REFEREED ARTICLE

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Comparative incident analysis of pressure cleaner injuries among employees on Austrian farms

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ABSTRACT

Reports of the Austrian Insurance Institutions (AUVA and SVB) about accidents at work indicate that employees in agriculture are exposed to accident risks. For a detailed investigation, data of the accident databank and the accident reports of the victims of accidents with high pressure cleaners for the period from 2008 to 2010 were analysed descriptively and analytically. The aim of the case study which was based on a small sample size with precise filled out accident reports, was to evaluate the usefulness of the European Statistics on Accidents at Work (ESAW) suggested variables and categories for the identification of safety deficits in the national databank, and furthermore, to identify the risk factors that may cause an accident during the human-machine interaction. The results showed that the victims were farm managers; the majority of them were over 40 years of age. Half of the incidents happened in autumn and on weekdays, especially in the afternoon, while cleaning machinery, stable parts and central heating boilers, as well as while filling the lye in the store tank, removing the hose, and transporting machinery. All incidents occurred due to different deviations and contacts with the machine or machine parts. Missing protective equipment and clothing, as well as improper handling and securing of the work area could be identified as safety deficits. The database analysis did not reveal the relevant parameters of the human-machine interaction by virtue of their generalisation. The analysis of the accident reports was required for the identification of the accident scenarios and causes related to the agricultural terminology and the incidental human-machine interaction, which allowed the determination of safety deficits for first prevention recommendations.

KEYWORDS: pressure cleaner; incidents; databank data; report; injury

1. Introduction

In 2010, the agricultural and forestry industry of Austria reported 6,520 accidents at work (SVB, 2010). The agricultural and forestry industry has one of the highest fatality rates of all occupations in Austria as well as in Europe and countries of other continents (European Agency for Safety and Health at Work, 2011; Bunn, *et al*., 2008). The vehicles, machinery, and devices used in this occupational sector caused 2,096 accidents at work in the year 2010, 31 of which were fatal. These accidents regarded 507 persons injured and 19 deaths at work with machinery, devices, and animals per 100,000 persons employed in forestry and agriculture in Austria (SVB, 2010). The rate of fatal agricultural-related injuries is 6.3 times greater than for the salaried workforce in Austria, which had 3 fatal accidents (2 at work and 1 on the way to work) per 100,000 persons in the year 2010 (AUVA, 2012). In the European Union, agricultural workers suffer 1.7 times the average rate of non-fatal occupational accidents and 3 times the rate of fatal accidents, making the sector particularly hazardous (European Agency for Safety and Health at Work, 2011).

Accidents and injuries cause painful situations for accident victims and their families, as well as economic costs. Analyses of the circumstances surrounding an injury-causing event are essential for determining injury mechanisms and guiding prevention efforts.

In previous studies, agricultural machinery has been identified as a principal source of non-fatal and fatal injuries or disability, but there exists still little information on the risk factors, especially related to the human-machine interaction (Gerberich, *et al*., 1998). The contextual nature of the farm environment plays an important role in the occurrence of injuries. Available studies have mainly evaluated demographic factors and few of them the safety device usage, so that there is a lack of analytic epidemiologic studies to identify potentially preventable risk factors for machine-related farm injuries (Layde, *et al*., 1995; Narasimhan, *et al*., 2010).

To describe the circumstances surrounding injury events, core data are needed to characterise the conditions preceding the event, the details of the event and the outcomes of it. Administrative health databases collect various coded data and narrative text fields for

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routine, monitoring, and analysis of injury causation and incidence.

Most of these administrative data systems, especially those relying on aggregate coded data, lack the details needed to understand the complexity of the injury event and to design effective injury prevention initiatives. For example, the widely used system for coding causes of injury is the external-cause-of-injury and poisoning (E-codes) of the WHO's (World Health Organization's) International Statistical Classification of Diseases and Related Health Problems (ICD-9), which, despite limitations in the specificity of its codes, provides a useful means of standardising external causes across different sources. This means that external cause codes have an imitated structure providing incomplete coverage and insufficient details to identify relevant injury factors (Wellmann, *et al*., 2004).

Several studies have pointed out the advantages of narrative text for providing further details to complement routine coded data of injury statistics or for classifying an injury post data collection if the dataset has not the required coding for the scientific questions to be examined (Smith, *et al*., 2006). The methods of obtaining information from the reports, the narrative text, are inconsistent and differ depending on the studies and the research field. The approaches range from basic keyword searches of text strings to complex statistical approaches using Bayesian methods and computerised technical methods (McKenzie, *et al*., 2010).

The system used for coding incidental information of Austrian accidents at work is the European Statistics on Accidents at Work (ESAW). The ESAW is a useful means for standardising external causes across different data sources (Eurostat, 2012). The variables contact and deviation have recently been added to the ESAW variables in order to elucidate the causes and circumstances of accidents, details of the cause-effect mechanism which used to be unknown. This extension of the variables should facilitate the development and prioritisation of preventive strategies. The ESAW can be used worldwide because it is very similar to the international system adapted and recommended by the International Labor Organization (Jacinto and Soares, 2008). It has not been evaluated yet to what extent there exist limitations in the specificity of its codes for the identification of circumstances of machinery injuries in agriculture and forestry, especially relating to the incidental human-machine interaction.

In this paper, based on this insufficient documentation results, a showcase regarding comparative incident analysis for one machine type, is presented, which implements the variables and categories of ESAW database and the identified ones in the accident reports by phrase analysis. The investigated machinery selected for this case study was the high pressure cleaner.

By analysing of the narrative texts of accident reports further details about the causes and circumstances of accidents in the agricultural language can be acquired.

2. Material and Methods

Comparative accident analysis was carried out using the databank data of recognised work-related accidents with pressure cleaners for the period 2008 to 2010 and anonymised reports. For a show case, accidents with pressure cleaners were selected for the comparative analysis that had a small sample size and sound filled out reports. The databank data and reports were provided by the Austrian Social Insurance Institutions in Vienna, the SVB (Social Insurance of Farmers), which documents incidents of farming occupations, and the AUVA (Austrian Workers Compensation Board), which collects information about incidents involving employees in agriculture and forestry (SVB, 2010).

The reports were written by the victims or their relatives within 5 days after an accident which caused incapacity to work for more than three days. The relevant information of these reports is documented in the databank, according to the EUROSTAT methodology for the European Statistics on Accidents at Work (ESAW). The variables of EUROSTAT cover the main characteristics of the accident: firstly, the victim and employer, where the accident happened, who was injured and when, the seriousness of the injuries and consequences of the accident. Secondly, it contains information on how the accident occurred, under what circumstances and how the injuries came about (Eurostat, 2012).

The variables that were examined for a type of machinery were personal characteristics of the victims (e.g., age, gender, and position in the farm organisation), incident time and date, injury characteristics (e.g., type of injury, body part, and body side), causes and circumstances (e.g., working environment and work process). Causes and circumstances in the databank were described by the variables working environment, work process, specific physical activity, deviation, and the contact. These variables have generalised categories so that they may apply to all professions for comparison purposes (Eurostat, 2012). Based on the identified information gaps about the incidental human-machine interaction during the work process, the variables workplace, task and cause (classified in agricultural terms) and the injury characteristics and safety defects were predefined for analysing the content of the accident reports. These are factors that would lead to and explain the injury once an accidental incident occurs.

For the identification of the relevant variables and their categories in the accident reports, the narrative text analysis was used. Keyword search was applied to identify un-coded circumstances of machinery injuries (Wellmann, *et al*., 2004). Each narrative text variable was coded according to the established categories. This method was selected as it affords an in-depth examination of the circumstances of incidents, especially for factors not captured by standardised ESAW coding schemes (McKenzie, *et al*., 2010; Smith, *et al*., 2006). For the classification of the incidental tasks in agricultural terms, the REFA method was applied (Lücking, *et al*.,2009; Luger, 2002). From the identified incidental human-machine interactions, the safety defects were derived.

3. Results and Discussion

The results of the databank analysis helped to identify the persons at risk, their gender and age, the accident

Table 1: Employment status, personal characteristics and accident time specific parameters of occupational accidents with high pressure cleaners in the Austrian agriculture (2008-2010)

Parameters	Number (n)
Employment status	**(n=12)**
Farm managers	12
Others	0
Gender	**(n=12)**
Male	12
Female	0
Age (years)	**(n=12)**
Under 40	4
Over 40	8
Season	**(n=12)**
Spring	2
Summer	2
Autumn	6
Winter	2

time and date, the injury characteristics, the generalized causes and circumstances. The results of the accident report analysis offered key information about the causes and circumstances in the agricultural language.

Personnel characteristics and accident date and time

A total of 12 incidents were documented in the databank; 11 incidents occurred with pressure cleaners and one incident with a compressor. The victims were male and professional farm managers (100%, 12/12); the majority of them were over 40 years old (66.7%, 8/12), and the incidents happened predominantly in autumn (50%, 6/12), on weekdays (75%, 9/12), and especially in the afternoon (50%, 6/12) (Table 1). The data for personal characteristics were anonymised in the reports. Most of the accidents happened in the year 2010 (50%, 6/12), followed by 2008 (25%, 3/12), 2009 (8.33%, 1/12) and 2006 (10%, 1/10); the information about two accidents was inaccurate.

Differences consisted in the information quality between these sources. The databank incorrectly categorised one compressor accident, while the accident reports did not include personnel information about the accident victims.

The injuries identified by databank data and report analysis were mainly wounds and superficial injuries (50%, 6/12; 60%, 6/10), followed by fractures (25.0%, 3/12; 2/10, 20%), sprains and others (9.09%, 1/11; 20%, 2/10), and chemical burns (8.33%, 1/12) (Figure 1). There was missing the documentation of one fracture and the chemical burns in two out of 11 accident reports.

The affected parts of the body were mainly the upper body parts (91.7%, 11/12), like extremities (33.3%, 4/12; 36.4%, 4/11) and head parts (33.3%, 4/12; 27.3%, 3/11), torso (25%, 3/12; 27.3%, 3/11) and the lower extremities (8.33%, 1/12; 9.09%, 1/11). The report analysis identified one eye injury that most likely occurred during the compressor accident which was not recognised by the report analysis.

The injuries occurred predominantly on the left (81.8%, 9/11; 77.8%, 7/9) and rarely on the right body side (18.2%, 2/11; 22.2%, 2/9). In the report databank information was missing about one fracture, the body part eye and twice the right body side, because the compressor incident and the chemical burns were not mentioned in the report of the lye incident.

Minor differences exist between the data in the databank and the data obtained through the report analysis in relation to injury type, body parts and body sides injured. However, the above provides important information for the identification of required body-related prevention measures.

Causes and circumstances of accidents

Major differences in information quality were recognised for the variables on causes and circumstances. The databank variable working environment was the workplace where the accident happened, the work process described the type of work and task, and the specific physical activity gave a broader description of the

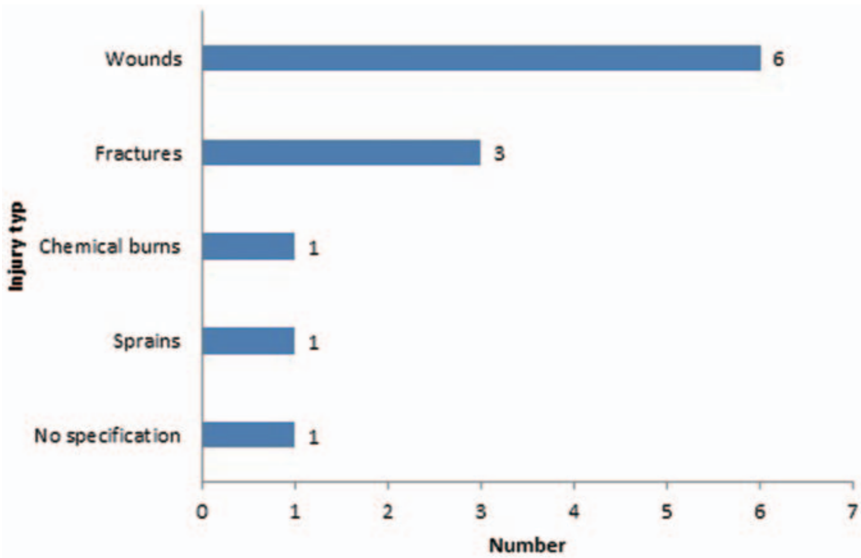

Figure 1: Injury type of accidents with high pressure cleaners in the Austrian agriculture (2008–2010) (n=12)

activity that the victim was performing when the accident happened.

The deviation depicted the abnormal event leading to an accident, the way in which the circumstances of the accident differed from normal practice, but the change from normal practice does not describe the root cause of the accident, nor the responsibilities (Eurostat, 2012).

The variable contact described how the victim came into contact with the 'Material Agent' that caused the injury. It described precisely how the victim was injured (Eurostat, 2012).

All accidents happened in the court of the farms (100%, 12/12; 100%, 9/9). The working environments of accidents were the breeding areas (33.3%, 4/12; 66.7%, 6/9), storage buildings (3/12, 25%), the court exterior area (33.3%, 4/12; 33.3%, 3/9) and unspecified farming area (8.33%, 1/12). These results corresponded mainly with the report analysis results. Two accident reports did not include any information about the working environments.

The identified categories of the work process were 'work-related tasks' (83%, 10/12) and 'agricultural type work, forestry, horticulture, fish farming, etc.' (16.7%, 2/12).

The identified specific physical activities were 'working with tools' (50%, 6/12), 'holding, handling objects' (33%, 4/12), 'operating machinery' (8.33%, 1/12) and 'walking, running, going up, going down, etc.' (8.33%, 1/12) (Table 2).

These are occupational independent terms describing accident work processes; they are not used agriculture-specific terms describing work-related tasks or physical activities in agriculture. Therefore, a comparison on this level with the information in the reports was not performed. Instead, accidental tasks, based on the REFA method (1984), were identified. According to Schneider and Heim (1974) a safety analysis requires the recognition of the task and the integration into elements.

The task analysis revealed that the agricultural tasks resulting in accidents were cleaning of machinery (70.0%, 7/10), stable parts and central heating boilers, filling the lye into the store tank (10.0%, 1/10), removing the pressure cleaner hose (10.0%, 1/10), and loading the high pressure cleaner for transportation on a tipper box (10.0%, 1/10).

Task 'Holding, handling objects' (4/12) of 'specific physical activities' corresponded probably with the tasks of 'filling the lye into the store tank' (1/10), 'removing the hose' (1/10) and 'transporting the high pressure cleaner' (1/10). The incidental cause 'working with tools' (6/12) was mainly given during the cleaning (7/10) when handling the lance. Cause 'walking, running, going up, going down, etc.' (1/12) corresponded probably with the cause slipping (1/10), which is mentioned as an accident occurring during cleaning. The counterpart of cause 'operating machinery' (1/12) could not be identified.

The accidents deviations were the 'loss of control' (75%, 9/12), 'fall of person and uncoordinated movements' (16.7%, 2/12) and 'breakage, bursting, slip, fall, collapse' (8.33%, 1/12). The 'loss of control' (75%, 9/12) occurred when the lance was inserted into the corn harvester during cleaning of machinery in the farm yard (9.09%, 1/11), the bouncing of the water jet on the chest and feeding equipment (18.2%, 2/11), slipping of the container from the hands during filling in the lye (9.09%, 1/11), bouncing of the hose on body parts (9.09%, 1/11) and bursting of the hose (1/11, 9.09%), rolling away of the high pressure cleaner on the tipper box and tripping over the hose (18.2%, 2/11). The 'fall of person' (2/12) was probably caused by tripping over the hose (9.09%, 1/11) and the 'breakage, bursting, slip, fall, collapse' (8.33%, 1/12) probably referred to the slipping and collapsing on a tractor wing (9.09%, 1/11).

Table 2: Work task, incidental cause and deviation of accidents with high pressure cleaners in the Austrian agriculture (2008-2010)

Parameters	Number (n)
Work task	**(n=10)**
Cleaning objects	7
Filling lye in the tank of the cleaner	1
Transportation of the cleaner	1
Removing the hose of the cleaner	1
Incidental cause	**(n=12)**
Working with tools	6
Holding, handling objects	4
Walking, running, going up, going down, etc.	1
Operating machinery	1
Deviation	**(n=12)**
Loss of control	9
All of person and uncoordinated movements	2
Breakage, bursting, slip, fall, collapse	1

The variable 'contact' of the databank, which expressed how the accident occurred, corresponded with the identified accident causes in the accident reports.

The variable 'struck by object in motion, collision with' (33.3%, 4/12) corresponded with slipping (27.3%, 3/11) and hose bursting (9.09%, 1/11). The 'horizontal or vertical impact with/against a stationary object' (25%, 3/12) was comparable with rupture of the hose in the victim's hand (9.09%, 1/11) or the hose and the brass nozzle coming in contact with the eye (9.09%, 1/11), the slipping and collapsing on a tractor wing (9.09%, 1/11), as well as the rolling away of the high pressure cleaner on the tipper box and falling to the ground, the toe (9.09%, 1/11). The 'contact with sharp material agent (knife/blade etc.)' (16.7%, 2/12) occurred by getting dirt into the eye (9.09%, 1/11) and bouncing of the water jet on the chest during cleaning (9.09%, 1/11). The 'contact with hazardous substances on/through skin and eyes' (8.33%, 1/12) matched with 'getting the lye into the eye' (9.09%, 1/11).

These variable categories of the accident work environments with process, deviation, and contact were generalised terms for the use in different professions. Identifying the agricultural accident tasks and their specific causes was not possible, but required an additional phrase analysis of the report contents. The report analysis revealed the relevant parameters of the incidental human-machine interaction for the derivation of safety deficits and first prevention measures.

Safety deficits and prevention measures

The safety deficits identified were the missing use of protective equipment, like eye and face protection (18.2%, 2/11) and protective clothing (9.09%, 1/11).

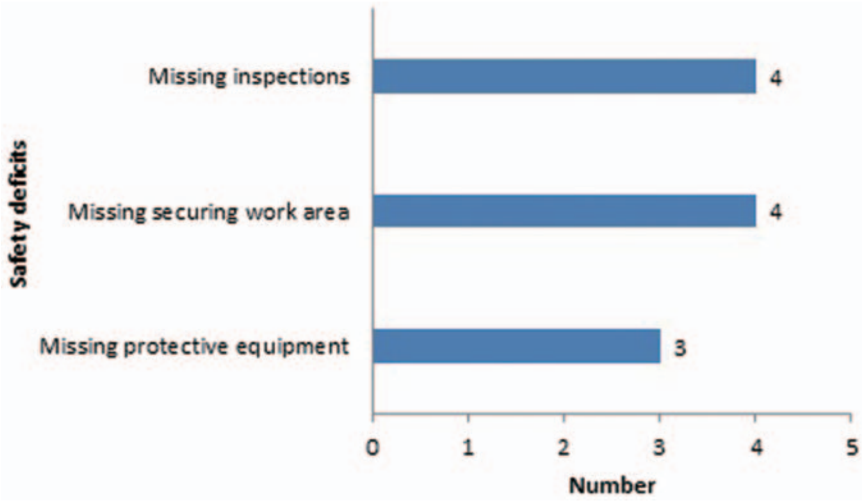

Figure 2: Safety deficits of accidents with high pressure cleaners in the Austrian agriculture (2008–2010) (n=11)

When handling the machinery, the load securing was not applied during the transport of the high pressure cleaner (9.09%, 1/11), the shutdown of the corn harvester for the cleaning task was missing (9.09%, 1/11), and the hose and nozzle had not been inspected for damages before starting the cleaning process (18.2%, 2/11).

Deficits in securing the work area in maintaining order and in wearing safety shoes or boots were probably the main reasons for slipping incidents during cleaning (27.3%, 3/11) followed by the incident of removing of the hose (9.09%, 1/11).

Removing of obstacles, like the hose (27.3%, 3/11), in the walkway and handling area and wearing of waterproof and no-slip shoes or boots (36.4%, 4/11) reduce the risk of slipping and stumbling (DGUV, 2012).

No eye and face protection were used during filling the lye into the store tank (9.09%, 1/11), cleaning the feeding equipment and central heating boilers, which is why the materials (lye concentrate, uncoupled dirt, hose parts, and nozzle) injured head parts (36.4%, 4/11), especially the eyes and the face.

Inattention and lack of safety clothing were responsible for the injuries caused by the impinging water jet in the chest area (9.09%, 1/11). Wearing of safety goggles (36.4%, 4/11) and safety clothing (tear proof) (9.09%, 1/11) during cleaning and lye refill tasks is recommended in the manufacturer manual. The quality aspects of the safety goggles are described in EN 166 and EN 170; important is the choice of the right mechanical and chemical strength and the fog freedom.

To ensure that safety goggles, face protection and safety clothing are worn by operators, warning and information signs (pictograms) should be attached in a highly visible area of the high pressure cleaner and protection equipment should be sold with any new high pressure cleaner (Bundesverband der Unfallkassen, 2002).

Missing inspections (18.2%, 2/11) of hose and nozzle for damages were responsible for detaching the nozzle and bursting the hose. The bursting of the hose and the detaching of the nozzle can be avoided by early registration of damages by checking the equipment before each use. These procedures and setup as well as maintenance and minimum requirements for the hose are recommended in EN1829-1, Directive 2006/42 EC and manufacturer manuals (Deutsche Norm, 2010; Richtlinie 2006/42/EG, 2006). High quality products indicate leaky hoses and nozzles damaged by an alarm display, recognised by pressure loss (Nilfisk-Alto, 2012; Kärcher, 2012).

The load securing and safety shoes were not in use (9.09%, 1/11) during the transport of the high pressure cleaner on a tipper box, which caused the toe injury.

Transport requirements are mentioned in EN 1829-1 and manufacturer manuals (Deutsche Norm, 2010). Measures are locking bar, beam, tension or tie-downs, and wheel chocks to ensure immobility during transport and wearing safety shoes with steel caps. High quality high pressure cleaners are already equipped with brakes, crane hooks or eyelets for fixation.

Summarised results

Reports of the Austrian Insurance Institutions (AUVA and SVB) about accidents at work indicate that employees in agriculture should provide information for accident risks. There are no studies available that examine the machinery-related reasons for this risk. To close this research gap, the data of the period 2008 to 2010 of the accident databank and the accident reports of the injured victims were analysed in detail.

Databank data analysis, narrative text analysis and inclusion of work into REFA were selected to analyse and compare the results of these two data sources in terms of information quality and relevance to the identification of safety deficits and further development of sustainable prevention measures.

Table 3: Prevention measures for accidents with high pressure cleaners in the Austrian agriculture (2008-2010)

Parameters	Number (n)
Prevention measures	**(n=11)**
Inspection before operating	4
Securing work area	4
Face protection and safety clothing	3

The results of the databank analysis was helped to identify, with minor inaccuracy, the persons in danger, their gender and age, their specific occupational sector, the scene of the incident, and times and injury characteristics.

Twelve incidents were documented in the databank, but only eleven of them occurred with pressure cleaners; the twelfth incident occurred with a compressor. The victims were farm managers; the majority of them were over 40 years old. Half of the incidents happened in autumn and on weekdays, especially in the afternoon.

The databank analysis did not reveal the relevant parameters of the human-machine interaction during the incident, a factor that is necessary to determine safety deficits. The variable categories of causes and circumstances were generalised terms for the application to different occupations; an identification of the agricultural tasks leading to an accident and their specific causes was not possible. It was necessary to choose a more specific categorisation; a classification of the work processes based on tasks of the REFA method (1984), which was applied and approved while performing a keyword search in the accident reports.

This search revealed that the agricultural tasks carried out when an incident occurred were mainly cleaning machinery, stable parts and central heating boilers followed by filling the lye into the store tank, removing the hose and transporting machinery.

The deviations or incidental circumstances identified included entering the lance in the corn harvester during cleaning, the bouncing of the water jet on the chest and feeding equipment, slipping of the container from the hands during filling in the lye, bouncing of the hose on body parts and bursting of the hose, rolling away of the high pressure cleaner on the tipper box, and falling to the ground during transport and most often falling over the hose as well as slipping and collapsing on a tractor wing.

The contacts or incidental interactions included slipping, being hit by the lance on the hand or hit by the hose and the brass nozzle on the eye, slipping and collapsing on a tractor wing as well as being hurt on the toes by the high pressure cleaner falling from the tipper box to the ground. Eye injuries were caused by dirt and ley, chest injuries by the bouncing of the water jet because of inattention, and finger injuries by a bursting of the hose.

The safety deficits identified were mainly the missing use of protective equipment like eye and face protection and protective clothing. During transport of the pressure cleaner a load securing was not used. During cleaning of the corn harvester the shutdown was neglected. The hose and nozzle were not inspected for damages before starting the cleaning process. Deficits in securing the work area, in maintaining order and in wearing safety shoes or boots were probably the main reasons for slipping incidents during cleaning and removing of the hose.

4. Conclusions

Overall, based on the databank analysis, it was possible to identify the personal, time and place characteristics of incidents with minor inaccuracy. The variable categories of the incidental work field and process of the databank were generalised terms for the application to different professions. The report analysis results are necessary for the identification of the accident scenarios and causes according to agricultural terminology in order to recognise the human-machine interactions leading to the accident. The identification of them allowed the determination of safety deficits for deriving the first prevention measures. In order to derive more accurate preventive measures, additional information about the accident machine and the machine-specific part-related interactions of humans are necessary. For this purpose, database results can be linked with accident reports and additional interviews with accident victims and accident machinery evaluations can be carried out to close information gaps and to ensure a practice-oriented further development of prevention measures. To derive more accurate preventive measures, missing information about the accident machine and the machine-specific part-related interactions of humans must be supplemented by interviews of accident victims and machinery evaluations to close information gaps.

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