitting in the front carriages proves to be most dangerous; causing the most severe and fatal injuries (Shackelford et al., 2011; Hambeck & Pueschel, 1981). A 1999 head-on collision in India is one example where there were more than 800 people injured and 256 fatalities; most of them were in the two first carriages (Prabhakar & Sharma, 2002).

Relatively little research has been conducted concerning internal carriage design. Rail carriage seats are not equipped with seat belts; thus, passengers are thrown against various structures and into each other, sustaining injuries in case of a crash (Braden, 1974; Braden, 1975; Fothergill et al., 1992). Passengers can even be thrown through the train windows landing beneath the carriage (Fothergill et al., 1992). Seats coming loose in a crash (Eriksson et al., 1984ab) or seat structure (Fothergill et al., 1992) also cause injuries. Ilkjær and Lind (2001) also found that passengers received injuries from tables. Unlike airplanes, train carriages do not have sealable luggage hatches allowing luggage to fly around like missiles causing injuries (Bradon, 1974; Eriksson et al., 1984ab; Fothergill et al., 1992; Cugnoni et al., 1994; Ilkjær & Lind 2001). More research is, therefore, needed to investigate modern carriage interior design and its injury inducing effect.

The Physical environment such as bridges or steep embankments can further aggravate the crash. In 2007, a passenger train derailed in Cumbria, Great Britain. All nine carriages derailed; eight of them subsequently fell down the steep embankment and five turned onto their sides injuring more than 80 passengers (Rail Accident Investigation Branch, 2009). In 2011 serious faults in a signaling system and poor management caused a fatal collision on
China’s high-speed network; killing 39 and injuring nearly 200 people. The initial impact of another train colliding into it from behind was aggravated when four of six carriages fell from a bridge (Railway Gazette International, 2012). Formal demands and regulations fit within the Socioeconomic environment factor and are of importance in the crash phase. For instance, if there is no seat belt law in trains, or formal demands on how luggage should be safely stored; it will be reflected on the interior construction. The consequences of this can be read in the vehicle and equipment factor section.

**Post-Crash**

The Human factors also play an important role in the post-crash phase. Evacuation knowledge and well prepared train crew are factors that can affect the outcome. Further, if passengers have not been provided with appropriate safety critical information they cannot be expected to know how to handle the situation when it arises. Besides the physical injuries and perhaps irrespective of their severity, train crashes affect the whole person (psychological, social, and existential). There are many studies focusing on, for example, psychological and psychiatric effects such as posttraumatic stress disorder (PTSD) among people who have been involved in serious disasters (Berg Johannesson et al., 2011; Rosser et al., 1991; Wang et al., 2005). Survivor’s reactions are considered severe immediately after the event, but many people find pathways to recovery (Bonanno, 2004). However, there are survivors who experience trauma affects from 5 years after event to lifelong (Hull et al., 2002; Lazaratou et al., 2008; Lundin & Jansson, 2007). There are a few studies focusing on psychological or psychiatric perspectives from train crashes. According to these studies passengers still suffer from psychological problems (Raphael, 1977; Hagström, 1995) after approximately 18 months (Arozenius, 1977; Boman, 1979; Selly et al., 1997), and up to more than 10 years (Lundin, 1991). To take advantage of narrated experiences from these survivors are not found despite that these stories can reveal other aspects of existential, psychosocial character that cannot be revealed in surveys. Narrated experiences have nevertheless been done in studies of the Asian Tsunami (Roxberg et al., 2010; Råholm et al., 2008; The National Board of Health and Welfare, 2008). One’s own strength, help from family and friends (the National Board of Health and Welfare, 2008), and visiting the event site (Heir & Weisaeth, 2006) were described as helpful for dealing with the situation. More deeply, existential effects and a struggle between life and death were also described (Råholm et al., 2008). Even if these effects, to some degree, can be transferred to train crashes it seems reasonable to assume that surviving a train crash is different from a large-scale severe disaster like the Asian Tsunami. Learning more about personal experiences from train crashes gives, not only knowledge about if they recovered or not, but also about how
they perceived the rescue process as well as give insight into possible preventive strategies.

At the scene of the event, besides passengers and rescue personnel, there are also bystanders and journalists. First on site, bystanders have been seen as helpful in the rescue effort in transport casualties (Nagata et al., 2006). Journalist’s staffs (photographers and reporters) have yet been described as intrusive, insensitive, and sensational; thus adding to the survivors’ grief (Coté & Simpson, 2006; Haravouri et al., 2011; Kay et al., 2010) and causing a secondary victimization (Campbell & Raja, 1999). Survivors might wish that media staff would help in the rescue, but instead they are professional eyewitnesses causing a dilemma (Englund, 2008; Englund et al., 2012). Also, rescue personnel become negatively stressed by the presence of the media (Lundälv & Volden, 2004). There is tension between the journalists’ need for information and the privacy of the survivors; making the encounter between the involved parties a mostly negative experience for survivors (Doohan & Saveman, personal communication; Roxberg et al., 2010). Rescue personnel are in a position to help the victims, including protecting them from being exposed in ways that increase their suffering. When considering human factors, there are many actors at a train crash scene who play various roles that might improve or deteriorate the rescue effort and survivors’ experiences in the post-crash phase.

The Vehicle/equipment factors involve clear and effective evacuation routes, and Weyman et al., (2005) have shown that there were serious shortcomings in functionality, including emergency exits and evacuation equipment at the rail crash at Ladbroke Grove. Displaced luggage also increased the difficulties for evacuation. Further, the design did not facilitate access through windows in overturned carriages; and the doors, which were now located upwards, were impossible for a lone individual to open (Braden, 1974). Braden stated that the interior design and the lack of roof hatches were factors hampering evacuation. Additionally, the internal doors can jam and obstruct evacuation and can further be aggravated by narrow stairways, trapping survivors in upper compartments in double-decker carriages (Weyman et al., 2005). The need to ease evacuation routes through intelligent design in railway applications is obvious.

In the Clapham rail disaster in 1988 the Physical environment made it difficult to evacuate and transport the injured from the steep embankment to the road (Stevens & Partridge, 1990). Further, railway crashes might happen far from roads as was the case when two trains collided head-on due to a signal malfunction in Japan, 1991, The rural setting of the crash hampered rescue efforts. Forty-two passengers died and 614 were injured (Ukai et al.,
In 2005, a passenger train collided with a truck in Israel. The collision resulted in a multiple-scene mass-casualty incident in an area characterized by difficult access and a relatively long distance from trauma centers. The crash resulted in 289 injured passengers and seven fatalities (Assa et al., 2009).

The *Socioeconomical environment* comprises, e.g., guidelines, competence, resources, and disaster plans. If rescue personnel are not prepared and trained for a train crash, this will most likely affect the outcome. Robinson (1975) showed the need for rapid evacuation of casualties as those who have died from traumatic asphyxia and crush syndrome might have survived if they had been rescued more quickly. In a 2008 train crash in Los Angeles, two of the fatalities were passengers trapped under debris. They most likely died from asphyxia due to the prolonged extrication time (Shackelford et al., 2011). In the Amagasaki, Japan train crash, it proved to be a success that the personnel were trained in confined-space medical techniques. Without this training, the two trapped with crush syndrome would probably have died. It took 22 hours until the last passengers were extricated because the rescue teams were forced to work with small hand held tools due to fire risk caused by a gasoline leak. This risk precluded the use of metal cutters and heavy machines (Nagata, 2006). In a collision in Hamburg, 11 persons were caught in the front part of the first carriage and the use of extensive cutting torch work rendered the rescue very difficult. It could further not be properly started until the carriages had been securely stabilized. All eleven died despite that these injuries would not necessarily have proved fatal (Hambeck & Pueschel, 1981). The Clapham rail disaster in 1988 highlighted the problem of gaining access to the carriages. The site was divided into three sections and ladders were needed to clamber from one carriage to another (Stevens & Partridge, 1990). Despite indicators that we need to pre-plan, exercise, and have efficient extrication and evacuation equipment there are incredibly few improvements implemented. Further research and development concerning tactic, technique and equipment is needed.
RATIONALE FOR THE THESIS

Train crashes causing severe consequences for passengers are not a problem of the past; rather they continue to be highly relevant today, in Sweden as well as abroad. The magnitude of the problem and the trends require illumination. Preventing train crashes in the first place must surely be the first priority and the most effective prevention strategy to achieve a safe railway environment. This idea is also reflected in research as much of previous research has been conducted with a pre-crash focus.

However, we cannot only concentrate research on the pre-crash phase because train crashes continue to occur and will continue to occur. Therefore, we also need to carry out research within the crash and post-crash phases to find important consequence reducing factors. The literature review showed that passengers suffer from both physical and psychological injuries in a train crash. Injuries that probably could be prevented and psychological consequences that may be reduced if survivors’ experiences were shared; yet, this is a neglected area. Therefore, it is important that more research is carried out on how to reduce the physical and psychological consequences resulting from a train crash experience. This thesis contributes in this direction by combining research on both physical and psychological consequences of two train crashes; addressing factors of importance for the passengers in the crash and post-crash phases. In Table 3, factors of importance are shown as well as the factors studied in this thesis.

This thesis argues that an increased awareness and knowledge of factors central to the crash and post-crash phases are of utmost importance. It serves as a basis for a much-needed preventive work to reduce passenger consequences when train crashes occur. Hence, we need to understand how train crashes affect passengers to identify and to further present possible opportunities for consequence reducing measures for future train crashes.
**Table 3.** Factors of importance in injury events with trains (modified for the thesis). (The thesis focus areas are marked grey).

<table>
<thead>
<tr>
<th>Human factors</th>
<th>Vehicle</th>
<th>Physical environment</th>
<th>Socioeconomic environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-crash</strong></td>
<td>- Carriage</td>
<td>- Railway track</td>
<td>- Company policies (safety rules)</td>
</tr>
<tr>
<td>- Age</td>
<td></td>
<td>- Signal system</td>
<td>- Speed limit</td>
</tr>
<tr>
<td>- Sex</td>
<td></td>
<td>- Level crossings</td>
<td>- Traffic control</td>
</tr>
<tr>
<td>- Education</td>
<td></td>
<td>- Bridges</td>
<td>- Seatbelt law</td>
</tr>
<tr>
<td>- Experience</td>
<td></td>
<td></td>
<td>- Exercise, training, education, and disaster plans</td>
</tr>
<tr>
<td>- Intoxication</td>
<td></td>
<td>- Weather</td>
<td></td>
</tr>
<tr>
<td>- Fatigue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Inattentiveness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Crash</strong></td>
<td>- Crashworthiness</td>
<td>- External objects (e.g., trees, tunnels, bridges, embankments)</td>
<td>- Formal demands of the trains crashworthiness and interior safety construction (e.g., luggage space)</td>
</tr>
<tr>
<td>- How the body moves in a crash</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Injuries</td>
<td>- The interior design and supply</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Post-crash</strong></td>
<td>- Clear and effective evacuation routes</td>
<td>- Geographical location</td>
<td>- Treatment and evacuation guidelines</td>
</tr>
<tr>
<td>- Evacuation knowledge</td>
<td></td>
<td>- Weather/climate</td>
<td>- Competence and training of EMS and fire brigade personnel</td>
</tr>
<tr>
<td>- Passenger experiences</td>
<td></td>
<td>- Access routes</td>
<td>- Resources for major incidents (emergency vehicles, hospitals, personnel, equipment)</td>
</tr>
<tr>
<td>- Bystanders</td>
<td></td>
<td></td>
<td>- Disaster plans and organization</td>
</tr>
</tbody>
</table>

**Overall aim**

The overall aim is to investigate the development and magnitude of major railway crashes and the physical and physiological consequences of train crashes on passengers with a focus on crash and post-crash phases.

**Specific aims**

I: to identify the magnitude and development of passenger rail crashes over the years in various continents and countries

II: to identify injuries and injury objects at the train crash in Kimstad, Sweden 2010

III: to identify the injury object and injury panorama and to determine injury inducing variables

IV: to explore survivors’ experiences from a train crash in Nosaby, Sweden 2004.

V: to explore survivors’ experiences of interacting with journalists, media coverage and personal media exposure following two Swedish train crashes
METHODS

The research process and design

This section describes the research process of this thesis and each study is illustrated in Table 4. Initially a holistic approach (Morton et al., 2012) was assumed and the methodological assumptions that guided the process were pragmatic (Morgan, 2007). Thus, train crashes first were described according to their context in a global perspective. Hence, the first paper (I) identified if major train crashes were still reckoned a problem. Indeed they are, and gave motive to further investigate the physical (II, III) consequences on the passengers in crashes. I decided to study train crashes in a Swedish context, both for practical and useful reasons. When collecting data for study II, III I came to understand that the passengers had significantly greater and more problems than physical injuries alone. This prompted the combining of qualitative and quantitative methods, and interviews were performed with a focus on survivor experiences (IV, V) both during and after a crash.

Table 4. An overview of studies I-V

<table>
<thead>
<tr>
<th>Study</th>
<th>Content</th>
<th>Design</th>
<th>Data collection</th>
<th>Disasters/participants</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Trends of railway disasters</td>
<td>Retrospective epidemiological study</td>
<td>Register data</td>
<td>529 train disasters</td>
<td>Descriptive statistics</td>
</tr>
<tr>
<td>II</td>
<td>Injury panorama and injury objects</td>
<td>Retrospective case study</td>
<td>Medical records</td>
<td>21 passengers</td>
<td>Quantitative content analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Semi-structured interviews (n=16)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Injury panorama and injury objects</td>
<td>Retrospective case study</td>
<td>Police records</td>
<td>73 passengers</td>
<td>Descriptive statistics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Printed press</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Semi-structured interviews (n=13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>Experiences from a train crash</td>
<td>Retrospective case study</td>
<td>Narrative and semi-structured interviews (n=14)</td>
<td>14 passengers</td>
<td>Qualitative content analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Police records Instruments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Experiences of media coverage</td>
<td>Retrospective case study</td>
<td>Semi-structured interviews (n=30)</td>
<td>30 passengers</td>
<td>Qualitative content analysis</td>
</tr>
</tbody>
</table>
Settings

The studies in this thesis are based on worldwide data from train disasters (I) and the two latest severe Swedish train crashes. One is the crash in Nosaby, 2004 (III, IV, V) where a truck, fully loaded with wood pellets became stuck between the gates at a level crossing. An oncoming three-carriage passenger train smashed straight into the side of the truck at 121 km/h (75 mph). The impact disintegrated the front of the first carriage allowing wood pellets from the truck to pour in. The first carriage hit a tree, disengaged from the others, rotated 180°, and overturned. The second carriage partly derailed and plowed into the ground alongside of the track, but remained on the railway embankment (Figure 3) (Swedish Accident Investigation Authority, 2006).

Figure 3. Photo from the crash site in Nosaby, 2004. Photo: Swedish Transport Administration
The other crash occurred in Kimstad, 2010 (II, V), where a six-carriage passenger high-speed train crashed into an excavator shovel working on the adjacent track (Figure 4). At the collision the front shovel cut up the whole side of the locomotive and then the excavator spun around and hit the other carriages several times (Swedish Accident Investigation Board, 2012).

Figure 4. Photo from the crash site in Kimstad, 2010. The first three carriages are seen. Photo: The Swedish Accident Investigation Authority

Sampling and participants

The inclusion criteria in study I were railway disasters from 1910 through 2009 with 10 or more fatalities and/or 100 or more people reported non-fatally injured (n= 529). Additional data from the register (2010-2011) are also presented in the results section. Study II, is based on all 21 passengers who came in contact with medical care from the train crash in Kimstad. The population sample in study III is based on all 73 known fatally and non-fatally injured passengers from the train crash in Nosaby (see Figure 5). In study IV, police authorities

Figure 5. Flow chart of participation in study III.
provided available records of the Nosaby train crash. Sixty-five of these passengers were asked to participate in interviews as three were deceased (two in the crash and one later on) and three could not be located. Out of these, 14 participants were recruited (IV). Study V, is based on all 16 adult passengers who sought medical care (four children excluded) from the train crash in Kimstad, and those 14 passengers who were recruited from the Nosaby train crash (see study IV). Thus, 30 survivors were interviewed.

Data collection

Register data
Data on railway disasters was made available from the Centre for Research on the Epidemiology of Disasters (CRED), which maintains the Emergency Events Database (EM-DAT), a worldwide database on disasters. Disasters included in study (I) were selected on two of CRED’s criteria defining a disaster: 10 or more reported fatalities and/or; ≥100 or more people reported affected. Within the criterion “affected,” a further sample specification was made to include only events resulting in ≥100 non-fatally injured victims. Thus, eight disasters are excluded where people had required immediate assistance during a period of emergency or had been evacuated, thus affected, but not injured. A total of 529 railway crashes were included, of these, six were subway disasters and one was a Maglev disaster. With the additional data for 2010/2011 another 20 disasters were analyzed.

Police and medical records
In study II data on passenger injuries were retrieved from medical records accessed through the Swedish Accident Investigation Authority. Data regarding passengers’ injuries (III) were collected from official police records including, e.g., medical charts, autopsy records, and own statements. Data on gender and age was also obtained from these sources. We also located four passengers with minor injuries through printed press (III).

Interviews
Narrative interviews (Riessman, 2008) were performed with passengers from the train crashes in Nosaby (n=14) (IV) and Kimstad (n=16). (Parts of the interviews from Kimstad will be analyzed and described elsewhere). An interview guide including a few semi-structured questions was constructed according to pre-crash, crash, and post-crash phases (Haddon & Baker, 1981). The interviews began with the question, “Please, tell me about where you were going?”, followed by “What happened during and after the crash?” Participants told their stories without restraint. At times, the narratives were
supported with follow-up questions such as, “What do you mean?” and “What did you experience then?” This was done to clarify the content of the interviews (Mischler, 1986). If not mentioned spontaneously, questions from the interview guide such as “Do you know the reason for the injury origin?”, “Can you point out your position in the carriage?” (II, III), and “What is your experience of interacting with journalists at the crash site?” (V) were asked. The interviews were performed face-to-face (n=13) at a location agreed to by the participants and by telephone (n=17), lasting 20 to 80 minutes (average 40 minutes). The interviews were recorded (except for one, from which notes were taken) and transcribed verbatim.

**Questionnaire**

As background data, participants in study IV also filled in two validated self-evaluation scales; PTSD Check List-Civilian Version (PCL-C) for estimation of posttraumatic stress reactions (Blanchard et al., 1996; Weathers et al., 1993) with 17 questions, and the General Health Questionnaire-12 (GHQ 12) (Goldberg et al., 1977) including 12 questions to evaluate participants’ general health.

**Data analyses**

**Statistics**

Descriptive statistics were used to analyze frequencies and proportions in studies I and III. Further, multivariate data analysis methods, such as Principal component analysis (PCA) (Wold et al., 1987) and Partial least square discriminant analysis (PLS-DA) (Wold et al., 2001) were used to determining correlations between injuries and inducing variables in study III. **PCA and PLS-DA** were performed with EVINCE 2.2.5 (UmBio AB, Umeå, Sweden). Matlab R2008b (The MathWorks, Natic, MA, USA) and Microsoft Excel (Microsoft, Seattle, WA, USA) were used for editing the matrices, calculations, and evaluation of statistical differences in score plots from PLS-DA and PCA models with unpaired NOPAPROD (Nyström et al., 2009; Bodén et al., 2011) where \( \alpha = 0.05 \). \( P \)-values < 0.05 were considered statistically significant.
Quantitative Content analysis
Quantitative content analysis (Krippendorff, 2012) has been used to organize and summarize injuries and injury objects in the Kimstad train crash (II). The method has also been used to, e.g., categorize injury objects recalled by the passengers in study III.

Qualitative content analysis
In studies IV and V the interview texts were analyzed using a qualitative content analysis (Graneheim & Lundman, 2004). In study IV the narrated text itself generated ideas for subthemes and themes and in study V we only analyzed text related to media and the semi-structured questions thus generated ideas for the categorization. Repeated readings led to divisions of meaning units that were condensed while preserving the core content. The condensed text was then abstracted and given codes. The codes were next sorted into preliminary subcategories (V) and subthemes (IV) and after content comparison within and across them combined into subthemes and subcategories. In the next step, themes (IV) or main categories (V) were formulated based on the text as a whole, the content of the subcategories and subthemes, and the interpretation of the underlying meanings (IV).

Methodological considerations
All methods have limitations and without careful consideration, wrong choices can distort the data or fail to describe the purpose of the study (Sandelowski, 1993; Sandelowski, 2000). Below, I therefore will discuss methodological choices in the studies.

Combination of quantitative and qualitative methods
The combination of quantitative and qualitative designs in the thesis has enriched the studies as the methods complement each other. Important information that is not revealed in quantitative studies emerges in the studies with a qualitative design and vice versa (Sandelowski, 2000; Pope & Mays, 1995). By combining these two designs a broader and deeper understanding on the passengers’ consequences and provided answers to various questions. The ability to bring various strengths within the different methods together in the same research project became an enormous benefit (cf. Morgan, 2007).

Register data
The EM-DAT has a standardized approach with a clear selection criterion for inclusion of unintentionally caused railway disasters in the database (≥10 killed and/or ≥100 non-fatally injured). Unreliable numbers of reported fatalities and non-fatally injured means that disasters may not be included in
the database. This was probably more common in the past because information systems have improved over the last decades. Therefore, the number of missed disasters in recent times was most likely higher in the past. Those train disasters that are caused by explosions of chemical spill are further categorized in another category in the database. Train incidents were occasionally caused by boiler explosions in the past which means that those events are not presented in the data. Another limitation in the selection procedure is that it is difficult in some cases, to ascertain whether a disaster was intentionally caused or not. Thus, some cases might be included that should not be.

Quantitative content analysis
In order to describe the data in study II and some of the data in study III a quantitative content analysis was used. This method was considered suitable, as we wanted to quantify frequencies of injuries and injury objects. This method yet needed to be supplemented with a statistic analyzes method to find correlations between injuries and inducing object in study III.

Interviews and Qualitative content analysis
The participants memory of the traumatic events can be questioned when a large amount of time has elapsed (4 years) between the crash and interview in study IV and V. The nature of memory of traumatic events can be discussed. Some researchers state that traumatic memories are fixed or unforgettable (Terr, 1990; Conway et al., 1994), while others have found memories to be flexible and subject to substantial alteration (Southwick et al., 1997). The participants’ stories from the Nosaby train crash were detailed and emotion filled; thus, I assume their memories from the event are also detailed and valid. Furthermore, in this context, whether their experience has changed or not, is less important. The relevance is their perceived experience and their reflections of what happened. In terms of qualitative research, the number of respondents is not crucial, but rather the quality of the interviews text achieving the purpose (Polit & Beck, 2011); ergo, the samples of 14 (IV) and 30 (V) participants can be seen as fully sufficient.

Using interviews as a data collection method is satisfactory when the desire is to explore people’s experiences (Graneheim & Lundman, 2004). However, one should not ignore that the interface between the interviewer and the interviewee leaves an opportunity for co-creation (Kvale & Brinkmann, 2009; Mishler, 1986). Nevertheless, this is not necessarily negative as it is possible to curb preconceptions and instead influence to get a more detailed story. The pre-understanding has nevertheless increased during the process because the studies are built on each other; therefore they also might have influenced the interpretations. The goal has, thus, been to keep close to the text (Kvale &
Brinkmann, 2009; Mishler, 1986). However, it is important to be aware of one’s own preconceptions during the interview and in the analysis process. During the interview I attempted to remain open-minded about the participants’ experiences, i.e., hold my pre-understanding in check. Having several researchers analyzing the text further minimized the pre-understanding to obscure the analysis process. This also resulted in that the most likely interpretation emerged. It has been ensured that that the coding, categories, and themes were in line with the meaning units and with the text as a whole. The procedure was repeated to refine and validate the chosen structure (Graneheim & Lundman, 2004). The internal logic and consistency are also verified by quotations from the text (Polit & Hungler, 2004). The aforementioned steps increase the credibility and transferability of the findings (c.f. Dzurec & Abraham, 1993; Polit & Beck, 2011). Several interpretations of narrated texts are nevertheless possible and can be valid, even if different (Krippendorff, 2012).

Finally, it is assumed that the findings in study (IV) are transferable to similar contexts where people’s lives are threatened, but especially relevant to those involved in a train crash. The results in study V are eminently transferable to other contexts where victims experience journalists and media coverage, but in the end, it is only the reader that can determine if the results are transferable to other contexts (Polit & Beck, 2011).

**Statistics**

It is difficult to use traditional statistics when seeking significant correlations between an injury and its causes because of dependency on multiple variables. Using multivariate data analysis methods simultaneously considers several variables for each passenger. Thus, it is possible to find more accurate correlations between the type of injury, location of injury, and the circumstance that caused the injury.

These methods, nevertheless, traditionally are not used in these types of data sets and therefore chemo metric methods may need to adapt better because, e.g., using only the most severe injuries on each body part when constructing the matrices a few injuries automatically were excluded, not given weight to the PCA and PLS-DA models. Despite this, results from multivariate analysis serve as indications of the injury inducing variables in the crash. Thus, the study is not a precise representation and more studies of similar nature, preferably on a larger dataset, are required to confirm the conclusions.
Ethical considerations

The studies in this thesis are performed in accordance with the principles outlined in the Declaration of Helsinki (World Medical Association, 2008). Study IV was approved by the Regional Ethics Committee at Umeå University (Dnr 09-143 Ö). Information about study IV was provided to the passengers by letter with a request to participate. If the passengers chose to participate, informed consent was given by phone or e-mail. Information about study V was given when these passengers were contacted on behalf of The Swedish Accident Investigation Authority. Informed consent was, thereby, given by phone. Participants (IV, V) were informed that participation was voluntary and of their right to withdraw at any time without explanation. Face to face interviews were conducted at a location agreed upon by the participants, and were recorded after obtaining permission. Because powerful emotions can arise when recounting their experiences psychiatric help was available if needed. However, no one chose to make use of the resource. Even though powerful emotions came up during the interviews, it was perceived more rewarding than demanding to recount their stories (c.f. Eilegård et al., 2011).

RESULTS

Global trends – major crashes

The number of railway disasters, people killed, and non-fatally injured has increased throughout the last hundred years — particularly during the last four decades (1970–2009), when 88% of all disasters occurred. Most railway disasters (74%), during 1970–2009, occurred in Asia and Africa. On those continents there is an increasing trend in the number of fatally injured passengers, whereas Europe and the Americas have experienced a decreasing trend; as shown in Figure 6.
Since the publication of paper (I) there have been 20 disasters globally during 2010-2011, compared with 15 during the two preceding years (2008–2009); indicating that the problem persists and might be increasing. Of the 20 incidents, 9 were in Asia, 4 in Europe, 4 in Africa, and 3 in South America.

The number of fatalities per railway disaster has decreased steadily throughout the years. From 1910-1949 there were 135 passengers killed per railway disaster; 84 during 1950-1969; and 41 from 1970-2009. Nevertheless, the average number of non-fatally injured per disaster has increased during the aforementioned periods, and has been 48, 89, and 92, respectively. From 1910-1949, the number of non-fatally injured was only 0.4 times the number of deaths, but since the 1970s, the number of non-fatally injured has averaged 2.2 times the number of deaths (Figure 7). The variation in total number of fatally and non-fatally injured per disaster has shown a slight decreasing trend; 184, 173, and 133, respectively, for the three periods above. During the last four decades (1970-2009) the number of fatalities per crash has remained relatively stable, while the number of non-fatally injured shows an increasing curve.

Disasters on different continents and countries- On the Asian continent, India reported the most railway disasters (104 of 233; 45%), followed by Pakistan (24; 10%). On the African continent, the most disasters were reported equally from South Africa (12 of 79; 15%) and Egypt (12 of 79; 15%). In Europe,
Russia reported the most railway disasters (17 of 95; 18%) followed by the United Kingdom (13 of 95; 14%). In South and Central America, Mexico reported more than half of all disasters (17 of 33; 52%) followed by Cuba (7 of 33; 21%). In North America, 21 (91%) of the 23 disasters occurred in the United States.

The fatality rate per disaster differs within the continents. South Africa and Egypt had the highest number of reported railway disasters (n=12 each) in Africa, but South Africa had a notably lower rate of average number of fatalities per disaster (n=17) compared with Egypt (n=65), and Angola (n=300). In Asia, Japan had 33 killed per disaster, close to the average for Asia.

**Global trends**

![Bar chart showing global trends](image)

*Figure 7.* The trend on fatally and non-fatally injured.
Crashes in Sweden

Crash phase
Several factors inside the carriages caused injuries (II, III). Impact against seats and tables were common as well as against other interior structures: walls, shelves and glass/windows. Many of these objects came loose turning into projectiles hitting the passengers. Passengers flew around colliding with other passengers and interior structures (III) and some were squeezed under different structures (III). Luggage falling on passengers was also reported as injury inducing objects (II, III).

The trunk (chest, abdomen/pelvis) was a frequent injury location constituting 33% of the injuries in the Nosaby crash (III) and 30% in the Kimstad crash (II), (Figure 8). However, head and neck injuries were also common (Figure 8), with an especially high rate in the Kimstad crash (II), (49% of the injuries), compared to 30% in study III. As many as 40% (III) and 24% (II) of the passengers sustained neck sprains; some were severe enough to cause long-term disabilities.

![Injury panorama](image)

Figure 8. Injury location in the Nosaby and Kimstad train crash

In the Kimstad crash (II) 21 passengers sought medical care. One suffered critical head injuries (MAIS 5) and was pronounced dead after two days of neurosurgical intensive care. One had severe trunk injuries (MAIS 4), while six passengers had moderate (MAIS 2) injuries such as concussion, fractures, etc. Eleven people had minor injuries (MAIS 1). Two passengers were admitted for observation; one with initial headache and one pregnant woman
without an injury diagnosed. Of the passengers onboard the train, 229 were uninjured or had so minor injuries that they were not medically treated.

Interior structures such as tables, seats and internal walls were related to the most severe injuries, luggage to moderate and minor injuries, and glass to minor injuries such as lacerations. However, the frequency was the opposite with lacerations as most common (II). In the Nosaby crash, two persons sustained fatal injuries, one from traumatic asphyxiation/suffocation caused by chest compression plus severe internal bleeding, and the other by maximal injuries - “traumatic dismemberment.” In total, 73 were injured in the Nosaby crash; one each with maximal, critical, and severe injuries (all in the first overturned carriage). Four had serious, 12 moderate, and 54 had minor injuries (III). One was suffocated by wood pellets from the truck the train had collided with, but was saved by fellow passengers. However, she sustained permanent anoxia induced damage to the brain.

In the Nosaby crash passengers in the overturned first carriage, suffered the most severe and lethal injuries (III) and in the Kimstad crash those passengers on the left side in the carriage hardest hit by the excavator, sustained the most severe injuries (II).

By using multivariate data analysis methods as Principal component analysis (PCA) (Wold et al., 1987) and Partial least square discriminant analysis (PLS-DA) it was possible to study injury inducing factors in the Nosaby crash (III). Having a table in front of a passenger significantly (p<0.05) influenced injury type and injury location. Those who traveled faced forward with a table in front of them in carriages two and three (not overturned) were more likely to sustain injuries to their abdomen/pelvis than those who traveled rear facing or those without a table. Neck sprains were significantly (p<0.05) more prominent for those who traveled rear facing. In carriage one (overturned) the passengers received injuries to their lower extremity, head, neck, and chest independent of facing direction; probably because they tumbled around and were impacted from several sides when the carriage overturned violently.

From interviews with the passengers from the Nosaby and Kimstad crashes (II-IV), additional and common comments of the crash sequence are presented in Figure 9 illustrating the crash and post-crash phase.
Figure 9. Citations from the Nosaby and Kimstad train crashes.

Post-crash phase

Rescue
Passengers stated that loose and detached objects such as seats, tables, interior/debris, and luggage as well as unsecured passengers were piled up (II, III). These items and wood pellets in the first carriage in the Nosaby train crash, made entrance for rescue personnel and evacuation of the injured difficult. Passengers also reported becoming trapped by some of these objects delaying evacuation. In the overturned carriage (III) it was exceptionally difficult to get out. It was further difficult to get out from the carriages still on the track due to the high height from the carriage down to the embankment (II). Additionally, the available rescue equipment was not suitable for the situation, which hampered evacuation.

Experiences
Passengers who survived the Nosaby train crash exhibited notably more experiences than only physical injuries sustained during the crash. Surviving a train crash had various consequences for the passengers (IV). Three themes were identified: Living in the mode of existential threat, Dealing with the
unthinkable, and Having cheated death. Living in the mode of existential threat was described as abruptly being thrown from normalcy and control to chaos and loss of control. They found themselves in a surreal situation, not knowing if they would survive. Living through this unimaginable chaos, fear, and uncertainty overwhelmed the passengers. They were hurtled into, e.g., interior structures and into each other, like being in a tumble dryer or riding a chaotic roller coaster. It was like waking up in a movie. They described that they were facing death and that they were fearful of further threats to life. Both silence and hysterical screams were heard. Their lives flashed in front of their eyes escalating a deep anxiety and fear of dying.

For some passengers, dealing with the unthinkable in this situation began just a few minutes after the crash, but for others it took longer. One way to regain control was to collect their belongings; some described an obsessive search for personal things and was found to be both surprising and sickening. Another strategy for regaining control was to help fellow passengers. This was done by, for example, remaining close together, talking calmly, and helping them out of the carriage. Focusing on others allowed them to maintain their own composure. Performing a task kept them from falling apart emotionally. They did not only help others, they also expressed a need to be with others: fellow passengers, family, and friends. A strong need for closeness was prominent for their well-being and security. Being together was central and even described as lifesaving. Some described a strong need to recount their stories from the event to someone close or who had the same experience, sometimes over and over again.

Another way of dealing with the unthinkable was to try to reconstruct the turn of events. Visiting the site and viewing the crashed train created different perspectives essential to putting the “pieces of the puzzle” together. Following news reports was helpful as was joining group meetings where investigators explained and illustrated the event. Thereby they gained more insight into their own stories. The experiences of group meetings were mixed; some found it helpful, others thought nothing was added, whereas others found it overwhelming.

Having cheated death by surviving a major trauma event, most of the survivors were tremendously grateful. Some remained stuck and afflicted by the past, whereas others described a richer, fuller life. Those passengers shackled by history are on the edge all the time, afraid of train travel, and suffer from nightmares. Several years later they described their condition as exhausting. As time passed some of them began to overcome the haunting of unforgettable memories. They came to terms with their experiences and moved forward with life. Memories could still be triggered, but different
strategies to deal with them were mentioned: interacting with family and friends, psychotherapy, and refusing to become a victim. All expressed gratitude and happiness for receiving a second chance at life, and they described the importance of family, friends, and small things in life. Last, some were glad for opportunities to meet many nice people they otherwise would never have met.

Survivors also described their interactions with journalists, experiences of the media coverage, and personal exposure in various ways (V). They were categorized into three groups; those who had negative, neutral, or positive experiences. The negative experiences when interacting with journalists could be perceived as harmful, and they felt violated as they were helpless and vulnerable in front of the journalists. They could not judge the significance of being exposed and felt unprepared for cameras. The confrontation violated their dignity. Passengers also described the interaction with photographers and reporters as demanding, burdensome, and others were provoked by the presence of the journalists, as they were not helpful. They were seen as passive witnesses, nonchalant, rude, and disrespectful. The crash experience was considered private. The passengers who had a more neutral approach to the interaction with journalists described it as negligible; some were unaware of the media presence as they were injured, lying down, or busy helping others. Others noticed the journalists but did not care; they expected the media presence and considered it normal in this situation. They were uninterested in the media coverage and cared little when, for example, they were misquoted in newspaper. The survivors who saw the interaction with journalists as helpful could describe feeling acknowledged. The journalists became necessary listeners to stories in the midst of the chaos. They also felt supported, as the journalists were experienced as genuinely wanting to help. They read, listened to, and watched all the news they could find. They saw this as a way of interpreting the traumatic event. They were grateful for the media coverage and photos of themselves, and it helped them recover. It was seen as healing.
DISCUSSION

As is often the case within the transport sector, a multi-factorial strategy would have the best potential to reduce losses. The results from the phases studied (crash and post-crash), which in many respects are neglected within the railway sector, may contribute partly in the work to minimize the consequences caused by railway crashes. The logical sequence of injury mitigation strategies by Haddon (1970) (see Table 2) is a suitable framework for analyses and discussion of data from the presented studies.

The first and the second strategies are not realistic today as they would require the reduction or suspension of train travel, and decreasing train speeds. Society would not accept this as train travel provides other benefits, e.g., it is environmentally friendly and its enormous passenger capacity reduces vehicle congestion in big cities and other densely populated areas. Passenger kilometers and speeds are on the increase (International Union of Railways, 2011), and probably will continue to increase, especially with the expected global development of high speed rail systems in the coming years. In the next 15 years, the new high-speed network is projected to be four times the length of the existing network (International Union of Railways, 2010).

The safety measures and systems introduced, especially during the last three to four decades, have not reduced the number of railway disasters (I), as has been the case in aviation in which the death toll has been reduced to one fifth (Björnstig & Forsberg, 2010). Factors related to this lack of disaster reduction may also be more passenger-kilometers traveled, more passengers inside each train carriage, and increased speeds. Comparison of risks based on passenger-kilometers traveled in different continents and countries was difficult to calculate because only International Union of Railways (UIC) members are represented in the passenger-kilometers statistics. Therefore, the few data references on the number of kilometers traveled used in this thesis should be considered rough.

Low safety standards in many countries, such as those in Asia and Africa are probably factors resulting in high fatality rates per disaster, and higher ratio of deaths to injuries. In high-income countries, as in Europe, the ratio of deaths to injuries has a more favorable development.

In this thesis (I) only major crashes with ≥10 killed and/or ≥100 non-fatally injured were included. Thus, these crashes only represent the “tip of the iceberg,” as noted by Kumar et al. (2012). For this reason, the present study does not aspire to give a complete picture of all railway crashes in the world.
The third strategy; “to prevent the release of energy,” is mainly focused on fail-safe systems. For example, ATC systems have been developed and refined during the last decades for the railway industry (Evans & Verlander, 1996; Khoudour et al., 2009). This may have contributed to limiting the adverse effect of higher speeds and increased traffic, especially in high-income countries (I).

The fourth strategy; “modifying the release of energy arising in a crash,” has been addressed in, for example, better crashworthiness in trains, where the risk of telescoping, overriding, and jack knifing (Shaw, 1978; Semmens, 1994; Kichenside, 1997) has been mostly reduced (I). However, these mechanisms may not be sufficiently reduced as, for example; the disastrous 2012 train crash in Buenos Aires may indicate (Sjöholm, 2012). A commuter train hit a stop block at a speed of less than 30 km/h – killing about 50 passengers and injuring 700 – the second carriage seems to have telescoped into the first. In the Nosaby crash (III), the travelers in the first carriage had the most extreme crash kinematics, and suffered the most severe and lethal injuries; a phenomenon also seen in other train crashes (Weyman, et al., 2005; Nagata et al., 2006; Shackelford et al., 2011). Change in the design of the train's exterior continues through simulated and experimental crash tests to evaluate the efficiency of design changes (cf. Kirk et al., 1999; Tyrell & Perlman, 2003; Kirkpatrick et al., 2001). One method to make the carriages safer has been shown by Gao and Tian (2007) who tested crash zones on either end of all train carriages. These crash zones could redistribute the compressing force from the front of the train to designated compression zones in each carriage.

The fifth strategy, “separate in space or time,” is applicable to crashes as those in Nosaby (III) and Kimstad (II). Despite improvements of existing level crossings between road and rail traffic and further a reduction of them, they still are a relatively common cause for crashes (Evans, 2011). Level crossings are still a major challenge (Davey et al., 2008; Khoudour et al., 2009; Millegran et al., 2009; Yan et al., 2010), of which the Nosaby crash is a typical example (III). This crossing had level crossing gates, but despite these the crash occurred, indicating that human factors (cf. Baysari et al., 2008; Edkins & Pollock, 1997; Cahn & Ju, 2008) are the reasons for crashes when they, for example, override the automatic system. Naturally, level crossings should be minimized, or eliminated, when new tracks are built. This is especially important on high-speed tracks as research shows that it is difficult to eliminate these crashes despite solutions of different safety systems (Saccomanno et al., 2007; Khoudour et al., 2009; Yan et al., 2010) or through education programs geared toward, e.g., motorists (Savage, 2006; Davey et al., 2008). Furthermore, as in the Kimstad crash (II), it is remarkable that

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construction and maintenance work proceeds on railway tracks adjacent to those in use by high-speed trains.

The sixth and seventh strategies, “separation by barrier” and “modifying appropriate contact surfaces (softening),” would be wise to introduce more extensively in train carriages, as has been implemented in other modes of transportation such as road traffic and aviation. The present studies II and III indicate that passenger injuries are caused by loose objects like luggage and other passengers and by interior structures, e.g., seats, interior walls, and glass shards (cf. Fothergill et al., 1992; Cugnoni et al., 1994; Madsen, 1998; Ilkjær & Lind, 2001; Eckstein and Heightman, 2009). In the Mundelstrup, Denmark crash, passengers sustained trunk injuries more often if they were seated at a table. They also found that neck rests reduced the risk for neck sprains. They draw the conclusion that tables that detach would reduce trunk injuries (Ilkjær & Lind, 2001). On the other hand, the tables should be deformable and firmly attached to compartmentalize passengers so they are not thrown around in the carriages (Parent et al. 2004). Omino et al. (2008) further showed that seat design was important for injury outcome. The injuries may be reduced if seats, tables, and other objects were better attached and were outfitted with softening surfaces. Further, sealable luggage hatches would prevent luggage from becoming projectiles and/or reducing the risk of trapping passengers. Improved interior safety would probably have great potential to reduce morbidity and mortality in future crashes and merits further investigation.

The passengers in the first, overturned carriage in the Nosaby crash (III) suffered the most severe and lethal injuries when they were tossed around. Higher lethality and injury risk has also been observed in other cases in which carriages have overturned (Braden, 1974). Interestingly, passengers seated backward without a table, in carriage one, were significantly less injured than the others (III). In this crash, passengers tumbled and fell several meters from one side onto objects and passengers on the other side; experience survivors liken to being in a tumble-dryer (IV) (c.f. Fothergill et al., 1992). These risks could be mitigated by compartmentalization inside the carriage, with impact friendly surfaces catching the passengers, seat belts, and/or by traveling rear faced.

There were a number of whiplash injuries in both the Kimstad (II) and Nosaby crashes (III); some of them giving long-term consequences. In the Nosaby crash, the rate was significantly higher for those traveling rear faced, given they traveled in a carriage that did not overturn. The seatbacks visually gave an impression of taking care of the head, but the seat backs elasticity might need to be evaluated. Perhaps they have elasticity similar to some seat
backs in cars from the early 1990s, which were especially prone to cause whiplash injuries (cf. Krafft, 1998). Additionally, lacerative broken glass caused many injuries (II), and is a reason why anti-lacerative glass may be discussed as a less injurious alternative. Maybe the car industry’s handling of interior safety can give ideas for injury mitigation measures in trains.

The eighth strategy, “strengthen the human resistance” is not studied – but in the light of the political will that public transport systems should be for all, including children and elderly, the above strategies will be even more important.

The ninth and tenth strategies denote the reduction of consequences after a crash has occurred, i.e., in the post-crash phase. It can, for example, relate to the rescue and acute care. At the Kimstad crash (II), well planned and trained disaster response provided an efficient rescue operation, at first supported and organized by initiative train crew and passengers onboard, while waiting for the rescue personnel. Physicians in the most demolished carriage started immediate resuscitation on the most severely injured (who died two days later from head injuries). Command and control as well as cooperation between ambulance and rescue service followed the well trained disaster plan for the area (Swedish Accident Investigation Authority, 2012).

The Nosaby crash showed the negative effects of too slow handling and extrication of the injured (III); also demonstrated by others (Hambeck & Pueschel, 1981; Robinson, 1975), who found that a number of victims might have survived if they had been extricated more quickly. In the Nosaby crash (III), the rescuers did not understand the crash scenario; had they, lives may have been saved and injuries lessened. The rescue started in the first carriages that the rescue personnel came to, i.e., not the train’s first, overturned, most demolished carriage; where the probability of finding severely injured passengers was highest. Consequently, it took time before they reached the passenger who died from traumatic asphyxiation caused by compression of the chest, and the passenger choking on pellets, who was dragged from the pellet pile by a fellow passenger. It took over eight hours until the fire brigade could ensure that no passengers were wedged down under the carriages, fortunately no one was (Swedish Accident Investigation Authority, 2006). The reason was lack of training in this kind of scenario and the absence of suitable rescue equipment, also emphasized by several other authors (Nagata et al., 2006; Weyman et al., 2005). Exiting the overturned carriage was particularly complicated (III), also shown by Weyman et al. (2005). The debris pile of loosened internal structures, luggage, and glass made it further difficult to evacuate the injured, as did the height difference between the carriages and ground. Installation of evacuation equipment such as rescue
ladders (cf. aviation) and easily understood emergency evacuation route information may facilitate evacuation.

“Reading the crash” is a skill that obviously needs to be practiced by rescue personnel during training (cf. III). Train crashes need to be accounted for in disaster planning and training because railway crashes put rescuers in complicated situations, with many new challenges. Cryer et al. (2010) studied two train crashes and found that revisions of pre-plans made the rescue more efficient and thus improved the quality of care. Assa et al. (2009) also found that the use of evacuation with aircraft in areas of inaccessible terrain minimized the rescue time and reduced the fatality rate. It was further helpful for transporting rescue personnel to the crash site.

The rehabilitation of the affected is very important. Psychological consequences can be reduced if the society understands what the passengers have experienced and how the traumatic events have affected them, and then the caring can be adapted according to their needs. The experiences from surviving a train crash were described as living in a mode of existential threat, losing control, being in unimaginable chaos, and facing death (IV). The experience of being close to death was also revealed in a survey of PTSD after another train crash (Hagström, 1995). Survivors from the Asian Tsunami described similar experiences as from the train crash; fear of losing control and the struggle between life and death (Råholm et al., 2008). When trying to restore control, passengers from the present train crash study described helping others as an important focus for them (IV). Similar findings are described by others; from a train crash (Arozenius, 1977) and from the Asian Tsunami (Rehnsfeldt & Eriksson, 2004). Helping others could be a pathway to resilience (Bonnano, 2004). Assisting others or receiving some kind of help, reveals the centrality of others. This is also seen in other studies (Berg Johannesson et al., 2006; Bowels, 1991; Rehnsfeldt & Eriksson, 2004). To be seen and validated by another person is one step to recovery (Råholm et al., 2008). Another way to recover and regain meaning was to narrate their stories, as also described in other studies (Raphael, 1977; Roxberg et al., 2010). To have someone willing to listen, a family member, a fellow passenger, or a journalist (cf. V) confirms that social support is crucial to survivors’ recovery (Bonnano et al., 2007; Roxberg et al., 2010). The importance of others and the interdependence among people, emerged as very important and especially family, friends, and fellow passengers who played a very important role in recovery. This needs to be taken into account when medical personnel arrive at the scene of a traumatic event and afterwards as a complement to psychological support from, for example, a crises team. Not all passengers found psychological support to be important, and they could even feel insignificant compared to other survivors’ experiences. Even if
formalized support has proven crucial (Bowels, 1991; Lundin, 1991) the need for it has to be individually assessed.

Being able to reconstruct the turn of events by visiting the crash site and listening to, for example, the Swedish Accident Investigation Authority explaining and illustrating what happened was another avenue for recovery and piecing the puzzle together. The positive effect from increased understanding has also shown important from other traumatic events (Heir & Weisaeth, 2006; Michel et al., 2009; Roxberg et al., 2009).

Experiences of being close to death were perceived as receiving a second chance in life. However, it was experienced in different ways; some could go on with their lives quite easily while others had difficulties moving forward. This result might not be surprising as not suffering long-lasting consequences is also confirmed by others (Linley & Joseph, 2004, Norris et al., 2004, North et al., 2004). Being shackled by history and finding it difficult to go constructively on with life is also described in other train crash studies (Arozenius, 1974; Bowels 1991; Hagström 1995; Sing & Raphael 1981) and from other traumatic events (Berg Johannesson et al., 2006; Bonnano et al., 2006).

The phase of being close to death is a situation Jasper (1970) called an existential limit situation, which is the transition from one phase to another. In study IV the interaction with others was helpful to understand what had happened and find new meaning in life, i.e., helped in the transition. This is also what Frankl (1963) claimed was a way to extract meaning out of suffering. The importance of facilitating a positive transition phase and minimizing health risks is something rescue personnel need to be aware of. Also, the importance of fellow passengers, family, friends and the positive effects of media (c.f. V) and that these aspects can constitute a part in the transition to recovery. It is also important to consider the psychological effects for those with less serious physical injuries, a group, which seems to be overlooked and thereby may receive insufficient help.

Another experience revealed by interviewing the survivors was their interactions with journalists at the scene and the following media coverage, including personal exposure (V). A broad spectrum of experiences was described, from very negative to very positive and the experiences could change over time. A surprising result was those who cared little about the media presence and media coverage; they found it expected and normal. Earlier studies have found both positive and negative experiences of interacting with journalists (Kay et al., 2010), but no one has mentioned those with a neutral attitude towards journalists. There were also passengers who described the collaboration with journalists as harmful and that the already
overwhelming stress was increased. Descriptions of journalists behaving unprofessionally and insensitively confronting survivors and relatives are also described by others (Doohan & Saveman, personal communication; Hodkinson & Stewart 1998). Media presence at a trauma event can add to the burden of grief among survivors (Jemphrey & Berrington, 2000; Swedish Government Official Reports, 1999). Media coverage and personal exposure was experienced as uncomfortable, re-traumatizing, and evoking irritation (c.f. Råholm et al., 2008). Despite that critical voices are often heard, there were also many positive examples described. At the site they had someone to talk to, who listened, and who was helpful. The journalists’ significance could also increase during the recovery process; some who were negative at the beginning could later see the media coverage as a helpful part of recovery and putting the pieces together.

Journalistic presence and media coverage is a natural part of a traumatic event but it is important that reporters and photographers keep a respectful distance, which is described as important for a person who endures a stressful experience (Morse, 2001), like a train crash. The media ethics and individual journalists’ way of interpreting the situation at the scene can be more or less problem solving, compassionate, personal, or professional (Englund, 2008), which of course influences the survivors’ experience. Nonetheless, by increasing the informative and descriptive media coverage more affected probably would experience positive effects of the media since this seems to help in the recovery process. This would perhaps also in the end result in a more positive attitude to interacting with journalists on the injury site. It develops to a win-win situation.

The rescue personnel, such as the ambulance crew may be the only ones who can speak for the injured and in some cases be gatekeepers between media and the injured persons (Englund et al., 2012). This may be as important as taking care of the physical injuries, the role of, for example, nurses is to provide total comfort, hence also handle psychological needs.

Final remarks
Based on the findings in this thesis, important preventive work within the crash and the post-crash phases seems to be neglected. This is alarming because the physical and physiological consequences on the passengers are far-reaching. Hence, several measures need to be undertaken to improve safety in the crash phase and further enhance the post-crash phase care.

I have, nevertheless, understood during these years that the process of implementing injury preventive interventions in this fragmentized sector is complicated; thus, one more strategy needs to be added to Haddon’s ten
strategies. The **eleventh** strategy needs to embrace implementation, which brings us back to the Haddon matrix and the need for one more dimension.

**One more dimension**

Returning to Haddon’s matrix, his research has been informative for this thesis in the regard that it has contributed to identifying weaknesses and helping to find alternative interventions. Nevertheless, this matrix has been developed further by researchers such as Runyan (1998) and Fowler (2009), adding one more dimension, which highlights and guides the decision making process in choosing and implementing injury preventive interventions. Fowler’s Revised Intervention Decision Matrix includes eight elements as criteria for selecting an intervention. 1) Effectiveness 2) Feasibility 3) Cost feasibility 4) Sustainability 5) Political will 6) Social will 7) Potential for unintended risks 8) Potential for unintended benefits. These all come into question after establishing that the intervention is ethically acceptable, which is a prerequisite. These additions to Haddon’s model are very constructive after identifying the problem to ease reflection on pros and cons of various intervention options.

Several of these criteria are relevant for discussion on how to improve railway safety. One example could be safe luggage storage, either through building hatches in new trains (like in airplanes) or adding nets over open shelves on older trains. This could have large benefits in terms of injury reduction on trains (even when they do not crash) and most of the above mentioned criteria would be met.

This issue is one of the most important ones, no matter what intervention is suggested, it is severely impeded by the fragmentation of the railway sector. I claim that this fragmentation is further exacerbated by the ongoing deregulation and privatization of the sector. A big-picture perspective is essential for a safe integrated railway system. Otherwise, unintended small errors may interact and the integration of the system could mean larger errors later on (c.f. Perrow 2006); something that may be more likely caused by the multitude of actors involved. Moreover, because of the obscurity between actors they are probably inclined to deny responsibility for errors or avoid taking the initiative to implement interventions. We have to adapt and find new strategies to how the sector is structured today to meet the safety needs; otherwise interventions in injury prevention will consequently continue to be compromised.

In Sweden, it will, therefore, be my future mission to transfer the results from this thesis through a systematic dissemination process, by use of e.g., translational science (Mitchell et al., 2010) to those involved in the railway
sector, and supplementary, establish lines of communication between them. Santos-Reyes and Beard (2006) highlighted from the Ladbrock Grove crash problems with communication channels in the fragmentized train sector. By involving all the actors in the railway sector, through regular meetings where system weaknesses and alternative interventions are discussed, the Swedish railway can be made safer.

PRACTICAL IMPLICATIONS

- Train crashes are inevitable; thus, the train sector needs to consider internal safety standards, as in aviation and automobile sectors. For example, interior should be designed with soft surfaces, windows ought to be in an anti-lacerative material and sealable luggage racks are essential. Further, passengers must remain in their seats in the crash.
- Train crashes can occur wherever train tracks exist, including areas with few and limited resources. Further, crashes can occur in inaccessible areas or in extreme cold areas. All communities that could become involved in a train crash should, therefore, pre-plan and practice on a regular basis to overcome the special rescue and evacuation complications.
- To be together with “others,” such as family, friends, other passengers, or be informed of investigation results helps the recovery process and should be promoted and facilitated.
- Media staff should not be excluded from incident sites as they prove to be an important part of many survivors’ processing and recovery, if the media cover informative and descriptive facts. Yet, it is important to limit and delimit areas for the media to enter– and when.

FUTURE RESEARCH

It is desirable to examine the number of disasters in different continents and countries in relation to the number of passenger kilometers traveled to gain a more accurate understanding of the problem. Further, it would be of great value to explore not only the disasters, but also the train crashes (not classified as disasters) that cause considerable consequences for passengers. The train disasters (≥10 fatal and/or ≥100 non-fatal injured) only represent the “tip of the iceberg” rather than a complete picture.

To our knowledge, multivariate data analysis has not been used previously when seeking injury-inducing variables in a train crash. Thus, more studies of a similar nature are required to confirm the conclusions of this study.
More technical and innovative research is recommended concerning injury reducing design solutions in train carriages. Soft surfaces, reversible chairs, and the use of safety belts are some examples requiring further investigation. Additionally, anti-lacerative windows ought to be considered. Deformation zones are placed at the end of the carriages where passengers stand; a solution to this also needs to be reviewed.

A larger study population would make it possible to investigate and discover how other factors such as, severity of injury, age, gender, or the degree of social support influence passengers’ experiences of a crash and the media coverage as these variables have not been considered in the present study.

Despite extensive crash avoidance, railway crashes and disasters occur all over the world and more passengers survive train crashes today than in previous years. These types of complex incidents are, moreover, difficult and time consuming to handle indicating that innovative solutions would facilitate and accelerate the evacuation phase.

The list could be long for possible and important research areas (see Table 3 in the rationale section). Of special interest, in addition to the aforementioned, is to study the socioeconomic environment, as some shortcomings concerning company policies and safety rules exist within the train sector. Furthermore, no seatbelt law for train travel exists. No formal demands on, e.g., how train interiors should be constructed (except for fire), exist and there is a lack of luggage stowage requirements. Why does it look this way, and what is it that distinguishes the rail sector from the aviation and automotive industries in terms of safety? This should be explored further.

**CONCLUSIONS**

Despite extensive crash avoidance systems train crashes are not a problem of the past; rather, they continue to be highly relevant today, in Sweden as well as abroad. The trunk and head/neck was most frequently injured body part. Interior structures, such as tables, seats, internal walls, and glass affected the injury panorama in the studied crashes, as did luggage and unbelted passengers. These factors also hampered evacuation because they were piled up in the carriages. Being surrounded by family, friends, fellow passengers, descriptive and informative media, and participating in crash investigations were some crucial factors when dealing with the life altering traumatic event.
ACKNOWLEDGEMENTS

There are many I would like to thank and who have meant a lot to me along the way. Nevertheless, there are those whom I owe especially much; my gratitude is, however, best expressed in my native tongue:

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“My interest is in the future because I am going to spend the rest of my life there”
Charles Franklin Kettering
One Hundred Years of Railway Disasters and Recent Trends

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Keywords: Accident, Collision; Crash; Derailment; Disaster; Incident; Injured; Killed; Mass casualties; Passenger; Rail; Railway; Railroad; Safety; Train.

Abbreviations:
CRED = Centre for the Research on the Epidemiology of Disasters
EM-DAT = Emergency Events Database

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Abstract

Introduction: Globally, railway transport is increasing steadily. Despite the adoption of diverse safety systems, major railway incidents continue to occur. Higher speeds and increased passenger traffic are factors that influence the risk of mass-casualty incidents and make railway crashes a reality that merits extensive planning and training.

Methods: Data on railway disasters were obtained from the Centre for Research on the Epidemiology of Disasters (CRED), which maintains the Emergency Events Database (EM-DAT). This descriptive study consists of 529 railway disasters (≥10 killed and/or ≥100 non-fatally injured) from 1910 through 2009.

Results: The number of railway disasters, people killed, and non-fatally injured, has increased throughout the last hundred years—particularly during the last four decades (1970–2009), when 88% of all disasters occurred. In the mid-20th century, a shift occurred, resulting in more people being non-fatally injured than fatally injured. During 1970–2009, 74% of all railway disasters occurred in Asia, Africa, and South and Central America, combined. The remaining 26% occurred in Europe, North America, and Oceania, combined. Since 1980, railway disasters have increased, especially in Asia and Africa, while Europe has had a decrease in railway disasters. The number killed per disaster (1970–2009) was highest in Africa (n = 55), followed by South and Central America (n = 47), and Asia (n = 44). The rate was lowest in North America (n = 10) and Europe (n = 29). On average, the number of non-fatally injured per disaster was two to three times the number of fatalities, however, in the African countries (except South Africa) the relation was closer to 1:1, which correlates to the relation found in more developed countries during the mid-20th century. The total losses (non-fatally and fatally injured) per disaster has shown a slight decreasing trend.

Conclusions: Despite extensive crash avoidance and injury reduction safety systems, railway crashes occur on all continents, indicating that this type of incident must be accounted for in disaster planning and training. Better developed safety, crashworthiness, and rescue resources in North America and Europe may be factors explaining why the number of crashes and losses has stabilized and why the average number of people killed per disaster is lowest on these continents.


Introduction

During the second half of the 19th century, railway passenger traffic began, and there were few major injury incidents because of limited traffic and low speeds. The railroad system underwent further technical and safety development during the 20th century, especially during the second half of the century. Over the last decades, train speeds have increased in many countries, and new high-speed lines (>250 km/h; 155 mph) are inaugurated frequently throughout the world. Currently, several trains operate at 300 km/h (186 mph). The Maglev (magnetic levitation) Transrapid train in Shanghai operates in regular traffic at speeds up to 430 km/h (267mph). Because of today's high speeds, severe damage and injuries are to be expected in a crash. Further complications can arise because crashes may happen in remote areas without access to roads and with limited rescue resources. Unprepared/untrained personnel may experience difficulties while managing these events. Some studies have shown that such shortcomings have caused a number of “avoidable deaths.” Rail passenger traffic will continue to increase along with higher speeds and more passengers. The
EM-DAT Data Inclusion Methodology
The EM-DAT database is compiled from various sources, including United Nations (UN) agencies, non-governmental organizations, insurance companies, research institutes, and press agencies. The CRED has established a method of ranking these sources according to their ability to provide trustworthy and complete data. The disaster occurrence, in terms of fatalities, injuries, or affected only is entered into the EM-DAT if at least two sources report exact values. Priority is given to data from UN agencies, followed by the Office of Foreign Disaster Assistance, governments, the International Federation of Red Cross and Red Crescent Societies. This prioritization is not only a reflection of the quality or value of the data, but also reflects the fact that most reporting sources do not cover all disasters, or may have political limitations that may affect the figures. The record is validated before final figures and relevant information is available to the public three months later. Annual revisions are also made one, two, and sometimes three years after the event.23

Results
100 Years
Railway disasters were relatively infrequent (23/529; 4%) during 1910–1949. During the following two decades (1950–1969), the rate began to increase, 39 of the 529 (7%) disasters occurred during these two decades (Figure 1). Since the 1970s, the number of railway disasters ($n = 467; 88\%$), as well as the number of fatally and non-fatally injured, has increased. The highest rates are found during the last three decades (1980–2009). The average

complex nature of responding to such events makes pre-event planning and training essential. As a basis for planning and training in different continents and countries, this study aims to shed light on the magnitude and development of passenger rail crashes over the years in various continents and countries.

Methods
A 100-year dataset, from 1910–2009 was made available from the Centre for Research on the Epidemiology of Disasters (CRED), which maintains the Emergency Events Database (EM-DAT), a worldwide database on disasters. Disasters included in this study were selected on two of CRED's criteria defining a disaster:22

10 or more people reported killed and/or; ≥100) or more people reported affected.

Events caused by intentional acts were excluded from the database. Within the criterion “affected”, a further sample specification was made to include only events resulting in ≥100 non-fatally injured victims. A total of 529 railway crashes were included. Of these 529 incidents, six were subway disasters and one was a Maglev disaster. Supplementary data also have been collected via different scientific and Internet sources using suitable keywords. Additionally, transport literature and media, including films and documentaries, were analyzed.

The EM-DAT categorizes the world into five continents (Europe, Asia, Africa, Americas, and Oceania). Because of socio-demographic reasons, the American continents were divided into “North” (USA and Canada) and “South and Central America”, respectively.
The number of passengers killed per railway disaster was 135 during 1910–1949; 84 during 1950–1969; and 41 between 1970–2009. The number of non-fatally injured people per disaster during the different time periods has been 48, 89, and 92, respectively. During 1910–1949, the number of non-fatally injured was only 0.4 times the number of deaths, but during the 1950s and 1960s, the number of non-fatally injured was about the same (1.1) as the number of deaths. From the 1970s, the number of non-fatally injured has averaged 2.2 times the number of deaths (Figure 1). The variation in total number of fatally and non-fatally injured per disaster has shown a slight decreasing trend; 184, 173, and 133, respectively for the three time periods.

Distribution by Continents and Countries 1970–2009
Disasters in Different Continents—Of 467 railway disasters during the last four decades (1970–2009), the highest reported number (n = 233; 50%) occurred in Asia, followed by Europe (n = 95; 20%), Africa (n = 79; 17%), South and Central America (n = 33; 7%), North America (n = 23; 5%), and Oceania (n = 4; 1%). In the 1970s, Europe reported the highest frequency, but since the 1980s, Asia has had the highest number per decade. During the 1990s, Africa has surpassed Europe and ranked in the last two decades (Figure 2).

The highest number of fatalities from 1970–2009 (10,298 of 19,348; 53%) occurred in Asia, followed by Africa (4,361; 23%), Europe (2,784; 14%), South and Central America (1,562; 8%), North America (237; 1%), and Oceania (106; 1%). In terms of fatally and non-fatally injured (losses), Asia, Africa, and Europe reported the highest losses, but the development in different continents were different during the period 1970–2009. Asia, Africa, and North America had an increase in losses (except for the last decade in which the upward trend declined slightly), and South and Central America reported a decrease in losses. Europe and Oceania showed only minor changes (Table 1). In terms of number of people killed, Africa experienced an increase of 198% (1,095 vs. 3,266) between the first and second half of the period, 1970–2009, Asia had an increase of 107% (3,359 vs. 6,939), and North America 32% (102 vs. 135). On the contrary, South and Central America had a decrease of 56% (1,086 vs. 476) and Europe had a 37% reduction in the number of killed (1,705 vs. 1,079). The average fatality rate per event was highest in Africa (55), followed by South and Central America (47) and Asia (44), while it was only 29 in Europe, 27 in Oceania, and 10 in North America.

In terms of non-fatally injured, the increase for the years 1970–1989, compared with 1990–2009, was 321% (621 vs. 2,615) in North America, 154% (1,863 vs. 4,740) in Africa and 154% (6,198 vs. 15,714) in Asia. A decrease of 76% (3,325 vs. 798) was reported from South and Central America and 16% (3,696 vs. 3,110) from Europe.
Disasters in Different Countries—On the Asian continent, India reported the most railway disasters (104 of 233; 45%) followed by Pakistan (24; 10%). On the African continent, most disasters were reported from South Africa (12 of 79; 15%) and Egypt (12; 15%). In Europe, Russia reported most railway disasters (17 of 95; 18%) followed by the United Kingdom (13; 14%). In South and Central America, Mexico reported more than half of all disasters (17 of 33; 52%) followed by Cuba (7; 21%). In North America, 21 (91%) of the 23 disasters happened in the US (Table 2).

Within the Asian continent, India had the highest number of people killed (4,402 of 10,298; 43%). In Africa, it was Egypt (779; 18%), in Europe, it was Russia (591; 21%), in South and Central America, it was Mexico (837; 54%) and for North America, it was the US (205; 86%). The fatality rate per disaster, nonetheless, differs within the continents. South Africa had the highest number of reported railway disasters (n = 12) tied with Egypt (n = 12) in Africa, but South Africa had a notably lower rate of average number of people killed per disaster (n = 17) compared to Angola (n = 300) and Ethiopia (n = 131). Azerbaijan (n = 337), and North Korea (n = 121) had the highest number killed per disaster within the Asian continent. Japan had 33 killed per disaster, close to the average for Asia. In Europe, it was Austria (n = 80) and Portugal (n = 70). Within the South and Central American continent, Brazil (n = 74) and Chile (n = 62) had the highest average killed. In North America, Canada and the US had 16 and 10, respectively (Table 1).

Discussion
The safety measures and systems introduced, especially during the last 3–4 decades, have not reduced the number of railway disasters, even though Fothergill et al9 have noted the crash-reducing effects of better signaling and other safety systems. In countries with rail traffic, it seems wise to plan and train for the needed complex responses and to prepare efficient cooperation with all other involved agencies; implementing what Oestern et al12 recommended after the 1998 high-speed train crash in Eschede.

Railway disasters were relatively rare before 1970, as only 12% of the disasters occurred during the first six decades of the study period. This was probably due to lower speeds and less passenger-kilometers traveled. Those passengers involved, however, more often suffered fatal injuries, as the rail carriages were made of wood. In a crash, the wooden carriages disintegrated in a manner called “telescoping” (Figure 3). Additionally, the crashes were more commonly complicated by fire24,25 and rescue techniques and resources may have been limited. The number of
Table 2—Number of railway disasters “top five” in different continents and countries during the last decade (1970–2009)

<table>
<thead>
<tr>
<th>Continent</th>
<th>No. of Disasters</th>
<th>No. of Killed</th>
<th>No. of Killed per disaster</th>
<th>No. of Non-fatally injured</th>
<th>No. of Non-fatally injured per disaster</th>
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<td>233</td>
<td>10298</td>
<td>44</td>
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Prehospital and Disaster Medicine
Because the last two crash phenomena currently are the most common worldwide, they would be the basis for developing a suitable tactical approach to overcome the special rescue and evacuation complications. The lack of heavy rescue equipment also has been as a significant problem, as emphasized by several authors. Further, Nagata et al emphasized the need for training in confined-space-medicine, since this was a lifesaving tactic used for trapped victims in the 2005 crash in Amagasaki, Japan. Moreover, Hambeck et al and Robinson demonstrated the need for rapid extrication of the injured. They found that a number of victims might have survived if they had been extricated more quickly. Additionally, interior design and baggage stowage have been reported to interfere with injury panorama and rescue procedures.

Examining the last four decades (1970–2009) more closely, the number of railway disasters, as well as the number of fatalities and non-fatal injuries, has increased despite all safety measures implemented. (cf. air traffic—the number of fatalities has decreased to 1/5 during the same time period). Factors related to this increase may be more passenger-kilometers traveled, more passengers inside each train carriage, and higher speeds. Improvements in crash safety probably contributed to the relation between fatal and non-fatal injuries shifting after 1970 to 1:2. Even when the number of fatalities per disaster consistently decreased, the number of non-fatal injuries per disaster has not decreased.

Older trains were engine-powered and oversized; they did not have passengers in the first carriage (engine). In contrast, modern interchanged multiple-unit trains carry passengers in the first carriage, exposing them to greater risks. Moreover, they are built of stainless steel or aluminum, making them less robust. On the other hand, these newer trains include deformation zones providing an added element of safety that did not exist on older trains.

It was noted that Asia (2010 billion passenger-kilometers), especially India (838 billion passenger-kilometers), reported the most rail passenger-kilometers traveled in 2009 as well as prior years. This partially may explain why most railway disasters, nowadays, happen in this region. Compared with other regions, the lower safety standards and train crashworthiness of several countries in Asia, Africa, and Central and South America are important factors resulting in high rates of fatalities per disaster to which overcrowded trains carrying passengers on the roofs and hanging out through windows contribute. Passengers riding in these manners may be predisposed to major injuries. Window bars and locked doors, as used in some regions, can be factors aggravating an incident especially when there is fire involved. The bars and locks not only make it difficult to exit the carriages, but may also hamper rescue operations.

**Limitations**

Information systems have improved immensely over the last decades and data are now more easily assessable and reliable. Because only severe railway incidents (≥10 killed and/or ≥100 people non-fatally injured) are included in this study, the number of missed disasters is probably low.

Train disasters caused by intentional antagonistic acts such as terrorist attacks and warfare are not included in this database. Even so, in a few cases of the selection procedure, it might have
been difficult to ascertain whether the disaster was intentionally caused or not.

Changes in national boundaries can cause ambiguities; most notably, the break-up of the former Soviet Union and the former Republic of Yugoslavia, and the reunification of Germany. Therefore, up-to-date boundaries have been used.

Comparison of passenger-kilometers traveled in different continents and regions is made with the knowledge that only International Union of Railways (UIC) members are represented in the statistics. Therefore, the number of kilometers traveled should be considered as approximate.

Conclusions

The trends identified indicate that the crash avoidance and safety measures worldwide have not been able to reduce the number of railway disasters, making this a reality requiring planning and training in many countries. High-speed rail constructions will place new demands on the tactics, techniques, and equipment used by rescue personnel. These elements are the basis for good disaster preparedness. Measures to facilitate rescue and escape routes, especially in overturned carriages, would be valuable. Furthermore, safer interior design and safer baggage stowage would have a potential to reduce injuries and to facilitate rescue and evacuation.

Acknowledgements

The authors thank CRED for providing the data, the Swedish National Board of Health and Welfare, the European Regional Development Fund (ERDF), and the Swedish Civil Contingencies Agency (MSB) Sweden for financial support and valuable information about railway safety issues. We also express our appreciation to the language revisers, Loren Gill and Michael Haney for reviewing the manuscript.

References

Inre säkerheten i tåg eftersatt

Fallstudie efter tågkraschen i Kimstad

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REBECCA FORSBERG, doktandar, leg sjukvårdskerska, båda vid Kunskapscentrum för katastrofmedicin, enheten för kirurgi, Umeå universitet, Umeå BRITT-INGER SAVEMAN, professor, leg sjukvårdskerska, institutionen för omvårdnad, Umeå universitet; Kunskapscentrum för katastrofmedicin, enheten för kirurgi, Umeå universitet


Inte heller säkerhetsystemen fungerar tillfredsställande, vilket tydligt visades när ett 16 vagnar långt godståg skadades gång till utfällbara stegar.


Resultat

Ungefär hälften (n=10) av de skadade satt i vagn 2. Dessa passagerare är dominerande skadade med omväxlande bakdel och grävskopa (Figur 1). Enligt SJ:s passagerarlistor fanns 244 resenärer och fyra anställda ombord [10]. Av dessa skadades 21 personer, en avled. Denna retrospektiva fallstudie belyser skador och skademekanismer vid Kimstadskraschen med utgångspunkt i frågeställningarna «Hur säger skadeplanoramath ut?», «Var ligger skademekanismerna?».

Metod

Medicinska journaler, ambulansjournaler och information från SJ har analyserats och intervjuer har gjorts med de skada-
skador, såsom hjärnskakning, axelluxation, stukad nacke, sår-
skadorn samt ytliga kontusionsskador. Endast fyra personer
från vagnarna 4–6 sökte sjukvård, och då för lindriga skador. I
vagn 1 fanns inga passagerare. Hos ungefär hälften av passage-
rarna var skadorna lokaliserade till huvud–halsregionen. En
sammanställning av skadebilden finns i Tabell I. Det var fram-
för allt passagerare som satt på tågets vänstra sida, där grävma-
skinens frontskopa slog i, som skadades.

**Skademekanismer**

De flesta skadorna orsakades av abnorm energiöverföring ge-
nom inträngning, flygande föremål eller alltför abrupt decele-
ration [13]: inträngning av grävskopan, islag eller klämning
(mot exempelvis stolar, väggar och hyllor) samt projektiler
(till exempel bagage, glas och löshäxor).

**Interiör.** Inverkan av interiören uppvisas av de flesta av inter-
vjupersonerna (n=14). Ett begränsat antal allvarligare skador
på grund av islag eller klämning uppstod på detta sätt. Lösryck-
ta stolar, bord, lampor, lister och skåps vallade bäckskar, re-
vbensfrakturer och hjärnskakningar. De två svåraste skadefal-
len (AIS 4+) hade orsakats av interiören. Passageraren som av
led hade förutom en kritisk skallskada andra allvarliga skador
(AIS 3), som troligen orsakats av ett stolspar lossnat och
tryckts bakåt mot henne (Figur 2). Passageraren skadades sann-
nolikt också av inträngande våld från grävskopan.

**Tabell I** Skadebilden för de 21 passagerarna (47 skador) från
tågkraschen i Kimstad.

<table>
<thead>
<tr>
<th>Skada</th>
<th>Huvud</th>
<th>Nacke/ hals</th>
<th>Övre extremitet</th>
<th>Nedre extremitet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sår och ytliga kontusioner</td>
<td>10 a</td>
<td>2</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Stukning</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hjärnskakning/ dödlig skallskada</td>
<td>4/1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fraktur/ luxation</td>
<td>1 b</td>
<td>2</td>
<td>2/1</td>
<td></td>
</tr>
<tr>
<td>Övriga</td>
<td>2 c</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totalt</td>
<td>16 b</td>
<td>7</td>
<td>14</td>
<td>7</td>
</tr>
</tbody>
</table>

a Tre med glassplitter i ögon, öron, näsa och/eller mun.
b Tandskada.
c Lungkontusion och gravid kvinna som fick värkar.

**Bagage.** Bagage som flög omkring orsakade skador vars allvar-
lighetsgrad var begränsad (AIS 1–2), däremot var intervjuper-
sonernas egna upplevelser ogvissnemål och vätnemål (n=11) mycket star-
ka. Skadorna var lokaliserade till huvud, nacke, axlar och rygg;
blond annat hjärnskakning, stukad nacke och ytliga kontu-
sionsskador. Bagageförvaringen var det som bekymrade passa-
gerarna mest. Många (n=8) av de intervjuede nämnde behov av
säkerhetsförbättringar vad gäller hantering av bagage. Flerta-
let hade samma förslag: att det borde vara som på flygplan, med
luckor som kan stängas så att bagaget inte kan rama ner. Ned-
fallet bagage i gångarna utgjorde också ett hinder vid evaku-
ringen (Figur 3).

**Glas.** Den skademekanism som flest intervjupersoner (n=13)
gav som en viktig skaderisk var glas. Glas stod för flest veri-
fierade skador (n=7), samtliga lindriga (AIS 1). Skadorna var
främst lokaliserade till bar hud och till kroppssdelar som befann
sig i samma höjd som fönsterrutan, det vill säga skärsär på ar-
mar, huvud och i ansvetet. Det fanns även exempel på att glasbi-
tar trängt igenom kläder. Framför allt uppgav flera att det var
obbefogaligt att få glassplitter i ögon, öron, näsa och mun.

**Evakuering.** Cirka hälften (n=9) av intervjupersonerna tyck-
te att det var svårt att ta sig ut från tåget på grund av avståndet
ner till banvallen. Det fanns ingen möjlighet att enkelt kliva ut
eller klättra ner. Passagerare som kunde lämna tåget till fot
var tvungna att antingen hoppa ner på banvallen eller bli ner-
yfta. Detta uppfattades som svårt för de allra flesta, för att inte
såga omöjligt för barn, äldre, rörelsehindrade och skadade. Flera
intervjupersoner ansåg att nödstegar bör ha funnits till-
gängliga på tåget, så att de själva och andra passagerare själv-
ständig och enkelt hade kunnat ta sig ut.

**Diskussion**

Att reducera antalet skador går i detta sammanhang ut på att
dels förebygga att energi och krafter överstiger den mänskli-
ga skadetröskeln, dels minimera konsekvenserna av en ska-
da genom effektiv räddning och vård. Detta knyter an till de
10 skadepreventiva strategier som William Haddon Jr lan-
serade år 1980 [13]. Det har gjorts viktiga framsteg när det
gäller konstruktion av tågens exteriör och koppel för att
minska konsekvenserna vid en krasch. För den inre säkerhe-
ten har motsvarande framsteg utarbetats [14, 15], trots att in-
teriören visat sig vara avgörande för skadeutfallet (vilket ex-

---

Figur 2. I vagn 2 slogs fönster in, och ett stolspar lossnade. Här satt
passageraren som avled, fastklämd under framförande stolspar.

Figur 3. I vagn 3 ses mittgången belagrad med bagage som fallit
ner från bagagehyllorna, vilket försvårade evakueringen.

---

**Tabell I** Skadebilden för de 21 passagerarna (47 skador) från
tågkraschen i Kimstad.
**Inre säkerhet.** Vid kraschen i Kimstad orsakade isläggning i interiören de allvarligaste skadorna. Skadorna skulle kunna minimeras om interiören utformas så att den ger en mjukare uppmobning. Detta tänkande är naturligt inom bilindustrin. Bord skulle kunna delvis kollapsa och fånga upp en person. En sådan prototyp har utvecklats i USA och testats genom simulering och krocktest [16]. Mjuka, flexible islägsytor som fungerar som en lämpande kudde är ett annat exempel, liksom en konstruktion där stolsryggen fungerar som en mjuk, absorberande krockzon som kan fånga upp bakomstående passagerare. Detta kräver en intilliggande, fast, enregelbundet, islagande barriär i vagmonster i motsvarande antilacerativt genomskinligt material, kan fungera som en avgränsande och uppbromsande barriär i vagan. Genom simulering och krocktest [16], vilket kan vara svårt att realisera för alla passagerare.

I Kimstad kom våldet huvudsakligen från sidan. Ett större fronttal väld skulle ha inneburit en mer abrupt energiöverföring och hade kunnat slita loss mer av inredningen. Vid ett stopp i de hastigheter dagens tåg kan hålla det i värsta fall bli som i Eschede, där en vagin tömdes helt på sitt innehåll: stolar, bord och passagerare [4].


I Kimstad fungerade det prehospitala omhändertagandet väl tack vare att kraschen inträffade i närheten av en väg. Vid en sådan situation kan en förhållandet underförstått för att kraschen inträffade i närheten av en väg, så att det är svårt att realisera för alla passagerare.

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26
A study of a mass casualty train crash focused on the cause of injuries using multivariate data analysis

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Abstract: This case study examines a level-crossing train crash that occurred in Nosaby, Sweden in 2004. The injury panorama and injury objects were analyzed with an emphasis on interior safety and injury prevention. The population sample included all 73 fatally and non-fataly injured people from the train crash. Descriptive statistic information on the injury panorama and severity was complemented by multivariate data analysis. The first carriage overturned and its occupants suffered the most severe and lethal injuries. Injury type and injury location differed significantly between carriage one and the other two carriages. Tables significantly influenced injury type and injury location of injury in all carriages, whereas the injured person’s seating position had significant effect only in the second and third carriage. Those who traveled facing forward with a table in front of them in carriages two and three were more likely to sustain injuries to their abdomen/pelvis than those without a table. Neck sprains were significantly more prominent for those who traveled facing backward. Other injury inducing objects were seats, interior structures, wood pellets, other passengers, and luggage. Improved train crashworthiness needs to account for interior safety to reduce crash injuries.

Keywords: accident, injuries, injury object, PCA, PLS-DA, railway

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1. Introduction

Globally (International Union of Railways, 2012), as well as in Sweden (Swedish Transport Administration, 2011a), passenger railway transport is steadily increasing. Furthermore, despite implementation of various safety systems around the world, train disasters (≥10 killed and/or ≥100 non-fatally injured) have increased worldwide (Forsberg and Björnstig, 2011). Although crash avoidance systems (Lewis, 2002; Tang and Yip, 2010) and carriage crashworthiness have been improved (Gao and Tian, 2007; Tyrell and Perlman, 2003) crashes and mass casualty incidents still occur (Oestern, Huels, Quirini and Pohlemann, 2000; Nagata et al. 2006).

A common cause for injury events are level crossing crashes and in Europe the number of level crossing incidents has remained the same between the years 1980-2009 (Evans, 2011). Because miscalculations or infringements by road users and other shortcomings often are related to level crossing crashes they are difficult to overcome. As such, crashes are likely to continue occurring; it is more a matter of where and when. Consequently, it is necessary to prepare for crashes by investigating what inflicts passenger injuries in order to implement injury preventive improvements and prepare rescue personnel.

Previous studies of train crash injuries (Braden, 1974; Eriksson, Ericsson, Lundström, Thorson, 1984a; Cugnoni, Fincham and Skinner, 1994; Ilkjær and Lind, 2001) use traditional statistics and show that interior safety improvements are warranted. However, it is difficult to apply traditional statistics in complex situations where multiple variables are generated, as in train crashes. Using multivariate data analysis methods as Principal component analysis (PCA) (Wold, Esbensen and Geladi, 1987) and Partial least square discriminant analysis (PLS-DA) (Geladi and Kowalski, 1986; Sjöström, Wold and Söderström, 1986; Stähle and Wold, 1987; Wold, Sjöström and Eriksson, 2001) enable correlations to be determined between different variables such as carriage location, travel direction, and the injury. Thus, research explaining the correlation between injury inducing variables and injuries is justified to support decision makers and engineers when developing safer carriages.

This case study of the train crash in Nosaby, Sweden, 2004, aims to describe the injury object and injury panorama where multivariate data analysis methods are applied to determine injury inducing variables. This could be important when suggesting interior injury preventive measures.

2. Material and method

2.1. The study context

In Nosaby, Sweden on September 9, 2004 a truck, fully loaded with wood pellets, became stuck between the gates at a level crossing. An oncoming three-carriage passenger train smashed straight into the side of the truck at 121 km/h (75 mph) causing the train to derail. The impact disintegrated the front of the first carriage allowing wood pellets from the truck to pour in. The first carriage then hit a tree, disengaged from the others, rotated 180°, and overturned. The second and third carriages stopped after the second carriage partly derailed and plowed into the ground alongside of the track, but remained on the railway embankment (Figure 1) (Swedish Accident Investigation Board, 2006).
From the front of the first carriage where the driver’s cabin once was. Pieces of loose interior were removed by rescue personnel to facilitate passenger evacuation. In the background carriages two and three are still on the embankment, facing the traveling direction. Photo: The Swedish Transport Administration

2.2 Material
A retrospective case study of exploratory and explanatory nature was conducted on those (n=73) who were fatally and non-fatally injured in the crash; 57 women, and 16 men, with an average age of 38 (range 16-68 years). Police authorities and medical records supplied data for 69 injured persons and data for four additional injured passengers was located through printed press. Thirteen injured occupants also participated in supplementary interviews (Forsberg and Saveman, 2011).

Two different matrices were constructed focused on injury type and injury location for the multivariate analysis. For every type of injury, the injury with the highest AIS (International Injury Scaling Committee, 2005) ranking was chosen for each body part when there were multiple injuries. The first data set represents seven injury types (K=7) (concussion; superficial contusion; laceration; sprain; fracture; “other” specified injury; “other unspecified” injury). The second dataset, on injured body parts, also has seven categories (K=7) (head; neck; chest; abdomen/pelvis; upper extremity; lower extremity; “other”). Injury severity is presented according to the “Abbreviated Injury Scale” (AIS) where maximum AIS (MAIS) represents the individual’s most severe injury. AIS=1 is a minor injury (cuts, sprains), AIS=2 is a moderate injury (concussion, fracture), AIS=3 is a serious injury (fractures of the femur, spleen rupture), while AIS= 4-6 are severe, critical and maximum injuries.

2.3 Data analysis
Each matrices was analyzed with PCA and PLS-DA. In the analysis, the fatally injured and passengers whose carriage, direction of travel, or seating position was unknown were excluded. Falling outside a 95% hoteling $T^2$ area in a PCA score plot identified outliers and/or by extensively exceeding the critical distance of 95% in a distance to model plot (Wikström et al., 1998); but no outlier was found. Thus, the data on which carriage the passengers were seated in contained 68 cases (carriage one n=20; carriage two n=32, carriage three n=16) and 50 cases (18 cases in carriage one and 32 cases in carriages 2 and 3 combined) were included when focusing on the effect of travel direction and tables. In carriage one the passengers were seated as follows: table/facing forward n=3; table/facing backward n=3; no table/facing forward n=3; no table/facing backward n=9. In carriages two and three the passengers were seated: table/facing forward n=13; table/facing backward n=5; no table/facing forward n=10; no table/facing backward n=4.

PCA and PLS-DA were performed with EVINCE 2.2.5 (UmBio AB, Umeå, Sweden). All matrices were variable mean centered and UV-scaled during the analysis. Matlab R2008b (The MathWorks, Natic, MA, USA) and Microsoft Excel (Microsoft, Seattle, WA, USA) were used for editing the matrices, calculations, and evaluation of statistical differences in score plots from PLS-DA and PCA models with unpaired NOPAPROD (Nyström,
Lindholm-Sethson and Geladi, 2009; Bodén et al., 2011) where $\alpha = 0.05$. $P$-values < 0.05 were considered statistically significant. Two principal components were calculated for each analysis model.

3. Results

3.1. Injury severity

A total of 73 people sustained fatal or non-fatal injuries. There was one case each of severe (MAIS 4), critical (MAIS 5), and maximum (MAIS 6) injuries. All occurred in the first carriage (Figure 2). The two persons with the highest MAIS died on site. Serious injuries (MAIS 3) (n=4; 5%) were evenly distributed among the carriages. Of the MAIS 2 injuries (n=12; 16%), eight of these were in the first carriage. A majority of the injured passengers (n=54; 74%) escaped with only minor injuries (MAIS 1), most of which (n=29; 40%) sat in carriage two.

Concerning the seating direction, in all three carriages more than half (n=37; 51%) of the 73 fatally and non-fatally injured were in forward-facing seats while approximately one third (n=26; 36%) of the injured passengers were in rearward-facing seats. Five people (7%) were standing or walking at the time of the crash and four of these had moderate or worse injuries (MAIS 2-5).

3.2. Injury panorama

Of the two fatalities, one died from traumatic asphyxiation caused by compression of the chest and from other extensive injuries, such as internal hemorrhages. The other died instantly from “traumatic dismemberment,” i.e., multiple maximal injuries.

Seventy-one survivors sustained 246 injuries (Table 1), primarily (n=177; 41%) lacerations and superficial contusions. One laceration nearly tore off a person’s ear. Twenty-seven (40%) of the passengers sustained sprained necks (n=27). Six of these passengers later experienced chronic problems with numbness and paresthesias in their upper extremities indicative of Whiplash Associated Disorder (WAD 2). Another person already suffering from WAD had her condition exacerbated. More than half of the passengers with sprained necks (n=15) traveled in the second carriage. The other two carriages had equal number of sprains (n=6 respectively). The number of WAD cases with long-term consequences, however, did not vary between the carriages with two cases in each carriage. Fractures (n=20) were sustained by 14 non-fatally injured people (20%). Four of eight passengers that sustained “Other specified injuries” (n=15) were seated in carriage one. Seven passengers (10%) sustained concussions or intracranial bleedings (n=7), of which five were seated in carriage one. The lowest number of injuries occurred in carriage three.

![Figure 2. Depiction of MAIS in carriage one. “D” represents the driver. Adapted from the Swedish Accident Investigation Board 2006.](image)
When injuries were analyzed by body part (Table 2), three passengers were excluded because they had unspecified multiple superficial contusions; thus the table includes 68 survivors with 243 injuries. The chest sustained a fifth of the injuries with several serious injuries such as hemothorax, pneumothorax, bilateral lung contusions, and heart muscle contusion. One person suffered from choking on wood pellets leading to permanent cerebral impairment. The upper extremities sustained another fifth of the injuries, the worst being fractures, nerve or tendon damage, and crush injuries to the hands. The lower extremities sustained roughly a sixth, mainly minor injuries, with the exception of two open fractures (AIS 3).

Table 1. Injury Panorama of all 246 non-fatal injuries in 71 survivors, divided among carriages

<table>
<thead>
<tr>
<th>Location</th>
<th>Laceration</th>
<th>Contusion</th>
<th>Sprain</th>
<th>Fracture</th>
<th>Concussion/Subdural hematoma</th>
<th>Specified “other” injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carriage one</td>
<td>28</td>
<td>42</td>
<td>6</td>
<td>16</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Carriage two</td>
<td>7</td>
<td>66</td>
<td>15</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Carriage three</td>
<td>3</td>
<td>31</td>
<td>6</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
</tbody>
</table>

* Additional injuries include: one eye injury, one permanent neurological deficit due to choking, one crush injury to the hands, and one deeper muscle bleeding in the pelvis and lower back region.

Table 2. Type and localization of 243 well-defined non-fatal injuries of 68 survivors (Three passengers’ injuries are excluded because the locations of their contusions and lacerations are unknown).

<table>
<thead>
<tr>
<th>Location a</th>
<th>Head/face</th>
<th>Neck</th>
<th>Chest</th>
<th>Abdomen/pelvis</th>
<th>Upper extremity</th>
<th>Lower extremity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laceration/contusion</td>
<td>14/15</td>
<td>2/1</td>
<td>1/36</td>
<td>3/19</td>
<td>11/34</td>
<td>7/31</td>
</tr>
<tr>
<td>Sprain</td>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fracture</td>
<td>3</td>
<td>9</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Concussion/intracranial bleeding</td>
<td>6/1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other injury</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a ‘Head/face’ includes all injuries above the neck. 'Neck' includes cervical spine injuries; 'chest' includes thoracic spine injuries; 'abdomen/pelvis’ includes lumbar spine and pelvis injuries. The ‘lower extremity’ includes all injuries below the pelvis and ‘upper extremity’ includes all injuries to the arms, shoulders and scapula.
More than a sixth of the injuries were head injuries, two of which were labeled as “other specified” in Table 2, referring to an eye injury and permanent facial nerve damage. The abdomen and pelvis sustained the least number of injuries but several of them where moderate such as liver and spleen contusions (Table 2). Head and neck injuries constituted more than a fourth of the injuries and were sustained by more than half of the survivors (n=44; 62%) on the train.

3.3. Injury producing objects
Thirty-seven passengers (n=26 with MAIS 1, n=11 with MAIS 2+ injuries) recalled 59 clear injury objects such as tables (n=24), seats (n=14), other interior structures (n=11), wood pellets (n=5), other passengers (n=4), and luggage (n=1) (Figure 3). These factors were reported as injury inducing either when passengers were hurled into them, or when the objects became projectiles or/wedged passengers in.

3.4. Factors influencing injury
The multivariate analysis using PCA (Table 3) and NOPRAPROD showed that the type of injuries and location of injury differ significantly ($p<0.05$) in the PCA score plot between carriage one and the other two carriages. The analysis also shows a significant difference ($p<0.05$) in the type of injury and location of injury if the passenger sat at a table or not, independent of carriage.

3.4.1. Carriage one
The first section of carriage one was devoted to first class travelers and the driver’s cabin (Figure 2). Only four people, including the driver, were in this section at the time of the crash. The driver just made it out of the driver’s cabin seconds before the crash warning the passengers that a collision was inevitable.

Table 3. Summary statistics of the PCA and PLS-DA models

<table>
<thead>
<tr>
<th>PCA model</th>
<th>A*</th>
<th>R2X b</th>
<th>N</th>
<th>K</th>
<th>Pre-processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of injury - Carriage</td>
<td>2</td>
<td>0.27: 0.17</td>
<td>68</td>
<td>7</td>
<td>Center+UV</td>
</tr>
<tr>
<td>Type of injury - Carriage</td>
<td>2</td>
<td>0.27: 0.23</td>
<td>68</td>
<td>7</td>
<td>Center+UV</td>
</tr>
<tr>
<td>PLS-DA model c</td>
<td>A</td>
<td>R2Y_cum d</td>
<td>N</td>
<td>K</td>
<td>Pre-processing</td>
</tr>
<tr>
<td>Location of injury, Carriage one</td>
<td>2</td>
<td>0.36</td>
<td>18</td>
<td>7</td>
<td>Center+UV</td>
</tr>
<tr>
<td>Location of injury, Carriage two and 3</td>
<td>2</td>
<td>0.32</td>
<td>32</td>
<td>7</td>
<td>Center+UV</td>
</tr>
<tr>
<td>Type of injury, Carriage one</td>
<td>2</td>
<td>0.34</td>
<td>18</td>
<td>7</td>
<td>Center+UV</td>
</tr>
<tr>
<td>Type of injury, Carriage two and 3</td>
<td>2</td>
<td>0.19</td>
<td>32</td>
<td>7</td>
<td>Center+UV</td>
</tr>
</tbody>
</table>

* Number of Principal Components
b R2X: explanation rate of variation for the first and second principal component respectively
c Y-variables: Backward table; Forward table; Backward no table; Forward no table
d R2Y_cum: explained variation of the PLS-DA model
Only one person in this section escaped with minor injuries (MAIS 1). The others suffered serious or more severe injuries (MAIS 3+) such as several open fractures, pneumothorax, a broken neck, internal bleeding, and one suffered from traumatic asphyxiation caused by a compressed chest. In two cases, the consequences were fatal. In the remaining part of the first carriage there were 18 second class travelers, all of which sustained injuries; the most serious were choking, heart muscle contusion, several spine fractures, a pelvic fracture and a crush injury.

When analyzing the data using PLS-DA in regard to seating direction and seated at a table or not as Y-variables (Table 3), the following is shown: in carriage one the location of injury did not differ significantly (p<0.05) for passengers seated at tables irrespective of seating direction; they were more likely to sustain injuries to the lower extremities, chest, neck, and head. These injuries were significantly more probable if seated faced backward at a table than face backward without a table. Furthermore, it was significantly (p<0.05) less plausible to sustain injuries to the abdomen/pelvis and upper extremities when seated faced backward with no table compared to seated faced forward with no table. Being seated faced backward without a table also led to significantly (p<0.05) different type of injuries compared to all other seating (backward with table, forward with table, forward without table). Those passengers were, e.g., less likely to sustain neck sprains than those seated faced backward with a table or fractures compared to those seated forward with no table (Figure 4ab).

**Figure 4.** Weights plot of PLS-DA models showing correlations between variables, (location of injury or type of injury) (circles) and discriminant factors (direction and tables) (triangles). Read as: the closer the circles and triangles the higher the correlation.

![Weights plot of PLS-DA models showing correlations between variables, (location of injury or type of injury) (circles) and discriminant factors (direction and tables) (triangles).](image-url)

- **a)** Location of injury for Carriage one correlated to Backward table, Forward table, Backward no table, and Forward no table
- **b)** Type of injury for Carriage one correlated to Backward table, Forward table, Backward no table, and Forward no table
- **c)** Location of injury for Carriage two and 3 correlated to Backward table, Forward table, Backward no table, and Forward no table
- **d)** Type of injury for Carriage two and 3 correlated to Backward table, Forward table, Backward no table, and Forward no table
3.4.2. Carriages two and three

The second carriage had the most occupied seats and had the highest number of injured passengers (n=32; 44% of the injured), with mainly minor injuries (MAIS 1). There were, however, three passengers with moderate or worse injuries (MAIS 2+) such as fractures, hemothorax, bilateral lung contusions, and subdural hematoma. Carriage three had the least number of injured passengers (n=16; 22%). Three people had moderate injuries such as minor liver contusions, a spleen contusion, and a concussion. Additionally, one person had a hemothorax (MAIS 3).

Differing from the PLS-DA results of the first carriage, the seating direction was a significant factor for the results from the second and third carriages. There was also a significant difference between those seated at tables facing backward and forward; those traveling forward with a table in front of them were more likely to sustain injuries to their abdomen/pelvis than those without a table (p<0.05). Compared to traveling forward with a table those traveling backward with a table were more likely to sustain neck injuries. Neck injuries were also correlated with sitting backward without a table. Those sitting faced forward without a table had significantly different types of injuries than all other seating. They were more likely to sustain fractures. Seated forward with a table was correlated with “other specified injuries,” e.g., lung and liver contusions. Sprains correspond to neck injuries and were significantly more prominent for those traveling backward, regardless of table or not (Figure 4cd).

3.4.3. Rescue

Passengers also stated that loose and detached objects such as seats, tables, interior/debris, and luggage as well as unsecured passengers were piled up. These items and wood pellets in the first carriage made egress difficult. Passengers also reported becoming trapped or pinned by these objects. Better triage planning and equipment might have reduced the consequences. The passenger who died from traumatic asphyxiation caused by compression of the chest, and the passenger being choked may have had a better outcome if the rescue personnel had begun triage in the first overturned demolished carriage, instead of the other two carriages. Additionally, the evacuation equipment was not user friendly which hampered evacuation.

4. Discussion

In this context, reducing injuries means (i) to prevent energy and forces greater than the human injury threshold reaching the person and (ii) minimizing the consequences of an injury through effective rescue and care. This definition ties to the 10 injury mitigating strategies launched by Haddon Jr. (1970). Regarding road traffic, injury mitigation strategies have been successful by improving crashworthiness and “passive – automatic” injury reducing interior measures such as soft surfaces, safer restraint systems, etc. Additionally, physical separation of oncoming traffic has been shown helpful. These strategies have contributed to a reduction in the number of fatally injured persons in Swedish car crashes to nearly the same level as in the 1930s, despite a large increase of road traffic (Transport Analysis, 2011; Swedish Transport Administration, 2011b).

Even with the improved technical systems and signal systems, train crashes are not simply a thing of the past (Forsberg and Björnstig, 2011). Level crossing crashes are particularly challenging to prevent because of conflicts with road users. Therefore, it would be of value to separate road traffic from rail traffic. Trains are operating at ever-increasing speeds while transporting many passengers. Thus, it would be wise to introduce interior safety measures in train carriages, as has already
been implemented in other modes of transportation, such as road traffic and aviation.

This study illustrates that travelers in the first carriage, which had the most severe crash kinematics, suffered the most severe and lethal injuries; a phenomenon also seen in other train crashes (Hambeck and Pueschel, 1981; Eriksson et al., 1984a; Prabhakar and Sharma, 2002; Weyman, O’Hara and Jackson, 2005; Nagata et al., 2006; Shackelford et al., 2011). Fortunately, there were only four people in the first section (first class) of carriage one which had a seating capacity of 16. One method to make the carriages safer has been shown by Gao and Tian (2007) who tested crash zones on either end of all train carriages. These crash zones could redistribute the compressing force from the front of the train to designated compression zones in each carriage.

Higher lethality and injury risk has also been observed in other cases in which carriages have overturned (Braden, 1974; Swedish Accident Investigation Board, 2006). As in the present crash, where carriage one overturned, passengers tumble and fall several meters from one side onto other objects and passengers on the other side of the train; an experience survivors describe like being in a tumble-dryer (Fothergill et al., 1992; Forsberg and Saveman, 2011). The passengers underneath are exposed to the weight and force from, e.g., fellow passengers (Cooksey, 1992) and get caught underneath them. In the present crash most of the interior loosened and become airborne in carriage one making it difficult for the victims to say what caused specific injuries. Interestingly, we could see that passengers seated backward without a table in carriage one were significantly less injured than the others. However, passengers’ seating direction did not have significance on type of injury or location of injury in our results as the directions were varied since the carriage rotated and overturned. The trunk (chest, abdomen and pelvis) was the body part that sustained the most injuries (cf. Alm, Johansson, Liljedahl and Sjödahl, 1975) and many of the passengers reported that they hit a table with their chest or abdomen concurring with findings by Ilkjaer and Lind (2001). These passengers sustained moderate or serious injuries like liver and spleen contusion, lung contusion and hemothorax; injuries also described by Malik and co-authors (2004).

Because tables were the most commonly reported injury object in our interviews it is important to research injury mitigating strategies, as has been performed by Parent, Tyrell, Perlman and Matthews (2004). Our study shows that there is a significant difference in the type of injury and location of injury if the passenger sat at a table or not, independent of carriage. In carriages two and three seated faced forward at a table was significantly correlated to abdominal and pelvis injuries.

There has been an interesting debate in regard to how tables should be constructed to reduce injuries. After the Mundelstrup crash in Denmark in 1994, Ilkjaer and Lind (2001) drew the conclusion that the tables should be constructed to break loose in the event of a crash. However, more recent studies by Severson and Parent (2006) suggest that tables should be firmly attached to the side of the carriage to catch passengers and give in to a certain point. Thus, the table should be constructed to both absorb energy and compartmentalize the passengers. Some researchers also advocate the use of safety belts (Braden, 1974, 1975; Fothergill, et al., 1992; Madsen, 1998), which probably would reduce the risk of hitting the table. This, however, is not without its challenges and more research is required to investigate the consequences of safety belts before making recommendations. Another injury mitigation measure could be the use of
seats that swivel like in the Shinkansen trains in Japan that have the ability to turn the direction of the seats allowing travelers always to sit rearward facing. This feature, however, is mainly used in Japan to sit faced forward (Japan-guide.com, 2011), for comfort reasons without contemplating the effect on safety. In previous research, forward-facing seating has been shown to increase the number and severity of injuries (Fothergill et al., 1992; Madsen, 1998). Our study shows that seating direction influenced type of injury and location of injury on the passengers in carriages two and three. Those faced forward with a table had significantly more injuries to the abdomen/pelvis compared to those who were faced backward with a table. These passengers suffered injuries such as neck sprains and lacerations to the lower extremities.

It was unclear if there was a difference in the number of neck sprains depending on seating direction (forward-facing n=13; rear-ward facing n=10; unknown direction n=4) in the descriptive statistics. However, further analysis showed that those seated backward in carriages two and three had a significant correlation with neck sprains despite the high backrests. This means that these seats (Figure 5) do not adequately support the neck or have an elasticity inducing a whiplash movement of the head. The relatively high rate of neck sprains were also observed in the train crash in Kimstad, Sweden, 2010 (Holgersson, Forsberg and Saveman, 2012). On the other hand, it was not significantly correlated with any worse (MAIS 2+) injuries.

Standing or walking at the time of the crash has also been shown to cause worse injuries (Wakeland, 1978; Cooksey, 1992; Cugnoni et al., 1994). This was observed in the present study as well, where four out of five standing people received moderate or worse injuries (MAIS 2+). It is therefore vital to remain seated, especially at high speed. This would require trains to be equipped with adequate seating to accommodate all passengers.

From a medical perspective, studies of train crash injuries show interior safety improvements are warranted as passengers’ injuries are influenced by, e.g., loose objects like luggage and pieces of the interior, e.g., seats, interior walls and headrests (Braden, 1974, 1975; Eriksson, Ericsson, Lundström and Thorson, 1983; 1984a, 1984b; Fothergill et al., 1992; Cooksey, 1992; Cugnoni et al., 1994; Madsen, 1998; Ilkjær and Lind, 2001; Eckstein and Heightman, 2009; Holgersson et al. 2012). Methods to improve interior safety to reduce morbidity and mortality in future crashes merit further investigation. Our study had too little data on luggage, seats, etc. to draw safe statistical conclusions. However, passengers reported being injured by interior and becoming wedged underneath. This highlights the importance of gathering as much data as possible after crashes to obtain a more solid base for injury mitigation measures.

One of the deceased was killed by compression of the chest and another suffered from choking resulting in permanent neurological deficit. Both were in overturned carriage one. Had fellow passengers not found the choking traveler and quickly cleared her airway, she probably would have died as the rescue

Figure 5. Type of seats in the carriages.  
Photo: The Swedish Transport Administration
personnel started their work in the other, less damaged carriages. Other studies have indicated that victims without serious injuries have died due to traumatic asphyxiation because they were wedged in or under various forms of debris (Robinson, 1975; Hambeck and Pueschel, 1981). Research from train crashes in the UK (Robinson, 1975), Germany (Hambeck and Pueschel, 1981), Japan (Nagata et al., 2006) and the United States (Shackelford et al., 2011) show that rapid rescue was crucial to the survival of passengers suffering from crush syndrome or traumatic asphyxia. Thus it is important that the rescue personnel learn to “read the crash” and begin rescue operations where the most acute injuries could be expected.

This emphasizes the need for rescue personnel to train for and plan for rapid extrication of the injured. Therefore, it is vital to facilitate accessibility for rescue personnel (and passengers), by adding access points such as roof hatches (Braden, 1974), or clearly marked places in the roof appropriate for the rescue personnel to cut. Safely stowed luggage would increase access and ease evacuation (Holgersson et al., 2012). Luggage racks like those in airplanes could be one solution and have already been installed in the Amtrak Acela Express trains (Railway-technology.com, 2011). Building smaller transparent compartments in the carriages may both keep passengers from becoming injured as they would not be thrown around over long distances, and simultaneously prevent passengers from piling on top of each other thus impeding accessibility. Compartments could also reduce the risk of being hit by other objects and subsequently becoming wedged in by them.

Sadly, research from many previous train crashes has shown that injuries and fatalities may have been prevented had injury mitigating strategies to train interior been implemented. Moreover, the number of train disasters has also been growing (Forsberg and Björnstig, 2011). There is no reason to believe that train disasters will simply cease to occur; leaving one question: How long will it take before the lessons of previous crashes are heeded?

4.1 Methodical considerations
To find correlations between an injury and its causes by using traditional statistics can be tough. By using multivariate data analysis methods, several variables for each passenger are considered simultaneously. Thus, it is possible to find true correlations between the type of injury or the location of injury and the circumstance that caused the injury.

In the present case, there were relatively few variables in datasets "type of injury" and "location of injury " (K = 7) and relatively few objects in each group making the validation of the PCA and PLS-DA and the NOPAPROD unfair. Therefore, two components have been calculated for each model regardless of eigenvalue or Q2X_cum (validation). The low explanation rates, R2X, for each component in the models (Table 3) depend on the multifactorial cause of an injury. This hampers the potential to determine exactly what caused the injury.

By only using the most severe injuries when constructing the matrices, several injuries are automatically excluded. Therefore, they do not give weight to the PCA and PLS-DA models. Despite this, the results from the multivariate analysis serve as indications of the injury inducing variables in the crash. Thus, more studies of similar nature are required to confirm the conclusions.
5. Conclusions

Eliminating passengers from the first carriage and reducing the risk of carriages overturning would be of great value because the first overturned carriage held the most severely and fatally injured. Injuries could be further reduced if there was sufficient seating available for all passengers and if they remained seated during the crash phase. Therefore, investigation concerning the injury mitigating potential of safety belts needs to be conducted together with strategies for compartmentalization. This would also decrease the danger of passengers and objects flying around. Improved train interior safety needs to consider design alternatives regarding seating direction and introduce soft interior surfaces such as table design to reduce their injury inducing potential, i.e. taking the brunt of the otherwise injury inducing force. If seats, tables, luggage, and other objects were firmly attached; injures could be further reduced. The aforementioned interventions would reduce the hazard of passengers becoming trapped and ease evacuation. Efficient evacuation routes and functional evacuation equipment are needed, and roof hatches could be beneficial.

Acknowledgements

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References


EMPIRICAL STUDIES

Survivors’ experiences from a train crash

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Abstract
Rarely described are people’s lived experiences from severe injury events such as train crashes. The number of train crashes named disasters with ≥10 killed and/or ≥100 nonfatally injured grows globally and the trend shows that more people survive these disasters today than did so in the past. This results in an increased number of survivors needing care. The aim of the study was to explore survivors’ experiences from a train crash. Narrative interviews were performed with 14 passengers 4 years after a train crash event. Qualitative content analysis was used to analyse the interviews. Experiences were captured in three main themes: (1) Living in the mode of existential threat describes how the survivors first lost control, then were thrown into a state of unimaginable chaos as they faced death. (2) Dealing with the unthinkable described how survivors restored control, the central role of others, and the importance of reconstructing the event to move forward in their processing. (3) Having cheated death shows how some became shackled by their history, whereas others overcame the haunting of unforgettable memories. Furthermore, the result shows how all experienced a second chance in life. Experiencing a train crash meant that the passengers experienced severe vulnerability and a threat to life and interdependence turned out to play a crucial role. Focusing on helping other passengers on site was one way to regain the loss of control and kept the chaos at bay. Family, friends, and fellow passengers turned out to be extremely important during the recovery process why such closeness should be promoted and facilitated.

Key words: Content analysis, experiences, interviews, nursing, train accident

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Several studies exist focusing on psychological or psychiatric perspectives of survivors of severe injury events using different kinds of quantitative methods (Bergh Johannesson, Lundin, Fröjd, Hultman & Michel, 2011; Rosser, Dewer & Thompson, 1991; Wang, Tsay & Bond, 2005). However, research from a nursing science perspective, which focuses on survivors’ experiences of having experienced severe injury events, is scarce (Isovaara, Arman & Rehnsfelth, 2006; Roxberg, Burman, Gulbrand, Fridlund & Barbosa de Silva, 2010).

A study of Swedish survivors of the Asian Tsunami 2004 (The National Board of Health and Welfare, 2008) showed that survivors’ outlooks on life after such an event were weakened for some but strengthened for others. One’s own strength as well as help from family, friends, and work colleagues was an important factor that helped the survivors deal with the resulting stress following the horrific incident. Additionally, visiting the incident site helped the survivors’ process what had happened to them. Råholm, Arman, and Rensfeldt (2008) showed that the significance of the Asian Tsunami was deeply existential and was described as suddenly having to struggle between life and death while devoid of any control. This sudden upheaval of one’s universe occurred in the context of absolute paradise that abruptly became the scene of total chaos and forced the survivors to form a new outlook on life.

Survivors’ reactions are considered severe immediately after a tragic event, but most reactions become more subdued within 1 year (Connor, Foa & Davidson, 2006). Bonanno (2004) means that resilience in the face of trauma is more common than is often believed, and there are multiple and sometimes unexpected pathways to resilience which means that several survivors only show minor and
transient disruptions after traumatic events. On the other hand, additional studies of long-term effects of traumatic events reveal that survivors continue to experience effects of the trauma 5–10 years later (Holen, 1990; Hull, Alexander & Klein, 2002) and some have lifelong effects even 25–50 years later (Lazaratou et al., 2008; Lundin & Jansson, 2007). According to Arozenius (1977), as many as 75% of the survivors of a train disaster had some kind of mental or psychosomatic disorder, and the majority of the survivors thought regularly about the traumatic event even after a year had passed. Furthermore, we deduce from other studies of injury events involving trains that posttraumatic stress symptoms were present (Hagström, 1995; Lundin, 1991; Raphael, 1977; Selly, King, Peveier, Osola & Thomson, 1997). The most obvious impact on the survivors was of having been close to death and survived. Nightmares and intrusive thoughts became problematic for the survivors. After the event, difficulties traveling by train and fear noises similar to those of train travel were also common (Hagström, 1995).

Globally, the rapid development of train traffic, including rising speeds and increasing traffic, in the world results in a growing trend of train crashes that is named disasters if ≥10 are killed and/or ≥100 are nonfatally injured. Nevertheless, the average death rate is decreasing resulting in a larger number of survivors (Forsberg & Björnstig, 2011), who probably have lasting affects causing distress and suffering. Despite the need to holistically consider and understand survivors’ experiences, we found no studies focusing on surviving passengers’ experiences of a train crash. Valuable understanding that can be used to improve the care and treatment of future survivors can be gained from such studies. Knowledge obtained about factors that affect their lives, regardless of the severity of sustained physical injuries or disabilites, can be used to alleviate their suffering and help them move on with lives. Thus, the aim of this study is to explore survivors’ experiences from a train crash.

Method

The study context

In September 2004 in Nosaby, Sweden, a truck fully loaded with pellets was stuck at a level crossing on a railway track when an oncoming three-carriage passenger train crashed straight into it (Figure 1). The first carriage was thrown off the track and rotated 180° after impacting a tree. It then overturned. The second and third carriages partly derailed but remained on the railway embankment. The crash resulted in deaths of the train engineer and one passenger. Forty-nine passengers were injured of which four were severely or critically injured (Swedish Accident Investigation Board, 2006).

Participants

The participants included in this study are survivors of the Nosaby train crash. The police authorities supplied us with all available records on 69 passengers and two crew members who were on the train. Out of these, 65 were asked to participate as three were dead (two in the crash and one later on) and three were of foreign nationalities and therefore could not be contacted. Fourteen survivors agreed to participate in the study, 12 women and two men aged 20–64 years (at the time of interview). Table I shows participants’ background data such as age, injury, location in the train, signs of posttraumatic stress disorder (PTSD), and decreased general mental health.

Data collection

Narrative interviews (Riessman, 2008) were carried out 4 years after the event. An interview guide including a few semi-structured questions was constructed according to precrash, crash, and postcrash phases (Haddon & Baker, 1981).

The interviews began with the question: “Please, tell me about where you were going”, followed by “What happened during and after the crash?”. Participants told their stories without restraint. Sometimes, the narratives were supported with follow-up questions such as, “What do you mean?”, “How did you feel?”, “What did you experience then?”. This was done to clarify the content of the interviews (Michler, 1986). If not mentioned spontaneously, questions from the interview guide, such as “How was the scene inside the train after the

Figure 1. The train crash in Nosaby, Sweden 2004. Photo: The Swedish Transport Administration

Citation: Int J Qualitative Stud Health Well-being 2011; 6: 8401 - DOI: 10.3402/qhw.v6i4.8401
<table>
<thead>
<tr>
<th>Passenger (fictive names)</th>
<th>Age (at time of crash)</th>
<th>Carriage location (1/3)</th>
<th>Physical injuries and mechanisms (according to hospital charts and interviews)</th>
<th>PTSDa diagnose (≥ 50 points)</th>
<th>Impaired general health (≥ 3 points)</th>
<th>Injury severity (MAIS)b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amanda</td>
<td>54</td>
<td>1</td>
<td>Hit by table on the left side of her chest and lost consciousness. Became wedged between loosened interior and buried by pellets. Was cyanotic and not breathing when she was dug up. Suffered from lack of oxygen that caused a brain injury. She also suffered a myocardium contusion, pulmonary bleeding, and rib fractures.</td>
<td>No</td>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>Beatrice</td>
<td>40</td>
<td>1</td>
<td>Hit by a table and got stuck under the rubble. Got transient numbness in the legs and compression fracture on Th12. Incurred open nose fracture, a laceration on the scalp, and a severe laceration from the mouth to the left ear. Had contusions to the abdomen (laparotomy was performed with no pathological findings).</td>
<td>No</td>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>Cecilia</td>
<td>41</td>
<td>1</td>
<td>Stood up and ran backward before the collision and woke up trapped from the waist down. She was under carriage interior pieces and loose debris. Got a closed radius fracture, an open femur, and patella fracture. There were also a number of tendon and nerve injuries. She suffered a traumatic pneumothorax, several rib fractures, and multiple lacerations on the scalp.</td>
<td>No</td>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>David</td>
<td>23</td>
<td>2</td>
<td>Was thrown into a table and into the armrest. Suffered bilateral lung contusions, superficial contusion hemorrhage in the lumbar and hip, and muscle damage in the lumbar and hip.</td>
<td>No</td>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>Erica</td>
<td>33</td>
<td>2</td>
<td>Loose carriage interior fell from above and a fellow passenger flew toward her and took the whole table with her when it stopped. Received a dislocation of the vertebra L1-L2 and muscle damage around the neck and back.</td>
<td>No</td>
<td>No</td>
<td>2</td>
</tr>
<tr>
<td>Gabriella</td>
<td>26</td>
<td>1</td>
<td>Got a hematoma behind the left ear and jaw. She also got bruises on one arm and both legs. She also got fractures, neck contusions, lacerations on the lower legs, and bruises.</td>
<td>No</td>
<td>No</td>
<td>2</td>
</tr>
<tr>
<td>Hannah</td>
<td>18</td>
<td>2</td>
<td>No physical injuries.</td>
<td>No</td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>Inez</td>
<td>64</td>
<td>3</td>
<td>Flew out of the seat and hit her head. Fainted and woke up on the floor with pain in the neck and forehead. She also suffered from a number of bruises on the floor.</td>
<td>No</td>
<td>No</td>
<td>2</td>
</tr>
<tr>
<td>Jane</td>
<td>22</td>
<td>3</td>
<td>Parts of the roof broke and fell down. She struck her head and got a hematoma behind the left ear and jaw. She also got bruises on the left arm and left hand, and also got a number of lacerations on the lower legs and bruises.</td>
<td>No</td>
<td>No</td>
<td>2</td>
</tr>
<tr>
<td>Kelly</td>
<td>29</td>
<td>2</td>
<td>Rib fractures, neck contusions, lacerations on the lower legs, and bruises.</td>
<td>No</td>
<td>No</td>
<td>2</td>
</tr>
<tr>
<td>Leia</td>
<td>41</td>
<td>3</td>
<td>Hit her head, passed out, and got stuck under the table. Got a closed radius fracture, an open femur, and patella fracture. There were also a number of tendon and nerve injuries. She suffered a traumatic pneumothorax, several rib fractures, and multiple lacerations on the scalp.</td>
<td>No</td>
<td>No</td>
<td>3</td>
</tr>
</tbody>
</table>

Table I. Participants' background data.

<table>
<thead>
<tr>
<th>Survivors' experiences from a train crash</th>
</tr>
</thead>
</table>

Citation: Int J Qualitative Stud Health Well-being 2011; 6: 8401 - DOI: 10.3402/qhw.v6i4.8401
The interviews were performed face-to-face (except for one that was performed by telephone) and lasted 30–80 min. The interviews were recorded and were transcribed verbatim resulting in approximately 200 pages of 1.5 spaced text. At the conclusion of the interview in addition to their narratives, background data, such as age, their carriage location and physical injuries, and injury mechanisms (from hospital records) were obtained. For further background data, they also filled in two validated self-evaluation scales; PTSD Check List—Civilian Version (PCL-C) for estimation of posttraumatic stress reactions (Blanchard et al., 1996; Weathers, Litz, Herman, Huska & Keane, 1993) and the General Health Questionnaire-12 (GHQ 12) (Goldberg et al., 1997) to evaluate participants’ general health.

Data analysis

The transcripts were analysed using a qualitative inductive content analysis, which means that the text itself generated ideas for concepts and themes. Both authors read and reread the transcribed text to acquire a broad overview of the passengers’ experiences and the consequences of those experiences on the passengers. Repeated readings led to divisions of meaning units that were condensed while preserving the core content. The condensed text was then abstracted and given codes. This was done by the first author and when uncertainty arose, it was discussed and given codes. This was done by the first author and when uncertainty arose, it was discussed and given codes. This was done by the first author and when uncertainty arose, it was discussed and given codes. This was done by the first author and when uncertainty arose, it was discussed and given codes.

The analysis has been performed in a logical and systematic way by both authors who have read, discussed, and worked with development of the subthemes and themes. The subthemes and themes...
were then checked by going back to the text and reviewing in light of our sense of what was narrated. The internal logic and consistency are verified by quotations from the text (Polit & Beck, 2006). We assume that our findings are transferable to other similar contexts where people’s lives are threatened, but especially relevant after having been involved in a train crash. However, several interpretations of narrated texts are possible and can be valid even if they are different (Krippendorff, 2004).

Ethical considerations
This study is in accordance with the principles outlined in the Declaration of Helsinki (World Medical Association, 2008) and was approved by the Regional Ethics Committee at Umeå University (Dnr 09-143 O). Information about the research study was given to the passengers by letter with a request to participate. They were informed that participation was voluntary and of their right to withdraw at any time without explaining why; but no one did. If the passengers chose to participate, informed consent was given by either phone or e-mail. Individual interviews were recorded after permission was given at a location agreed with the participants. Psychiatric help was available; however, no one asked for this assistance. This remained true even though powerful emotions surfaced when recounting their experiences. Participants were guaranteed confidentiality; therefore, fictive names have been used throughout the article.

Findings
The analysis of the text revealed three themes that illuminate the survivors’ experiences from a train crash. (1) Living in the mode of existential threat, (2) Dealing with the unthinkable, and (3) Having cheated death. Themes and subthemes are illustrated with quotations. Table III shows the results presented in three themes with three subthemes, respectively.

Table II. Example of the analysis.

<table>
<thead>
<tr>
<th>Meaning unit</th>
<th>Condense</th>
<th>Sub-theme</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>You sit and talk, you are not at all prepared for that (the crash)</td>
<td>It was totally unexpected, I was not at all prepared and it was absolutely hysterical</td>
<td>Unpredictability</td>
<td>Losing control</td>
</tr>
<tr>
<td>to happen. It was so totally unexpected (-) It was just a dead stop and then</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>we just slid, then it started to fall down, the interior from the top and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>she flew towards me. People screamed very much and it was absolutely</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hysterical. I remember thinking “does this ever end?”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel like tightness in the chest, like a blast wave. I feel like</td>
<td>I understood nothing, it was like waking up in a movie</td>
<td>Surreal threat</td>
<td>Being in unimaginable chaos</td>
</tr>
<tr>
<td>when I run, my arms are seemingly everywhere, just like</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>when you blow away a spider or something like that … and then … I wake</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>up lying on my back, it’s so sunny outside and all this dust that came</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>from seats and furniture … it is like curtains over … over the air and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>then I think, what kind of movie is this? I understood nothing. It was</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>as if one has fallen asleep in front of the television and then you wake</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>up in a movie (-)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have never in my whole life had such panic as I had then. To just stand</td>
<td>Never had such panic, I was hyperventilating and wonder, will I die now?</td>
<td>Death threat</td>
<td>Facing death</td>
</tr>
<tr>
<td>there and hyperventilate and wonder … Will I die now, Will I die? I’ve</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>never been in such a situation before where I needed to ask myself the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>question if I would survive.</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

This study is in accordance with the principles outlined in the Declaration of Helsinki (World Medical Association, 2008) and was approved by the Regional Ethics Committee at Umeå University (Dnr 09-143 O). Information about the research study was given to the passengers by letter with a request to participate. They were informed that participation was voluntary and of their right to withdraw at any time without explaining why; but no one did. If the passengers chose to participate, informed consent was given by either phone or e-mail. Individual interviews were recorded after permission was given at a location agreed with the participants. Psychiatric help was available; however, no one asked for this assistance. This remained true even though powerful emotions surfaced when recounting their experiences. Participants were guaranteed confidentiality; therefore, fictive names have been used throughout the article.
Losing control. Early morning sun shone through the train windows and the weather was lovely. Everything was normal. People were on their way to work or school and others were on their way to their long anticipated vacations. Students were laughing, others were talking, or napping, and a few were reading when the tranquility was suddenly interrupted. The train made an abrupt movement and everything started to shake erratically. Distress was experienced as the train started to lurch, and simultaneously loud noises emerged from the train. The gut-wrenching moment continued as the train engineer pulled on the brakes. The train shuddered, squeaked, and abruptly decelerated. Helplessness overwhelmed the passenger as they were exposed to this unexpected turn of events:

Gabriella: I sit and write in my diary and, like, ‘Oh what fun, we’ll go on a trip!’ Then it just slams and it just stops. It’s like I experience it like a mountain face, rock hard as well. Bang! Stop! Dead stop! And we look at each other and we do not understand anything.

Facing death. Passengers were trapped inside the carriages and were fearful of further potential threats to their safety. Silence turned into hysterical screams. People were screaming “we are going to die, we’re dying” and the screams reverberated throughout the crashed train. Passengers became overpowered by uncertainty as to whether they would make it out of the train alive or not; a moment that was described as the worst thing you could ever experience. A thousand different thoughts emerged while they experienced proximity to their own death. Their life flashed in front of their eyes and pictures of family members appeared escalating deep anxiety and fear of dying. Some were catatonic, while others were hyperventilating. Those who managed to find their way out from the wrecked train were covered with dust and looked like ghosts with wide eyes:

David: When you are forced to think the thought that now might be the end... there are strong emotions that arise, it is the worst thing you can experience... experiencing some form of close to death or death anxiety.

Being in unimaginable chaos. Fear and uncertainty overwhelmed the passengers as they sat inside the train without anything to hold on to when the train was thrown back and forth. Unimaginable chaos ensued as passengers were hurtled into tables, chairs, and into each other as though they were inside a tumble dryer. At the same time luggage, unsecured objects, and loose interior became projectiles inside the confined carriages. It was like riding a chaotic roller coaster that never seemed to end. The train finally came to an abrupt stop and shouts of panic turned into a chilling silence. The carriages had turned into an unidentifiable place of pandemonium while rays of sunshine emerged through the haze of pellets and dust. The situation was surreal and described as waking up in a movie:

Mariah: Things flew against me. There were people and seats that I was thrown into and against. I was pushed to and fro and I thought; now we have gone out in the field or into the woods. Suddenly, it struck again and we were thrown the other way and I wanted something to hold onto but there was nothing (-). We just went with it, like in a tumble-dryer. You just go with it and get thrown into things. I wanted off this ride! Finally, I lay on my back and the soil just kept coming over me.

Dealing with the unthinkable

The content of this theme takes place a few minutes after the crash, but the experienced length of the phases varied between the participants. For some, this will be a lifelong process. This phase includes how the passengers deal with their experiences of something that prior to the incidents seemed unthinkable and how they by various strategies initially regained the loss of control. It also clarifies the importance of others in the processes and the need to understand what they had experienced.
or daily planners, despite the insignificance of the items in light of the situation. It was an act that passengers found both surprising and totally sickening in the middle of it all. Another important act was to help fellow passengers by staying close, talking to them, retrieving lost possessions, or helping them out of the carriage. Some, even those who did not consider themselves as calm, started to talk soothingly to passengers in need, asked how people felt, and comforted those who cried. They tried to calm others by, for example, telling those passengers who remained trapped to take deep breaths and explaining that rescuers were on the way. By focusing on another person, they were able to regain control and keep themselves composed. Having a task to accomplish drew the focus away from the chaos and closed out the noise. It kept them from falling apart emotionally:

Mariah: I’d lost my shoes. They had fallen off, but of course you try to gather your stuff (laughs) in the middle of it all. I found a bag that was mine and one more shoe. I also wanted to find my fellow passengers that had been sitting by the table. I had a need to check if all were in their seats and if not, to see where they were.

Erica: She was badly injured, I focused on her. She was very scared and worried. I felt that I had to take care of her so I stayed with her, it was the most important task and then I got some sort of peace within me.

Amanda: One of my daughters had to stay with me in the hospital, she slept with me, she showered me, did all the nursing, she took care of me. On Sunday I found out that she had to move out, and then I said that in that case, I discharge myself in this condition. Security and trust of having relatives close was more important than what could possibly happen to my heart, so my family had to stay.

Most of the participants also experienced a strong need to talk about the event over and over again. They explained that they poured out their experiences to persons close to them continuously and doing so was very helpful. On the other hand, it was also described as difficult to talk with people who had not had the same experience because the participants felt that others could never understand and imagine the traumatic event. Conversations with professional therapists helped some participants in processing emotions and were very important to the healing process:

Jane: I really earnestly needed to talk about it a lot. I talked about it all the time. It was not that I had problems with people asking; it was just that . . . I wanted to talk about it with those who had been involved. We talked the whole time and went through what we remembered over and over and over again . . . I remember, we dwelled on it for ages . . .

Centrality of others. The need to be with others; for instance, fellow passengers, family, friends, or hospital staff turned out to be of central importance to the passengers in dealing with the unthinkable event. Strong needs of closeness were prominent and were perceived as providing support, well-being, and security while the participants were in the state of uncertainty. It forced them to comprehend that they were still alive and was even described as life saving. When loneliness was experienced, it was expressed in terms of despair, anxiety, and panic. Being close to someone also signified that the participants were able to think of something other than the crash. The chance to distance the mind from the injury event was highly appreciated by some:

Gabriella: She really became my support in this. If I think about the trip without her . . . then I do not know . . . She sat and held me. She was my support and she held me and almost made me realize that I was alive. She was really my support in all of this.

Reconstructing the turn of events. Understanding how everything had happened by visiting the site of the train crash was one way to deal with the incomprehensible event. Viewing the crashed train and the crooked track afterward created a completely different perception. For some, it was essential to revisit the crash site and make it easier to understand what had happened and to process the trauma. Those who did not get the opportunity to observe the crash site expressed disappointment and jealousy as they felt they were missing something in the process that others got:

Nora: Then we went to the scene . . . The teachers followed us there . . . It felt really nice because it was a completely different view . . . It was not the same as when you were there last and it felt like it was good for one to see it all, right there where it happened last Friday and this is how it looks today. It helped to get it off the mind and it felt great to have been there.
To follow the news was another thing that was helpful in the process of reconstructing the events. Watching every newscast and saving each article from the newspaper made it easier to get holistic understanding of the experience. One participant, however, did not take note of the media information from the crash and she expressed having an enormous regret for not having done so. Another participant had to cover up pictures of the crashed train because it was too tough to watch:

Hannah: It was really useful to follow the media. Then you could see, check out more how everything looked. And, you probably switched it off when you were at the accident site, somehow it was nice to watch on television and in newspapers to see what you had experienced (−).

Arranged joint group meetings organized in some municipalities were helpful when reconstructing the crash. It was valuable to see and listen to the investigators explaining and illustrating how the carriages had been thrown around and rotated. During these gatherings, it was possible to collect more elements of understanding from fellow passengers, which had been missing in one’s own “puzzle.” Identifying who and where other passengers had been sitting was also satisfying and fulfilled a need. Additionally, it helped the passengers to put words to what they had experienced.

However, those who had been sitting in the first carriage had seen the worst effects of the crash and had been exposed to greater threats; consequently, they told more serious stories. This made those in the second and third carriages think that they had nothing to add to the conversation even though they had had their own chaotic experiences. Despite less physical injuries, they still had lived through the same life-threatening train crash and felt mentally ill. Not everyone was able to attend the arranged group meetings; thus, missing pieces and unanswered questions remained. On the other hand, not everyone desired to participate in the group meetings. They felt it was “too much” and that they had no need for it:

Amanda: The meeting with the others was very good. All the perceptions we had of each other, the different pieces of the puzzle, meant we got a better overview of what we had gone through. The investigators also drew a picture of the railway carriages, which made it possible to write down who sat in the first carriage and so on.

Having cheated death
Lifelong memories are created by having survived a major event such as a train crash. Those experiences and memories affect most aspects of life to varying degrees and lengths of time. Most survivors are tremendously grateful to have survived such an unthinkable event. However, the survivors also seemed to divide themselves into two groups when mentioning what the event has meant for them. While some felt stuck in life and haunted by the past, others spoke of how the experience had made their lives richer.

Being shackled by history. The crash affected all participants in some degree. Passengers were classified as physically disabled to varying extents. Nonetheless, most of them were also affected psychologically, for example, by fear of train travel. In their minds, they find themselves anticipating the train to derail, and rail sounds cause unpleasant feelings to resurface. Participants also expressed that they continue to be on edge all the time. The sound of a creaking bicycle, the slightest lurch, or a sneeze can cause them to tremble with fear. Several participants mentioned being haunted by nightmares about the crash, even several years after the crash. They spoke of their lives as if divided into two parts; before and after the train crash. Some feel that their lives after the train crash are hindered because fear prevents them from doing the things they did before the crash. Living life in this postcrash manner has been described as exhausting:

Beatrice: I still wake up at night sometimes and I have everything on the mind. I have a very hard time with trains. When the train comes, I usually try not to be so close to the track, or so. I stand with my back against it so I will not see when the train comes. Otherwise I get anxious and it is extremely painful in my chest. I have not traveled by train yet. I will never go by train again (−). I have come as far as up on a platform when the train was not there. I wanted to run away at once, it was very anxiety loaded (−). It has affected my life very much indeed, both with pain and psychologically.

Overcoming the haunting of unforgettable memories. As time passed, powerful memories about the crash began to fade allowing the participants to come to terms with the traumatic event and move on in daily life. They no longer thought about the event on a daily basis, but memories could still be triggered by
specific events were similar to the train crash. Different strategies were mentioned for moving forward. One way was to write everything down and then allowing it to gradually fade away. Individual psychotherapy was also attributed as the reason for recovery. Other reasons given for recovery were the importance of interacting with family, friends, and fellow passengers. One passenger determined to turn the tragedy into a positive experience and chose not to be afraid; she refused to become a victim. Some expressed feelings of guilt as a hindrance for moving on too easily:

Gabriella: I feel like I recovered pretty fast. Of course the first night memories were strong but then it faded very fast and I felt that I could keep up a normal life again. I found it pretty easy to cleanse it out.

_Nora:_ You appreciate life a lot and all the people you have around you even more (-). I see life in a completely different way and appreciate life so much.

**Discussion**

The aim of this study was to explore survivors’ experiences from a train crash. The findings revealed that the themes, living in the mode of existential threat, dealing with the unthinkable, and having cheated death, illuminated the passengers’ experiences in an area that prior had not been explored and had not been described in nursing research.

Living in the mode of existential threat involved feelings of losing control, being in unimaginable chaos, and facing death; experiences that are in line with previous research from the Asian Tsunami of 2004 (Réholm et al., 2008). The research from the Asian Tsunami showed that fear of loss of control over life dominated one’s feelings and the unexpected struggle between life and death took place in a state of total chaos. From another train crash, Hagstöm (1995) showed that the most obvious impact on the survivors was the experience of having been close to death.

Restoring control through being close to others and reconstructing the turn of events were how dealing with the unthinkable was accomplished. We found that the passengers had intense needs to resume the lost control by, for example, focusing on helping fellow passengers. This concurs with Rehnsfeldt and Eriksson (2004) who found that it was important for survivors to have specific needs to perform such as searching for and helping fellow human beings. In another Swedish train crash, powerful needs to help others at the crash site were also described (Arozenius, 1977). Focusing on assisting fellow passengers could be one way of what Bonanno (2004) calls a pathway to resilience. These findings can give ideas for how to help survivors by helping others.

Our study reveals the centrality of others that has also been shown in other studies (Berg Johannesson, Michel, Arnberg & Lundin, 2006; Bowels, 1991; Rehnsfeldt & Eriksson, 2004). Réholm et al. (2008) found that the first step toward progression and recovery is to be seen and validated by another person. Raphael (1977) pointed out that survivors had overwhelming needs to narrate the injury event in detail. Experiences from the Asian Tsunami (Roxberg et al., 2010) also showed that recounting their stories to someone willing to listen helped the survivors to regain meaning. In the present findings, the importance of meeting others who had the same experiences became visible and is in line with other findings confirming that social support is crucial to survivors recovering from serious incidents (Bonnano, Galea, Buccarelli & Vlahov, 2007; Roxberg et al., 2010). In the present study, high value is shown to be placed on the authorities explaining and illustrating what happened during the crash. It was considered essential for putting together the survivor’s puzzle of the event. To join group meetings was important to many of the participants as is also emphasized by Réholm et al. (2008).

Psychological support after train injury events has been proven to be crucial (Bowels, 1991; Lundin, 1991). Retelling their story over and over can be seen as one path of mourning (c.f. Ricoeur, 1988). On the other hand, there were those who felt that the group meetings were not a positive experience. Their experiences were downgraded in comparison to others. This concurs with other studies that have shown that debriefing may exacerbate or lead to the
development of long-term psychological symptoms following traumatic events (Rose, Bisson, Churchill & Wessely, 2009; Wessley & Deahl, 2003).

The participants in this study expressed a need to reconstruct the turn of events by visiting the crash site. Similarly, one-third of respondents in the Asian Tsunami study had visited the affected area and almost all of them viewed this as important (Michel, Berg Johannesson, Arnborg & Uttervall, 2009). Comparable results have also been demonstrated by other researchers (Heir & Weisaeth, 2006; Roxberg et al., 2010) and further narrated by Bowels (1991). These positive effects are considered to be related to an increased understanding of the disaster events (Michel et al., 2009).

The meaning of having cheated death implies a memory for life but can take different paths. Being shackled by history means that passengers had difficulties to moving forward constructively in life and they suffered from, for example, anxiety, nightmares, and depression. These findings are supported by Berg Johannesson et al. (2006) who found that some individuals have difficulties overcoming traumatic memories. Bonanno, Galea, Bucciarelli, and Vlahov (2006) also pointed out that some individuals will be affected in varying degrees over time. Participants in this study were also sensitive to loud noises and were afraid of traveling by train. Similar findings from other train injury events have also been found (Arozenius, 1975; Bowels, 1991; Hagström, 1995; Singh & Raphael, 1981). According to Arozenius (1975), almost all of the survivors affirmed that the train crash remained constantly in their thoughts 13–18 months later. Similarly, other studies (Roxberg et al., 2010) have shown that negative consequences of road trauma last many years after the injury event. On the other hand, there were participants in our study who expressed that they were able to move past the event quite quickly and leave almost everything behind, that is, overcome the haunting of unforgettable memories. Most people affected by major events do not suffer any long-lasting harm (Norris, Murphy, Baker & Perilla, 2004; North, Kawasaki, Spitznagel & Hong, 2004). Positive consequences from trauma experiences are also confirmed in many other studies (Linley & Joseph, 2004; McMillen, Smith & Fisher, 1997; Tedeschi & Calhoun, 1995; Updegraff & Taylor, 2000).

Most of the participants felt that they were given a second chance in life irrespective of how they managed their memories; a result that concurs with what Roxberg et al. (2010) found in their study. Survivors of the Asian Tsunami explained how they initially became anxious about almost everything, but later on became more attentive to caring for family and friends and developed a deep gratitude for being alive.

Objective perspectives, for example, from rescue staff injury databases and survivor questionnaires dominate research reports related to injury events. Few studies exist with a subjective perspective, for example, narratives revealing survivors lived experiences. These two approaches should not be considered to contradict each other because they complement one another with different understandings and knowledge about the same phenomena. Our findings, however, are that the self-estimation scales (GHQ-12 and PCL-C) seem to differ from the subjective narratives. According to these scales, 5 of 14 (36%) suffered impaired general mental health (GHQ-12) and 2 out of 14 (14%) suffered PTSD (PCL-C) (Table I). However, we saw in our results that there were more participants who expressed a negative impact from the train crash than what emerges from the result of the two tests. Based on the participants’ own narratives, it appears that almost all had near death experiences during the crash. Additionally, many were shackled by history, a result worthy of consideration.

A prominent occurrence in this study was that most of the participants experienced the event as unclear, uncontrollable, and insusceptible that according to Enander, Larsson, and Wallenius (1993) are key dimensions to understand and explain individual reactions when exposed to disasters. Additionally, many of the passengers perceived a threat to their lives during the crash, which according to Ozer, Best, Lipsey, and Weiss (2003) is one predictor for PTSD. Experiencing a life threat during uncertain circumstance may thus explain why so many of the survivors were shackled by history in the present study.

Another thought that comes to mind is those who suffer severe injuries from major events receive more attention than those who suffer relatively minor physical injuries. Those with severe physical injuries receive more understanding and help than do their counterparts who are observed to have lesser physical injuries. The result may be that those observed as less seriously injured are overlooked and may not get sufficient help. We suggest a more thorough assessment of those with seemingly mild physical injuries as their need for support might be equal to those with more severe physical injuries.

The findings in this study can also be viewed from other perspectives to reach a deeper understanding of the results. Something that stands out in this study is the participants’ experience of having been close to death; a situation Jaspers (1970) called an existential limit situation. That is, the transition from one phase to another. This transition
challenges the persons’ identity and identity development. Swanson and Tripp-Reimer (1999) pointed out that nurses and other health professionals are in a position to promote well-being during periods of transition. By formulating interventions and strategies, it is possible to facilitate positive transition and minimize health risks.

The implication of this is nonetheless questionable. There are other theories (Bruner, 2004; Erikson, 1998; Lieblich, Tuval-Mashiach & Zilber, 1998; McAdams, Josselson & Lieblich, 2006) relating to the discussion of development of identity and how it is connected to a social environment. In the present context it can, in both the acute phase and in the long run, be seen as the importance and centrality of others. Put in other terms, Frankl (1963) claimed that we are able to understand the world around us and find meaning in life through interaction with others. In our study, the interdependence emerged as extremely important. It appeared, however, that it was primarily family, friends, and fellow passengers who played an important role in recovery, and not medical personnel. Therefore, such closeness with important others should be promoted and facilitated.

Our findings correlate with those of Frankl (1963) who showed how some people can deal with difficulties in a constructive way, whereas others succumb and give up when they run into difficulties. Furthermore, he argued that you can choose an approach and that it is possible to extract a fundamental meaning out of suffering. Antonovsky (2005) took a similar position showing that some people can handle heavy stress better than others and some may even grow from it. This position can be seen in the present study in those who appeared to overcome the haunting of unforgettable memories when others became ill and felt relatively unhealthy as a result of what happened and thus were shackled by history.

Methodological considerations

Studies have pointed out that, for example, severity of injury (Blanchard et al., 1996; Selly et al., 1997) can influence how you feel in the aftermath. Other factors associated with recovery can be age, race/ethnicity, education, level of trauma exposure, social support, frequency of chronic disease, and recent and past life stressors (Bonnano, Galea, Bucciarelli & Vlahov, 2007). None of the factors mentioned above have been considered in the present study because the study group is too small to make any general conclusions. However, it is realistic to assume that these factors influenced experiences of the crash and further the capacity to handle and recover from the crash.

The proportion of women and men among the interviewed is about the same as the proportion of passengers on board the train (83% vs. 86% women), respectively. One reason for the low number of participants (22%) is likely because they had to actively contact us if they desired to be included. We may had have more participants if we had been able to contact them. We cannot ignore that our results would probably have been slightly different if more men had participated in the study because it is known that women generally have a higher risk for greater distress when exposed to, for example, traumatic events (Berg Johannesson et al., 2006; The National Board of Health and Welfare, 2008). However, life itself can become more meaningful to women than for men after a traumatic event (Berg Johannesson et al., 2006). Women may be more likely to experience greater levels of personal growth than what men would (Tedeschi & Calhoun, 1995). Clearly, it would have been useful to have greater variation in the sample, for example, more men and more passengers participating. This would be especially true for survivors from the third carriage. Perhaps, if we had the greater variation in participants, it would have given us a greater variation of experiences resulting in broader understanding.

Out of 65 possible participants, 14 participated. Passengers who were less affected by the train crash were possibly less motivated to participate in the study as they may have thought that they did not have much to contribute. On the other hand, the situation could also be reversed, that is, the low number of participants could be because passengers who were still deeply affected avoided participation. However, the latter is less likely because a comparable study following the Asian Tsunami of 2004 (Hussain, Weisaeth & Heir, 2009) revealed that nonparticipation correlated to lack of interest and to thinking that one did not have relevant experiences.

Conclusion

Passengers who have been involved in a train crash have experienced severe vulnerability and a threat to life irrespective of the estimated severity of the train event, for example, measured in number of fatalities and severely injured passengers. In our study, the interdependence emerged as important and was proved by focusing on helping other passengers on site. By doing so, they regained the loss of control and kept the chaos at bay. The need for family, friends, and fellow passengers during
the whole recovery process turned out to be crucial as well.

**Implications**

The centrality of others, especially family, friends, and fellow passengers, turned out to be central to one’s well-being why such closeness should be promoted and facilitated. It may also be helpful to utilize survivors who want and are able to help others on site after an injury event. This could constitute a way of coping both for them and for those whom they are helping. It is important to listen to the survivor’s narratives regarding their physical injury because survivors with minor injuries or those who do not show signs of, for example, PTSD may otherwise be overlooked, thus risking their health and prolonging their suffering.

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**References**


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Survivors’ experiences of media coverage after traumatic injury events

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Keywords:
accident site, journalists, media exposure, survivors experience, train crash, trauma journalism, qualitative content analysis

Abstract
Survivors’ experiences of media coverage at traumatic events, is still a limited research area. The aim of this study was to explore survivor’s experiences of interacting with journalists at the scene, opinions about the media coverage that follows and of personal media exposure. Qualitative interviews were conducted with passengers from two train crashes in Sweden. A qualitative content analysis generated meaning units, subcategories, and categories. Survivors experienced interacting with journalists mainly in three ways: harmful, negligible, and helpful. Media content and personal media exposures were experienced in a similar way: uncomfortable, insignificant, and useful. Journalists and media coverage have a large impact on survivors’ experiences following a traumatic event. This knowledge is an essential tool for emergency responders, such as ambulance nurses, to minimize the negative outcomes of collaborations between victims and media staff at incident sites. Media coverage can, in the long term become an important piece of the puzzle aiding the victims in understanding and processing the traumatic event.
INTRODUCTION

Traumatic injury events usually lead to intensive media coverage, both at the scene and during the aftermath. Survivors must handle and collaborate with the media under the influence of acute stress and loss of control. The media needs the survivors’ eyewitness accounts and the public desire information about the events. But, how do survivors experience journalists at the scene and the media coverage following the event? Can media coverage also be helpful and supportive to the survivors? A better knowledge about survivors’ experiences could be of extreme value to emergency responders, such as ambulance nurses. Research in this field is limited.

BACKGROUND

Both the public and people directly affected tend to criticize media coverage from traumatic events. Roxberg and co-authors (2010) found that media coverage caused memories of the tsunami disaster in Asia, 2004 to return. A study on survivors’ experiences of a major bus crash found that encounters with the media at the crash site and in the immediate aftermath to be mainly negative. Passengers felt the filming and photography was intrusive and scary (Doohan and Saveman, personal communication). Other studies indicate risks of revictimization when interviewing shocked survivors. Journalists’ actions sometimes are perceived as intrusive, insensitive, and sensational – adding to the survivors’ grief (Côté and Simpson, 2006; Haravouri et al., 2011; Jemphrey and Berrington, 2000; Kay et al., 2010; Libow, 1992; Maercker and Mehr, 2006). Studies also show that tension exists between the journalists’ need for information and the privacy of the survivors. Some survivors perceive journalistic presence on incident sites as disturbing. It is a provocative situation to both survivors and emergency personnel when reporters and photographers act as professional eyewitnesses instead of helping. The latter is not their role at the scene, but a regular wish of the survivors (Jemphrey and Berrington, 2000; Englund, 2000; Englund, 2008, Englund et al., 2012; Swedish Government Official Reports: 1999a; 1999b).

Ethical and practical guidelines for media staff exist globally (mediawise.org.uk) and are often published by the national journalists’ trade unions. Some of these ethical considerations will appear both at incident sites and at hospitals meaning that, e.g., nurses may enter the situation either facilitating or preventing contact between victims and journalists.

A Gothenburg fire disaster study (Englund, 2008) showed that in certain situations it can be challenging for the present journalists to follow the Swedish Codes of Conduct (Swedish Union of Journalists: www.sjf.se). Policies like “be careful with pictures” and “show due respect when on photographic assignments and when obtaining pictures, especially in connection with accidents and crimes,” leave much leeway for individual interpretation. Working under stress, journalists sometimes find it hard to make proper decisions. A study by Lundålv and Volden (2004) showed that there is an obvious risk that photographers reinforce the negative stress of emergency responders at incident sites. This may ultimately also affect the victims. The emergency responders further had experiences of fatalities and severely injured victims having been portrayed dramatically in the media. Englund (2002) found the interaction between emergency responders and media staff heavily influenced by the interaction between the media and victims. Working under acute stress with medically and psychologically vulnerable victims makes the professional work and ethical decisions difficult. The media often becomes a communication channel for suffering, stressed, and angry survivors. This demands extraordinary skill and composure from professionals working at a trauma scene.

The media management in Norwegian healthcare, after the terrorist attacks July 22, 2011 in Oslo and Utøya, was recently evaluated by the Swedish National Board of Health and Welfare (Englund et al., 2012). Among the conclusions were that media management guidelines were extremely important for emergency responders at the scene and for hospital staff. This was especially true when the affected are psychologically or medically unable
to evaluate the consequences of participating in media interviews or photo sessions. Earlier studies have highlighted the importance of teaching and preparing nurses for the needs of survivors who have gone through life-changing trauma (Råholm et al., 2008). Previously mentioned studies indicate that media coverage from traumatic events constitute risk of aggravating the situation, and in the long term could lead to secondary victimization (Campbell and Raja, 1999) of survivors and other affected persons. Insensitive or unprofessional encounters between the media and survivors or eyewitnesses can hypothetically further burden those affected.

Train injury events are relatively uncommon and usually cause considerable media attention. Still, while minor and major injury events – not at least man made or technical ones – are more frequent than major disasters, we find it important and interesting to study those smaller “everyday accidents.” Even if rescue operations and media attention are less, the individual experience of surviving a traumatic event can be equally strong and difficult for the victims as after bigger incidents.

Exploring how the survivors’ experience encounters with journalists and photographers at traumatic events and how survivors reflect on the impacts on their recovery, is of interest. The aim of this study is to explore survivors’ experiences of interacting with journalists, media coverage, and personal media exposure following two Swedish train crashes.

METHODS

The study context

The basis of our study is two Swedish train crashes. In Nosaby, 2004, a truck fully loaded with wooden pellets was stuck at a level crossing on a railway track when an oncoming three-carriage passenger train crashed straight into it (Swedish Accident Investigation Board, 2006). The crash resulted in two deaths and 71 suffered non-fatally injured (Forsberg, Holgersson, and Björnstad, personal communication). In Kimstad, 2010, a six-carriage passenger train crashed into the front bucket of an excavator resulting in one death and 20 non-fatally injured (Holgersson, et al., 2012).

Shortly after the events several passengers were documented – interviewed and photographed – by journalists from both the print, radio, and television media that arrived to the scene. Both events received intensive national, regional, and local media coverage the first day.

Police records provided information on the 71 passengers of the Nosaby train, 65 were asked to participate in this study. Three were deceased (two in the crash and one later) and three were foreign nationals. Fourteen passengers agreed to participate, 12 women and two men aged 20-64 (at time of interview). One reason for the low number of participants is likely because they needed to contact the researchers if they desired to be included. The Regional Ethics Committee determined this design. The Swedish Accident and Investigation Board provided records for the Kimstad train crash for the one fatality and 20 passengers. Sixteen passengers were asked to participate because four were children (<18 year) and therefore excluded. All agreed to participate; an equal number of women and men between the ages of 20-63 (at time of interview). In total 30 survivors were interviewed, 14 participants from the Nosaby train crash and 16 from the Kimstad train crash.

Data collection

An interview, including semi-structured questions concerning the media, was carried out four years after the Nosaby train crash and about three months after the Kimstad train crash. One question was: “How did you experience the presence of journalists at the crash site?” others were “To what extent did you experience journalists showing due respect to you and others affected?” and “Did you, at any point, suffer from “publicity injury?” The interviews were performed face-to-face (n=13) and by telephone (n=17). Also, during the interview the participants freely narrated (Riessman, 2008) their crash story, which is reported elsewhere (Forsberg and Saveman, 2011). The interviews lasted 20 to 80 minutes (average 40 minutes) and were recorded and transcribed verbatim.
Data analysis

The transcribed interview parts (Kvale and Brinkmann, 2008) relating to the semi-structured questions was processed using a qualitative content analysis (Graneheim and Lundman, 2004). The transcribed text was read and reread to acquire a broad overview of the passengers’ experiences. This led to divisions of meaning units that were condensed while preserving the core content. The condensed text was later abstracted and given codes, which after comparison (within and across them) were sorted into 11 separate subcategories. Six categories were then formulated based on the whole text, the content of subcategories and the pre-understanding of the text. Example of the content analysis can be seen in Table 1.

Ethical considerations

This study is in accordance with principles outlined in the Declaration of Helsinki (World Medical Association, 2008) and is approved by the Regional Ethics Committee at Umeå University (No 09-143 Ö). Information about the research study was given to the Nosaby passengers by letter with a request to participate. If passengers chose to participate, informed consent was given either by phone or e-mail. Information about the research study was given to passengers from the Kimstad crash when they were contacted on behalf of The Swedish Accident Investigation Board. Informed consent was, thereby, given by phone. Participants were informed that participation was voluntary and were guaranteed confidentiality; therefore, fictive names have been used in quotations. Participants from the Nosaby crash were given names starting with the letter N and passengers from the Kimstad crash with the letter K.

RESULTS

The analysis generated a total of three categories and six subcategories concerning survivors’ experiences of interacting with journalists. Their experiences of media content and personal media exposure also generated three categories and five subcategories. The results show patterns and diversity of media coverage experiences. Categories, subcategories, and related quotations are shown in Tables 2 and 3.

Experiences of interacting with journalists

Survivors experienced interacting with journalists in diverse ways. Some survivors found it harmful feeling violated and provoked by the journalists. Other survivors experienced interaction with them as negligible; explained by them becoming unaware and unaffected. Finally, some experienced interaction with journalists as helpful, acknowledging, and supportive after the traumatic event.

Interacting with journalists is harmful

Being violated. One category of passengers described feeling helpless and vulnerable to the photographers; meaning they were easily outraged. This group of survivors felt dizzy, shocked, and unable to judge the significance of being interviewed or photographed during the stressful situation. Some mentioned they were unprepared for the cameras. Other passengers felt that the photographers confronted them “flying at them.” The photographs and interviews further triggered their already overwhelmed stress levels and violated their privacy. Some repeatedly told the media representatives that they refused to be interviewed. That was experienced as quite offensive. This could be seen as the final straw pushing them over the edge. There were further examples of stressful interactions ending as demanding and burdensome. The media presence hindered their coping ability.
Then, after a couple of days at home, one reporter from a local paper called and kept asking, asking, asking and I said that I had no comments about the whole thing /…/ but he went on and on until I started crying – also that time – and I hung up on him.

They are like vultures, I feel sorry for them, but they are the ones who choose the profession. They even stood outside the ambulance intake and took photos. If I had been exposed myself, I would have hit them.

Table 2. Categories, subcategories and quotations on experiences of facing journalists

<table>
<thead>
<tr>
<th>HARMFUL</th>
<th>NEGLIGIBLE</th>
<th>HELPFUL</th>
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</thead>
<tbody>
<tr>
<td>Being violated</td>
<td>Being provoked</td>
<td>Being unaware</td>
</tr>
<tr>
<td>Being unaffected</td>
<td>Being acknowledged</td>
<td>Being supported</td>
</tr>
<tr>
<td>We all sat in uncertainty, and then someone came and wanted a story /…/ I didn’t find that very dignified /…/ I recall that he asked me questions before he asked if I wanted to participate /…/ My privacy was not protected in any way. (Nadine)</td>
<td>There were a lot of people with cameras around their necks and the paramedics wanted help to carry a stretcher. I just couldn’t understand why they were not helping. I was very angry and irritated [with the journalists]. That was really frustrating. (Nicole)</td>
<td>I did not notice any journalists because I closed my eyes and concentrated on breathing the whole time. (Naomi)</td>
</tr>
<tr>
<td>They are just doing their job /…/ I was not bothered by it, I understood. He did the research, he wanted to portray what had happened and it was important that it was done and he did it in a good way anyway. (Ken)</td>
<td>They are just doing their job /…/ I was not bothered by it, I understood. He did the research, he wanted to portray what had happened and it was important that it was done and he did it in a good way anyway. (Ken)</td>
<td>The first memory I have is of a journalist who came up and asked how I felt. (Nicolas)</td>
</tr>
<tr>
<td>I actually was asked if there was something the journalist could do. So I told him that the guys were really thirsty. He went away and bought lemonade, with his own money… That was great, I would say! (Kim)</td>
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Table 3. Categories, subcategories and quotations on experiences of media content and personal media exposure

<table>
<thead>
<tr>
<th>UNCOMFORTABLE</th>
<th>INSIGNIFICANT</th>
<th>USEFUL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-traumatizing</td>
<td>Irritating</td>
<td>Untouching</td>
</tr>
<tr>
<td>I thought it was very uncomfortable to look at. (Kate)</td>
<td>It is typical for the media always to … distort the truth a little. (Katelyn)</td>
<td>A few hours later there were lots of pictures on the Internet from when I crawled out of the carriage /…/ They had not asked me, but I did not bother. (Nicole)</td>
</tr>
<tr>
<td>While seeing the papers, I immediately started to cry. (Nancy)</td>
<td>They wrote things I definitely had not said /…/ several things to the contrary of what I said. (Ken)</td>
<td>I thought it [the media coverage] was good, actually because the event was so unreal. It sort of became a way to comprehend what had happened. (Niki)</td>
</tr>
<tr>
<td>I was very angry and annoyed at reporters that day, later I was nevertheless very grateful because it provided evidence of my coping. That was useful to me /…/ I would not have come this far if it had not been for those press photos. (Nicole)</td>
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</table>
Being provoked. Other passengers felt provoked by the presence of journalists because media representatives did not help. Viewing reporters and photographers as passive witnesses elevated their feelings of anxiety, “just there to snoop around...” The crash experiences were considered private and not something to be portrayed in the press. They thought, “Journalists really had nothing to do with it!” On one occasion a survivor thought that the reporter was “an irrelevant jerk” because he waited outside the ambulance doors just to take the right photo. Passengers confronted by journalists at the scene, could find them very nonchalant, rude, and disrespectful. One example is of a photographer begging a passenger not to smile too much for some snapshots. This irritated the passenger. To cope, some passengers even degraded certain reporters as something “inferior” or “subhuman.”

Interacting with journalists is negligible

Being unaware. One category of passengers never noticed journalists at the site. Some survivors were inattentive for different reasons. Their minds were elsewhere; some explained it like being inside a bubble. Others were injured, lying down, or concentrated on helping other injured passengers. Because of these reasons they did not notice various kinds of professionals and eyewitnesses at the scene or what happened around them.

Being unaffected. Even though some passengers noticed journalists early, they did not care. They found the media presence expected and normal at such events. These passengers also spoke of journalists staying in the background and not approaching too close. They considered that all reporters must keep the balance between sensationalism and news journalism but still fulfill their mission.

Interacting with journalists is helpful

Being acknowledged. To be interviewed and photographed at the crash scene also meant that the passengers were seen and acknowledged by somebody else. The journalist became a listener in the midst of chaos and was perceived as caring. These survivors expressed a great understanding for the journalists’ mission. They also perceived the media staff to show due respect to passengers, and kept a safe distance behaving professionally.

Being supported. Passengers also could experience journalists as practical and helpful in the middle of the confusion. One reporter was described as a “servant,” highly appreciated by the passengers. Another was perceived as genuinely wanting to help and not primarily looking for good media coverage.

Experiences of media content and personal media exposure

The media coverage and personal media exposure, when applicable, was described as uncomfortable. These passengers found it re-traumatizing and irritating and avoided watching TV or listening to radio news. Another kind of experience was to see the media coverage and exposure as insignificant, and thereby not emotionally touching. Nevertheless, there were experiences of the news coverage and exposure as a useful tool because it served to enlighten and aid healing.

Media content and exposure is uncomfortable

Re-traumatizing. Watching TV, listening to the radio, or reading newspapers could be painful to some survivors as well as for some relatives. Continuous news reports about the crash became an emotional trigger. While survivors were transferred from the crash site to the hospital, radio news on the bus was described as stressful. Passengers had to wait days, weeks, or months before they felt able to view or listen to any media coverage. Some still cannot – after several years. One passenger explained that she still covers photos of the train carriages with her hand, when looking at the press cuttings.
Irritating. Without their permission, passengers could find themselves on a tabloid front page. It also could be annoying that the media chose to write in the way they did, because the survivor experienced the event in a totally different manner. One opinion was that the reports were generalizing and exaggerating. Media bias only allowed a very selective view of what happened.

Media content and exposure is insignificant

Untouching. Some survivors were uninterested in consuming any media coverage of the event. They were so focused on their own recovery from the incident that they cared little when misquoted in the newspaper. Passengers also could mention that they took part in the coverage but never thought anything special about it; thus, they remained unaffected by the media reports. There were examples of passengers seeing photos of themselves in the papers. Nevertheless, most found this normal because journalists are always on hand at such events. It was not strange and not perplexing.

Media content and exposure is useful

Enlightening. The day of the crash could also be described as a black hole for passengers, unrealistic and difficult to comprehend. Media reports and crash photos that void and were perceived as helpful in reconstructing what really happened and why. Passengers with these kinds of reactions read, listened, and watched every report they could. It helped them understand what they had gone through and became a tool for interpreting the traumatic event. Furthermore, it was experienced as important for relatives.

Healing. Survivors expressed gratitude for the media coverage and photos of themselves. In hindsight, they said they used the media content as a coping mechanism against reactions after the event. Some collected all the reports that came their way. By collecting information about the crash, survivors could go back to the “box of memories,” which provided a sense of security. There are also examples of passengers who chose not to, but who knew where to look and what to look for if they desired.

DISCUSSION

The main findings were that passengers described both interacting with journalists at the scene and media coverage, including personal exposure, in many ways. Varieties appeared through a broad spectrum of experiences – from very negative to mainly positive. The perceptions were, however, not always static and could change over time.

A somewhat surprisingly category was expressions from passengers who did not care much about media presence or media coverage. They found the media presence expected and normal at such events. However, earlier studies mainly have highlighted examples of survivors experiencing either good or bad behavior among journalists (Kay et al., 2010).

There were passengers perceiving collaboration with journalists as harmful, involving feelings of violation and invasion of privacy. Others expressed that the photographing and interviewing exasperated their already overwhelmed stress reactions. Experiences from a bus crash showed that many journalists acted unprofessionally at the crash scene and further confronted relatives in an insensitive way. Some journalists even waited outside funeral parlors to get interviews with family members of deceased passengers (Doohan and Saveman, personal communication). Similar examples are mentioned in earlier studies as well (Hodkinson and Stewart, 1998). A study from school shootings in Finland, furthermore, showed that interviews were associated with elevated distress (Haravuori et al., 2011). Other studies also show that media presence at trauma events can add to the burden of grief among survivors. The Hillsborough disaster 1989 and the shootings at Dunblane Primary School 1996, both in the UK, are some examples (Jemphrey and Berrington, 2000). The 1998 Swedish fire disaster in Gothenburg (Swedish Government Official Reports 1999b) shows similar tendencies. Media coverage and
personal exposure also can be overwhelming; something victims have to find ways to deal with (Råholm et al., 2008). In the present study there were examples of survivors experiencing media content and exposure as uncomfortable, raising feelings of re-traumatization and irritation. Even so, pictures of the crashed train could be handled by covering them.

Despite critical voices often being the most heard ones after traumatic events, there were many examples of positive experiences in our study; both positive collaboration with journalists on site and positive experiences of the media coverage. Passengers felt they were seen, had someone to talk to, and even helped by a journalist. One interesting finding was that survivors’ experiences of reporters and photographers roles changed. During the recovery process the significance was manifested. Passengers could at the crash scene experience journalists harmful nevertheless they later found media content including personal exposure as a helpful part of their coping process. Many parts of the media coverage became important puzzle pieces for their individual recovery. In a way, the media coverage contributes to a “sense of coherence” (c.f. Antonowsky, 1987) and a part of the collective memory. The latter was also exemplified in a study with survivors from the Gothenburg fire disaster in 1998 (Peterson, 2006).

Morse (2001) states that a person who endures a stressful experience needs distant respect from others, therefore, there is a need to view survivors’ experiences considering media ethics. This leaves much room for individual interpretations: What is due respect? As shown in our study, survivors do not always find the media to follow their own rules – that they do not show “due respect.” Despite media ethics, journalists assume different roles, which can partly describe why journalists behave as they do and are perceived so differently. The individual approach can be more or less problem solving and compassionate and more or less personal or professional. This, of course, influences survivors’ experiences (Englund, 2008).

We regard journalistic presence and media coverage to be natural and important parts of traumatic events. Nevertheless, the journalists should be sensitive to the situation and needs of the survivors. The Jokela School shootings (Haravouri et al., 2011) showed that a traumatic event may cause mental blackouts leaving the affected oblivious. As in our study, they may be unaware of the media’s presence – perhaps not even aware of being interviewed. In these cases, emergency responders, like ambulance nurses, suddenly become the only ones who can speak for the injured. Similar experiences were accomplished at the July 22nd terror attacks in Norway 2011. Hospital staff performed an important role as gatekeepers between the injured and journalists (Englund et al. 2012). Passengers from a bus crash described that they did not know how to escape the journalists because they were surrounded (Doohan and Saveman, personal communication). Therefore, it is important that emergency responders are aware that being, for example, photographed or interviewed in this condition can add to the burden of grief and suffering for survivors and their relatives. Unfortunately, non-physical needs are occasionally unnoticed (Bryne, 1997; Baillie, 2005). Nevertheless, medical care has to be viewed, as more than just handling acute physical needs. Morse and co-authors (1994) argues similarly that the role of nursing is to provide total comfort, but that it is unattainable in patient care. It, however, is important that photographers’ get access to document the event, i.e. photos of the crashed train and that reporters can describe what happened. This documentation can be important pieces in the coping process for the survivors. To use the words of Coté and Simpson (2000): Avoiding all contact with deeply troubled people is not the solution. A goal, instead, could be “to encourage more of the better and less of the worse” (p. 223).

These results give us perspective of what emergency responders such as ambulance nurses and journalists can consider at traumatic events.

The two crashes occurred six years apart. Even so, we assume that the journalists’ way of working at trauma scenes has not changed significantly during these years. The time between the crash and the date of the interview differed between the two studies. In the case of Nosaby, more time elapsed before the interviews were conducted than in Kimstad. This might have, in
some way, influenced the survivors’ reflections when telling their stories.

The analysis has been performed in a logical and systematic way by all three authors. The subcategories and categories were checked by going back and forth to the text, and the internal logic and consistency was verified by quotations from the text (Table 2 and 3) (Polit and Beck, 2006). We assume our methods and findings are transferable to other similar traumatic events where survivors have experiences of interacting with journalists, media content, and personal media exposure. We also argue that our findings are valid; even if narrated texts are open for different interpretations (Krippendorff, 2004).

CONCLUSIONS AND IMPLICATIONS

The media needs survivors as eyewitnesses, and the public desire stories and information. Media coverage has a large impact on survivors’ experiences following traumatic events. Survivors and their relatives need the stories for their coping, recovery, and search for meaning after traumatic events. The reporting should, however, be done in the most sensitive and appropriate way. The knowledge generated by this study could be valuable for emergency responders, such as nurses because they suddenly can become important spokespeople for the injured, but also for journalists and reporters.

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CONFLICT OF INTEREST

No conflicts of interest exist. No other sources of financial support, corporate involvement, patent holders, nor personal relationships with other people or organizations exist that could inappropriately influence the work.
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