Slips, Trips and Falls in the New Zealand Dairy Farming Sector

Report on Phase 1(b), Follow-up Investigations, for the Partnership Programme/JRP Steering Committee

October, 2003

Dr Tim Bentley*
Department of Management and International Business, Massey University at Albany, Auckland.

Dave Moore* and David Tappin
Centre for Human Factors and Ergonomics, Forest Research, Massey University at Albany Campus, Auckland.

Richard Parker and Liz Ashby
Centre for Human Factors and Ergonomics, Forest Research, Rotorua.

Professor Stephen Legg and Dr Ian laird
Department of Human Resource Management, and Centre for Ergonomics, Occupational Safety and Health, Massey University, Palmerston North.

Dr Sophie Hide (Postdoctoral Research Fellow)
Centre for Ergonomics, Occupational Safety and Health, and Department of Management and International Business, Massey University at Albany, Auckland.

***Corresponding authors**

Acknowledgements

This research was funded jointly by the Health Research Council of New Zealand, ACC and OSH.

Contents

1. Introduction and Study Background

Slips, trips and falls (STF) are a leading cause of occupational injury across the majority of major industry sectors internationally (Bentley & Haslam, 1998). In New Zealand, STF are the leading occupational injury problem in dairy farming (Bentley & Tappin, in press). A review of the ergonomics and safety research literature found this industry sector to be largely overlooked, with no articles found relating to dairy farming STF. Phase 1 of this research project (exploratory research), therefore, focused on identifying high-STF risk areas for dairy farming. This was achieved through a descriptive epidemiological analysis of ACC claims for dairy farming STF for the two-year period, 2000-2002.

Some 475 cases with sufficient data to identify them as STF cases were analysed (Bentley et al, 2002; Bentley and Tappin, in press). Lowest STF incidence was observed from the April to June 'drying-off' period when milking stops and many farmers take time away from the farm. STF cases occurred most frequently in the Waikato (36%), reflecting the high density of dairy farming in this region. Just 21% of claimants were under 31, further supporting the findings from STF research overseas that older workers more frequently incur falls. Females comprised 28% of dairy farming STF claimants, reflecting the role of female farm owners, workers and family members in this sector.

STF cases occurred most commonly in the milking shed, yard and paddock, and frequently occurred in the process of climbing on or off a vehicle or other equipment or plant. Injuries incurred following a fall from a vehicle resulted in a larger proportion of fractures than other events, suggesting this injury mechanism results in more serious injuries than other STF on dairy farms. Falls onto concrete appear to present the greatest risk to dairy farmers.

Dairy farming STF were most frequently foot slip events, rather than trips, or jumps leading to injury of the ankle for example. Findings from semi-structured exploratory interviews suggested that a range of surface contaminants, including manure, water, milk and cleaning alkaline, along with sloped and stepped surfaces, were perceived as slip risks in the milking shed in particular.

This paper reports findings from the second phase of the project (1b), in which detailed dairy farming STF follow-up investigations and incident-independent interviews with dairy farm workers were conducted and reported as a series of case studies. The research particularly targeted STF that were incurred in work environments identified in Phase 1 (Bentley et al, 2002; Bentley & Tappin, in press) to be high-risk for STF.

The key aims of the study were to:

i). identify and analyse individual, task, footwear and equipment, design and work organizational factors and their interactions, for the purpose of designing research-led STF interventions

ii). produce a preliminary list of potential intervention ideas, based on findings reported here, to provide a baseline for intervention design research

2. Method

The main methodology for this research phase was detailed STF incident follow-up investigations, involving a detailed face-to-face semi-structured interview with the injured worker (see *Appendix 1:participant information sheet & consent form and Appendix 2: Interview Schedule*), site observations, plus photographic evidence where useful.

Injured dairy farmers and employees were all ACC claimants, and were identified from the ACC claims database (from selected incident categories: e.g. slipping and skidding) for dairy farming claims for the 12 month period 1.7.02 – 30.6.03. The researchers did not receive any information about claimants' identity until claimants had consented to participate in the study by letter.

The site visits took, on average, around 90 minutes to complete, and follow-up telephone calls were used to collect any further information or missing data following the site visit. The data produced from these methods were triangulated and analysed by the investigators and a further member of the research team experienced in STF incident analysis to create case studies for each incident. Injury events and circumstances were recorded on Events and Contributory Factors Charts (Haslam and Bentley, 1999) (see Figure 1 for an example), detailing events from 'activity immediately preceding the STF' to 'post injury event'. Incident-independent information on respondents' perceptions of general STF risks on dairy farms were also collected through semi-structured interviews with the STF-involved worker. A written case study report provided detail on key factors recorded on the chart and other relevant information. The major aim of this approach was to identify key risk factors and incident scenarios for dairy farming STF injuries that could not be obtained through other methods, such as injury epidemiology.

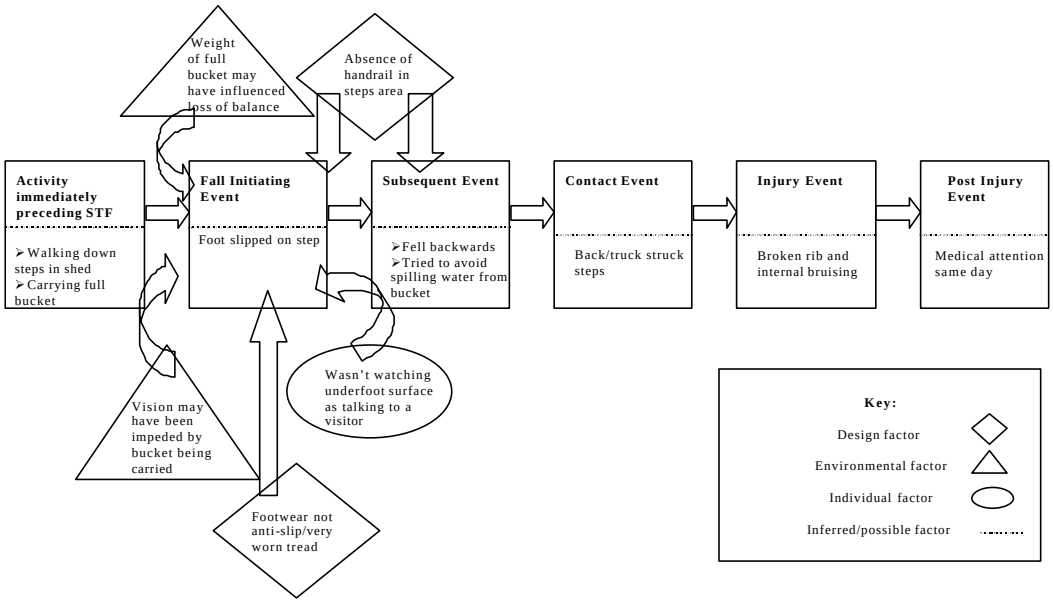

Figure 1. *Example of events and contributory factors chart used for summarising dairy farming STF*

3. Results: Key Findings from Slips, Trips and Falls Investigations

Of the 143 letters sent to ACC claimants who had made claims for STF injuries, 32 (22%) respondents agreed to participate in the study (six respondents provided information about more than one STF). This result is considered to be reasonably good given the sensitive nature of the study and the fact that small business surveys commonly experience relatively low response rates.

39 dairy farming slips, trips and falls investigations were conducted. This section outlines basic demographic details from the study sample; geographic, temporal and establishment details; task and injury location details; footwear details; key risk factors and their interactions and common incident scenarios. Case study accounts are used to illustrate the role of key risk factors and their interactions in STF incidence. Where possible, the demographic and regional distributions of the sample of STF investigated are compared to those observed for ACC claims for dairy farming STF for the 2000-02 period (Bentley and Tappin, in press) for the purpose of determining the representativeness of cases included in this study.

3.1 Sample Demographics Summary

Table 1 shows the distribution of injured worker's age, gender, employment status, time in dairy farming and time on present farm.

Table 1. *Distribution of demographic and temporal variables for dairy farming STF investigated*

Age group	Cases (n)	Proportion of cases (%)	Letters sent	Response rate (%)
16-20	1	3	12	8
21-30	4	10	18	22
31-40	5	13	38	38
41-50	13	33	35	40
51-60	10	26	28	38
>60	6	15	12	40

	Cases (n)	Proportion of cases (%)
Gender		
Female	11	28
Male	28	72
Employment Status		
Farm owner	19	49
Sharemilker	13	33
Employee	7	18
Time in dairy farming		
0-5 years	3	8
6-10 years	9	23
11-20 years	3	8
21-25 years	13	33
>25 years	11	20
Time on this property		
0-5 years	15	38
6-10 years	2	5
11-20 years	11	28
21-25 years	4	10
>25 years	7	18

This sample is disappointing from the perspective of getting a representative inclusion of younger farm employees, owners and share milkers, with just 5 (13%) respondent cases from the 16-30 age groups participating in the study. By contrast, 25% of claims to ACC during 2000-2002 were for this age group (16-20: 8%; 21-30: 17%) (Bentley and Tappin, in press). The study did not formally investigate why younger claimants may have been under-represented in the follow-up investigations.

The gender distribution of the sample for this study was far more representative of ACC claims, with 28% of respondents being female (this compares to 28% of claimants to ACC for 2000-2002 Bentley and Tappin, in press).

The proportion of farm workers participating in the study who described themselves at interview as employees was low (18%) by comparison to the 40% of the 312 ACC claimants listed as employees during 2000-2002. Again, this low response was not formally studied, but farmers commented that the employee population can be relatively transient, with a change of staff each year on dairy farms being more common these days. It is possible therefore that the contact details held by ACC are less reliable for employees than for claimants with ownership in dairy operations.

The distribution for time in dairy farming suggests the majority of respondents were very experienced in this industry, with some 69% of respondents having 11 or more years experience in dairy farming work. Furthermore, 56% had 11 years or more experience on the farm at which the STF took place.

3.2 Geographic Location

Table 2 shows the regional distribution of respondents' farms where STF were investigated. Much of New Zealand's dairy farming sector is centred in the northern part of the North Island, particularly the Waikato region. The high proportion of investigations in this region reflects the 2000-02 claims for this sector. The distribution of investigations across the other major regions also represents a successful sample in terms of regional representativeness.

Table 2. *Dairy farming STF investigations by region and comparison figures for 2000-02 dairy farming STF claims to ACC.*

Region	Cases investigated in present study		STF ACC claims for 2000-2002
	(n)	(%)	(%)
Waikato	18	46	36
Taranaki	9	23	11
Canterbury	5	13	10
Northland	4	10	10
Bay of Plenty	5	13	7
Tasman	1	3	2

3.3 Establishment details

Farms on which STF occurred were mostly relatively large in size, with all but one of the establishments visited had land in excess of 42 hectares, and with some 50% of establishments being larger than 100 Hectares. All but two establishments were used exclusively for dairy farming.

3.4 Temporal Distributions

The monthly distribution of dairy farming STF investigated did not closely match that of ACC STF claimants during 2000-02, where the lowest proportion of claims were reported during the April-June 'drying-off' period (when milking stops and holidays are often taken). Some 20% of incidents investigated in the present study occurred during this period, compared to 17% for 2000-2002 claims. Largest numbers of investigations were undertaken for STF occurring during February, April, and August to November.

The majority of STF investigated were reported to have occurred in the morning period, with 58% before 9am. Some 22% of STF were reported to have occurred after 12 noon.

3.5 STF Location and Task at Time of STF

Table 3 shows the distribution of STF incident location on the farm, including general and specific details of location, and tasks commonly undertaken at the time of the STF in the major locations.

The majority of STF incidents investigated occurred in the milking shed, yard or paddock. The distribution of 'general location' is similar to that for dairy farming STF ACC claimants for 2000-2001, where 20% of incidents occurred in the milking shed or yard, and an estimated 19% occurred in a paddock. STF also occurred in a range of other locations, including race (the unsealed routes laid specifically for the cows to use when moving between grazing blocks and the milking shed) and parking areas.

Table 3. *Distribution of STF incident location and tasks commonly undertaken at time of STF in major locations.*

Location (general)	n	%	Location (specific)	Tasks being undertaken at the time of the injury in the general Location include:
Paddock	12	31	Farm vehicle Near shed or race By gate or fence Grass bank/slope Other	Getting cows into race Getting cows in/out for milking Moving cows to new grazing Fence moving/maintenance Feeding out Maintenance activities
Milking shed	11	28	Pit Steps Milk vat Other	Milking Preparation for milking Cleaning Maintenance
Yard adjacent to milking shed	4	10		Cleaning Inspection/maintenance activities
Races	5	13		Moving cows in for milking or between paddocks Attending to calving
Other	7	17	On ladder or plank Barn Land fill site	Maintenance activities including building repair and painting Cleaning activities Loading/dumping Pruning trees

'Other' includes outside the farm house, and in the hayshed and barn. A number of STF occurred on a vehicle, on steps, and in the milking pit. A wide range of general tasks were identified as being undertaken at the time of the STF, the most common of which were milking, herding cattle/getting cows in for milking, maintenance and cleaning.

Specific activities being undertaken at the time of the STF (for common tasks) included:

Running when chasing a cow/cows	(n=6)
Running for another reason	(n=3)
Climbing off something (e.g. vehicle)	(n=6)
Climbing onto a vehicle	(n=2)
Climbing/descending steps	(n=4)
Carrying a heavy object	(n=3)
Walking down/across a grass slope/bank	(n=2)

This taxonomy shows the range of potentially hazardous activities for STF being undertaken at the time of the STF. For example, the risk of running on a slippery surface, such as that covering much of the dairy farming working area, is well documented in the STF literature (e.g. Bentley and Haslam, 2001). Slips and trips are also known to be common during the descent of steps and slopes, and when climbing in/descending from vehicles.

3.6 Underfoot Surface and Underfoot Hazard Details

Table 4. shows the distribution of underfoot surface and hazards identified for each underfoot surface category for dairy farming STF investigated. Concrete surfaces, found predominantly in the milking shed and yard, appear to be almost permanently slippery due to the presence of water, milk, manure and other contaminants, such as alkaline for cleaning. The range of different surfaces dairy farmers work on suggests different footwear requirements to cope with different surface types and contaminants (see Section 3.8). For example, several slips occurred on steel surfaces, where others were incurred on mud, wood and concrete surfaces.

Table 4. *Distribution of underfoot surface and hazards for dairy farming STF investigated.*

Underfoot Surface	n	%	Specific underfoot hazards for underfoot surface
Concrete	10	26	Water/water and manure contaminant Water and alkaline contaminant Obstacle underfoot Irregular steps Unexpectedly high friction surface
Paddock and Race	9	22	Wet/dewy grass or mud Slippery object on grass (e.g. log or branch) Hole Rutted or uneven surface Hard, dry broken ground
Farm vehicle	6	15	Protruding pedal/gear lever (in dismount area) Wet/muddy footplate Wet trailer surface Wet/muddy wheel hub
Steel surface (non-vehicle)	4	10	Wet steps Wet ramp
Obstacle on walking surface (that shouldn't be present)	5	13	Hose Barbed wire Steel rods
Wood	5	13	

3.7 Underfoot Hazard Detection and Control/Information Processing in Relation to Hazard

The analysis considered the hazard and incident events from the view of an information processing model of hazard detection and control. This allowed analysis of information processing in relation to hazard detection from the view of whether the injured worker had perceived the hazard, identified it as a risk and attempted to avoid or control the hazard. In 26 cases the underfoot hazard was not detected or identified as a STF hazard by the worker prior or immediately prior to the STF. A range of explanations were provided by respondents for their failure to detect the hazard (Table 5).

Table 5. *Reasons given for not detecting, perceiving or identifying underfoot hazard*

Why underfoot hazard was undetected	**n**	**%**
Was looking at something else – usually cattle or individual cow (conflicting concurrent visual task)	18	46
Something that obscured view of underfoot hazard (eg. object being carried)	5	13
Insufficient illumination	1	2
Hazard seen, but not assessed as STF hazard	2	5
Total	*26*	*66*

The problem of divided attention is particularly significant for STF in environments where the underfoot surface is relatively variable, changeable and uncontrollable (eg. Bentley and Haslam, 2001). Clearly, cases of divided attention, such as needing to watch

the stock while also moving across an unpredictable underfoot surface, present major risks of STF on dairy farms. This risk factor was often exacerbated by the fact that the worker was running after a cow or cows at the time, further increasing the STF potential.

Of those cases where the worker was aware of the presence of the hazard (e.g. where the hazard was a permanent slippery underfoot surface), five workers had taken some form of control action to prevent STF either sometime prior to the STF or immediately prior to the STF.

The underfoot hazard involved in the STF should have been where it was in the judgement of the injured worker in 25 cases. In these cases the hazard was usually a permanently slippery surface or some physical feature of the working environment, such as steps or a slope. Underfoot hazards were perceived to be where they were erroneously in 12 cases, often as a result of the actions or inactions of a third-party (e.g. another worker or visitor). The hazard was noted by respondents as being present on this and other farms 'always' or 'usually' in 24 cases. Underfoot hazards were thought to be present on this or other farms 'sometimes' or 'rarely' in 14 cases.

3.8 Fall Initiating Event (FIE)

Table 6 shows the distribution of FIE for the dairy farming STF investigated. The proportion of foot slipped FIE investigated is similar to the distribution of FIE for ACC claimants during 2000-2002. The largest FIE group investigated was slips (56%), involving a range of underfoot hazards, although the major surface type was concrete, comprising 30% of all cases investigated. The contaminant making concrete surfaces slippery varied, but usually involved water which is used extensively for cleaning and other tasks in and around the milking shed (Table 4). In several cases investigated poor housekeeping practices (e.g. workers leaving hoses laying on the floor rather than hung-up; underfoot working conditions slippery due to cleaning practices) contributed to STF.

Table 6. *Distribution of FIE for the dairy farming STF investigated*

Fall Initiating Event	n	%	Underfoot hazard	n	%
Foot slipped	22	56	Slick concrete surface	12	30
			Wet/muddy grass	2	5
			Footplate or other steel surface	4	10
			Gate or fence rail	2	5
			Wood surface	4	10
Foot tripped	5	13	Obstacles left in wrong place	3	8
			Rubbish	1	2
			Step (irregular geometry)	1	2
Underfoot surface collapsed/gave way Trod on/stepped in	3	8	Poorly maintained/damaged equipment	2	
Foot caught	3	8	Gear lever/foot pedal	2	5
Stepped on/in	1	2	Hole in paddock	1	2
Jumped	2	5	Wall	1	2
			Gate	1	2
Other	3	8			
Total	*39*	*100*			

3.9 Footwear

Footwear condition, and in particular the relief of the sole and wear status in relation to the underfoot surface worked on, is known to be an important factor in slipping injuries (Tisserand, 1985; Haslam and Bentley, 1999). This is particularly true where work takes place with water and other forms of contaminant affecting underfoot conditions (e.g. Gronqvist and Roine, 1993).

In all but six cases the injured worker was wearing gumboots at the time of the STF. Overall, footwear worn at the time of the STF was more than six months old in 29 (74%) cases, and one year or older in 18 (46%) cases. Footwear was inspected and photographed (where possible) by the researchers in 30 cases. Of these, it was judged that 13 (43%) would have had 'poor' or 'very poor' condition tread (worn smooth or little tread remaining or damaged tread) at the time of the injury. This is of concern given the often difficult underfoot conditions faced by workers in this sector and the high rate of STF injuries recorded. The footwear worn at the time of the STF was the footwear normally worn in that area of the farm or for that task in 35 (88%) cases.

Some 33 (83%) respondents reported wearing the same footwear on all parts of the farm and for all tasks. This fact belies the reality of the many and varied underfoot surfaces present on a typical dairy farm and the wide variety of tasks performed by these workers. The most common reason giving for not changing into lace up workboots with ankle support when doing jobs away from the milking shed and out on broken surfaces was the need to stay dry. Lush paddock grass will stay wet when other surfaces have dried. The extra time taken in untying and tying them each time they called by the house was also mentioned.

3.10 Key Risk Factors Summary and Important Risk Factor Interactions

This section details key risk factors common to a number of events and their interactions with other risk factors. The extent to which risk factors were contributory to STF is not easy to ascertain, although the analysis used for each case study did distinguish 'possible' from 'probable' contributory risk factors. Table 7 shows the distribution of key risk factors (identified in case study analyses as 'probable' contributory factors) for dairy farming STF cases investigated. It should be noted that each event, having many potential contributory risk factors, could have several risk factors under some of the categories (eg. design and behavioural factors).

The term 'latent failure' refers to errant decisions unwittingly made at the organisational level, which, over time produce potentially hazardous situations. For example, a new worker decides to head off an animal by taking a short cut and dashing across an area of long grass in the corner of the yard concealing discarded machine parts and other waste and twists an ankle. The decisions at some point in the past to use that area as an unofficial dump, and later to allow long growth concealing the debris, are latent failures. The decision on the day (to take the short cut) is sometimes called an 'active failure'.

Table 7. *Key risk factors for dairy farming STF cases investigated.*

Key risk factor	Cases factor present (n)	(%)	Factor classification	Latent failures involved?
Moving too fast for the conditions, or taking a short-cut	24	62	Behavioural	No
Weakness in design of plant and equipment	24	62	Design	Yes
Work organisation mismatch (particularly time pressure)	25	64	Work organisation	Yes
Water or other surface contamination	20	51	Physical environment	No
Inappropriate (or worn) footwear	20	51	Design/behavioural	Yes
Divided attention	20	51	Task	Yes
Inaccurate injury assessment	19	49	Individual - decisional	No
Uneven/obstructed underfoot surface	10	26	Physical environment	No
Predisposed by an existing injury	10	26	Individual – physical	Yes
Unpredicted stock behaviour	8	21	Environmental – animal	No
Shortcoming in housekeeping	7	18	Behavioural/environmental	Yes
Maintenance/equipment failure factors	7	18	Equipment – maintenance	Yes
Fatigue	6	15	Individual – physical	Yes
Working alone	5	13	Work organisation	Yes
Hazard perception/risk assessment failure	5	13	Individual – perceptual	Yes

A major benefit of this type of detailed case study research is the ability to identify the presence and role of latent factors removed in time and space from the incident in injury events. The use of an events and contributory factors chart methodology (Haslam and Bentley, 1999) also allowed both latent and more immediate factors to be identified at the appropriate point in the incident sequence. A large number of key risk factors were identified from these investigations, many of which are latent in nature. Indeed, 73% of cases involved organisational factors and 60% design factors.

Table 7 indicates that work organisation factors (often significant time pressure as a result of work scheduling or work-rest schedules), equipment and plant design factors played key roles these dairy farming STF. Time pressure was common to a large number of incidents, and often motivated unsafe or time-saving behaviours that contributed to STF. Time pressure was seen as an inevitable consequence of variations in workloads over time, peak periods, small staff numbers and the nature of the work itself.

Design factors included equipment design weaknesses, such as: the absence of safe positioning for feet when climbing onto/off equipment, the necessity to climb up onto or jump down from elevations to view aspects of the task, clothing design and fit issues and aspects of task design that necessitate unsafe operation. Section 3.10 covers further the nature and role of design factors in the STF investigated.

Another key risk area, previously highlighted in this report (Section 3.6), is the presence of concurrent visual tasks – those to be undertaken at the same time as walking and/or monitoring a hazardous underfoot environment (Marletta, 1991; Bentley and Haslam, 1998). Naturally, the workers conduct more than one visual task most of the time. For example while attaching cups to one cow as the primary task they will be monitoring peripherally for gross movements of nearby animals who may be getting agitated. Periodically they can also look up and scan the line as their primary task.

A common problematic scenario involving divided attention in these incidents was were there was a need to move quickly across an unpredictable surface while also watching the movement of individual animals during stock moving or milking-related activities. For example, an animal ducking the wrong way while moving through a gate, requiring the worker to dash to head them off. This factor was identified as a risk where it contributed to the injured worker not seeing the underfoot hazard involved in the STF (e.g. a sudden change in surface friction or abrupt vertical protrusion). Aspects of task design may play a role in exaggerating this problem for certain activities undertaken on dairy farms. For example, the distance and route to a particular gate or control point from the pit.

Several workers made decisions to continue work knowing or suspecting that they had a moderate to serious injury. It is recognised that this factor is not generally a risk factor for STF, although it can increase the chance of a further fall. However, it can contribute to the consequence of the STF; the extent of the injury and/or period required for rehabilitation can be significantly increased in some cases. Respondents put this behaviour down to working alone during busy times (particularly milking), extreme time pressure, and the absence of other staff to complete the work if they stopped. It was also consistently commented that in farming communities seeking medical help is not as quick and easy as in town, and therefore there was a different culture. The practice of working on and leaving injuries a couple of weeks to see if they come right on their own was prevalent.

Underestimating the severity of injury may also have been a factor in some cases, with injured workers only finding out the real extent of the injury on a later visit to the doctors. In many cases the injured worker noted that their decision to delay getting a medical diagnosis had possibly resulted in an aggravated injury and/or slower recovery.

The role of behavioural factors, specifically running, was also found to be contributory in a large number of STF cases investigated. Moving quickly was often necessary as workers were working alone, but were required to cover a large area when controlling cattle movements in and around the milking shed. The combination of rapid movement, divided attention and moving across an unpredictable surface predictably resulted in a

number of STF. Other behavioural factors included various short-cuts, including jumping down from elevations onto hard or uneven surfaces.

Poor housekeeping and maintenance factors were contributory to a number of STF. In some cases these factors interacted with design factors that appear to encourage such practices. For example, the presence of hoses laying on the floor across milking shed walking routes was noted to be influenced not only by haste and untidy workmates but also in some cases simply the absence of an adequate stowage arrangement that all would use. In newer sheds many dairy farmers have removed this problem at source through improved hose system design.

Footwear factors (see Section 3.8) included: absence of appropriate and/or adequate tread for working on the slippery underfoot surfaces, unsuitability for the task, and fit. The decision to use inappropriate footwear for the conditions and to continue to use worn-out footwear can be regarded as latent failures on the part of the wearer. The use of a single type of footwear for all farm environments and tasks means that, for some situations, the footwear is not going to be well-matched to the conditions. Mismatched footwear-surface interaction was present in many cases investigated.

3.11 Focus on Design Factors in STF Investigated

Plant and equipment design risk factors were identified in 24 of the dairy farming STF cases investigated (Table 7). The 23 separate factors that were identified as contributory in these cases are shown in Table 8.

Table 8. *Design factors identified as contributory to STF investigated.*

Design factor classification	**Item**	**Detail of design factor**
Equipment	Pit hose	Reliance on single milking shed hose
	Hose	Absence of hose stowage arrangement in milking shed
	Hopper	Viewing panel necessitates climbing up implement to view level
	Footplate	Absence of purpose designed footplate for safe ascent of spreader
	Climbing system	Weak design and poor condition of ladder fold clips
	Support system	Absence of appropriate support system for maintenance work at elevations
	Handrail	Absence of handrail on spreader
Apparel	Footwear	Footwear design/dimensions limitations
	Footwear	Footwear/task/surface mismatch
	Apron	Too long for user obscuring view of underfoot surface (limited size options)
Built environment	Steps	Irregular step geometry in milking shed
	Steps	Upstand for containing surface water built onto lip of top step - presents as a tripping hazard
	Handrail	Absence of handrail on high steps
	Milk vat	Milk vat design – necessity to conduct maintenance in hazardous area
Environment	Drainage system	Poor drainage control
	Waste management systems	Absence of skip or other vessel to contain farm waste
	Farm vehicle access	Absence of safe vehicle access to dumping areas
Vehicle	Loader arms	Retro-fitted loader arms on tractor interfering with dismount method as designed
	Footplates	Positioning and dimensions result in an angled climb and hence the feet applying sideways as well as downwards force
	Guard rail	Absence of guard rail on trailer
	Trailer	Absence of satisfactory means of mounting trailer for loading – access system

The most common design contributors to STF were equipment and built environment factors. However, several design factors were identified related to apparel, environment and vehicles.

Design factors related directly to the design of the underfoot surface in six cases, two of which were footplate-related and two to do with step geometry. Two design factors

related to the need to climb-up onto something to view an aspect of the task. The absence of a suitable viewing panel in the hopper, for example, led to the worker climbing up the structure to check levels.

A number of design factors related to the absence of some form of safe access or/and egress system for viewing the task (e.g. the necessity to climb up onto the pit wall to observe cows further down the line). Hand or guardrails were absent in areas where they would have helped prevent the STF in two cases. Environmental design and management was a key factor in three STF investigated, as the hazardous underfoot surface condition was avoidable had these measures been in place. The problem of pit hoses as tripping hazards around milking sheds is well understood by dairy farmers. While two cases were identified in this study, this risk is probably reducing as improved hose system design has largely addressed this issue.

While the above design factor information is useful in itself for targeting potential STF control design interventions, information about interactions between design and other risk factors for dairy farming STF has the potential to help researchers, designers and those employed in the industry understand more about the context in which design factors increase STF risk. Table 9 shows common risk factor interactions with design factors identified in STF investigations.

Table 9. *Common risk factor interactions with design factors identified in dairy farming STF investigations.*

Factor occurring in association with design factor	**n**	**% of cases where factor occurred with design factor**	**Examples of interacting factors**
Slippery underfoot surface	13	51	Wet concrete Wet/muddy grass Footplate or other steel surface Gate or fence rail Wood surface
Unsafe/timesaving behaviour	13	51	Rushing Jumping down from elevation
Other design factors	11	46	*(see discussion below)*
Inattention/conflicting concurrent visual task	9	38	Looking at cows Looking at underfoot surface
Pre-existing injury	4	16	
Uneven underfoot surface/obstacle	3	13	
Work organization	3	13	
Other	15		

The key points to note from the analysis summarised in Table 9 are the common interactions between design factors and slippery underfoot surfaces, unsafe behaviours and other design factors.

Analysis of interactions between divided attention and design factors suggests no obvious causal links for most of the cases investigated. However there are some. For example, steps with irregular geometry will require greater attention when ascending or descending than a consistent flight, and so the irregularity will be more likely to catch them out when their attention on this task reduces.

Examples of common design factor and slippery surface factor interactions include:

Case 1: irregular pit step geometry (factor 1), the presence of water and contaminants on the footwear and step (factor 2) and the wearing of worn footwear (factor 3).

Case 2: absence of guard rail on trailer and presence of low head board (factor 1), the presence of a slippery wooden trailer deck/working platform (factor 2) absence of suitable footwear for the task (factor 3).

Case 3: presence of retro-fitted loader arms (causing the worker to step over to reach footplate) (factor 1), inappropriate footplate dimensions (factor 2) absence of suitable footwear for the task (factor 3) and the presence of mud on the footplate (factor 4).

The above factors testify to the influential role design factors play in the presence of slippery underfoot conditions. For example, in case 1 the worker should not have been in contact with the slippery underfoot surface. In case 2 the worker's injuries were as a result of the design of the trailer as much as the initiating event itself (a sudden stop of forward momentum of the trailer). In case 3 the need to step over the loader arms and the small breadth dimensions of the footplate greatly increased the risk of a slip on the muddy footplate on dismount.

Unsafe behaviours, often running, were related to design factors in a large number of cases. Many of these interactions involved the worker running on a slippery surface wearing footwear without anti-slip properties. Exceptions included the absence of a safe alternative for dismounting a wall (and safer platform than a wall for viewing milking), and jumping from an elevation onto concrete.

Design factors interacting with other design factors included: step design and footwear; absence of handrail and footwear; requirement to stand on handrail and footwear; no viewing panel, no handrail and no footplate; and inadequate drainage system around areas where walking is common, and race design.

This section has focused on the role of design factors in dairy farming STF investigated. This focus recognises both the important role design factors can play in STF aetiology, and the potential for improving STF safety in work environments through design methods. In the cases discussed above, it is clear that improvements to plant, equipment and footwear design have the greatest potential for reducing dairy farming STF risk.

4. Incident-Independent Factors and Relationship to Key STF Risk Factors

Respondents provided incident-independent information (i.e. information unrelated to the STF incident investigated) in semi-structured interviews. This information was mostly related to respondents' perceptions of general STF risks around their farms.

Table 10 summarises the more frequently mentioned STF risks and respondents' suggestions for intervention measures. Respondents' risk perceptions for dairy farming STF were largely related to the underfoot surface, and many of their STF prevention suggestions related to the reduction in STF risk through control of surface conditions. These risk perceptions further support the primacy of slippery concrete surfaces as a STF risk area. Respondents also recognised the role of risk-elevating behaviour, particularly running and rushing, on dairy farms. Again, this reflects the investigation findings. What is clear from respondents' comments is that many are concerned with the issue of time pressure and its influence on behaviour and worker health and safety.

Importantly, respondents recognised that work organisational interventions were a good option for controlling STF risks, notably improvements in workload scheduling, prioritisation of tasks, and the use of extra labour during busy or peak work periods (e.g. calving). A number of respondents noted the need for better anti-slip footwear, particularly for working in the milking shed. A number of respondents stated that they used new gumboots in the milking shed – demoting them to general 'around the farm' use as they wore.

Table 10. *STF risk areas most frequently identified and interventions suggested by the respondents.*

STF risk areas identified by respondents	**Specific factors mentioned**	**Respondents' Ideas for interventions**
Slippery concrete (particularly in the milking shed and yard)	▪ Algae/mould build-up ▪ Alkaline ▪ Water ▪ Milk ▪ Manure ▪ Drench/Saliva ▪ Combinations	Farm communications - alert others to hazards (eg. alkaline down) Underfoot surface contaminant control - spray to clear growth off surface - clear-up spillages straight away - water-blast to prevent film build-up - regular hosing down and good drainage Footwear-surface interaction - select anti-slip footwear matched to the surfaces - use gumboots with good tread - have a good pair of boots kept only for shed work Concrete design - use roughened concrete - roughened edges for steps
Paddock hazards	▪ Holes ▪ Mud ▪ Uneven ground ▪ Ruts	Informational/behavioural - better awareness of paddock risks - know precisely where hazards are on the farm - better attention to underfoot surface when walking - take care/don't rush while walking on paddocks - use appropriate footwear/anti-slip Paddock condition control - re-grass paddocks - heavy harrow paddock to smooth surface
Hose hazards	Yard and shed hoses	- tidy away hoses after use - improve design and placement of hoses on farms - remove kinks in hoses - put in swivels so don't get hose twisted and they lie straight
Cattle unpredictability	Cattle running away Uncooperative cattle Cattle turning on workers	- don't run after cattle – too risky - be aware of paddock risks when moving cattle - better stock handling skills - better training for new staff - 'stock sense' video on stock behaviour and its management - get extra help at busy times
Time pressure	Stress and fatigue Workload overload Busy periods (e.g. calving)	- get help/extra cover during peak periods - better work organisation - job sharing and balanced workloads so fair to all staff - don't neglect maintenance at busy times - good milking shed design reduces time for tasks and increases ease of use meaning less rushing

5. Summary of Key Risk Factors

A wide range of risk factors have been identified through STF follow-up investigations and from analysis of respondents' perceptions of risk around dairy farms. Of these, slippery concrete surfaces, arising from the presence of a range of contaminants, can be argued to be the primary risk area.

However, this factor alone will not cause a STF (a person can walk safely on ice if they are aware of it's frictional properties and adjust their walking gait appropriately), as it is necessary for one or more other risk factors to be present at the same time as slippery concrete surfaces. Probably the most important of these are:

- rushing (usually running)
- use of worn footwear or footwear poorly matched to the surface characteristics
- divided attention (distraction from underfoot surface) and
- plant or equipment design factors (e.g. requirement to climb-up onto a structure).

Underlying these risks, most of which can be categorised as more proximal or active risk factors, are latent factors related to work organisation. It is apparent that time pressures created through uneven workloads and peak work periods, workload management and staffing levels are of key concern for dairy farming STF risk.

5.1 Limitations

The study was subject to a number of limitations. Notably there was a lower response rate from the younger age groups, and there is the possibility that those who did reply were those claimants more motivated to be pro-active in injury prevention. Employees (who may change contact details more frequently) were not as easily contacted through the chosen sample selection route (via ACC) as farm owners, and this may have been part of the reason for the low representation of employees in this study. Researchers were unable to view the injury site in many cases, and recall bias and error may have been a factor as investigations took place some months after the incident.

6. Intervention Possibilities Arising From Phase 1 Research

The following section briefly outlines some potential intervention ideas for the control of dairy farming STF. The interventions suggested here are based on the findings from Phase 1 research, and can therefore be considered to be research-led. This report does not provide details of intervention design, nor how each intervention will be developed or implemented, as this is the purpose of phase 2 research. Table 11 shows a range of possible intervention measures, based on incident-specific and incident-independent research in Phase 1, organised under the various work system categories used elsewhere in this report.

Table 11. *Possible interventions to reduce the risk of STF in dairy farming - for further discussion within industry.*

Work system category	**Possible interventions - for further discussion**
Footwear-surface interaction	▪ Investigate potential with manufacturers to improve boot-surface match for working on a) contaminated concrete, b) paddocks, c) races ▪ Provide basic guidance on selecting the best footwear to match tasks and environments ▪ Footwear replacement – assisted by footwear tread wear indicator ▪ Concrete surface retro-roughening for cows and people ▪ Communication between staff about underfoot conditions
Environmental design	▪ Grazing – optimise sequencing and locations to avoid work on difficult surfaces ▪ Erosion control and drainage to minimise ruts and holes, especially around gates and dips in races ▪ Use skips, bins and well defined fill holes to contain waste – not loose tips that can spread.
Plant and equipment design	▪ Advertise positive features of new milking shed design that reduce STF risks through design, including: step geometry, remote gate controls, and personal escape routes ▪ Promote a wider ranges of personal protective equipment (PPE) sizes - matched to user requirements ▪ Handrails for all steps and elsewhere as required in milking sheds ▪ Frictional surfaces on foot contact points ▪ Provide guidance on good design of systems (footplates, handholds) for access/egress, mounting or alighting from equipment or vehicles ▪ Equipment design specifications that account for all functions (use, maintenance, cleaning etc.) ▪ Better trailer design (safety systems, mounting and alighting safety) ▪ Communication systems to get help quicker in case of an injury (e.g. 'farm alarm') ▪ Publicise good ideas on minimising unpredictable behaviour by cattle through farm design ▪ Hose design and stowage arrangements – make tidy storage the easy option ▪ Get ahead of STF hazards/risk assessments with preventive maintenance ▪ Consider sourcing coloured alkaline to use in cleaning surfaces walked on

Work organisation Work organisation (continued)	▪ Encourage farmers to try and budget to get more help during peaks of busy periods ▪ Encourage investment in milking shed systems to make one person operation smoother - otherwise use two staff where task requires it ▪ Prioritise tasks especially during busy periods to minimise goal conflicts for workers, reduce rushing and short cuts and keep the jobs sustainable ▪ Encourage farmers to plan ahead with competent cover for staff in the event of injuries, so that individuals do not feel obliged to delay getting medical help if it's needed
Training and hazard awareness	▪ Provide training video on effective stock handling for those new to the industry ▪ Alert farmers to training resources on safe and effective practices in the ancillary jobs they do on the farm, including tree pruning, roof maintenance and exterior decorating ▪ Produce summary information from this study on a fuller range of the actual STF risks in dairy farming than farmers currently recognise ▪ Provide resources for and encourage formal induction OSH training for new staff. To include: milking shed hazard management responsibilities, the importance of breaks, age limitations, coping with seasonal pressures, fatigue effects, footwear (choice, use, maintenance and replacement), moving at a pace to suit underfoot conditions and the risks from divided attention ▪ Formalise communication on OSH matters. Including: changing underfoot conditions (eg. fluids in use), other factors (eg. mechanical problems or deadline changes) housekeeping messages – including shift tidy-up and clean-up ▪ Research and distribute fuller guidance on basic diagnostics and appropriate first aid (as with R.I.C.E.) ▪ Advice on the costs of delaying getting medical help when needed – charts and scenarios showing recovery time and outcome differences for early and late attention ▪ Discuss measures to facilitate the seeking of medical attention earlier (e.g. teledoctor) when needed by people in more remote locations

7. Conclusions

Important details about risk factors for dairy farming STF, unobtainable through the use of other epidemiological methods, were produced through the use of the detailed STF follow-up methodology. Of particular benefit was data on distal risk factors such as work organisation and the design of environment, plant, and personal equipment. This information will help inform the design of research-led interventions to help counter this high-risk injury problem for the New Zealand dairy farming industry.

The intervention ideas in Table 11 will be considered alongside other suggestions from industry in response to this report and other contacts made during the course of Phase 2 research. The industry will be consulted regarding the selection of the most promising intervention measures for dairy farming STF prevention. Of particular concern to the researchers will be the issues around intervention fit within the industry and design of interventions to maximise the uptake and acceptance by intended users. Researchers will also consult the industry with regard to intervention implementation and evaluation. For further details about Phase 2 of this research please contact Dave Moore or Tim Bentley.

References

Bentley, T.A. & Haslam, R.A. (1998). Slip, trip and fall accidents occurring during the delivery of mail. *Ergonomics*. 41, 1859-1872.

Bentley, T.A. & Haslam, R.A. (2001). Identification of risk factors and countermeasures for slip, trip and fall accidents during the delivery of mail. *Applied Ergonomics*. 32, 127-134.

Bentley, T.A. & Tappin, D.C. (in press). An exploratory analysis of slips, trips and falls in New Zealand dairy farming. *Journal of Occupational Health and Safety.*

Bentley, T.A., Parker, R., Ashby, L., Tappin, D., Moore, D., Legg, S., Laird, I. (2002). An exploratory investigation of slips, trips and falls in the New Zealand small business residential construction and dairy cattle farming sectors. Interim Report (Phase 1 Exploratory Findings). COHFE and Massey University Report.

Gronqvist, R. & Roine, J. (1993). Serious occupational accidents caused by slipping. In R. Neilsen & K. Jorgensen (Eds). *Advances in Industrial Ergonomics and Safety V.* London: Taylor & Francis (515-519).

Haslam, R.A. & Bentley, T.A. (1999). Follow-up investigations of slip, trip and fall accidents among postal delivery workers. *Safety Science, 32,* 33-47.

Marletta, W. (1991). Trip, slip and fall prevention. In D. Hansen (Ed). *The Work Environment, Vol. 1: Occupational Health Fundamentals.* Michigan: Lewis Publishers (pp. 241-261).

Tisserand, M. (1985). Progress in the prevention of falls caused by slipping. *Ergonomics, 28,* 1027-1042.