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Citation for the original published paper (version of record):

Gustafsson, T., Eriksson, A. (2013)

Off-road vehicle fatalities: a comparison of all-terrain vehicle and snowmobile accidents in Sweden

International Association of Traffic and Safety Sciences (IATSS) Research, 37: 12-15

<https://doi.org/10.1016/j.iatssr.2013.06.002>

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Research article

Off-road vehicle fatalities: A comparison of all-terrain vehicle and snowmobile accidents in Sweden



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ARTICLE INFO

Article history:

Received 9 April 2013

Received in revised form 17 June 2013

Accepted 17 June 2013

Available online 29 June 2013

Keywords:

All-terrain vehicles

ATVs

Snowmobiles

Fatal crashes

Fatalities

Off-road vehicles

ABSTRACT

This study investigates accident fatalities involving two types of off-road vehicles: snowmobiles and all-terrain vehicles (ATVs). All snowmobile fatalities in Sweden from the 2006/2007 season through the 2011/2012 season, and all ATV fatalities from 2007 through 2012, were retrospectively examined. A total of 107 fatalities—57 snowmobile-related and 50 ATV-related—were found. Most deaths occurred on weekends (71% of the snowmobile-related and 72% of the ATV-related). A majority of the fatalities were males (91% and 94%), with the largest share in the age group 40–49 years (19% and 24%). The most common causes of death were blunt trauma (56% and 66%), drowning (30% vs 6%), and traumatic asphyxia (9% vs 14%). Among victims who were tested (95% vs 92%), a very high share was found to be inebriated (59% vs 61%), and mean blood alcohol concentration was also high (1.9 vs 1.7 g/l). Forty-seven percent of snowmobile-related fatalities and 48% of ATV-related fatalities had a blood alcohol concentration above 1.0 g/l. This means that there was a very strong association between off-road vehicle fatalities and drunken riding; steps to prevent riding while intoxicated seem to be the most important preventive measure. Automatic measures such as alcolocks are probably the most effective. The obvious at-risk group to target is middle-aged men with high alcohol consumption.

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1. Introduction

Previous literature on the nature of vehicular crashes and fatalities has mostly focused on road traffic incidents, while only limited interest has been paid to off-road vehicle crashes and fatalities. It is however of interest to examine fatalities associated with off-road vehicles due to the rising popularity of such vehicles. In Sweden, for example, the two most popular off-road vehicles are the snowmobile and the all-terrain vehicle (ATV); for every 100 passenger cars registered there are currently ~5 snowmobiles [1] and ~2 ATVs registered (Johan Strandroth, Swedish Transport Administration, personal communication 2013).

Since its introduction to the Swedish public in the 1960's, the snowmobile has been steadily increasing in popularity and has shifted from being used mostly for work purposes to being used mostly for leisure activities. The number of registered snowmobiles has grown from ~177,000 in year 2006 to ~223,000 in 2011 [1]. ATVs have also grown in popularity; the number of registered ATVs increased from ~36,000 in year 2007 to 91,000 in 2012 [1]. Because ATVs are designed to move in rough terrain, they are used in forestry,

farming and hunting. The main explanation for their increasing popularity, however, is their use as recreational vehicles [2].

The increasing use of these vehicles, however, has had some drawbacks. Many riders do not have the special skills needed to handle off-road vehicles. In addition, both snowmobiles and ATVs are related to a significant share of deaths occurring outside of the designated terrain, such as driving a snowmobile into open water or through ice, or driving an ATV into the roadside environment while driving on a road. Furthermore, fatalities with both of these vehicle types are highly related to alcohol inebriation [3–5].

The aim of this study was to analyze recent trends regarding fatal crashes involving off-road vehicles, and to compare and contrast commonalities and risk factors regarding the two main types of off-road vehicles.

2. Materials and methods

All fatalities related to the use of either snowmobiles or ATVs that were examined at any of the six Departments of Forensic Medicine in Sweden were included. The time period studied included ATV-related deaths from 1 January 2007 through 31 December 2012, and snowmobile-related deaths from the 2006/2007 season through the 2011/2012 season.

A complete autopsy was performed in each case. Police reports (presenting the vehicle, its damages and defects, the circumstances

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Peer review under responsibility of International Association of Traffic and Safety Sciences.

of the crash, and background data on the victim, etc.) and hospital records (in case of initial survival; presenting the condition of the victim on arrival, clinical findings, therapeutic measures, etc.) were studied. Furthermore, the medico-legal autopsy reports (presenting injuries, gross and microscopic pathoanatomical findings, toxicological findings, cause and manner of death, etc.) were reviewed.

The laws and regulations regarding medico-legal autopsies, stating that all unnatural deaths must be subjected to a medico-legal autopsy, ensure that there are few, if any, missing cases.

3. Results

A total of 107 deaths were included in this investigation.

3.1. Snowmobile-related deaths

We identified 57 snowmobile-related deaths during the study period, an average of 9.5 annual fatalities. No obvious time trend was detected (Fig. 1). All fatal events occurred from October through May with a peak in April (26%) (Fig. 2). A large proportion (71%) of the deaths occurred on weekends (Friday through Sunday) with the highest share on Saturdays (41%).

3.1.1. Victims

Of the 53 (93%) fatalities where it was documented, 46 (90%) were riders and 7 were (10%) passengers. Most fatalities occurred in the age groups 30–39 years (19%) and 40–49 years (19%) (Fig. 3). The majority (91%) of victims were males.

3.1.2. Injuries

Collisions with immobile objects and going through the ice were the most common mechanisms of injury (32% each) followed by being thrown from the vehicle (10%), being pinned under the snowmobile (9%), and collision with another vehicle (7%).

The most common mechanisms of death were blunt force trauma (56%), drowning (30%), traumatic asphyxia (9%), and hypothermia (5%). Blunt trauma to the head was a more common (66%) cause of death than blunt trauma to the chest (34%). A majority of cases with fatal chest injury involved rib fractures (82%).

3.1.3. Alcohol

Blood alcohol analyses were performed in 54 cases (95%), with alcohol detected in 32 (59%). The mean alcohol concentration in femoral vein blood was 1.9 g/l, and 47% of all fatalities had a blood alcohol concentration exceeding 1 g/l.

3.1.4. Helmet use

Documentation regarding helmet use was lacking in 42 cases (74%), but among the 15 cases where it was documented, 7 (47%) were wearing a helmet while 8 (53%) were not. Among those who

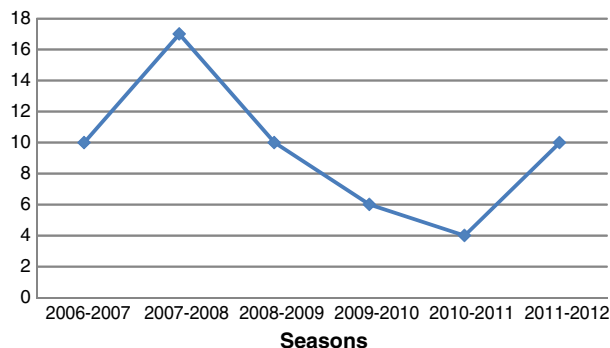


Fig. 1. Snowmobile-related fatalities per season, 2006/2007 through 2011/2012 (n = 57).

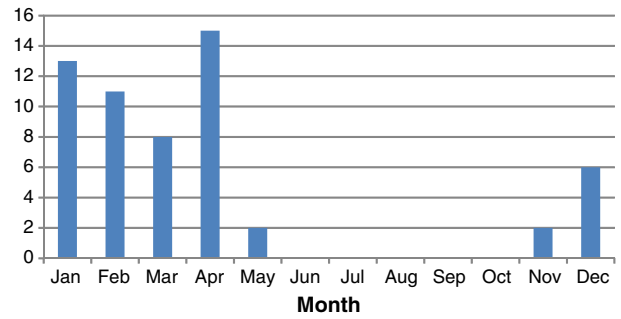


Fig. 2. Snowmobile-related fatalities per month, 2006/2007 through 2011/2012 (n = 57).

were not wearing a helmet at the time of the crash, 5 (63%) suffered fatal head or neck trauma. Among those who were wearing a helmet, 2 (29%) individuals suffered such trauma, one of whom had not properly fastened the helmet.

3.2. ATV-related deaths

There were 50 ATV-related deaths from 2007 through 2012, an average of 8.3 annually. A peak was reached in 2011 with 11 deaths, but no obvious time trend was seen (Fig. 4). Fatal incidents were spread throughout the year (Fig. 5) with a peak in June–September (52%). A large proportion of the deaths (72%) occurred during weekends (Friday through Sunday), with a peak during Saturdays (38%).

3.2.1. Victims

Out of the 46 (88%) fatalities where documentation was available, 44 (96%) were riders and 2 (4%) were passengers. Most fatalities occurred in the age group 40–49 years (24%) (Fig. 6). Only three female victims were found, all of whom were in the age group 10–39 years.

3.2.2. Injuries

Driving the ATV into the roadside environment while driving on the road was the most common accident mechanism (26%), followed by being pinned under the ATV (22%), collision with an immobile object (20%), being thrown off (16%), collision with another vehicle (10%), going through the ice (2%), and being pulled by winch (2%). In one case, the mechanism of injury was unknown.

The most common mechanisms of death were blunt trauma (66%), traumatic asphyxia (14%), drowning (6%), natural death due to cardiac disease (8%), and complications of trauma such as pulmonary embolism (2%) and fat embolism (2%). In one case the cause of death could not be determined (2%). Head injury (58%) was the most common type of fatal blunt trauma, followed by chest injury (27%) and

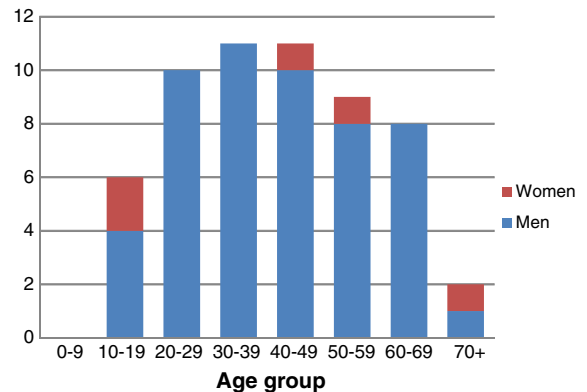


Fig. 3. Age and sex distribution among snowmobile-related fatalities, 2006/2007 through 2011/2012 (n = 57).

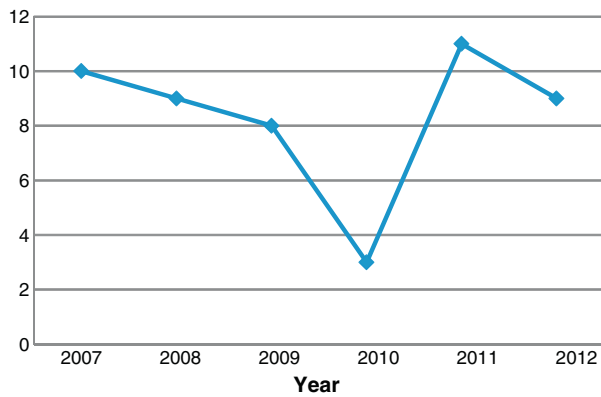


Fig. 4. All-terrain vehicle-related fatalities per year, 2007 through 2012 (n = 50).

abdominal injury (15%). A majority of cases with fatal chest injury involved rib fractures (89%).

3.2.3. Alcohol

Blood alcohol analyses were performed in 46 cases (92%); blood drawn from the femoral vein (in one case from pleural blood) tested positive for alcohol in 28 cases (61%). The mean alcohol concentration was 1.7 g/l, and 48% of all fatalities had a blood alcohol concentration of more than 1.0 g/l.

3.2.4. Helmet use

Documentation of helmet use was lacking in 35 cases (70%). Among the 15 where it was documented, 2 (13%) were wearing a helmet while 13 (87%) were not. Out of those who *were not* wearing a helmet at the time of death, 9 (60%) suffered fatal head or neck trauma. Further, both of those who *were* wearing a helmet received fatal head or neck trauma.

4. Discussion

In this study we examined all fatalities related to snowmobiles and ATVs occurring in Sweden during the recent 6 year study period. Although theoretically there may be missing cases, this number is expected to be very low and not to influence the results of the study.

The fatality incidence remained steady during the study period, and did not show any obvious time trends, despite an increase in the number of registered snowmobiles from ~177,000 in 2006 to ~223,000 at the end of 2011 (a 26% increase), and an increase in the number of registered ATVs from ~36,000 in 2007 to ~91,000 at the end of 2012 (a 153% increase) [1].

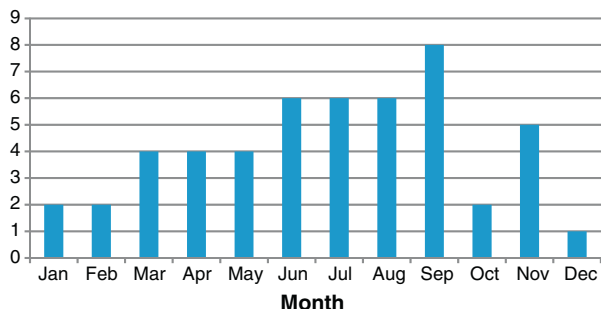


Fig. 5. All-terrain vehicle-related fatalities per month, 2007 through 2012 (n = 50).

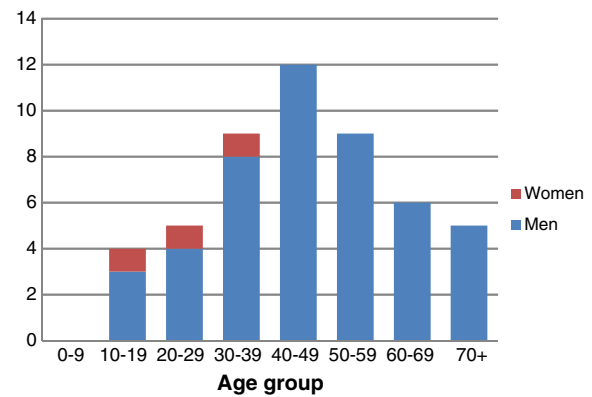


Fig. 6. Age and sex distribution among all-terrain vehicle-related fatalities, 2007 through 2012 (n = 50).

4.1. Snowmobile-related fatalities

An annual average of 4.9 deaths per 100,000 registered snowmobiles during the study period represents a significant decrease as compared with previous studies that reported an incidence of 8.0–8.6 per 100,000 registered snowmobiles [3,6].

Most fatalities occurred during weekends, as demonstrated previously [3,6,7], reflecting the fact that the major share of snowmobile usage is during leisure time. A peak was seen in the month of April, probably related to increased exposure during the Easter holidays, increased daylight, higher temperatures, and compressed snow allowing higher speeds.

4.1.1. The victims

The average age of the victims was 42 years, with the vast majority male. This reaffirms previous studies of fatal and non-fatal snowmobile accidents in Sweden and elsewhere [3]. The share of male victims was significantly higher than for passenger car fatalities, possibly because snowmobile riding in general is more popular among men.

4.1.2. The injuries

As in previous studies, the majority of lethal injuries were caused by blunt trauma, mostly to the head. Though the benefit of a helmet law has been questioned [7], data gathered in this small series of fatalities suggest that helmet use may have some injury-reducing effects. This question obviously needs further investigation, but requires significantly improved reporting of helmet use in police reports.

The high number of drowning fatalities in vehicle incidents is a characteristic of the snowmobile as compared to other land motor vehicles (cf [8]) and confirms findings from previous studies [3,6] that highlight the danger of riding a snowmobile on frozen water.

4.1.3. Alcohol

Snowmobile fatalities seem to constitute one of the groups—perhaps the group—with the highest share of alcohol inebriated victims (55–81%) [3,6] among all accident fatalities, despite the fact that in Sweden the law regarding drunk driving is the same for snowmobiles as for passenger cars and motorcycles. This high share—and high mean blood alcohol concentration (1.6–1.9 g/L)—has been unchanged for decades [3,6]. These high blood alcohol concentrations are highly suggestive of chronic alcohol abuse [9]. In this study, 47% of all fatalities had a BAC exceeding 1.0 g/l, the limit of aggravated drunken driving in Sweden, indicating that disregard of alcohol legislation is much more widespread than among drivers of passenger cars.

4.2. ATV-related fatalities

Among ATV-related fatalities there was an average of 9.6 deaths annually per 100,000 registered ATVs; due to a gap in data about ATV registrations, this average is limited to the time period of 2009 through 2012. There was an average of 8.3 deaths per year, representing a dramatic increase since the beginning of the 1990s when there was an average of 1.8 deaths annually [5].

As in previous studies, most fatalities occurred during the weekend and, as with snowmobile fatalities, were strongly related to alcohol consumption. Although the distribution of deaths over the year did not show large variation, a slight increase during June–September may indicate a somewhat higher exposure during summertime and a strong relation to leisure usage.

4.2.1. The victims

A mean age of 46 years among the victims, and the large majority of male victims, reaffirms findings in previous studies of fatal ATV incidents in Sweden [4,5], but contrasts with an American study in which younger males constituted the most common victims [10]. Just as with snowmobiles, the percentage of male victims was significantly higher than for automobile fatalities. It is possible that this finding can be explained by the fact that drunken driving is a predominately male phenomenon [11] and because off-road vehicles are much more often ridden by men.

4.2.2. The injuries

The vast majority of the fatal injuries were caused by blunt trauma to the head, in agreement with the findings of earlier studies [4,5]. Although little data is available so far, there is no obvious support for the hypothesis that helmet use would have a clear protective capacity against skull and/or neck trauma in ATV accidents. This is somewhat surprising since another investigation showed helmet use to have a significant injury mitigation effect [12], which may be explained by difference in type of terrain. Additional research is needed in order to reach more certain conclusions concerning this important issue; as with the findings for snowmobile-related deaths, police reporting of helmet use in off-road vehicle fatalities needs to be significantly improved.

4.2.3. Alcohol

ATV-related deaths show a high share of alcohol inebriated victims (61–76%) [4,5], an alarming similarity to snowmobile victims. A very high mean blood alcohol concentration (1.7–2.2 g/l) [4] confirms the findings in previous studies [4,5]. As mentioned, these high alcohol concentrations suggest a user base with a high alcohol consumption. The high share (48–54%) [4,5] of victims with a BAC higher than 1.0 g/l, the limit of aggravated drunken driving in Sweden, also indicates a marked disregard of alcohol legislation similar to that of snowmobile riders.

4.3. A comparison between snowmobile-related and ATV-related fatalities

Both vehicle types have shown a dramatic increase in popularity in the last decade—ATVs arguably more so—with a concomitant increase in the number of fatalities. The fatality risk is lower with snowmobiles than ATVs if related to the number of registered vehicles (9.6 deaths per 100,000 ATVs compared to an average of 3.6 deaths per 100,000 snowmobiles during the seasons 2008/2009 through 2011/2012). This difference may be due to the more seasonal character of

snowmobile use, to repeated injury-prevention campaigns targeting snowmobile riders (which are more widespread since ATVs represent a 'new' vehicle type), and/or due to the padding effect of snow [13].

For both vehicle types, most fatalities occurred during the weekends, with a very high percentage under the influence of alcohol. This illustrates again the well-known dangers of operating powerful vehicles under the influence. The high blood alcohol concentrations also indicate a high share of alcohol abusers, suggesting that off-road vehicle drunken driving is far more socially accepted than when driving traditional road vehicles.

In both vehicle groups, the majority of victims were middle-aged males, possibly illustrating a combination of higher risk taking among males, higher alcohol consumption among this group of men [11], and that off-road vehicle riding is far more popular among men.

Further, in both groups the most common cause of death was blunt trauma to the head. Despite this, we could not confirm an association between lack of helmet use and increased risk of head/neck trauma among either vehicle victim group. In winter time crashes, the padding effect of snow may represent part of the explanation [13].

5. Conclusions

There is a strong association between off-road vehicle fatalities and drunken riding, and actions against driving while intoxicated seem to be the most important preventive measure, e.g., in the form of the alcohol lock. The group most obviously at risk is middle-aged men with high alcohol consumption. Although the usefulness of mandatory helmet use has not been confirmed, compliance among a group of riders who ignore basic safety principles regarding alcohol is probably low. Other preventive measures to consider are protective chest plates and/or floatation devices, given the high share of fatal chest trauma with rib fractures and drowning.

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