

# Narrative Text Analysis of Accident Reports with Tractors, Self-Propelled Harvesting Machinery and Materials Handling Machinery in Austrian Agriculture from 2008 to 2010 – A Comparison

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## Abstract

The aim of this study was the identification of accident scenarios and causes by analysing existing accident reports of recognized agricultural occupational accidents with tractors, self-propelled harvesting machinery and materials handling machinery from 2008 to 2010.

As a result of a literature-based evaluation of past accident analyses, the narrative text analysis was chosen as an appropriate method. A narrative analysis of the text fields of accident reports that farmers used to report accidents to insurers was conducted to obtain detailed information about the scenarios and causes of accidents. This narrative analysis of reports was made the first time and yielded first insights for identifying antecedents of accidents and potential opportunities for technical based intervention. A literature and internet search was done to discuss and confirm the findings.

The narrative text analysis showed that in more than one third of the accidents with tractors and materials handling machinery the vehicle rolled or tipped over. The most relevant accident scenarios with harvesting machinery were being trapped and falling down. The direct comparison of the analysed machinery categories showed that more than 10% of the accidents in each category were caused by technical faults, slippery or muddy terrain and incorrect or inappropriate operation of the vehicle. Accidents with tractors, harvesting machinery and materials handling machinery showed similarities in terms of causes, circumstances and consequences. Certain technical and communicative measures for accident prevention could be used for all three machinery categories. Nevertheless, some individual solutions for accident prevention, which suit each specific machine type, would be necessary.

## Key words

Accident prevention, agricultural machinery, injuries, narrative text analysis

## INTRODUCTION

Half of the injuries in agriculture and forestry occur when operating machinery, as a study in Ontario showed [1]. Most fatal accidents involve tractors [2] and in 50% of these accidents the vehicle turned over [3]. Findings from Sweden [4] and Canada [2] also suggest a high relevance of accidents with tractors and materials handling machinery.

Tractors are used for a wide range of tasks. In several areas of day-to-day agricultural and silvicultural tasks, the limitations in the use of tractors are exceeded, resulting in considerable accident risks [5]. In the state of Kentucky (USA) more than half of the accidents with tractors occurred on slopes, embankments and ravines [3]. Analyses of fatal agricultural accidents in Canada yielded that in about 60% of the rollovers the vehicle tipped over on its side and in about 30% the vehicle rolled over backwards [6].

Materials handling machineries, especially forklifts, are used for various transport tasks. Their narrow design and high centre of gravity lead to occupational accidents [7, 8]. In Austrian agriculture and forestry, small wheel loaders are increasingly used on farms because of its small dimensions

and manoeuvrability. There is a considerable risk of tipping over which may result in injuries [9].

Accidents with self-propelled harvesting machinery occur both in grassland management and in arable farming. Machinery specifically designed for grassland management in mountainous regions, such as two axle mowers and transporters, entail a certain accident risk despite their good slope capability [10]. Jumping on and off harvesting machinery, such as combines, forage harvesters, sugar beet and potato harvesters, particularly frequently leads to injuries [9].

The identification of most frequently happened accident scenarios and causes from existing accident reports with tractors, self-propelled harvesting machinery and agricultural materials handling machinery is the aim of the study. The chosen machinery types are the most common used self-propelled machineries in Austrian agriculture which indicate similarities in main accident scenarios, indicated by press reports.

The preliminary study, an analysis of an accident database, showed that regarding the circumstances and causes of accidents, an insufficient quality of information existed about agricultural tasks, accident scenarios, causes and etiological factors, particularly related to human-machine interaction, for deriving sustainable prevention measures [11]. Complete information on the circumstances of the occupational accidents is only available in the narrative reports. But the reports contain no coded variables.

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An appropriate method to identify accident scenarios, causes, etiological factors and similarities between the mentioned machinery types from existing report material is a narrative text analysis [3, 12, 13]. It can provide information about risk factors that cannot be gained by evaluating a database [13]. The gained results compared with studies of other countries will give a first indication about the accident scenario related market potential for developing of new and implementing existing safety technologies for prevention, particularly ICT- and sensor-based ones. By parallel identification of potential prevention opportunities solutions can be developed and applied in further investigations to the investigated machinery types in a more efficient and effective way.

## MATERIALS AND METHOD

The Austrian Social Insurance Institution for Farmers provided anonymized copies of accident reports in paper form of medium severe, severe and fatal acknowledged working accidents. This material is digitally stored at this institution and was submitted by the victims of occupational accidents with tractors, self-propelled harvesting machinery or materials handling machinery between 2008 and 2010. At first, existing accident analyses were evaluated [2, 6, 14]. Their results are based on statistical database analyses. A narrative text analysis of accident reports that were filled out by the accident victim was not found in literature.

A narrative text analysis provides extra details to supplement routine statistical data analysis in accident prevention [3, 12]. Accident reports and administrative health databases contain for example narrative text fields that supply additional information on injury events [12]. A preliminary database analysis [11] showed an insufficient quality of information about the accident circumstances. The narrative text analysis was chosen as an appropriate method to identify accident scenarios and circumstances between the mentioned machinery types by analysing accident reports [3, 12]. The narrative text analysis was a basic keyword search. The principal categories for the narrative text analysis were established based on the predefined questions of the reports. The relevant categories were the location, the accident scenario, the accident cause and the farming task performed while the accident occurred. For each category the relevant passages were extracted. Once the importing of all relevant passages was completed, the passages were narratively searched to different variables in each category. These variables were defined and compared in accordance with existing literature [6, 14] for example the variables slope or technical fault in the category accident cause. There were created variables in the course of analysis which did not occur in the pre research, for example the accident causes distraction or carelessness and runaway vehicle. Each narrative text variable was searched and coded in accordance with the established categories. The frequencies of each variable were determined. The variables were recorded electronically and evaluated numerically and graphically by means of a comparison of the machinery types.

The information included in the report that had been filled in by the accident victim or by their relative was relevant. If relevant information could not be imported, it was missing from the report. Information could be provided not necessarily in the predefined space, but could also be

included in another part of the accident report. Since the accident reports had been filled in according to different guidelines and, in parts, unstructured, this approach was necessary.

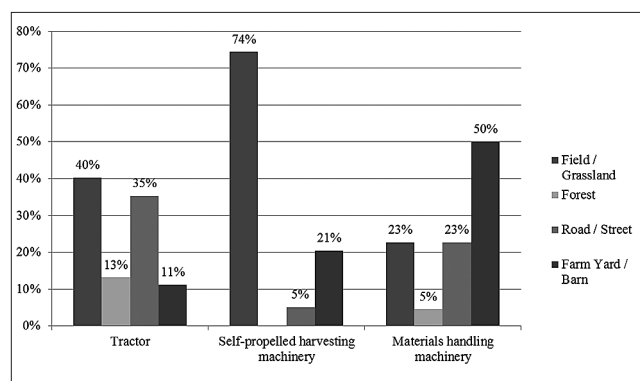
In addition to entering identified relevant variables and categories, important information was recorded in note form in a spreadsheet. This information was used to better identify and describe the scenarios, circumstances and causes of the most important accidents. The gained results were discussed with available literature results of other countries, based on the consideration, that the machines or technique used in other industrialised countries are the same or similar. It will indicate similarities and differences of countries, although the data base and the methods in all studies were different.

From the identified accident categories and variables of the report analysis first recommendations for accident prevention were shortly summarized. The prevention measures aroused from the described causes and circumstances. The opposite of the stated causes and circumstances was derived as a preventive measure. On the one hand typical guidelines of operating these machines and on the other hand open questions and research gaps for further investigations were mentioned for each accident type.

## RESULTS AND DISCUSSION

The majority of accidents with tractors and harvesting machinery tended to occur on fields and grasslands in Austria (**Fig.1**). About 40% (40.3%; 104/258) of accidents with tractors and more than two thirds of accidents (74.4%; 29/39) with self-propelled harvesting machinery happened there. With a proportion of 50% (22/44), most of the accidents with materials handling machinery tended to occur on farm yards or in barns. Compared with the other machinery categories, the number of accidents with tractors, namely about one third (35.3%; 91/258), which occurred on roads was considerably higher. Compared to Canada this is a very high proportion. Accidents with tractors in the Canadian province of Alberta occurred on roads in 16% of the cases [15]. Regardless of the Canadian material and method that is about 20% less than in Austria. Around one quarter of those accidents in Canada occurred on farm yard areas and about half of the accidents occurred on farmland. That is about 10% more than in Austria during the period 2008 to 2010. The data of the Canadian investigation were obtained from the Canadian Farm Accident Monitoring System, a database on injury accidents and fatalities related to machinery. Although the data base and the method were different this comparison indicates differences of the two countries.

A further result of the narrative text analysis was the farming task performed while the accident occurred. While driving along roads, approximately 30% (28.5%; 84/295) and while felling and materials handling timber, about 15% (14.9%; 44/295) of the accidents occurred with tractors and self-propelled harvesting machinery. In addition, accidents with tractors and self-propelled harvesting machinery were highly relevant while harvesting and mowing hay and silage. The joint proportion of both tasks was 18% (53/295) for tractors and 15% (16.4%; 9/55) for harvesting machinery. The proportion of accidents with tractors was 5% in each of the following tasks: coupling and uncoupling of equipment, fertilisation and crop protection as well as tillage, sowing and



**Figure 1.** Comparison of the accident location for tractors, self-propelled harvesting machinery and materials handling machinery

preparation of farmland. Finnish accident analyses showed that around 30% of the accidents with tractors occurred during coupling and uncoupling of equipment. In the Finnish study statistical data on 403 tractor accidents and case studies on 50 tractor accidents were used. In comparison to the Austrian results, there is – independent of the different Finnish data base and the method – a difference of more than 25% [16].

The tasks during which most of the accidents with self-propelled harvesting machinery occurred tended to be repair and service work with a proportion of slightly more than one third (36.4%; 20/55). While executing repair and service tasks on tractors and materials handling machinery only 5% of all accidents occurred. An American accident analysis showed that, in the context of agricultural machinery, 17% of the injuries were sustained during repair work. Compared to Austria this is a high value, which results from having more detailed accident documentation, based on interviews in 3,939 farm households with 13,144 persons about their injury experience and farming operation-related exposures in Minnesota, Wisconsin, North Dakota, South Dakota and Nebraska [17].

With more than 20% (20.7%; 12/58), most of the accidents with materials handling machinery occurred during construction work. The task that showed the second highest number of accidents with materials handling machinery was barn work and feeding of animals with a proportion of 16% (9/58). A number of accidents with materials handling machinery also occurred while working on vineyards and in orchards (10.3%; 6/58) and while spreading manure (8.6%; 5/58).

Table 1 provides an overview of the scenarios of the accidents that were identified by means of the narrative text analysis. In more than 50% of the accidents with tractors (55.6%; 140/252), the vehicle overturned or tipped over. About 5% of the accidents were fatal [11]. In comparison, about 50% of the fatal accidents with tractors analysed by Bunn et al (2008) had also been caused by the tractor overturning or tipping over [3]. Despite a different analysis method the share is equal. Accident research in the American state of Georgia showed that 75% of fatal accidents with tractors had been caused by the vehicle overturning [18]. Day (1999), who analysed fatal agricultural accidents in the Australian state of Victoria, found that 61% of them had been caused by the vehicle overturning [2]. In all cited literature references regardless of the method and database, the proportion of rollovers is above 50% [2].

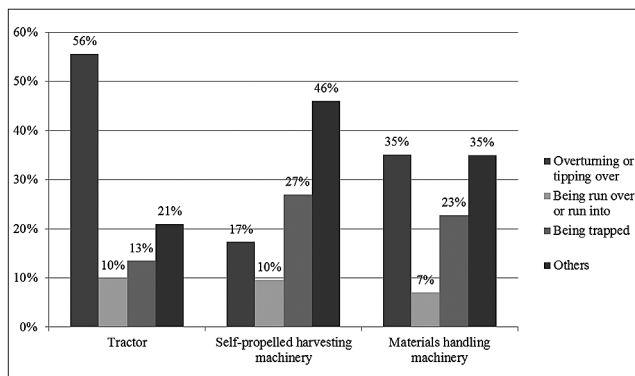
The second most frequent accident scenario with tractors was being trapped, with a proportion of 14% (34/252). The third most frequent scenario was running over and running into a person (9.9%; 25/252). Accident analyses showed that in Alberta in 22% of the accidents with tractors a person was run over. There is a difference in method and database, but the comparison indicates nevertheless that there were a higher proportion of runover accidents than in Austria [15].

**Table 1.** Main scenarios and causes of occupational accidents with tractors, self-propelled harvesting machinery and materials handling machinery following a narrative text analysis (2008–2010)

	Tractor		Self-propelled harvesting machinery		Materials handling machinery		
	N	%	N	%	N	%	
Accident scenario	Jumping off/down	3	1.2	3	5.8	3	5.3
	Falling or falling down	6	2.4	12	23.1	15	26.3
	Hitting controls or cab elements and components	19	7.5	3	5.8	1	1.8
	Being trapped	34	13.5	14	26.9	13	22.8
	Collision	14	5.6	3	5.8		
	Being thrown from the cab	11	4.4	3	5.8	1	1.8
	Being run over or run into	25	9.9	5	9.6	4	7.0
	Overturning or tipping over	140	55.6	9	17.3	20	35.1
		252		52		57	
Accident cause	Distraction or carelessness	16	9.2	8	28.6	1	4.5
	Embankment, ditch or uneven pavement	25	14.4			3	13.6
	Operator was sick	7	4.0	2	7.1	1	4.5
	Incorrect or inappropriate operation of the vehicle	26	14.9	3	10.7	6	27.3
	Slippery or muddy terrain	22	12.6	6	21.4	4	18.2
	Runaway vehicle	21	12.1	4	14.3	1	4.5
	Slope	30	17.2	2	7.1	1	4.5
	Technical faults	27	15.5	3	10.7	5	22.7
		174		28		22	

The most relevant scenarios of accidents with harvesting machinery were being trapped (26.9%; 14/52) and falling or falling down (26.3%; 15/57). With 17% (9/52), overturning or tipping over was the third most frequent scenario. More than one third (35.1%; 20/57) of the accidents with materials handling machinery were caused by the vehicle overturning or tipping over. Falling or falling down (26.3%; 15/57) and trapping of body parts (22.8%; 13/57) occurred with the same frequency. Only a small number of injuries were caused by being run over or into (7.0%; 4/57). In the USA the most important cause of accidents with forklifts was overturning, with a proportion of 22%. A considerable proportion of accidents were caused by running over a person (20%) and falling off the vehicle (16%). Data was obtained from a database system of the National Institute for Occupational Safety and Health (NIOSH). Although the data base and the method were different a comparison with the Austrian results indicates that there is a higher proportion of overturning accidents in Austrian agriculture that is predominantly hilly than in the US industry [19].

The direct comparison of the three analysed machinery types shows differences in frequency of accidents caused by overturning and tipping over (Fig. 2). While this was the case in only 9 accidents (17.3%; 9/52) with harvesting machinery, 35% (20/57) of accidents with materials handling machinery and 56% (140/252) of those with tractors were caused by overturning or tipping over. In all categories analysed, people sustained injuries from being trapped. This was especially the case for accidents with harvesting machinery (26.9%; 14/52) and with materials handling machinery (22.8%; 13/57). In these two machinery categories, more than 20% of the accidents were also caused by the person falling off a vehicle.



**Figure 2.** Comparison of the accident scenarios for tractors, self-propelled harvesting machinery and materials handling machinery

Besides the scenarios of the accidents, table 1 also shows the main causes – provided that this information was included in the accident reports. The narrative text analysis yielded that steep slopes (17.2%; 30/174) and technical faults (15.5%; 27/174) were the main causes of accidents with tractors. Similar results are available from Finnish and German studies. Suutarinen (1992) points out that 26% of the tractors analyzed during his study were in bad technical condition [16] and Hoppe et al (2005) demonstrated in their studies of accidents with tractors on public roads that about 13 to 15% of the tractors had technical faults [20]. It could not be ascertained whether these technical faults caused the accidents. As mentioned in the Finnish study statistical data and case studies on tractor accidents were used. The Finnish analysis was done in 1992 with a different method and database. Nevertheless, the comparison with the Austrian results indicates that there were a higher proportion of technical faults in Finland in 1992 than in Austria in 2012.

The narrative text analysis helped to identify distraction or carelessness as the cause of 30% of the accidents with self-propelled harvesting machinery (28.6%; 8/28). Less than 10% of the accidents with materials handling machinery (4.5%; 1/22) and with tractors (9.2%; 16/174) were caused by distraction or carelessness.

Operating machinery incorrectly or inadequately was reported as the cause of less than 15% of the accidents with tractors and those with harvesting machinery, while it was the most frequent cause of accidents with materials handling machinery, with a proportion of 27.3% (6/22). About 20% of the accidents with materials handling machinery were caused by technical faults (22.7%; 5/22) and by slippery or muddy terrain. Slopes, embankments or uneven pavement

were reported by the accident victim as the main cause of 14% (3/22) of the accidents. Forklifts have stability problems, especially on uneven terrain and that speed constitutes a significant factor in accidents [7, 8].

The following section provides an in-depth description of accident scenarios including the most important causes and possible preventative measures:

**Overturning and tipping-over.** The analysis of accident reports showed that overturning and tip-over accidents with tractors often occur at steep slopes and adjacent embankments and ridges. These scenarios were also reported for accidents with self-propelled harvesting machinery, especially two axle mowers and transporters. Further factors contributing to an overturning accident were the inadequate choice of the attached implement and the relatively inappropriate loading or securing of the load. On roads and tracks, overturning accidents were most frequently caused by the tractor or the attached implement veering off the street. The scenarios of the accidents were adversely affected by unsurfaced roadsides, steep ditches or slippery roads. Tip-over accidents with materials handling machinery, especially small wheel loaders, were caused by steep inclines and, above all, uneven surfaces. In addition to slippery roads caused by snow and ice, accidents with small wheel loaders and forklifts were caused by sagging terrain while performing excavation work. Technical faults were also identified as causes of overturning accidents. These include technical problems with transmission (among other things, changing gears not possible or gears jump or loss of oil pressure in continuous transmission), breaks, tires and rims.

The analysis of the accident reports helped to identify the following measures for the prevention of overturning accidents: on fields and grasslands, the operator needs to assess the gradient, the terrain and the distances to limit dangerous situations. A further important basis of the safe operation of tractors, self-propelled harvesting machinery and materials handling machinery is that the operator knows how to use the machinery correctly on slopes, for example in forelands, and knows how the machine reacts in extreme situations and in situations where implements are attached. Technologies for the recognition of dangerous situations may prevent such accidents. To prevent accidents with small wheel loaders, the stability of small wheel loaders needs to be improved and the correct operation needs to be trained by means of corresponding training schemes. A particular focus should be put on the correct loading and securing of the load. Assessing speed, distances and road conditions and operating vehicles with trailers correctly is highly relevant to operating tractors on roads and tracks.

**Being trapped.** The analysis of accident reports yielded that the accidents with tractors caused by being trapped most frequently occur while attaching or detaching implements or equipment. Injury scenarios are extremities being trapped in mechanical or hydraulic top links, lower links or power take-off (PTO) shafts. Provided that the cause was included in the report, the main causes of accidents include mistaking or unintentionally activating the controls (transmission, control device, PTO shaft). In parts, the faulty function of the automatic top and lower link system was the reason for that. In comparison with tractors, accidents with self-propelled harvesting machinery occurred mainly during repair and

service work. During checks on presumably broken V-belts or V-belt pulleys of combine harvesters, hands and fingers got caught. While attempting to clean or shut off components of combine harvesters, limbs were injured in air compressors, fans, coasting cutting tables of maize stalk choppers or when switching on and off the straw chopper on transmission parts. When using sugar beet harvesters, accident victims mainly had their limbs trapped during repair work, among others, on running V-belts, V-belt pulleys and gearbox drives of cleaning lines. When operating materials handling machinery, the accident reports analysed showed that people had their limbs trapped when using excavators and forklifts. Such accidents with forklifts occurred most frequently while attaching or adjusting the forks.

From the analysis of the accident reports, the following preventative recommendations can be derived: as many people are trapped when attaching and detaching implements or equipment, it is vital that mistaking or unintentionally activating the controls (transmission, control devices, PTO shaft) is avoided. The analysed accidents may be prevented if the coupling elements, such as top or lower links and cable connections, and corresponding automatic controls were designed ergonomically. Accidents with self-propelled harvesting machinery occurred mainly during repair and service work done while the machinery was still running. It is necessary to prevent work done while the machinery is still running by providing technical solutions and by training the operators of such machinery. For the operation of excavators and forklifts, it is vital to prevent people having their extremities trapped when attaching or detaching equipment, by providing technical solutions.

**Being run over or run into.** The analysis of accident reports yielded that several people were run over by tractors that rolled away uncontrolled. Such incidents occurred during repair and service works, while attaching and detaching equipments as well as on fields and grasslands. Reasons reported for the tractors rolling away without the driver operating the vehicle included malfunction and incorrect operation of the stop brake. Such accidents were also reported for two axle mowers. The vehicles rolled away for the reasons given above and ran over people working nearby. Attempts at jumping onto the vehicle that was rolling away were reported for tractors, two axle mowers and small wheel loaders. In these cases, the person was run over by the rear wheel of the vehicle. In all machinery categories analysed, accidents occurred where people who were nearby, were overlooked and run over. In most cases, an obstructed view of the surrounding area of the vehicle was reported as the cause of the accident. With tractors, this resulted from large implements obstructing the driver's view, among other things. In all of the accidents with combine harvesters and beet harvesters analyzed in this study, people were run over by vehicles rolling backwards. In accidents with forklifts, people or their extremities were run over when the vehicle was started or reversed. In an accident involving an excavator, one person working nearby was caught by the excavator's arm.

For the prevention of accidents where people are run over, a distinction has to be made between two scenarios: vehicles that roll away driverless and run over the driver and accidents where people who are nearby are run over by the vehicle. In the first case, a working stop break and its adequate operation is required. The correct operation and

behaviour when vehicles roll away uncontrolled can only be communicated by means of information. For example, a sound or light signal should provide the operator with information about the status of the break. In the second case, people working nearby should be informed about the correct behaviour when approaching the vehicle. An obstructed view of relevant component parts and people nearby can be improved by technical solutions – both mechanically and electronically through ICT-based technologies.

## CONCLUSION

A narrative text analysis was used for analysing of existing accident reports to find out most relevant accident circumstances to create a base to identify prevention measures in a sustainable way. No publication was found in literature that used similar materials and methods before. The analysis results offer more information than an evaluation of the existing database. The advantage of the narrative text analysis was the identification of tasks, accident scenarios, causes and etiological factors that could have not been achieved through an evaluation of existing coded data. The narrative text analysis helped to create a dataset with alternatives that was specifically adapted to the field of research to identify and present the accident circumstances.

A disadvantage of the narrative text analysis was the inconsistency of the imported text passages. Due to the different forms in which the accident details had been reported, errors in interpretation could not be excluded. This could result in underestimating accidents. Estimating the true magnitude of an accident was difficult. Another disadvantage was that the outcomes could only be discussed with results of some industrialised countries which were generated by database analyses. Based on the accident reports, general design-engineering and behavioural preventative measures could be identified. The analysis of the accident reports mostly showed which accident scenarios should be avoided. The technical and behavioural solutions to avoid these scenarios need to be identified in a further step. The analysis of accident reports forms a foundation for guided interviews with accident victims and manufacturers of agricultural machinery in order to close some identified still existing information gaps for choosing of most adequate preventative measures.

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