Agricultural injuries in Korea and errors in systems of safety

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▮ **Abstract**

Introduction. Agriculture is known to be a dangerous industry in Korea, as well as in other countries. According to earlier studies, the root cause of occupational injury can be identified with errors in the various systems of safety, and such identification is helpful for the prevention of occupational injury.

Objective. The aims of this study were to examine the root causes of cases of agricultural injury in Korea, based on insurance claims and identification of errors in systems of safety.

Materials and method. Using the Korean Mutual Aid Insurance's injury claim database, 277 injury cases were identified, of which 68 were contacted. Root causes were categorized, using the logic tree diagramming method and the systems of safety described in the literature.

Results. Seventy-five percent of all injuries were attributable to falls, strangulation, amputation and collision from flying and falling objects. 194 root causes were found for all injuries. The percentages of errors in all the systems of safety for each root cause were 24.7% – training/procedure, 20.3% – design, 11.9% – mitigation, 9.3% – human factor, 6.2% – maintenance/inspection, and 1.0% – warning/notification. The percentage of root causes which could not be categorized due to a shortage of information was 18.6%.

Conclusions. It was found that most agricultural injuries were caused by a complex layer of root causes which were classified as errors in the systems of safety. This result indicates that not only training and personal protective equipment, but also regulation of safety design, mitigation devices, inspection/maintenance of workplaces, and other factors play an important role in preventing agricultural injuries. The identification of errors will help farmers to implement easily an effective prevention programme.

▮ **Key words**

Korea, agriculture, injury, system of safety, error, root cause

INTRODUCTION

As in many other countries, agriculture in Korea is vulnerable to the risks of occupational injuries. Farmers are exposed to a variety of hazards, such as machinery, pesticides, musculo-skeletal risk factors, organic gases, organic dust, and other hazards involved in farm work. In a recent study, the injury rate in Korea was reported as 1.4–3.2% [1]. Even though earlier studies concerning agricultural injury in Korea have reported different rates [1, 2], farmers certainly face the worst occupational health and safety conditions, compared with other industries, which has also been stated by the International Labour Organization [3].

Since the enactment of occupational health and safety legislation in Korea in 1981, there have been many initiatives to promote the health and safety of workers in the manufacturing industry. However, farmers, whose number is approximately 1.7 million, were not included within the scope of the legislation.

Since 2006, few intervention programmes have been conducted on the basis of education designed to prevent human errors during work. According to a previous study, human error, however, can be seen as an effect rather than

the cause of accidents [4]. Very little evidence was found indicating a reduction in the injury rate due to intervention, including the training of farmer as one way for the correction of human errors [5, 6]. Local experts in occupational health and safety in Korea agree that it is time to find alternatives, considering the effectiveness and easiness of agricultural safety and health interventions.

Major advances in the prevention of injuries would continue to require a more analytical approach to understanding the complex array of factors that influence the incidence, severity, and outcomes of injuries [7]. Previous studies about the risk factors leading to agricultural injuries mention the relationship between age, gender, type of task, use of personal protective equipment (PPE), and other factors and incidence rate or characteristics of injury [8, 9, 10].

In a recent study, a narrative text analysis of accident reports mostly showed which accident scenarios should be avoided; the technical and behavioural solutions to avoid these scenarios need also to be identified as a further step [11].

Failures in various systems of safety, such as warning and mitigation devices, were identified for injuries or near misses in a health and safety programme in the USA [12], demonstrating a more detailed insight into the scenarios leading to the occurrence of injury. The authors of the presented study expected that identification of errors in the systems of safety resulting in agricultural injuries could be prevented through the development of intervention programmes concerning agricultural injury as a further step.

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OBJECTIVE

The aims of this study were to examine the root causes in injury cases, based on insurance claims, and the identification of errors in systems of safety.

MATERIAL AND METHOD

Subjects from injury claims record. Subjects for this study were chosen from the injury insurance claim database of the Mutual Aid Insurance of the Nation Agricultural Cooperation Federation (NACF) of Korea. In 2006, the total number of injury claim cases was 27,864. Of these, 227 cases were selected on the basis of the following criteria:

a) cause of injury (contact with machinery/facility/tool, slip/trip/fall, strangulation, contact with sharp materials, collision with materials);

b) injury occurred after 1 January 2005;

c) the injured party was born after 1950;

d) the insurance paid out was 300,000–500,000 Won (approximately 300–500 USD), according to type of injury;

e) sufficiency of data (telephone number, detailed description of injury).

Contact was made in 75 cases (33.0%) by telephone from among the selected 227 cases, and interviews conducted in 2007. During the telephone interviews, the following topics were discussed in order to acquire more detailed information about the injuries sustained: career in agriculture; characteristics of the injury and task; farmer's opinion about the cause of the injury and risks related to the task; characteristics of the materials included in the task, such as machinery/facilities/tools; use of safety equipment; experience of training/education. Seven of these cases failed to provide enough further information; therefore, the final number of cases analyzed was 68.

Method for identifying errors in systems of safety. With the information from the interviews and injury claim database, the root causes of each case were analyzed using the logic tree diagramming method. This is a method used to determine the root causes of injuries and near misses through a necessary and sufficient test concerning the factors that caused or made possible the event to take place [13]. Figure 1 is an example of an analysis using the logic tree diagramming method.

The root causes of injuries were identified with systems of safety. Table 1 provides criteria concerning the systems of safety for categorizing the root causes in the presented
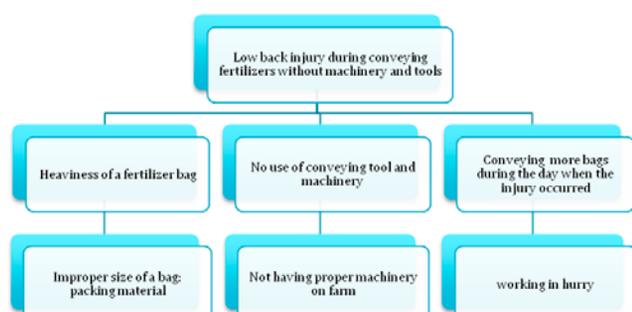

Figure 1. Example of logic tree diagramming about low back injury by heavy workload

Table 1. Definition of systems of safety and sub-systems

Systems of safety	Sub-systems
Design (Systems of safety to eliminate or substitute hazard on farm)	– Safety design of agricultural machinery, workplace, roads, tool and storage material – Existence of proper tools, machinery, infrastructure, facilities for safety at the workplace
Maintenance / Inspection (Systems of safety to inspect or maintain safety status)	– Maintenance and inspection of infrastructure, machinery, facilities and workplace
Mitigation (Systems of safety to reduce or minimize exposure to hazard and injury)	– Shutdown or isolation devices – Size of packing material for reduction of weight – Mechanical ventilation
Warning / notification (Systems of safety to raise alarm or notify worker about hazard)	– Sign or board for notification and warning
Training / procedures (Systems of safety to make farmer act safely during work)	– Existence and observance of procedure for safe task (Stable posture, pre-start-up review, wearing seatbelt, turning off engine, clear visibility, positioning of materials, use of proper tools, working slowly and with co-worker) – Recognition of safety information – Experience of training and education in safety
Human factor (Systems of safety to make each farmer protected from hazard individually on farm)	– Personal Protective Equipment (PPE) – Clothes for work – Working with less fatigue

study. The definition of each system in this study is a little different from that suggested in previous studies [13, 14], as the conditions in the agricultural workplace are different from other industries.

Some farmers did not want to talk about the moment of their injury owing to the mental pain of the recollection, and also for other reasons. As a result, some of the root causes were classified as NMI (Need More Information) due to insufficient information. Root causes that were based on natural events or could not be removed artificially, such as weather conditions, snow, the weight of stone, etc., were defined as unpreventable errors.

RESULTS

Demographic characteristics of subjects and type of injury. The number of male and female subjects were 60 (88.2%) and 8 (11.8%), respectively. The age of most subjects was between 40–59 (87.7%). Fall, strangulation, amputation and collision from flying and dropping objects accounted for 75% of all cases (Tab. 2). Some injuries due to a fall were found to have occurred as a result of slipping or tripping. If a fall due to a slip or trip resulted in injury, the case was categorized as a fall.

The sources of injuries were classified into 4 categories (machinery/facility, heavy material, tool/equipment, and others), of which about half (58.8%) were caused by machinery/facility. The types of tasks in this study were categorized as operation, maintenance/preparation, conveyance and transportation, considering the characteristics of each task. Based on this categorization, 29 (42.6%) out of 68 cases were classified as maintenance and preparation of

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Table 2. Demographic characteristics of subjects and type of injury (N=68)

Variable/Category	Frequency	Percent
GENDER		
Male	60	88.2
Female	8	11.8
AGE		
Below 40	6	9.6
40 - 49	25	42.5
50 - 59	32	45.2
60 and above	5	2.7
Type of injury		
Fall	19	27.9
Strangulation	11	16.2
Amputation	11	16.2
Collision with flying / dropping object	10	14.7
Overturn	8	11.8
Pulling a muscle	4	5.9
Slip	2	2.9
Disease	1	1.5
Puncture	1	1.5
Trip	1	1.5

facility/machinery and maintenance of the farm workplace/road (Tab. 3).

Classification of root causes with systems of safety and subsystems. 194 root causes were found, of which the percentage of errors ranged from 24.7% (training/procedure) – 1.0% -warning/notification. The number of NMIs was 36 (18.6%), which could not be categorized in the systems of safety due to the shortage of information about the injuries (Tab. 4).

DISCUSSION

Sixty-eight agricultural injuries in Korea were analyzed, firstly by the type and source of the injury. 27.9% of the total number of injuries were the result of a fall. This result is similar to the research by McCurdy and Carroll (2000), who found that falls represented up to one-quarter of injury cases on farms [15]. According to the obtained results in the current study, almost 60% of injuries occurred as a result

of machinery/facility. This result is consistent with those obtained in earlier studies which reported that machinery was strongly related to agricultural injuries [15, 16].

Secondly, the current study aimed to extract root causes from among the 68 agricultural injuries by logic tree diagraming method, and to classify the root causes as errors in the systems of safety, which was used in earlier studies [12, 14].

The identified errors in the design systems were mostly due to faults in the safety design of machine/infrastructure, such as no seat belt equipped in a cultivator, too narrow road for a tractor, and various other errors. These errors could be avoided, not by the farmer's own actions or training, but by the re-construction of narrow roads or the replacement of machinery which has a faulty safety design. Fourteen injury cases (20.6%) from among the 68 studied injuries were caused by not having the proper tools and/or machinery at the workplace. This result stresses the importance of ensuring that safety should be focused on prioritising proper tools and machinery as well as PPE. The use of proper tools and machinery substantially prevents body parts from coming into contact with the sources of hazards, such as hot surfaces, pesticides, machines, and many others.

Concerning the inspection/maintenance system, it is difficult to maintain the outdoor workplace in agriculture. On the basis of this, root causes in the outdoor workplace were classified, such as ground made slippery with snow, as unpreventable errors. The root causes related to the indoor workplace and uneven road/workplace were classified as errors in the maintenance/inspection system. In the presented study, 8 injuries (11.8% of all injuries) were due to errors in road maintenance. In 2002 in Finnish agriculture, 758 injuries (13.8%) from among 5,507 injuries were caused by uneven and slippery terrain [9].

In the mitigation system, errors were caused not only by the shut-down and isolation device but also by the size of packing material. The weights of materials which caused injuries were above 15 kg. The weight of material, such as fertilizer and other farm products, depended on the size of the packing materials, which is usually dependent not on the farmer's ability but the ability of machinery to effectively convey such material. The reduction of weight by resizing packing material is a more effective measure in the reduction of musculoskeletal injuries than training in ergonomic posture.

The percentage of errors was lowest in the warning/notification system. Farmers usually work on small-scale farms, in a field, and separated from other farmers [16].

Table 3. Number of injuries (N=68) by type of task and source of injury (%)

Task	SOURCE				
	Machinery/ Facility	Heavy material	Tool/ Equipment	Nail, stone, broken glass and others	Total
Operation of facility/ machinery	7 (87.5)	0 (0.0)	0 (0.0)	1 (12.5)	8 (100.0)
Maintenance and preparation of facility/ machinery	14 (82.4)	1 (5.9)	1 (5.9)	1 (5.9)	17 (100.0)
Maintenance of farm workplace/ road	5 (41.7)	2 (16.7)	2 (16.7)	3 (25.0)	12 (100.0)
Conveyance/ Packing during harvest	0 (0.0)	6 (75.0)	1 (12.5)	1 (12.5)	8 (100.0)
Transportation	9 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	9 (100.0)
Other[a]	5 (37.5)	2 (14.3)	3 (21.4)	4 (28.6)	14 (100.0)
TOTAL	**40 (58.8)**	**11 (16.2)**	**7 (10.3)**	**10 (14.7)**	**68 (100.0)**

[a] Spraying fertilizer or pesticide, pruning, and others

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Table 4. Number of errors in the systems of safety

Category of systems of safety	N (%)	Errors by sub-system (No. of errors/No. of injuries caused by the error)	
Design	38 (19.6)	Faultiness of machinery and infrastructure design (21/21)[a] Faultiness of tool design (1/1)	No proper machinery (8/8) No proper tool (7/7) Faultiness of storage material (1/1)
Maintenance/ Inspection	12 (6.2)	Inadequate maintenance of road (8/8) No inspection of machinery (1/1)	Inadequate maintenance of workplace (3/3)
Mitigation	23 (11.9)	No shutdown device (9/9) No isolation device (6/6)	Faultiness of size of packing material (8/8)
Warning/ Notification	2 (1.0)	No warning signal (1/1)	No notification about work in a dangerous place (1/1)
Training/ Procedure	48 (24.7)	Not turning off engine (9/9) Working alone (5/5) Insufficient training (4/4) Insufficient visibility (2/2) Not fixing material (2/2) No use of tool existing in workplace (1/1) Working above machine, which is prohibited (1/1) Not using safety pin for fixation (1/1) No traffic control inside workplace (1/1) Winding hose for pesticide spraying on body (1/1)	Placing materials in wrong position (5/4) Working in a hurry (5/5) Failure in identifying hazard (2/2) Not wearing seat belt (2/2) Working in narrow space (2/2) No knowledge of hazard (1/1) Unstable posture (1/1) Mistake with a clutch (1/1) Not removing mud from shoes Not making sure body parts are in safe position (1/1) Grabbing handle of cultivator while getting off (1/1)
Human factor	18 (9.3)	Not wearing PPE-gloves (6/6) Fatigue due to heavy workload (2/2) Improper clothes (1/1) Not wearing PPE-helmet (1/1)	Not wearing PPE-shoes (5/5) Not wearing PPE-clothes (2/2) Not wearing PPE-harness (1/1)
Unpreventable root cause[b]	17 (8.8)	Working at heights (5/5) Slope in workplace (2/2) Stone outside of workplace (1/1) Heavy weight of natural material (1/1) Unavoidable busy period, e.g. harvesting time (1/1)	Slippery place due to water and other factors (3/3) Working above vehicles, e.g. a truck (2/2) Falling materials (1/1) Narrow workplace in field (1/1)
NMI[c]	36 (18.6)		
TOTAL	**194 (100.0)**		

[a] ***Faultiness of machinery and infrastructure design.*** Bad design or absence of system of safety in machinery and infrastructure, such as no seat belt in machinery, narrow road, inclined workplace, uneven dirt road.
[b] ***Unpreventable root cause.*** Root cause due to a factor which could not be controlled, such as weather, weight of stone and other factors.
[c] ***NMI (Need More Information).*** Root cause in which more information was needed to identify the category of systems of safety.

Therefore, the possibility exists that the use of a warning/notification system for co-workers is not taken seriously by farmers, except for machinery. One case of injury to a migrant worker who knew little of the Korean language was found in the database. McCurdy and Carroll (2000) cited the linguistic barrier as the one of the injury risks in US agriculture [15]. It is evident that the need to develop a warning/notification system, especially for migrant workers, also exists in Korea.

Errors in the training/procedure system were difficult to identify in agriculture. Most tasks did not have standard safety procedures, except for machinery/facility used in other industries. Consequentially, common sense factors were used in the current study, such as use of a seatbelt, not working in too much of a hurry, turning off an engine before carrying out maintenance, and other common safety procedures, to identify errors. Approximately one-quarter (24.7%) of all root causes were identified as errors in the system. Of these, errors such as working alone or in a hurry caused 14.7% of all injuries. The result that agricultural injury was caused by working in a hurry is similar to results found in earlier studies [17, 18].

Among all root causes, errors with PPE (8.8%) were relatively rare, considering the errors in other systems. According to Angoules et al. (2007), most agricultural injuries can be prevented with the use of protective clothing, better education and safety precautions [16]. There was, however, no evidence that educational interventions are effective in decreasing injury rates among agricultural workers in a review study [5]. Kaustell et al. (2011) stated that it was more effective to eliminate physical hazards than to train workers to work safely or use personal protective equipment [19].

In the presented study it was found that not only education/training and PPE, but also safety design, the resizing of packing material, inspection/maintenance of uneven roads and other corrections of errors, play important roles in the prevention of even one agricultural injury. These results indicate that most agricultural injuries were caused by complex layers of root causes which were classified in the systems of safety.

This study did not reflect the general characteristics of errors in agricultural injuries. First of all, the number of analyzed cases was small when it came to comparing the detailed characteristics. Secondly, access to information from injured workers was limited, mainly due to the interviews raising unpleasant memories of the accidents. Thirdly, the logic tree diagramming method for classifying root causes needed as much information as possible. This study used an insurance claim database, from which the quality of information was not always satisfactory enough for analyzing the root causes of injuries. Therefore, an additional telephone interview was conducted. The results of the interviews may have involved potential recall biases, and 18.6% of all root causes was categorized as NMIs.

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Few intervention studies have been able to report positive results, and a user-centred approach can facilitate the development of more effective and easier health and safety interventions [19]. Considering this aspect, the results of this injury-based approach with the logic tree diagramming method can have a significant implication for creating good intervention programmes for farmers, as well as for occupational health and safety experts.

CONCLUSIONS

In this study, most agricultural injuries were caused by complex layers of root causes in the systems of safety. This result means that intervention should be focused on not only training and PPE but also safety design, mitigation devices, inspection/maintenance and warning/notifications for the more effective prevention of agricultural injuries. Also, the categorization of errors can be used for developing intervention tools, such as an easy-to-use checklist for a walk-through survey for farmers and occupational health and safety experts.

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