

# Safety Performance of Animal Confinement Floors: Slip, Trip, and Fall Injuries in Finland

K. O. Kaustell, T. E. A. Mattila, R. H. Rautiainen

**ABSTRACT.** *Slip, trip, and fall (STF) injuries are common in agriculture. The aims of this study were to characterize STF injuries and to identify floor-related safety problems that can be reduced or eliminated through building design. Our material consisted of Finnish agricultural injury claim records for the period 1992-2002. The material included 6,414 slip, trip, and fall injuries that occurred in dairy, beef, and swine production and were caused by floor structures. We examined coded information and injury descriptions to identify causes and contributing factors. The performance approach (PA) was used as a framework for discussing findings and their application to building design. PA provides a logic model for building design that considers the needs of workers, animals, and production processes. Nearly half (42%) of agricultural injuries occurred in dairy, beef, and swine production work. Fourteen percent of these injuries were slips, trips, and falls (STF) related to floor structures. More than 450 work years were lost due to disability resulting from these injuries. Many STF injuries occurred in milking (n = 1135), moving feeds (n = 962), and animal transport and care (n = 880). More than half (59%) of STF injuries occurred while carrying or moving a load. STF injury causes included floors, door sills, gutters, curbs, steps, ramps, grates, and contaminants like water, ice, snow, manure, detergent, forage, and hay. Men had a lower STF injury risk compared to women (RR = 0.63, 95% CI: 0.61-0.67). The magnitude and nature of STF injuries suggest that there is a need for improving the safety performance of floors and related structures. Key areas include slip-resistant floorings, effective contamination control, macro structures (elevations, entrances, access ways), and logistics for materials handling and storage spaces.*

**Keywords.** *Accident, Agriculture, Animal confinement, Building design, Floors, Hazard, Injury, Performance approach, Performance evaluation, Risk, Safety.*

The requirements of workers, animals, and production processes are critical in the planning and design of animal confinements. Failing to meet these requirements contributes to injuries and results in economical losses as well as decreased human and animal welfare. The quality of animal confinement planning is closely related to injury events (Carstensen et al., 1995). Slip, trip, and fall (STF) injuries are common injury types in agriculture (Nordström et al., 1996; Solomon, 2002; Hartman et al., 2003;

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McCurdy et al., 2004; Rautiainen et al., 2004). We used STF injury claims data to evaluate the safety performance of floors and floor-related structures.

The purposes of this study were to:

- Assess the magnitude of slip, trip, and fall (STF) injuries in animal confinements.
- Characterize these injuries with focus on contributing floor-related design factors.
- Identify safety problems that could be reduced or eliminated through building design.

This study connects to a larger research initiative that aims to develop functional designs of agricultural production buildings. We reviewed the safety performance of animal confinement floors in the context of building design using the performance approach (PA) (Spekkink, 2005).

## Materials and Methods

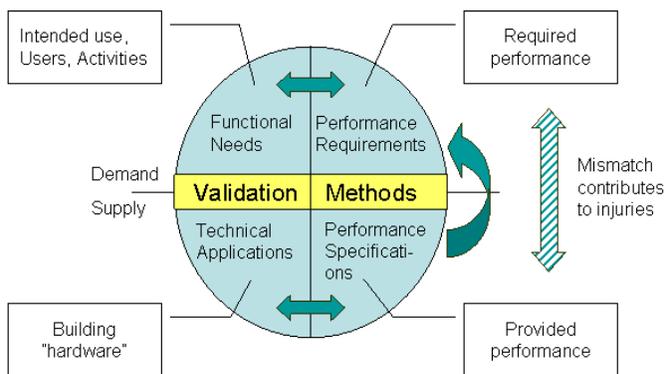
The materials included injury claim records, compensated by the Finnish Farmers Social Insurance Institution (Mela) during 1992-2002. A compensable injury is described as a sudden unexpected forceful event with an external cause, which results in bodily damage or an ailment, and which occurs in the course of agricultural work. The analysis focused on those injuries that occurred in dairy, beef, and swine production and were “caused” by a floor structure, such as a floor, door sill, ramp, feeding table, manure gutter, or pen ( $N = 6,414$ ). This limitation excluded, for instance, injuries caused by machinery, equipment, and animals. In Mela’s injury coding system, the “cause” describes the physical object, tool, or factor that the injured person was in contact with before or at the time of the injury. The materials enabled comparison of injury characteristics caused by a floor structure to (1) all agricultural injuries during 1992-2002 ( $N = 110,142$ ) and (2) all dairy, beef, and swine production injuries that occurred during 1992-2002 ( $N = 46,634$ ).

The review used Mela’s injury classification codes, which are entered into the claims database as part of the claim adjudication process. Typically, an injured farmer is treated at a local health service center. He or she reports the injury to Mela at a local agent’s office using a claim form. The forms are sent to the insurance headquarters, where they are processed and coded. Missing information is verified by contacting the farmer or appropriate sources. Specific injury coding variables include work activity, cause, nature of incident, a short (up to four lines) description of the injury event, ICD10 health outcome, and resulting compensation in various categories, as well as the duration of compensated lost work time.

Our analysis of injury characteristics addressed the number, rate, severity, and contributing factors of slip, trip, and fall injuries (STF injuries). While work activity, cause, and injury event coding is very useful, we also determined whether more detailed categorized information of the injury mechanism or contributing factors could be constructed based on the injury descriptions for further characterizing of STF injuries.

We used PA as the framework for evaluating and discussing safety issues related to floor design. PA and the concept of performance-based building design have been the subject of scientific discussion and development during the past four decades (Sneck, 1972; Foster, 1972; Cronberg, 1973; Gallagher, 1979; ISO, 1984; Spekkink, 2005; Szigeti and Davis, 2005). This approach encompasses the development of performance-based specifications and guidelines derived from the users’ activities and intended use, as well as performance evaluation of existing built environments.

We used injury data analysis as a method for post-occupancy evaluation of the safety performance of animal confinement floors and related structures. We looked for



**Figure 1. Elements of the performance approach (Szigeti and Davis, 2005).**

information on the *user* (the injured person) and *activity* (work activity at injury time) as well as *building "hardware"* (characteristics and details of the physical environment). Any references to a *mismatch* contributing to injury, e.g., comments on slipperiness, were registered (fig. 1). This information contributes to an understanding of the *provided performance* of the floor and floor-related structures as well as the activity- and user-based *performance requirements*. Understanding the causes of mismatches between required and provided performance can help develop guidelines on how to prevent STF injuries.

## Results

### Agricultural Population and Injuries

During the period 1992-2002, farm size increased and the number of farms decreased rapidly in Finland. The number of dairy, beef, and swine farms decreased from 56,645 in 1992 to 28,932 in 2002 (table 1). The average cow herd was 13.1 in 1992 and 19.5 in 2002. The average finishing pig herd was 78.8 in 1995 and 137.9 in 2002 (Ministry of Agricultural and Forestry, 2004). The overall agricultural injury rate decreased from 12 to 9 injuries per 100 farms during this period. The annual injury rate in dairy, beef, and swine production work varied from 9 to 11 injuries per 100 farms (table 1).

**Table 1. Livestock farms, injuries, and injury rates in agriculture in Finland, 1992-2002.**

|                            | 1992  | 1993  | 1994  | 1995  | 1996  | 1997  | 1998  | 1999                 | 2000  | 2001  | 2002  |
|----------------------------|-------|-------|-------|-------|-------|-------|-------|----------------------|-------|-------|-------|
| No. of farms               | 56645 | 53913 | 52336 | 48123 | 44602 | 41860 | 39069 | 35824 <sup>[a]</sup> | 32578 | 30671 | 28932 |
| No. of injuries            | 6404  | 5487  | 5459  | 5020  | 4347  | 4074  | 3513  | 3331                 | 3197  | 3023  | 2779  |
| Injury rate <sup>[b]</sup> | 11    | 10    | 10    | 10    | 10    | 10    | 9     | 9                    | 10    | 10    | 10    |
| No. of STF <sup>[c]</sup>  | 903   | 809   | 840   | 736   | 635   | 544   | 465   | 412                  | 402   | 357   | 311   |
| STF/all injuries (%)       | 14    | 15    | 15    | 15    | 15    | 13    | 13    | 12                   | 13    | 12    | 11    |
| Severe STF/all STF (%)     | 21    | 22    | 22    | 23    | 19    | 23    | 23    | 21                   | 20    | 20    | 23    |

[a] Calculated as an average of years 1998 and 2000.

[b] Injuries per 100 farms.

[c] STF = Slip, trip, and fall injuries caused by a floor structure.

## Magnitude of Injuries

In 1992-2002, about 42% of all compensated injuries in agricultural work occurred in dairy, beef, and swine production. The cause of these injuries was typically an animal (47% of the cases), but the working environment also had a significant role (31% of the cases) (Ministry of Agriculture and Forestry, 2004).

Animal confinement floor structure was coded as the immediate cause of 6,414 slip, trip, and fall injuries during 1992 to 2002. This represented 6% of all agricultural injuries and 14% of injuries in dairy, beef, and swine production work. The number of STF injuries decreased during the 11-year period. The proportion of STF injuries out of all injuries clearly decreased ( $r^2 = 0.82$ ,  $p < 0.001$ ). The proportion of severe injuries remained high and showed no significant trend ( $r^2 = 0.007$ ,  $p = 0.81$ ) (table 1).

The total number of lost days due to STF injuries was 168,795 days (462 person-years based on 365 workdays per year) during 1992-2002. The average duration of disability resulting from an injury was 26 days. About 22% of the cases were severe, leading to more than one-month disability, and they represented 60% of all lost workdays. The injured part of body was most often lower limb (36%), back (24%), or upper limb (19%).

The number of STF injuries was 3176 for men and 3238 for women during 1992-2002. The number of person-years was 856,953 for men and 556,714 for women, respectively. The STF injury rate was lower among men compared to women: rate ratio (RR) 0.63; 95% confidence interval (CI) 0.61-0.67. The STF injury risk for men in relation to women decreased over our 11-year study period from 0.66 in 1992 to 0.56 in 2002 ( $r^2 = 0.35$ ,  $p = 0.07$ ).

## Characteristics of STF Injuries

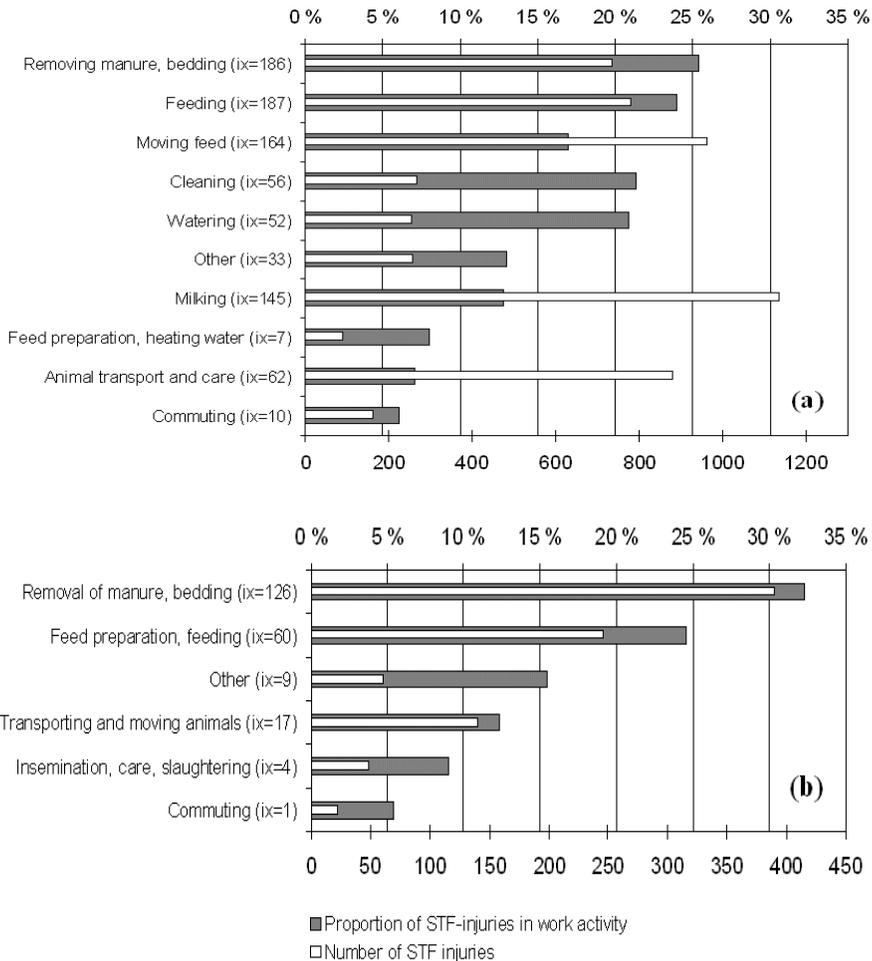
### WORK ACTIVITY DURING STF INJURY

In dairy and beef production, the work activity with the highest count of STF injuries was milking (includes preparation) (1135 injuries), followed by moving feed (962 injuries) (fig. 2). Animal transport and care (880 injuries) had the third highest count; it includes artificial insemination, breeding, calving, brushing, cleaning, and care of sick animals. The number of STF injuries was also high in manure handling and feeding. More than half (59%) of the STF injuries occurred while carrying or moving a load.

The proportion of STF injuries, calculated from all injuries in respective work activity, was high in bedding and handling manure (25%) and in feeding (24%) (fig. 2). Preparation of milking had a high proportion of STF injuries (19% of injuries in this work activity), much higher than actual milking (11%). The most commonly reported immediate causes of STF injuries were the floor and door sill; in milking preparation activities, they represented 84%, in manure handling 60%, and in feeding 59% of all cases.

In swine production, floor-related STF injuries were frequent in handling manure (32%) and feed (25%) (fig. 2), and the proportions of STF injuries caused by the floor or door sill were 62% and 79%, respectively. Manure gutter was reported as the cause in 19% of manure handling injuries.

To be able to identify high-risk work activities, we developed a weight factor index (ix). The factor for a particular work activity is calculated by multiplying the number of STF injuries by the proportion of STF injuries in that work activity. Thus, the most weight is put on work activities that have both a high absolute number of injuries and where STF injuries are most prevalent compared to other injury types. Using this weight factor, the most hazardous activities were removing manure and feeding (fig. 2). These two work activities were selected for a secondary analysis of injury descriptions to identify more specific contributing factors for injury.



**Figure 2. Distribution of STF injuries in (a) dairy and beef production and (b) swine production by work activity during injury. High risk weight factor ix is displayed in parentheses.**

### *Injury Mechanisms and Underfoot Hazards in Injury Descriptions*

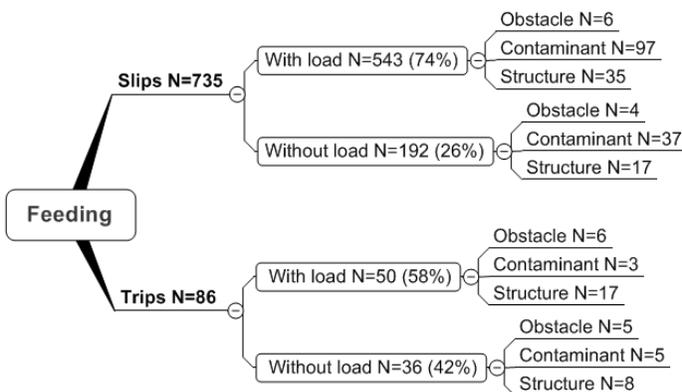
The most hazardous work activities, i.e., feeding and manure removing activities, were selected for secondary analysis ( $N = 2,116$ ). We read and coded the injury descriptions (table 2) according to their injury mechanisms (slip, trip, or fall). We also scanned the descriptions for three common underfoot hazards, as reported by Bentley et al. (2005):

- Obstacles that should not be present (e.g., watering hose or rope).
- Contaminants, (e.g., water, manure, feed residue).
- Structures that are fixed (and more or less designed) parts of the environment.

The secondary analysis showed that 77% of the cases were slips and 7% were trips. The rest of the cases (16%) were generally described as falls or the mechanism could not be derived from the description. Slips typically occurred when lifting or carrying a load, while a load was less frequent in trip injuries (figs. 3 and 4).

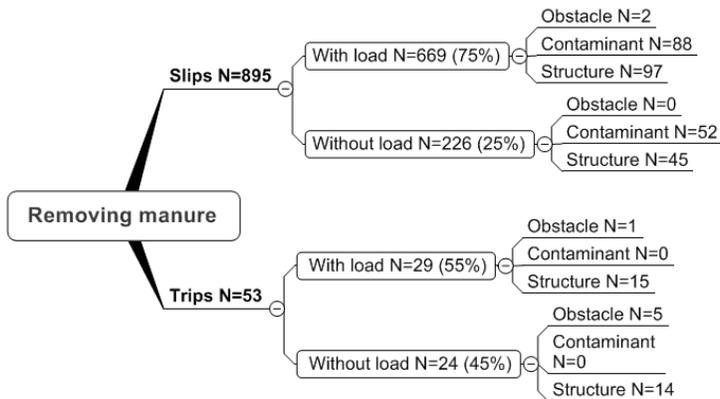
**Table 2. Example of using injury descriptions for secondary coding for the injury mechanism (M) and presence of obstacle (O), contaminant (C), and hazardous structure (S).**

| Description (translated from Finnish by authors)  | M    | O      | C        | S         |
|---|------|--------|----------|-----------|
| The farmer was moving forage to cows. While pulling a wheelbarrow on a sloping ramp to the feeding table, his feet suddenly slipped and he fell on his back onto the concrete feeding table and strained his back.  | Slip | --     | --       | Ramp      |
| While carrying feed to cows, he slipped and fell on a feeding table that was slippery from water splashed from the watering cups.   | Slip | --     | Water    | --        |
| The farm wife was feeding feeder pigs, reaching over the edge of the pen. The floor was wet and slippery. Her feet slipped and she fell on top of a steel pipe. After the fall, she tried to pull the feed bucket back from over the pen wall but could not bend her body to do that. | Slip | --     | Moisture | --        |
| The farmer was carrying forage to the cows with a pitch fork. He tripped into the door sill and fell backwards. His hand got between the pitch fork handle and the floor and his wrist was fractured.   | Trip | --     | --       | Door sill |
| The farm wife was spreading forage to cows. She tripped into a forage pile on the feeding table, fell on her back, and injured her shoulder blade and neck.   | Trip | --     | Feed     | --        |
| While I was carrying a feed sack, my right leg hit an icy patch on the floor. My leg slid and got caught under a feed pallet. I fell to my left with the sack I was carrying, and my right knee got rotated around as the foot was stuck and could not turn.                          | Slip | Pallet | Ice      | --        |



**Figure 3. Distribution of contributing factors to slip and trip injuries during feeding activity.**

We identified some contributing factors in 33% of the injury descriptions. Most common structures and contaminants are presented in table 3. For slips, the presence of a contaminant was reported frequently. Typical contaminants were water, manure, and feed or feed residues. Structures were involved in many trip injury descriptions and in slips during manure handling. For trips, common contributing structures included door sill, doorstep, or other threshold. For slips during manure handling, the contributing factor usually was the manure gutter or grate. Obstacles (ropes, container lids, tools, equipment, etc.) were rarely reported.



**Figure 4. Distribution of contributing factors to slip and trip injuries during manure removal.**

**Table 3. Structures and contaminants reported as contributors to STF injuries.**

| Structure    | Slips | Trips | Contaminant                 | Slips | Trips |
|--------------|-------|-------|-----------------------------|-------|-------|
| Gutter       | x     | x     | Forage, feed <sup>[a]</sup> | x     | x     |
| Curb         | x     | x     | Manure, urine               | x     | x     |
| Higher level | x     | x     | Moisture <sup>[b]</sup>     | x     |       |
| Grate        | x     | x     | Detergent                   | x     |       |
| Hose         | x     |       | Ice                         | x     |       |
| Sill         | x     |       | Snow                        | x     |       |
| Surface      | x     |       | Dust                        | x     |       |
| Stairs       | x     |       | Hay                         |       | x     |
| Bunk         | x     |       | Afterbirth                  | x     |       |
| Ramp         | x     |       |                             |       |       |
| Door         | x     |       |                             |       |       |
| Step         |       | x     |                             |       |       |
| Stanchion    |       | x     |                             |       |       |
| Fence        | x     | x     |                             |       |       |
| Door step    |       | x     |                             |       |       |
| Plank        | x     |       |                             |       |       |

[a] Dry, moist, or frozen feed or forage; flour, grain, pellets, potatoes, etc.

[b] For instance, splashed from cow watering cups.

## Discussion

### Magnitude and Characteristics of STF Injuries

Nearly half (42%) of all agricultural injuries in Finland occurred in dairy, beef, and swine production work. A relatively high percentage (14%) of these injuries were slips, trips, and falls (STF) related to floor structures. Out of these injuries, slips were more common (77%) than trips (7%). STF injuries were frequent in milking and moving feed. More than half of STF injuries occurred while carrying, pushing, or lifting a load. The proportion of STF injuries (out of all injuries in respective work activities) was high in bedding, handling manure, and feeding.

Men had a significantly lower risk of STF injury than did women in dairy, beef, and swine production work. Since no data were available on working hours for men and women, we cannot conclude whether this difference is due to differences in working

hours or actual risk of injury. Traditionally, women have worked more with livestock while men have worked more with machinery and field work, but these gender roles have decreased in modern agriculture. This apparent higher STF injury risk among women would require further studies with the capability to measure person-time at risk.

The coding of injuries in the Finnish farmers' injury claims data is quite detailed, but any coding system can only provide limited information on the injury situation and contributing factors. Secondary analysis of case descriptions appeared useful. We found at least one of the targeted contributing factors (structure, contaminant, or obstacle) in 33% of the case descriptions.

The injury claims in this study provided direction for a more thorough performance evaluation of floors and related structures. We identified many potential problem spots from the coded injury information and short injury event descriptions. This study quantified the magnitude of STF injuries, identified main problem areas where injuries occur, and suggested some specific structures that should be avoided in building design.

### **User Characteristics and Floor Safety**

Characteristics of workers and users of buildings can contribute to injuries. Many demographic features have been identified as injury risk factors. Mobility problems, impairments in gait and balance, as well as neuromuscular and musculoskeletal impairments are risk factors. Reduced activity level as well as high activity level are associated with risk of falls. Other risk factors include cognitive impairment and visual deficits (Myers et al., 1996). Certain medications may increase the risk of injury (Mustard and Mayer 1997; Neutel et al., 1996). Older age (Formiga et al., 2006), osteoporosis (Lehmann et al., 2000), Parkinson's disease (Gutknecht 2003), arthritis and hearing difficulties (Sprince et al., 2003) are among risk factors. Fall injuries, particularly hip fractures, are a special concern for older people. Farmers are aging in many countries. The pension and generation change programs have kept the average age of farmers relatively low (47.6 years) in Finland (Mela, 2007) in comparison to the U.S. (53.3 years) (USDA, 2007).

Although many demographic risk factors have been identified, they may not be readily applicable for building design. Many individuals with different demographic characteristics often work in the same building. Therefore, several potentially conflicting requirements need to be considered and optimized. Some personal risk factors change over time, while the building may be used unchanged for decades. In some cases, adjustment can be made to accommodate individual user needs; for instance, milking parlors can be designed with adjustable floor height. However, in many cases, individual adjustments are not possible and the building features must be designed within some reasonable parameters.

### **Safety Performance of Floor Structures**

We considered good safety performance in this context as providing a safe, efficient, and trouble-free working environment with minimal risk of injuries, near misses, and interruptions. In this study, the focus was on slip, trip, and fall safety. Animal confinement floor structures were reported as the immediate cause of 6,414 (14%) STF injuries in dairy, beef, and swine production work, resulting in loss of more than 450 work years. The magnitude and nature of STF injuries suggest that there is a need for improving the safety performance of floors and related structures. Besides floor design, other factors such as work processes, environmental factors, footwear, and actions of workers must be considered as well (Grönqvist et al., 2001; Lehane and Stubbs, 2005; Shu et al., 2005). Consideration of multiple factors is complex, and a systematic approach is needed to

determine how the performance of floors and structures could be improved to minimize their contribution to STF injuries.

A study of nonfatal occupational injuries from slips, trips, and falls among older workers treated in hospital emergency departments found that case descriptions for same-level falls to the floor primarily implicated floor contamination and tripping hazards (Layne and Pollack, 2004). This was confirmed in our study; in slips, the presence of a contaminant was reported frequently, particularly in feeding and manure removing activities. The common contaminants were water, manure, and feed or feed residues. Kemmlert and Lundholm (2001) concluded that improving orderliness in the workplace should be the initial approach to the prevention of STF accidents. In our study, obstacles (ropes, container lids, tool, equipment, etc.) were rarely reported. However, they were likely coded as hand tools or loose obstacles and excluded from our study material.

Safety aspects should be considered when selecting alternative production methods in facility design. Injury data from this study indicate that working methods that include carrying, lifting, pushing, and pulling different loads involve high risk of STF injury. Slippery floors caused injuries, particularly in feeding and handling manure, which should be considered in floor surface design for those areas. Mechanizing, automating, and providing appropriate facilities for handling materials could reduce such injuries.

Injury descriptions provide examples of features that should be avoided in floor and structure design. Preventing the accumulation of moisture on walkways and building access areas could prevent slip injuries. Placement and type of animal waterers could help reduce accumulating moisture on walkways. Areas where feed residues and other contaminants can accumulate should be made easy to clean. Structures such as gutters, curbs, ramps, and door sills are often involved in STF injuries and they should be avoided in building design, whenever possible. All work areas should be on the same level, but if differences are necessary, slight slopes should be used between elevations. Special attention should be paid to elevation differences when adding on to existing buildings. Door sills can be eliminated in most cases. If a seal is needed, a flexible (rubber) section can be added to the bottom of the door. Grates should be designed so that they provide good grip in all directions. Animal transport and loading areas need rough surfaces with good friction. Handrails should be provided in areas with greater elevation differences.

The storage of supplies, equipment, tools, materials, and waste items should be considered in the design process, so that there would be no need to store them on floors and walkways. Many of these issues, such as effective contaminant control (e.g., drainage, non-spilling feed and watering systems) and efficient small supply logistics require knowledge of the actual working processes in the design phase. It is important for the designers to work in collaboration with the building owner and various other stakeholders to learn as much as possible about the required performance issues for the confinement to ensure successful design.

### **Performance Approach in Planning Floor Structures**

Injuries signal mismatches in required and provided performance. Analysis of claim records provided information on the magnitude of the injury problem and some information on specific work activities, methods, structures, and worker characteristics involved in injuries. We reviewed this information in the context of building design using the PA (fig. 1). This approach has the benefit of matching the needs of the users, production activities, and building hardware. It provides a logic model that enables bringing these factors together to facilitate informed and reasoned design and construction solutions, while considering different production methods.

Footing conditions, requirements for materials handling, and other factors must be considered in making design decisions that can eliminate falls but also meet other requirements (Shu et al., 2005). The same structure (e.g., floor surface area) can have several functions, such as an access way for workers, animals, feed carts, etc. All of these functions are affected by design decisions, such as flooring material, slope, and surface treatment, e.g.: rough, broomed, stamped, or polished concrete; tile; polymer coat; slatted surface; etc.

“A performance-based design process is a process in which performance requirements are translated and integrated into building design” (Spekkink, 2005). The performance approach in floor design should involve a systematic assessment of relevant requirements derived from the activities and processes that occur in the building. Based on our findings, factors to consider in building design include: (1) moisture: wet, dry; (2) temperature: heated, cold; (3) user combination: worker, animal, machine; (4) task combination: milking, manure removal, bedding, moving animals, etc.; (5) cleaning requirement: daily, weekly, periodically; (6) chemical exposure: acid, chlorine, disinfectants, oils, etc; (7) stationary equipment: milk tanks, vacuum compressors, washers, ventilation equipment, etc.; (8) mobile equipment: power washers, feed carts, milking carts, etc.; (9) materials handled: pallets, sacks, hay, silage, concentrated feeds, manure; and (10) special needs: manure storage openings, veterinary procedure areas, scales, office areas, storage of tools, etc. ISO standard 6241 (ISO, 1984) provides a master list of user requirements for building design. Our list of factors refines the ISO 6241 master list by providing details that are specific to floor structures in animal confinement buildings. These factors can be used to identify functional zones within a building, and appropriate floor structures can be designed for each zone. This concept of specifying functional parts (“subsystems”) of a building has, in a broader context, been suggested by Cronberg (1973), and it is included in the standard definitions of the PA (ISO, 1984).

Performance-based design concerns user- and activity-based needs, their translation into performance requirements, and matching these with corresponding performance specifications for feasible technical applications. It is crucial that the needs are translated into specific requirements that building planners and builders understand. If this design logic is not followed, then some user needs may remain overlooked and the hardware will be based on convention or random assumptions. Our findings suggest that different uses (or functions) of floors, related structures (manure handling, walkway, storage, etc.), and working methods (carrying a load, pushing, pulling) need more attention when designing physical environments.

## **Limitations**

The injury data used in this study were extracted from an insurance database. Limited information was available on the environment, work activities, and characteristics of persons involved. Site investigations and interviews would be needed to collect more detailed information on user (the injured person) characteristics, working methods during the incident, as well as the technical applications (building hardware) and environments.

Under-reporting occurs in insurance systems. Some claims are made but not compensated (below 10% in this system). Compensable unclaimed cases are more common. A mail survey in 1986 indicated that about three out of four self-reported injuries requiring professional medical care were also found in the claims data, and out of unclaimed injuries, 80.7% caused no disability (Eskelinen et al., 1989). The true magnitude of unclaimed injuries and near misses is not well known, but they contribute to the injury burden.

## Conclusions

Animal confinement floor structures caused 6,414 STF injuries in dairy, beef, and swine production work during the 11-year study period in Finland. More than 450 work years were lost due to disability resulting from these injuries. Many STF injuries occurred in milking ( $n = 1,135$ ), moving feeds ( $n = 962$ ), and animal transport and care ( $n = 880$ ). More than half (59%) of the STF injuries occurred while carrying or moving a load. STF injuries comprised a high proportion of all injuries in bedding and handling manure (25%), feeding (24%), and preparation for milking (19%). STF injury causes included floors, door sills, gutters, curbs, steps, ramps, grates, hoses, and contaminants like water, ice, snow, manure, detergent, forage, and hay.

The magnitude and nature of STF injuries suggest that there is a need for improving the safety performance of floors and related structures. Key areas include slip-resistant floorings, effective contamination control, macro structures (elevations, entrances, access ways), and logistics for materials handling and storage spaces. Working methods and processes should be planned with respect to minimizing the need of carrying loads. PA provides a logic model for building design that considers the needs of the workers, animals, and production processes. The analysis of injury claims provided information for specific problem areas related to floor structures. This information can be used for planning and improving the safety performance of floors and related structures.

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