

# Occupational accidents with mowing machines in Austrian agriculture

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## Abstract

The number of recognized accidents during agricultural work is still very high in Austria. In the years 2008 to 2009, there occurred 84 approved work accidents with mowing machines. The main causes of accidents were the loss of control of machines, transportations or conveyances, hand tools, objects or animals. In the literature, numerous studies of general agricultural and forestry accident situations are available. Detailed studies on specific types of agricultural machines, which describe concrete circumstances and causes of accidents, are in limited numbers. The accident database from the General Accident Insurance Institution and the Austrian Social Insurance Institution of Farmers, with personal and accidental data information about mowing machine accidents, were analyzed. The results showed that most accidents occurred on mixed agricultural farms (68%). The majority of the injured persons were male (86%), over 40-years-old (86%) with an agricultural or forestry education (91%). The most common accidents occurred in the summer months (69%) and on afternoons during the working week (79%). The majority of accidents were caused by contact with the machine (55%) and the loss of control (73%) during their operation (60%) and harvesting work (63%). The most frequently injuries were wounds, fractures and superficial injuries (81%) to the upper and lower extremities (66%). The results of the chi-square test showed significant correlations between the specific task with the form of contact, the working process, the day and season. Results of the odds ratio determination showed an increased risk of suffering serious injury for men in the first half of the year and half of the day due to loss of control over the machine during agricultural harvesting work.

## Key words

accidents, mowing machines, injury, data analysis, chi-square test, odds ratio

## INTRODUCTION

The number of recognized accidents, with some fatalities, during agricultural and forestry work is still very high in Austria. In 2010, 6,520 recognized work accidents occurred in this sector [1]. In comparison, there were a total number of 167,012 work accidents in the same year in Austria [2]. Across Europe, the number of fatal accidents in agriculture and forestry is higher than in any other industry; only the number of fatal accidents in the construction industry is comparably high, although it continuously declines [3]. The scenarios in which people were injured vary greatly. In spite of continuously improving technology, coordinated prevention and better training, the number of accidents at work in agriculture is too high. The common cause of accidents in agriculture is the 'loss of control of a machine, means of transport or handling equipment, hand-held tool, object or animal' [1]. Regarding the total number of work accidents in Austria, the 'loss of control of a machine, means of transport or handling equipment, hand-held tool, object or animal' followed by 'fall of persons' and 'body movement without any physical stress' are the three most common causes of accidents [2].

Farming of grassland plays a central role in Austrian agriculture. About 2.4 million hectares of utilized agricultural area in Austria are covered with grasses that are mowed mainly (80%) for feed use, depending on altitude,

2–6 times a year. These areas are of various sizes and shapes (<0.5ha -> 5ha), altitude levels (200 -> 1500m) and inclination (<25%, 25–50%, >50%). Around half of all grassland fields in Austria are smaller than 0.5 hectares and only 2.0% are larger than 5 hectares. Approximately 360,000 individual plots of land can be managed only with special machines and equipment. These facts show how difficult it is, despite modern technology, to utilize these areas for economic purposes [4]. In Austria, different mowing techniques are employed. The equipment ranges from hand tools (scythes) to different types of mowing machines (motor and brush mowers) attached to tractors in front and rear areas, and self-propelled mowers. Besides mowing for harvesting, mowing machines are used for maintaining grasslands (flail mower and shredders) in the municipal sector [5]. Because of these various machine configurations and design differences, the operators are subject to different injury risks. These risks consist especially in touching sharp and rotating objects while changing blades or removing covers, being struck by flying objects during mowing and maintenance work, such as repairing, cleaning, coupling and uncoupling of mowers from the towing vehicle. Specific requirements for the safety design of mowing equipment for marketing on the European market, especially to prevent these accidents, can be found in Machinery Directive 2006/42/EG and ISO 4254–12 (Agricultural machinery – Safety: Rotary mowers and mowers). In agricultural practice, mowers show very strong signs of usage and wear. Careless maintenance and improper handling pose a high injury risk for farmers. A variety studies regarding general agricultural accident situations exists [6, 7, 8, 9, 10, 11, 12, 13, 14, 15]. Additionally, investigations differentiated by types of machines were

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carried out for tractors, tillage equipment, harvesting and fertilizing machines, and equipment for conveying [16, 17, 18, 19, 20, 21]. Although these studies include mechanical inspection priorities, hitherto no detailed studies have examined mowers, including descriptions of accident scenarios and causes. The data provided by AUVA und SVB was evaluated in order to differentiate the accidents according to person-specific and company-specific data, to determine the exact location and time, identify accident scenarios, causes and deviations according to the activities carried out, and to describe resulting injuries according to frequency and severity. These parameters were tested together to identify relationships. The odds ratio analysis conducted serves to represent parameters that cause light and severe injuries. The aim of this study was to analyze accidents with mowing machines in the period 2007 to 2010 in order to enhance the understanding of the causes and courses of accidents, and to improve current prevention measures.

## MATERIALS AND METHOD

The database for the descriptive and statistical accident analyses is a part of the database of accidents at work of the General Accident Insurance Institution (AUVA) for 2007–2009. It included 84 accidents of employees with mowing machines in agriculture and forestry. The 84 accidents were analyzed according to the documented variables of gender, economic class, age, occupation, time of accident, damage type, work process, specific task, deviation, contact, injury, body parts and others. The variable specific task refers to the specific physical activity prior to the accident. The variable deviation represents the course of events that led to the accident. The work process is defined by the general nature of the work performed at the time of the accident. The contact describes the triggering cause of the accident. The other variables include classifications that did not fit into any of the above-mentioned categories due to low frequencies and differences. The data selected were analyzed using the statistical programme SAS 9.2<sup>®</sup> descriptively and analytically according to the above parameters. The chi-square test was used for testing contexts (contingencies) of qualitative (discrete) features to determine significant relationships [22]. Javadi & Rostami [23] used this statistical method for the analysis of farm machinery accidents. Another analysis procedure used was the odds ratio, which is a measure of the association of two attributes (variables). According to their very good interpretability, it is the preferred method used in medical and accident statistics. Its significance applies only to two attributes (variables); therefore, it is used in combination with logistic regression to treat multivariate questions. It provides a sound mathematical foundation for identifying the optimum dimension of attributes (variables) in order to explain an excellent and desired feature by examining other necessary characteristics, and neglecting redundant ones [24].

## RESULTS AND DISCUSSION

Generally, most of the accidents with mowing machines occurred in agriculture (99% 83/84), and only one accident could be allocated to forestry (1.00%, 1/84). A further

classification of agriculture in its subdivided areas shows that the accidents recorded occurred on mixed agricultural farms (68%; 57/84), followed by livestock farms (31%; 26/84), forestry and other establishments (1.0%; 1/84). More men (86%; 72/84) than women (14%; 12/84) were injured. The persons injured were up to 67% (56/84) over 40 years old and to 32% (27/84) under the age of 40. Persons with agricultural and forestry education were affected up to 91% (67/84) and labourers and others – 9% (8/84), by accidents with mowing machines. Comparative studies on human factors in the agricultural accident questionability show that, as in Austria, more men (54%–98%) are affected by agricultural accidents [9, 10, 16, 19, 20]. The high proportion of injured males can be explained by the distribution of farm operators by gender (66% men, 34% women) in Austria [25]. The age of the persons injured through mowing machines showed that 67% (56/84) of the accident victims were over the age of 40, and about 33% (27/84) under that age. These values agreed exactly with the age structure of Austrian agriculture, where 66% of all operators are over 45-years-and 34% are under 45- years-old. Comparable results of the age of accident victims showed that 52%–65% of the accident victims were over the age of 40 [10, 15, 27].

**Time of accident.** Most of the accidents with mowing machines happened in the summer (69%; 58/84) and spring months (19%; 16/84). In the autumn (9.0%; 11/84) and winter months (1.0%; 1/84), only a small number of accidents occurred. Re-emerging accidents in the first half of the year with values between 52%–65% can be found in surveys of farm accidents, particularly accidents involving machinery [9, 19], whereas more agricultural accidents (in all areas) happened in the second half (53%–63%) of the year [15]. Goldcamp et al. [8] found no difference (50%/50%) in the number of accidents between the year halves. When comparing the accidents divided into seasons, the different types of machines used for typical farm work processes during the year should be considered. About 79% of the accidents with mowing machines occurred on weekdays. About 20% (16/84) happened on weekends and public holidays. More accidents occurred in the afternoons than in the mornings. As the use of mowing equipment and associated grassland harvesting is very dependent on the weather conditions, the distribution of accidents on working days is not very meaningful. Significant results showed that accidents during mowing with ‘hand tools’ (67%) and ‘machine’ (86%) increased during the week, and were lower at weekends and on holidays ( $p$ -value = 0.04). In the first half of the year, more accidents happened during ‘operation of a machine’ (53%) and in the second half during ‘working with hand tools’ (70%) ( $p$ -value = 0.04). For the odds ratio determination, the injuries were divided into light and severe. For men, there existed a higher risk (odds ratio [OR] = 1.7; 95% CI = 0.4–7.2) of suffering severe injuries by operating mowing machines than for women. There was a decreased risk (OR = 0.5; 95% CI = 0.2–1.6) for operators aged over 40 suffering severe injuries than for operators under 40 years. In the first half of the year and first half of the day, there was a higher chance (OR = 1.5; 95% CI = 0.6–3.8) to be seriously injured than in the second half of the year and second half of the day (Tab. 1).

**Specific task and working process.** The increased number of accidents caused by the operation of a machine and performing a mode of transport (60%, 49/84) can be

**Table 1.** Personal and accident time-specific odds ratio analysis

Factors	Number	Odds ratio	95% CI
Gender	Male	72	1.7
	Female	12	1.0
Age	< 40 years	27	0.5
	> 40 years	56	1.0
Time	1st half of the year	36	1.5
	2nd half of the year	48	1.0
	Weekdays	66	1.0
	Weekends and public holidays	18	1.0
	0–12h	33	1.5
	12–24h	46	1.0

explained by a variety of risks to which people are exposed during mowing. These range from different exposures of the field sizes and shapes, difficult soil and slope conditions, the non-wearing of work clothes to physical conditions and work experience. The manual handling of objects is also an increased injury risk (40%, 33/84). Parameters influencing the risk of accidents included human behaviour, working technology, work clothes and safety of the workplace. Significant results showed that 73% of accidents involving mowing machines occurred while 'working in agriculture and forestry', operating machines and operating a means of transport, compared to 27% happening while handling objects manually. During maintenance, repair, preliminary work and others, 63% injuries occurred while handling objects manually and 37% while operating a machine or a means of transport (p-value 0.0012). Similar accident trends with values between 54%–69% can be found for the general operation of farm machinery, for tractors, tillage and fertilizing machines [6, 7, 16, 17]. Values between 13%–42% for the proportion of recorded accidents caused by the use of agricultural machinery in general [8, 9, 13] and for the operation of tractors, tillage, harvesting and other machinery [14] could be recorded. Analyses of the work process revealed that 63% (53/84) of accidents occurred on agricultural and forestry land and harvesting operations, and 37% (31/84) in maintenance, repair, preliminary work, and others. Similar high shares for accidents caused by maintenance, repair, preliminary work, and others (17%–34%), were shown for general agricultural machinery [19], especially for tractors, tillage and harvesting equipment [21].

**Derivation and type of contact.** The 'loss of control of machine, means of transport or handling equipment, hand-held tool, object or animal' ranked first in the classified specified variations describing the course of events. The variable category 'loss of control' (73%, 61/84), followed by 'fall of person' (18%, 15/84) and 'other movement of the body' (9.0%, 8/84) was the most common deviation that led to an accident with mowing machines. Similar results for accidents caused by a fall, with values between 15%–32%, were shown for agricultural machinery in general [7, 10, 11, 13]. The proportion of accidents caused by other deviations of agricultural machinery, especially for accidents involving tractors, tillage and fertilizer spreaders, similar to accidents with mowing machines, was below 10% [7, 10, 11, 13]. A further variable, which was the cause of an accident, was the type of contact. In accidents with mowing machines,

this was mainly 'contact with the machinery' (55%, 39/71). In a comparable study on agricultural machinery, Solomon [11] found slightly lower values (24%) for the 'contact with machinery'. For mowing machines, 15% (11/71) of accidents were caused by breaking, bursting, splitting, slipping, falling, and collapsing of the 'material agent'. Shares between 3.0%–34% were determined for general agricultural machinery [10] and for accidents with tractors regarding breaking, bursting, splitting, slipping, falling, and collapsing of the 'material agent' [17]. For the category 'others' a share of 30% (21/74) could be allocated to accidents involving mowers.

For 15% (13/84) of the accidents, no information about the kind of contact that caused the accident could be found. Significant correlations were found between the kind of contact with the specific activity and the working process. Machine contact while handling objects manually caused 56% of the injuries and machine contact while operating a machine or a means of transport caused 44%. 'Trapping or crushing in, under or between objects' caused 36% of the accidents while handling objects manually, and operating a machine or a means of transport. Other types of contact led to 19% of injuries while handling objects manually, and about 81% while operating a machine or a means of transport (p-value = 0.02). The odds ratio analysis revealed that the loss of control of the machine led to a 2.4 times (95% CI = 0.7–8.7) higher risk of serious injury compared with other factors. For machine contact, the risk of serious injury was 0.5 (95% CI = 0.2–1.8) lower than for other factors (Tab. 2).

**Table 2.** Work factor-specific odds ratio analysis

Factor	No.	Odds ratio	95% CI
Work factor	Contact with machine	50	0.5
	Others	21	1.0
	Operation of a machine	49	1.0
	Others	33	0.4
	Loss of control	68	2.4
	Others	16	1.0

**Injury and body part.** About 81% (67/83) of injuries were 'wounds, fractures and superficial injuries' followed by 'sprains' (11%; 9/83), 'amputation' (6.0%; 5/83) and 'burns' (2.4%; 2/83). Comparable results for types of injuries with mowing machines were shown for accidents involving farm machinery in general [10, 15] and for investigated accidents with tractors, tillage and harvesting machinery [21]. The body parts affected most were 'lower extremities' (35%; 29/84), 'upper extremities' (31%; 26/84), 'torso' (18%; 15/84) and 'head' (17%; 14/84). There were significant correlations between body parts, the work process and specific task. Half of the injuries to the head occurred during maintenance, repair, preliminary work, and others (50%), and half during agricultural and forestry tillage and harvesting operations (50%). Injuries to the torso were recorded in more than 90% of the cases during tillage and harvesting operations (93%), and in 6.67% of the cases during maintenance, repair, preliminary work and others. Injuries to the upper extremities were caused in 62% of the cases by maintenance, repair, preliminary work and others. and in 38% of the cases by tillage and harvesting operations. The lower limbs were

affected in 75% of the cases during agricultural and forestry activities and in 25% of the cases during maintenance, repair, preliminary work and others (24%) ( $p$ -value = 0.0013). During manual handling of objects, 15% of injuries occurred to the head, 6.06% to the chest, 51% to the upper extremities and 27% to the lower extremities. The operation of a machine or a mode of transport caused 39% of the injuries to the lower extremities, 27% to the torso, 18% to the head and 16% to the upper extremities. The types of injuries sustained to the lower extremities were attributed to the fact that the rotating work tools of mowing machines in working position were too close to the operator's lower extremities and responsible for causing serious injury. The incidence of wounds and superficial injuries resulted from the sharp working tools of mowers to which farmers are exposed while blade replacement or sharpening of the tools. Similar frequencies were reported (27.9%–46.6%) for injuries sustained to the upper extremities during the operation of agricultural machinery [13, 20]. Regarding injuries of the torso and head, proportions of 10%–29% were found [20]. The odds ratio analysis showed that for agricultural harvesting work, opposite to maintenance, repair and cleaning work, a 10.8 times (95% CI = 0.9–131.2) increased risk of serious injury exists. An increased risk of 1.8 of serious injury (95% CI = 0.3–9.4) exists at the workstation, compared to outside the company. The lower extremities, compared to the upper ones, are exposed to a reduced risk of serious injury of 0.6 (95% CI = 0.2–1.6). The direct cause and the course of the accident cannot be deduced from the results for specific activity, process, deviation and type of contact in the case of accidents with mowing machines in Austrian agriculture obtained from the evaluation of the database. Due to lack of information in the database about the accident machine type and their interaction with the victim during the accidents in agriculture, no safety deficits, changes in the design and wear of a machine which contributed to an accident, could be identified (Tab. 3).

**Table 3.** Injury-specific odds ratio analysis

Factors	No.	Odds ratio	95% CI	
Work process	Agricultural harvesting work	53	10.8	0.9–131.2
	Maintenance, repair, cleaning	31	1.0	
Work place	At the company	74	1.8	0.3–9.4
	Outside the company	10	1.0	
Body area	Upper extremities	55	0.6	0.2–1.6
	Lower extremities	29	1.0	

## CONCLUSION

Grassland farming plays a central role in Austrian agriculture. The areas which are covered with grassland are subject to a variety of structures. Depending on altitude, slope and size of the areas, different harvest frequencies occur and different machinery and equipment are used. Accidents are frequently caused by different tasks and courses of action. In the literature, many studies related to the land and forestry accident problem exists, but none focus on mowing machines. The analysis results of the database data of accidents with mowing machines in Austrian agriculture reflect a variety of circumstances to which farmers are exposed when operating mowers. Men over 40 years who work on mixed agricultural

farms with agricultural and forestry education have most commonly accidents with mowing machines. The accidents occurred mainly during the summer and spring months, and in the second half of the day from Monday to Friday. The specific task, process and deviation which led mainly to an accident was the loss of control during operating a machine while agricultural harvesting. Contact with the machine caused predominately wounds and fractures on the lower and upper extremities. Significant correlations between the specific task and the variables contact, work process, year and day were found. The odds ratio analysis in which injuries were divided into light and severe showed that an increased risk of suffering serious injury exists for men (OR 1.7) in the first half of the year and half of the day (OR 1.7) due to loss of control over the machine (OR 2.4) in agricultural harvesting (OR 10.8) on the farm (OR 1.8). From the database results, the causes of accidents depending on the agricultural operation cannot be defined. Lack of information about the accident machines and machinery part-related accident interaction with the victim in agricultural terms allowed no immediate conclusions for improving preventive measures and requires further investigations by conducting surveys of victims.

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