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Appendix I

Massey University

Staying on top: ATV Survey 2002

Information Sheet

Principal Researcher:	Dave Moore. Ergonomist. Centre for Human Factors and Ergonomics. Forest Research. Building 94, Enterprise Centre, Massey University Campus, Albany. PO Box 300-540, Albany, Auckland. Ph. Direct dial 09 415 9026. University extension 9888. . Mob. 025 290 6954. Email. Dave.Moore@cohfe.co.nz
Principal Supervisor:	Professor Tony Vitalis. Head of Department. Department of Management. Palmerston North. Email. A.Vitalis@massey.ac.nz Further contact details as on letterhead.
Secondary Supervisor	Dr Tim Bentley. Senior Lecturer. Department of International Business. Massey University, Albany. Private Bag, North Shore Mail Centre. Ph. 09 443 9700. Extension 9115. Email. T.A.Bentley@massey.ac.nz

Purpose of the study

It is estimated that around 70,000 4 wheeler farm bikes (ATVs) are now in use in New Zealand. Whilst highly valued as worktools they do now factor highly in farming accident statistics. On average, seven people a year are killed in New Zealand while using ATVs, and well over 100 times this number are seriously hurt. The full costs to the families affected can only be guessed at, but the ACC bill alone approaches $1million p.a.

Your help as users is needed in gaining an understanding of the problems. The aim of this project is to learn more about the ways in which we use ATVs, on farms in particular, and the more common factors in loss of control incidents. Once I have carried out enough of the detailed case investigations for patterns to emerge (estimated at 120), I will then have a more informed view of what can be done to reduce the number and severity of the injuries.

About **the Researcher**

I am Dave Moore from the Centre for Human Factors and Ergonomics [COHFE], a specialist group within the Rotorua-based Crown Research Institute Forest Research, and will be carrying out this work over the next few months. The work is funded principally by government through the Public Good Science Fund & ACC and will be part of a PhD programme with Masssey University supervised by Professor Vitalis and Dr Bentley.

The project is being run in close collaboration with the ATV Forum Group which comprises: Federated Farmers, the Motorcycle Distributors Association, OSH and ACC. If you did not contact me in response to media reports on the project, your name would have been on the list of ATV-related injury claimants provided to me in strict confidence by ACC.

What is involved?
After the initial exploratory 5 minute phone call from me, each on-site interview session should take around 40 minutes. I will be asking about your ATV: what kind it is, who uses it & what for, and any ideas you may have for improving them as working tools.

In addition I would like to know if you have had a loss of control incident. Earlier studies reported that just about everyone who uses ATVs has experienced at least one of these at some point. I am interested in: the task(s) you were doing at the time, the conditions that day, what equipment you were using, the terrain and any other factors you think played a part.

Your rights
You are under no obligation to participate in this project at all. However, any help you can give may help others avoid the suffering that you and your family have experienced. If you do agree you have the right to:

- decline to answer any questions you choose
- refuse to answer any particular questions
- withdraw from the study at any time prior to completion of the research project on Dec 1st 2002
- ask me whatever questions you like about the study during participation
- provide information on the understanding that your name will not be used unless you give permission to the researcher
- be given access to a summary of the findings of the study when it is concluded.

It will not affect any ACC claim you may have in any way as ACC will receive no identifiable details about your specific case. If you have any queries or concerns about your involvement in the project, feel free to contact Professor Tony Vitalis (supervisor) at Massey through whom support services can be accessed. His contact details are at the head of this sheet.

What happens to the information given?
The data will be compiled on a database that allows me to conduct analysis that will hopefully lead to practical interventions with a good chance of success.

All information you give will be treated as confidential, and every step, within the law, taken to ensure that it remains known only to the researcher and supervisors named on this sheet. Each interview will be coded with a number rather than using your name and the master list of names will be kept separate from the data. I may ask if video footage can be collected with participants using a scale model ATV to describe their loss of control incident. This footage will be similarly protected to maintain anonymity. Your face will not appear on the recordings – just your hands and the model.

The information collected will be coded and aggregated prior to analysis, so that I will not identify you personally in any way in the reports produced for Massey University, Public Good Science Fund, or ACC unless at some point in the future you give us specific permission to do so. At the completion of the project, site data will be destroyed and a summary of the findings of the study sent to you if you would like one.

This project has been reviewed and approved by the Massey University Human Ethics Committee, PN Protocol 011128. If you have any queries about the conduct of this research, please contact Professor Sylvia V Rumball, assistant to the Vice-Chancellor (Equity and Ethics), telephone 06 350 5249.
Email S.V.Rumball@massey.ac.nz

MasseyUniversity

Staying on top: ATV Survey 2002

Consent Form

I have read the Information Sheet and have had the details of the study explained to me. My questions have been explained to my satisfaction, and I understand that I *may* ask further questions at any time.

I understand that I have the right to withdraw from the study at any time before the completion of the research on Dec 1st 2002, and to decline to answer any particular questions.

I agree to provide information to the researcher on the understanding that my name will not be used without my permission. (The information will be used only for this research and publications arising from this research project).

I agree / do not agree, to any section of this interview being video (vision and sound) taped.

I also understand that I have the right to ask the ***video/audio*** *recorder to be turned off at any time during the interview.*

I agree to participate in this study under the conditions set out in the Information Sheet.

Signed: ....

Name: ....

....

Appendix II

Interview schedule for on-farm Context study

Event and causal factor chart template – as used in LCE Investigation study

MasseyUniversity

ATV Study

Interview schedule – context study

Principal Researcher: Dave Moore. Ergonomist. PhD candidate, Department of Management Systems, Palmerston North
Supervisors: Professor Tony Vitalis. Management Systems.
Dr Tim Bentley. Department of International Business

1. Preliminaries

Information sheet and consent forms

- Ensure all taking part have received information sheet and consent form, if not issue extra ones.
- Allow time to read and then run through the details to check comprehension. Do not assume literacy

Referral

- Note source of referral eg. ACC, Farmers Mutual etc.

Identification

- Allocate unique identifier code for each participant, based on region, farm and number of total quadbike users

2. Establishment

Farm activity

Activity description	%
Dairy	
Beef	
Sheep	
Horticulture	
Cropping	
Other…. ***State***	

Land area

Hectares	Acres

Ownership of quadbikes

Rider	Owns	Employee using farm-owned

Awareness of manufacturers stated limits on use

e.g. Terrain limits (max slope), speed, maximum weights and positions for loading

Yes / No Comment ……

Induction practices

How would they approach the introduction of a new rider on this property?

Example: Terrain limitations and NO GO areas

Description …… 1^0 2^0 3^0

2. People and tasks

	Rider (state UI)		
Elements	**1**	**2**	**3**
Hours by role (circle) Farm owner Employee Family member Visitor Other (state)			
Characteristics			
Age			
Sex			
Quad experience in yrs			
Training Formal Informal by workmates Self taught			
PPE used Gumboots Boots with ankle protection Overalls Helmets Gloves Other (state)			
Tasks by person Primary tasks Description of task including frequency			
Replacement of quads Alternatives – how would all these tasks be done without quads			
Suitability for the tasks Give **3** design improvements that would make the **quadbike** a better suited tool for the tasks on this farm			
Any other comments relating to tasks or improvements to system design			

3. Quadbikes

	Machine UI	
Specification	1	2
Make		
Engine capacity (cc)		
Year of manufacturer		
Total hours and kilometres of use (taken from instruments)		
Bought new or used		
Modifications (including ROPS)		
Tasks by machine		
Implements commonly used with each machine		
Condition		
Tyres Pressures (max 4psi diff) Tread (min 5mm on all) Wear (even across all four)	*Add diagram*	*Add diagram*
Park brake (holds against 20kg horizontal force applied to rack applied on flat ground)		
Wheels & steering Bearing and ball joints (no play) Steering head race (no clunk)		
Tow bar (no bending or cracking from excessive loading)		
Suspension (recovery bounce comparable to new model – ok for rough ground use)		

ATV Study. Investigation chart

Rider and event UI ……………………………...

Event detail checklist: Season - context. Urgency. Tasks that day. Time of day. **Health/wellbeing.** Food and drink. Work-rest pattern. Weather conditions at the time. Slope and surface characteristics. Distance to help. Modifications and equipment carried. Time on farm – tenure.

Data: Photos. Video. Slope measurement. Material samples.

Organisational factors

WHY?

Contributing factors

WHY?

Immediate contributing factors

WHY?

Activity immediately preceding the event	Initiating events	Contact Events	Injury Events	Post Injury Events

Appendix III

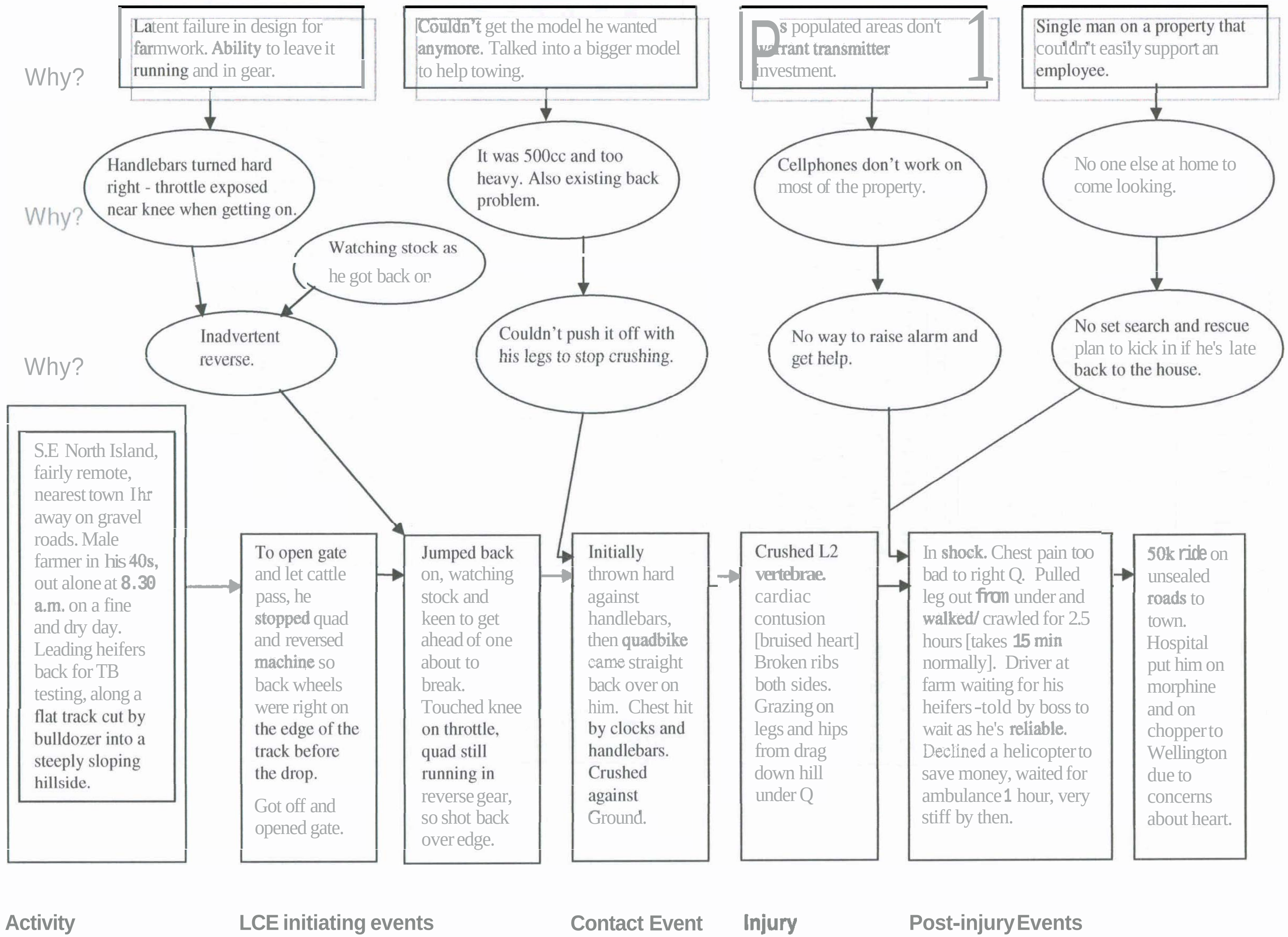
Examples of event charts completed for actual cases – by task with supporting contextual data

Example One: Mustering

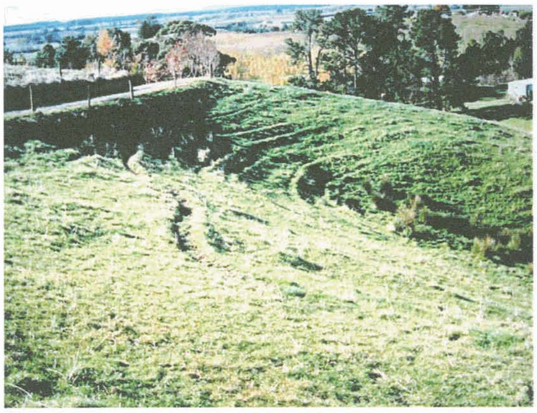
Rider	Single male aged 43. Works alone, a bachelor on the old family farm for the last eight years since parents moved into town. Described by friends as careful to the point of fussy, and has always prided himself on his accident-free farming career. Treats maintenance of vehicles as a very high priority due to the acknowledged risks involved in operating alone on an isolated farm mostly without cellphone coverage. Experience with quads - 5 years Formal training - none PPE worn - gumboots
Task	Moving stock
Location	Sheep and Beef farm 3300 acres, 75% steep or very steep.
Time on the property	39 years
Aware of manufacturer's limitations on operation?	'Yes, but: they are stated just to safeguard the manufacturer.' 'As long as you can do it safely you exceed them.' 'It's not possible to just leave quads lying around unused anyway.'
Terrain limitations and No-Go areas. How would he familiarise a new rider to the property?	Objects to nieces and nephews hooning around. Tells them to stick to the tracks, treat it with respect and don't take it into silly places. The dogs (4) can read it well, 'they get off when it looks hairy and leave me to it.' Doesn't formally show new riders around or hand out a map.
Machine	Honda 500. 2001. Has done 5000k in 482 hours. Only modification was the added Dog Mat.
Tasks of machine	Personal and dog transport

Implements used with the quad	Trailer most commonly, then spraying using a rear-mounted tank and a DIY 10 foot spray boom.
Machine condition	Tyres pressure and wear - all even and within limits Park brake – holds Wheels • bearings and ball joints - no play • steering joints – no clunk Towbar – undamaged no sign of excess load damage Rear shocks – bounce comparable to new model
Use by rider	**30** hours a week, mostly mustering
How were the tasks done before quads were used and how would it be done now without	He could and used to manage the workload with a two-wheeler, but the dogs couldn't. It's a four mile walk out to bring in the 3000 sheep. He lost a good dog through heart attack at age **6.5years** (normally live for 8 years) and so bought a quad to give them a ride. Cost benefit; Dogs don't get useful until four years old and they have to be worked, trained and fed up to this age. He runs a pack of 10. Now he gets on average two years more out of each animal – twice the return on the investment.
Busiest times	Nov-Dec for shearing
3 design improvements that would make it a better suited tool for this farm	• Changes to reduce the chances of inadvertent reversing. Reckons an audible warning would do for a start • Transmission lock instead of a cable-operated handbrake which stretches and can't be inspected as it's encased. Have had them break on him. Cable operated ones will allow the machine to creep even when it's in gear, which is no good when sitting up on ridges. • GPS based system to alert emergency services when he's lying injured. Just like the pilots who go down have as you'd need a helicopter to get him out of some of the places on his property too. Unit would need to be clipped into his belt or on the chest pocket so that it was on him at all times in all weathers not attached to the bike which could have bounced away into a gully.



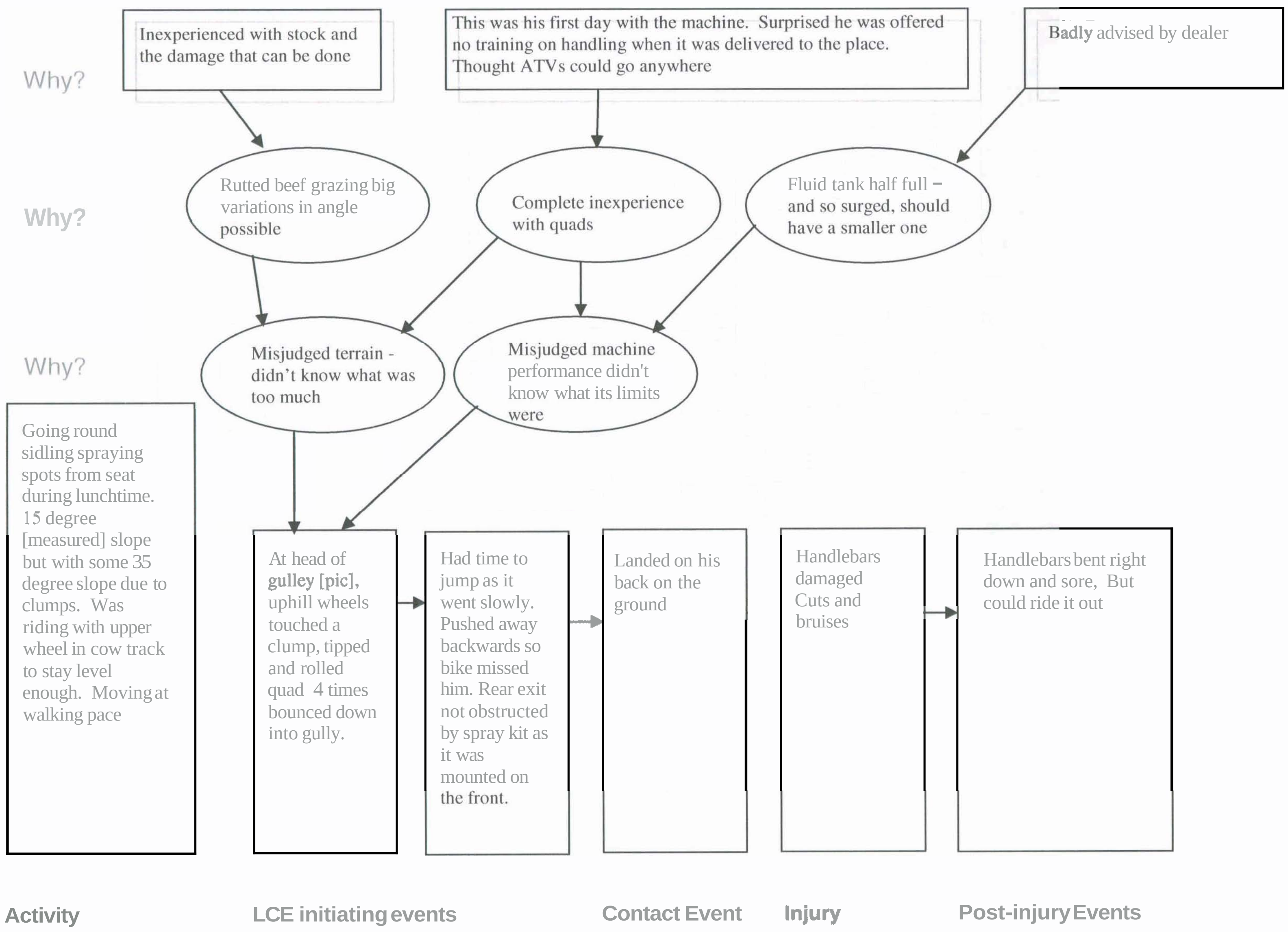
Why?
Why?
Why?
Latent failure in design for farmwork. Ability to leave it running and in gear.
Couldn't get the model he wanted anymore. Talked into a bigger model to help towing.
s populated areas don't warrant transmitter investment.
Single man on a property that couldn't easily support an employee.
Handlebars turned hard right - throttle exposed near knee when getting on.
It was 500cc and too heavy. Also existing back problem.
Cellphones don't work on most of the property.
No one else at home to come looking.
Watching stock as he got back on
Inadvertent reverse.
Couldn't push it off with his legs to stop crushing.
No way to raise alarm and get help.
No set search and rescue plan to kick in if he's late back to the house.
S.E North Island, fairly remote, nearest town 1hr away on gravel roads. Male farmer in his 40s, out alone at 8.30 a.m. on a fine and dry day. Leading heifers back for TB testing, along a flat track cut by bulldozer into a steeply sloping hillside.
To open gate and let cattle pass, he stopped quad and reversed machine so back wheels were right on the edge of the track before the drop.
Got off and opened gate.
Jumped back on, watching stock and keen to get ahead of one about to break. Touched knee on throttle, quad still running in reverse gear, so shot back over edge.
Initially thrown hard against handlebars, then quadbike came straight back over on him. Chest hit by clocks and handlebars. Crushed against Ground.
Crushed L2 vertebrae. cardiac contusion [bruised heart] Broken ribs both sides. Grazing on legs and hips from drag down hill under Q
In shock. Chest pain too bad to right Q. Pulled leg out from under and walked/ crawled for 2.5 hours [takes 15 min normally]. Driver at farm waiting for his heifers - told by boss to wait as he's reliable. Declined a helicopter to save money, waited for ambulance 1 hour, very stiff by then.
50k ride on unsealed roads to town. Hospital put him on morphine and on chopper to Wellington due to concerns about heart.
Activity
LCE initiating events
Contact Event
Injury
Post-injury Events

Example Two: Spraying



Riders	Married male aged 44, wife 39, son 12, sometimes a visitor. Experience with quads - 8 years Formal training – none PPE worn - none
Tasks	Subject – spraying mostly, checking stock, mending fences and gates, dumping rubbish. Wife – checking stock, fetching milk from the box 500m away. Son – riding the quad while dad walks along holding the spraying hose
Location	Small-holders in Tasman District running beef on 35 hectares (25% flat or undulating, 55% rolling, 20% steep to very steep)
Time on the property	9 years
Aware of manufacturer's limitations on operation?	'Yes, there are plenty of stickers on it anyway and documents in the handbook.' The towing limit and the front rack weight limit of 30kg 'make sense' but he still doesn't adhere to it as he always has 60L fluid in the front tank and have also towed in excess of the limit suggested.
Terrain limitations and NoGo areas. How would he familiarise a new rider to the property?	Tells them to stick to the flat tracks (this limits the user to fetching the milk in reality) and only go straight up and down slopes - not across. Reluctant to let anyone on with a competency check, but has passed on that responsibility at present to the guy leasing the grazing by putting it in his contract that its up to him to check.
Machine	Owns one Honda 300 TRX 1994. Has done 5000k in 1080 hours. Modifications: spray tanks, rear tool box on tray, longer mudflaps.
Tasks of machine	Spraying
Implements used with the quad	Front-mounted CDAX tank and a 15m spray hose for hand held application (added 3-4 years ago for safety) used a boom mounted to the machine before that.

Machine condition	Tyres pressure and wear - all even and within limits Park brake – holds Wheels • bearings and ball joints - no play • steering joints – no clunk Towbar – undamaged no sign of excess load damage Rear shocks – bounce comparable to new model
Use by rider	**3** hours a week, mostly spraying
How were the tasks done before quads were used and how would it be done now without	Bought it for spraying. It would take **3-4** times as long to do without and would make the operation questionable for his family – might sell up.
Busiest times	Peak weed growth
3 design improvements that would make it a better suited tool for this farm	• Wider wheelbase • Clear guidance indicating what it can and can't do with regard to slopes, especially before and after modifying it with spray tanks etc. • Restrictions on manufacturers to force them to put in baffles in the spray tank or some other way of reducing the destabilising surge when riding with only 30L in a 60L tank.

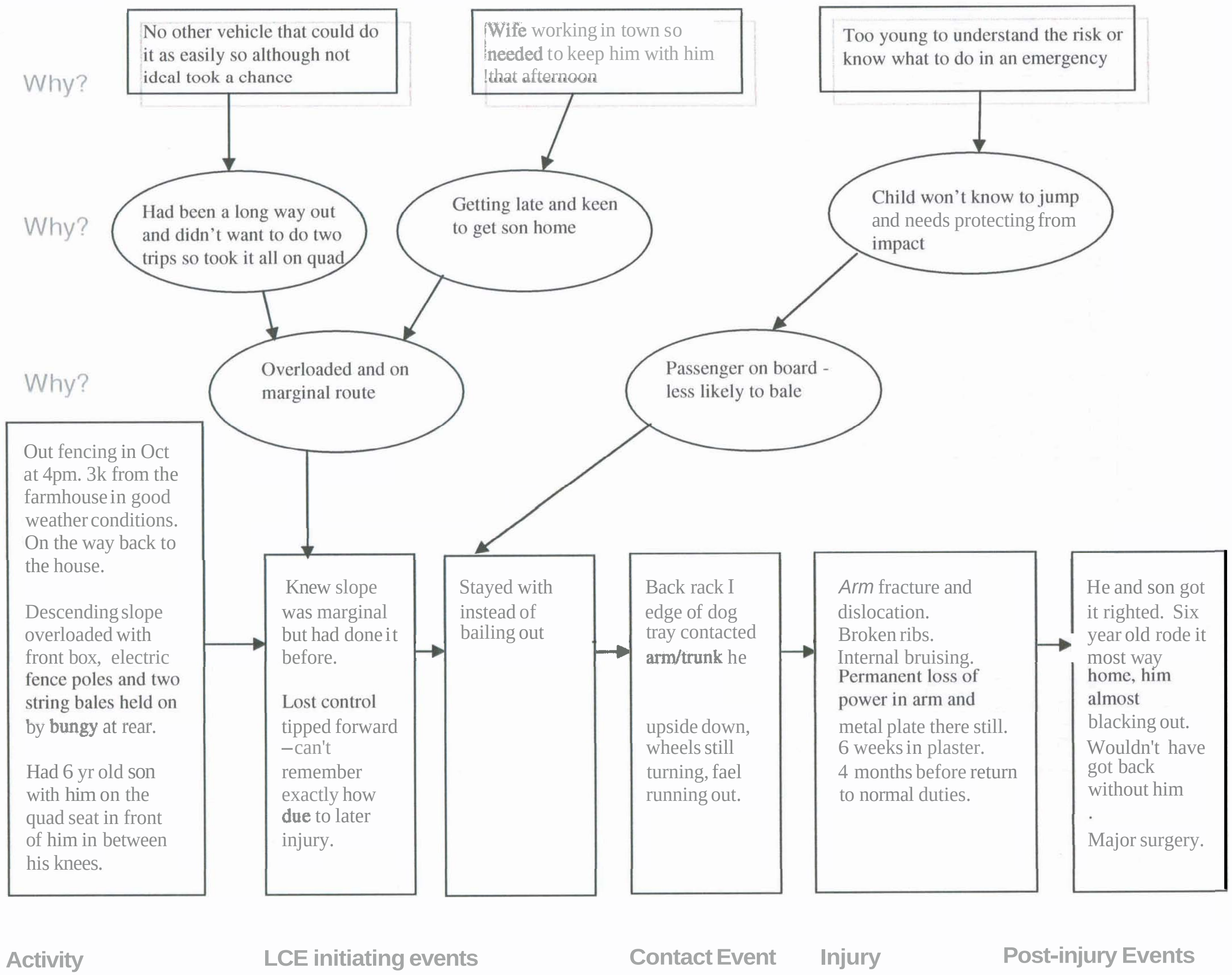

Why?
Inexperienced with stock and the damage that can be done
This was his first day with the machine. Surprised he was offered no training on handling when it was delivered to the place. Thought ATVs could go anywhere
Badly advised by dealer
Why?
Rutted beef grazing big variations in angle possible
Complete inexperience with quads
Fluid tank half full – and so surged, should have a smaller one
Why?
Misjudged terrain - didn't know what was too much
Misjudged machine performance didn't know what its limits were
Going round sidling spraying spots from seat during lunchtime. 15 degree [measured] slope but with some 35 degree slope due to clumps. Was riding with upper wheel in cow track to stay level enough. Moving at walking pace
At head of gulley [pic], uphill wheels touched a clump, tipped and rolled quad 4 times bounced down into gully.
Had time to jump as it went slowly. Pushed away backwards so bike missed him. Rear exit not obstructed by spray kit as it was mounted on the front.
Landed on his back on the ground
Handlebars damaged Cuts and bruises
Handlebars bent right down and sore, But could ride it out
Activity
LCE initiating events
Contact Event
Injury
Post-injury Events

Example Three: Fencing

NB. Typical terrain at lower level on this property.
No photo of actual site due to very poor visibility during visit.

Rider	Single male aged 39. Wife doesn't use it – not confident. Experience with quads - 18 years Training - self PPE worn – boots and overalls
Task	90% moving stock
Location	Beef and Sheep farm 500 acres, 80% rolling to moderately steep, 20% steep or very steep.
Time on the property	15 years
Aware of manufacturer's limitations on operation?	Yes, the weight limits.
Terrain limitations and NoGo areas. How would he familiarise a new rider to the property?	Familiarised the new riders over a period of time prior to being left in charge.
Machine	Honda 300 TRX. 1997. Has done 23,039k in 2610 hours. Modifications: Dog Mat, front toolbox, stickholder tube (see pic)
Tasks of machine	Stockwork
Implements used with the quad	Mostly none but sometimes trailer although he doesn't feel comfortable with it.
Machine condition	Tyres pressure and wear - all even and within limits Park brake – holds Wheels • bearings and ball joints - no play • steering joints – clunk starting

	Towbar – undamaged no sign of excess load damage Rear shocks – bounce comparable to new model
Use by rider	**30** hours a week
How were the tasks done before quads were used and how would it be done now without	Some with the two-wheeler, some with tractor and possibly some with horse. He would also need to employ help.
Busiest times	Calving / lambing
3 design improvements that would make it a better suited tool for this farm	• Better stowage for lambs. • Better throttle – thumb activated one not ideal as too exposed. Dogs hit it, leg touches it when leaning to open gate. • Better handbrakes on Hondas and mandatory Warrants of Fitness to keep standards up.



Why?
No other vehicle that could do it as easily so although not ideal took a chance
Wife working in town so needed to keep him with him that afternoon
Too young to understand the risk or know what to do in an emergency
Why?
Had been a long way out and didn't want to do two trips so took it all on quad
Getting late and keen to get son home
Child won't know to jump and needs protecting from impact
Why?
Overloaded and on marginal route
Passenger on board - less likely to bale
Out fencing in Oct at 4pm. 3k from the farmhouse in good weather conditions. On the way back to the house.
Descending slope overloaded with front box, electric fence poles and two string bales held on by bungy at rear.
Had 6 yr old son with him on the quad seat in front of him in between his knees.
Knew slope was marginal but had done it before.
Lost control tipped forward – can't remember exactly how due to later injury.
Stayed with instead of bailing out
Back rack I edge of dog tray contacted arm/trunk he
upside down, wheels still turning, fael running out.
Arm fracture and dislocation.
Broken ribs.
Internal bruising.
Permanent loss of power in arm and
metal plate there still.
6 weeks in plaster.
4 months before return to normal duties.
He and son got it righted. Six year old rode it most way home, him almost blacking out.
Wouldn't have got back without him
.
Major surgery.
Activity
LCE initiating events
Contact Event
Injury
Post-injury Events

Appendix IV

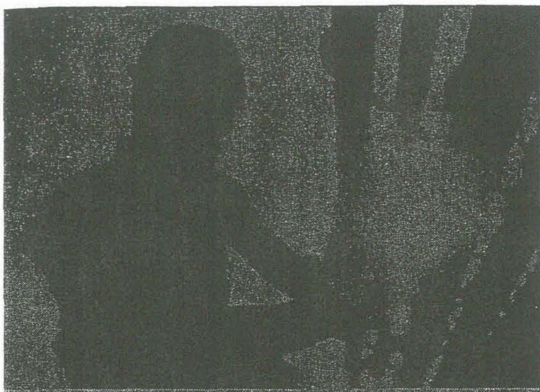
Journal and refereed conference papers

Moore, D. & Bentley, T. (2004). All-terrain vehicle-related Accident Compensation Corporation claims in New Zealand 2000/1: a descriptive analysis. *Journal of Occupational Health and Safety – Australia & New Zealand.* 20(4): 335-343.

Moore, D., & Bentley, T. (2002). Staying on Top: loss of control events involving quadbikes on New Zealand farms. In: *Putting Research to Work - Proceedings of the 11th Conference of the New Zealand Ergonomics Society, Wellington. 14-15 November 2002.* (Recipient of Best Paper award)

Moore, D.J., Tappin, D.C., Vitalis, T., Bentley, T.A., & Parker, R.J. (2006). Developing interventions to reduce quadbike incidents in New Zealand In: *Proceedings of the 16th IEA Triennial Congress of the International Ergonomics Association, Maastricht, Netherlands.*

Moore, D.J., Tappin, D.C., Parker, R.J., Vitalis, T., & Bentley, T. (2006). The context of quadbike use on NZ farms. In: *Proceedings of the 13th conference of the New Zealand Ergonomics Society, Christchurch, 11-12 May, 2006..*



All-terrain vehicle-related Accident Compensation Corporation claims in New Zealand 2000/01: a descriptive analysis

D MOORE

T BENTLEY

Dave Moore, BA (Hons) (Arch), DipErg, CNZErg, is a Research Ergonomist at the Centre for Human Factors and Ergonomics, and Tim Bentley, BSc (Hons) (Psychol), MSc (Erg), PhD (HSErg), CNZErg, is a Senior Lecturer in the Department of Management and International Business, both at Massey University.

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This article describes an epidemiological study of 850 identifiable Accident Compensation Corporation (ACC) claims related to all-terrain vehicle (ATV) use on New Zealand farms in the period July 2000–July 2001. The findings, covering mostly claimants from agricultural/land-related occupational groups, indicated that incidents occurred most frequently during the busy, but milder, spring and summer months. Also, that in 75% of cases, the ATV rolled, the most common injury agency being the ground surface or the ATV itself.

Limitations of the study include the incompleteness of the database provided by the ACC — not all AN-related claims will include a narrative description of the event by which to identify them. The briefness of the narrative text entries also limits positive identification of bike type, causal factors and event sequences. More in-depth studies that consider the complex context of A N use on farms are required before evidence-based interventions can be formulated.

KEYWORDS

- FARMING
- ALL-TERRAIN VEHICLES
- INJURIES
- ACCIDENT COMPENSATION CORPORATION

Introduction

In the 12-year period 1978–1989, a total of 12 fatalities were recorded in the hospitalisation data for all two, three and four-wheeled motorcycle incidents on farms.[1,2] However, the annual fatality rate has subsequently increased. During the 1990s, 27 people died while using all-terrain vehicles (ATVs) on New Zealand farms — with 22 of the fatalities occurring in the second half of the decade.[3]

It is estimated that ATV claims to the national body, the Accident Compensation Corporation (ACC), amounted to between $NZ500,000 and $NZ1m annually during the late 1990s.[4] The Occupational Safety and Health Service (OSH) in the Department of Labour has identified ATVs (or quad bikes as they are also known in New Zealand) as the most common single factor in traumatic deaths on New Zealand farms.[5]

The attractions of ATVs over tractors or utes to farmers include affordability, compacmess, speed in remote areas, low impact on plant beds and other sensitive surfaces, and the ability to carry loads of more than one-third of the vehicle's own weight.[6] For the purposes of this study, ATVs were defined as four-wheeled motorbike-derived vehicles, with handlebar steering systems that may or may not require weight-shift in riding.

All-terrain vehicles have to a large degree replaced light tractors on many farms as these cheaper, lighter machines become more powerful and better equipped for a wider range of tasks.[7] Trade estimates suggest that 5,000–6,000 machines are now sold annually in New Zealand, with the market worth between $NZ75m and $NZ95m per annum.[8]

It has been noted that in New Zealand and elsewhere, the use of ATVs is relatively under-regulated.[2,9,10] In New Zealand, there is no legal requirement to register or gain a warrant of fimess for ATVs used solely on private land. In addition, there is effectively no control on the age or employment status of riders. This is because ATVs weigh less than the 700 kg weight limit for operating self-propelled mechanical plant by people under the age of 15 years, as set out in the 1995 regulations (regulations 57 and 60) pertaining to the *Health and Safety in Employment Act 1992.* As a result, younger family members who are excluded from driving tractors can legally ride ATVs.[11]

The joint survey by OSH and Federated Farmers of New Zealand in 1998 indicated that family members use ATVs more than the farmers themselves, both as riders and passengers.[12] A limited number of epidemiological studies have been undertaken overseas (notably in the United States) since the initial flurry of publications in the 1980s when concerns were initially raised about ATVs.[13] However, the applicability of these findings to New Zealand is questionable. Although New Zealand and the US may have fatality rates of between 0.8–1.0 per 100,000 machines per year, 90% of the ATVs in the US are used for recreational riding. In New Zealand, 90% are believed to be sold for work.[8,14] Hence, similarities in the causal patterns and contexts behind those figures cannot be assumed.

Project aims

The aims of this epidemiological study were:

1. To identify patterns and trends in ATV-related escalated claims in New Zealand for the period July 2000–July 2001. Specifically, to determine the distribution of claims across:

— occupational groups;

— locations/incident scenes;

— geographical regions;

— months/seasons;

— demographic variables (sex, age, employment status); and

— injury types/diagnosis and body areas injured.

2. To determine incident event/injury mechanism information, specifically:

— the activity immediately preceding the incident;

— the first and subsequent events in the event sequence; and

— the injury agencies.

This analysis was intended to inform the progress of further research, including the design of detailed ATV incident follow-up investigations by the research team. Findings from the epidemiological study will also be triangulated with other research in determining key risk factors and possible interventions to reduce the impact of these key risk factors.

Method

The ACC provided researchers at the Centre for Human Factors and Ergonomics with a database containing 882 cases, representing all ATV-related claims for the period July 2000–July 2001 that could be identified from the narrative text descriptions of the incidents. These cases were drawn from the full ACC claims database (All Accounts) using the following keywords: quad bike; farmbike; quad; four-wheeler; ATV, and all-terrain vehicle. The data set was cleaned by the researchers, removing all non-four-wheel/quad bikes from the data set through a manual inspection of the data fields (particularly the narrative text). This lefi 850 ATV-related claims which were believed to involve ATVs (as described in the introduction). Having removed all information associated with the claimant's identity and other confidential and non-useful information, variables available for analysis were: narrative text field (one-line description of the inddent); date of birth; sex; work-related (yes/no); incident date; scene (for example, farm, road); employment status; serious injury (yes/no); fatality (yes/no); diagnosis (for example, fracture, soft tissue); injury site (for example, hand, face); location (district); and occupational group (for example, livestock producer, labourer).

These data were entered into Excel and data preparation was undertaken. This included:

— transforming incident date data to month codes;

— collapsing location data into 19 district codes, using Statistics New Zealand regional boundaries; and

— collapsing occupational group data into agricultural/land-related, non-occupational, students and children, other occupational, and occupation not stated or unclear (for example, labourer).

The narrative text fields describing inddent events were coded into four new variables: (1) activity; (2) first event; (3) subsequent event; and (4) injury agency. Coding of the narrative text fields involved the following process:

— sample content was analysed to determine the quality of information that the narrative could provide in regard to these variables;

— a sample of 100 cases was coded to produce category codes for each of the four variables using the narrative text and, where available, supporting information from other data fields;

— percentage agreement was calculated (> 95%) on sample coding of 100 cases between two experienced epidemiological researchers; and

— coding of the entire data set for the four new variables was carried out by one of these two researchers and then reviewed by both.

Analysis methods used were restricted to basic frequency and cross-tabular distributions as the data were not considered suitable for further statistical analysis that would be helpful to the study aims. The analysis was performed using the Statistical Package for the Social Sciences.[15]

Results and discussion

A total of 850 escalated claims to the ACC during the 13-month period July 2000–July 2001 involved ATVs. Of these, six were fatalities.

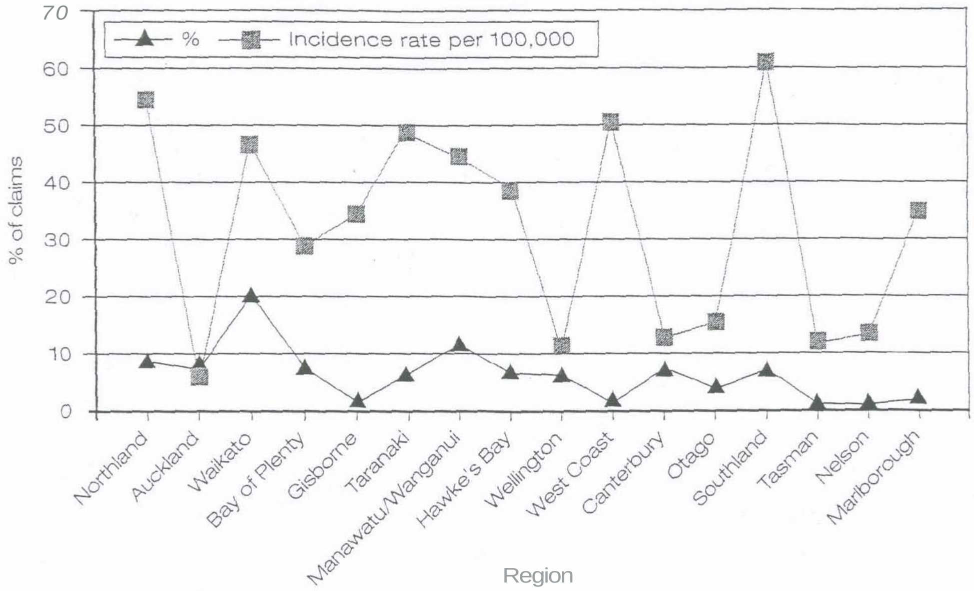
Employment status

Claimants were mostly either classified as self-employed (n = 398, 47%) or employed (n = 383, 45%). Some 5.5% of claimants were non-earners.

FIGURE 1

Regional distribution of claims and claim incidence rates by region

Source: Statistics New Zealand Census 1996.



Occupational group

Agricultural/land-related occupations were by fir the largest group, accounting for 518 incidents (61%) Non-occupational claims by adults and other occupations combined comprised 221 incidents (26%)) with students/pre-school children involved in 50 incidents (6%).

Scene of incident

The large majority of incidents occurred on a farm (n = 361, 43%) or in an industrial place (n = 200, 24%). A large number of incidents occurred in non-industrial semngs, with 96 (11%) classified as "home" and 52 (6%) as "road". It is likely that many incidents classified as occurring at home and on the road were work-related, for example, the farm is also often the home, roads and verges are used for moving staff and stock between separated blocks of farms and verges may be grazed, and employees' accommodation may also be located such that use of public roads is unavoidable.

A further 28 incidents (3%) occurred in a place for recreation and sport. From the findings of follow-up investigations (yet to be published), the authors suspect that many of these events will have involved commercial adventure tourism clients — as opposed to "rally" events organised less formally by ATV owners.

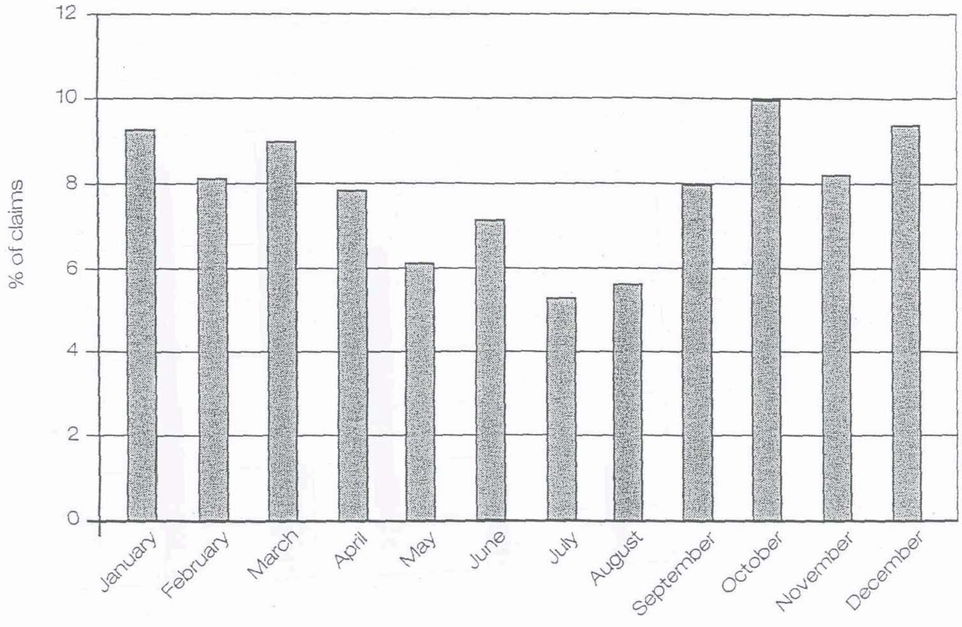
Region

Figure 1 shows the percentage of ATV-related claims by region* for the study sample of 850 cases, together with the claims incidence rate per 100,000 of the population for that region minus urban dwellers.

Regions with strong dairy activity (such as Northland, Waikato, Taranaki and Southland) rated comparatively highly. There were few cases on the West Coast, which has a very small population. The apparently high incidence rate there is not a significant finding. The high incidence rate in Southland prompted particular focus on this area in the subsequent studies.

* Regions as defined by Statistics New Zealand for census purposes as at September 2001

FIGURE 2
Distribution of ATV-related claims by month



Month of incident

The pattern of ATV-related incidents across the year* is shown in Figure 2. M-terrain vehicle-related incidents occurred more commonly during the milder months. The wetter, colder weather during the months of May to August may have been expected to yield a larger proportion of injuries due to riders having to contend with muddy, frosty or icy conditions. However, the findings showed a higher frequency of injuries during the spring and summer months. This may reflect the greater workload during busy periods (such as lambing) when fatigue is also present.

Age and sex distribution

Males registered 707 ATV-related claims (83%), and females 143 (16%).Figure 3 shows the age and sex distribution of ATV-related incidents. The majority of incidents involved people in the main working age groups (that is, 21–60), with a total of 374 incidents (44%) involving persons in the 31–50 years age group. Young adults and children (0–20 years) incurred 98 injuries (12%).

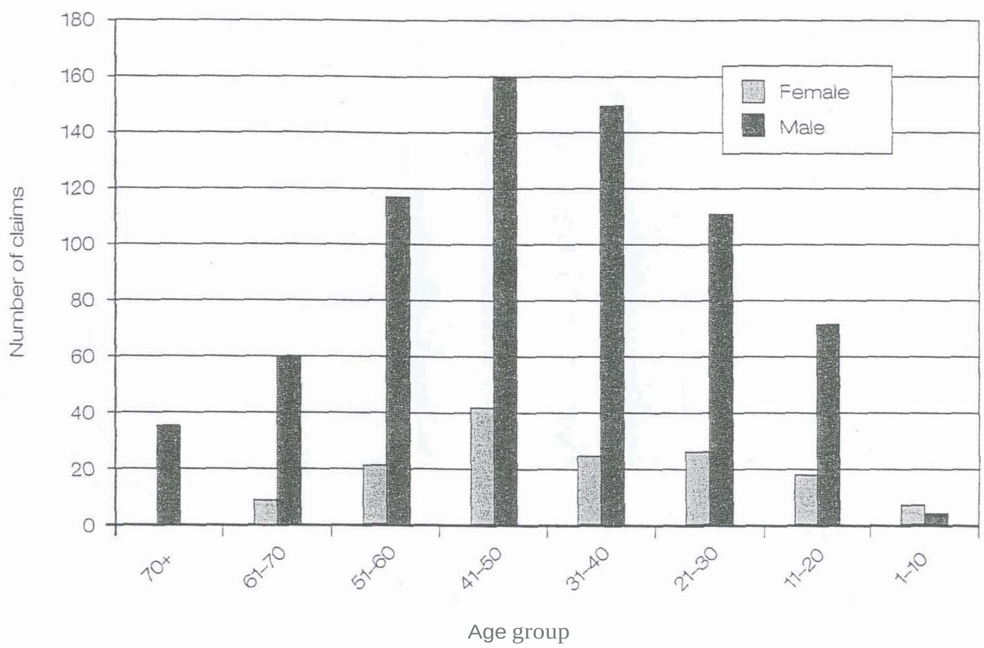
Females were overrepresented in the 0–10 years and 11–20 years age groups, with 5% of female injuries involving children in the 0–10 years age range compared with 0.4% for males. Older females were underrepresented in the oldest two age groups.

Female claimants more commonly incurred injuries in non-occupational/industrial settings, with 17% of incidents involving females classified as occurring at home compared with 10% for male claimants. Similarly, 6% of incidents involving females occurred at a place for recreation and sport compared with 3% for males.

Incidents involving children and young adults occurred at home more frequently than for other age groups, with some 20% of all home incidents involving claimants under the age of 21 years, while home claims made up just 11% of all claims.

* Claims for July 2001 have been removed from the data set for the purpose of this analysis (that is, Figure 2 refers to claims made between 1 July 2000 and 30 June 2001).

FIGURE 3
Age by sex distribution for ATV-related claims



It is of interest that previous work by Langley et al, drawing on hospitalisation data in New Zealand between 1978 and 1989, noted that the 15–19 years age group had the highest claims incidence rate per 100,000 of the rural population? Of all the injuries reported, 25%involved those under the age of 15 years. This contrasts with the greater prevalence of injuries in middle age noted in the present study. However, the data set used in this study was built by searching the narrative field of claims files, and narrative is not captured for all ACC claims. An internal review at the ACC in 2002 found that, at that time, 93%of claims in the Earners Account included a narrative description of the incident, but that this was true for only 25%of those appearing in the Non-Earners Account. It was also predicted by ACC statisticians that this would be skewed towards elderly claimants as they are more likely than children to be claiming support for independence (which would require the narrative field to be completed on their file). These factors confound direct comparisons with the earlier studies at this stage.

Diagnosis and body region injured

Claimants most often sustained soft tissue injuries (n = 483, 57%), fractures or dislocations (n = 162, 19%), or lacerations (n = 103, 12%).Injuries were most frequently located at the knee (n = 83, 10%) and lower back (n = 80, 9%), with some 89%of knee injuries and 75% of lower back injuries recorded as soft tissue injuries. Other high-frequency body part regions were the shoulder (n = 74, 9%) and chest (n = 67, 8%), both of which involved a relatively high proportion of fractures or dislocations (shoulder = 34%;chest = 39%).

Activity immediately preceding the incident

Activities immediately preceding the ATV-related injury event as identified from the narrative text fields* are shown in Table 1. The most common activity immediately preceding the incident was riding the ATV as a driver (n = 690, 81%). Approximately 16% of incidents involved activities

* See Method section for classification of activity criteria.

other than riding/driving an ATV. Children and young adults were found to be overrepresented among claimants not riding/driving the ATV, with 55% of injuries to ATV passengers involving claimants in the 0–20 years age group. Moreover, the claimant was either a student or from another non-occupational category in 80% of incidents where the claimant was a passenger.

Incident event sequences for major activity categories

The most common event sequence was riding the ATV as a driver when the ATV rolled, tipped or overbalanced and the rider was thrown from the ATV (see Figure 4). This event sequence occurred in 433 cases *(75%)*.Other frequent events (all activities) involved the ATV (n = 123, 15%) or rider (n = 122, 15%) being struck by or striking against an object. Where the ATV struck an objecr, the most common subsequent event was for the rider to fall from the ATV (54%). In 19% of cases where the ATV struck an object, the rider incurred a strain/sprain injury.

Injuries incurred while climbing on or off an ATV most commonly involved the claimant stepping onto an uneven surface or slippiig on the footplate or muddy surface. (It is not dear whether or not the machine was moving at the time (jumping off the ATV without stopping first to catch sheep at lambing time was also subsequently reported to the authors)). In the majority of cases, manual handling-related injuries involved lifting or pushing/pulling (often pulling the ATV out of a ditch or mud, or off a trailer).

Injury agency

The most common injury agencies identified from the narrative text include the ground surface (n = 283, 49%), the ATV (n = 214, 37%), and airborne debris (n = 28, 5%). The roll bar was specifically mentioned as having struck the claimant following a fall from the ATV in only five cases. However, it is possible in some cases that, where the narrative indicated that the person was struck by the ATV after a fall, the person may have been struck by the ATV's roll bar. Where the ATV rolled, the injury agency was most often the ground surface (n = 283, 65%)or the ATV (n = 134, 31%).Where an object struck the rider, the injury agency was airborne debris (for example, mud, insects) in 23% of cases. The injured body area was the eye in the majority of struck by airborne debris cases.

It is important to bear in mind that the ACC database does not lend itself in its present form to the recording of multi-factorial events. Except in the sole narrative field, only one entry is afforded per field per case. Analysis and interpretation of events from these records is therefore limited.

Conclusion

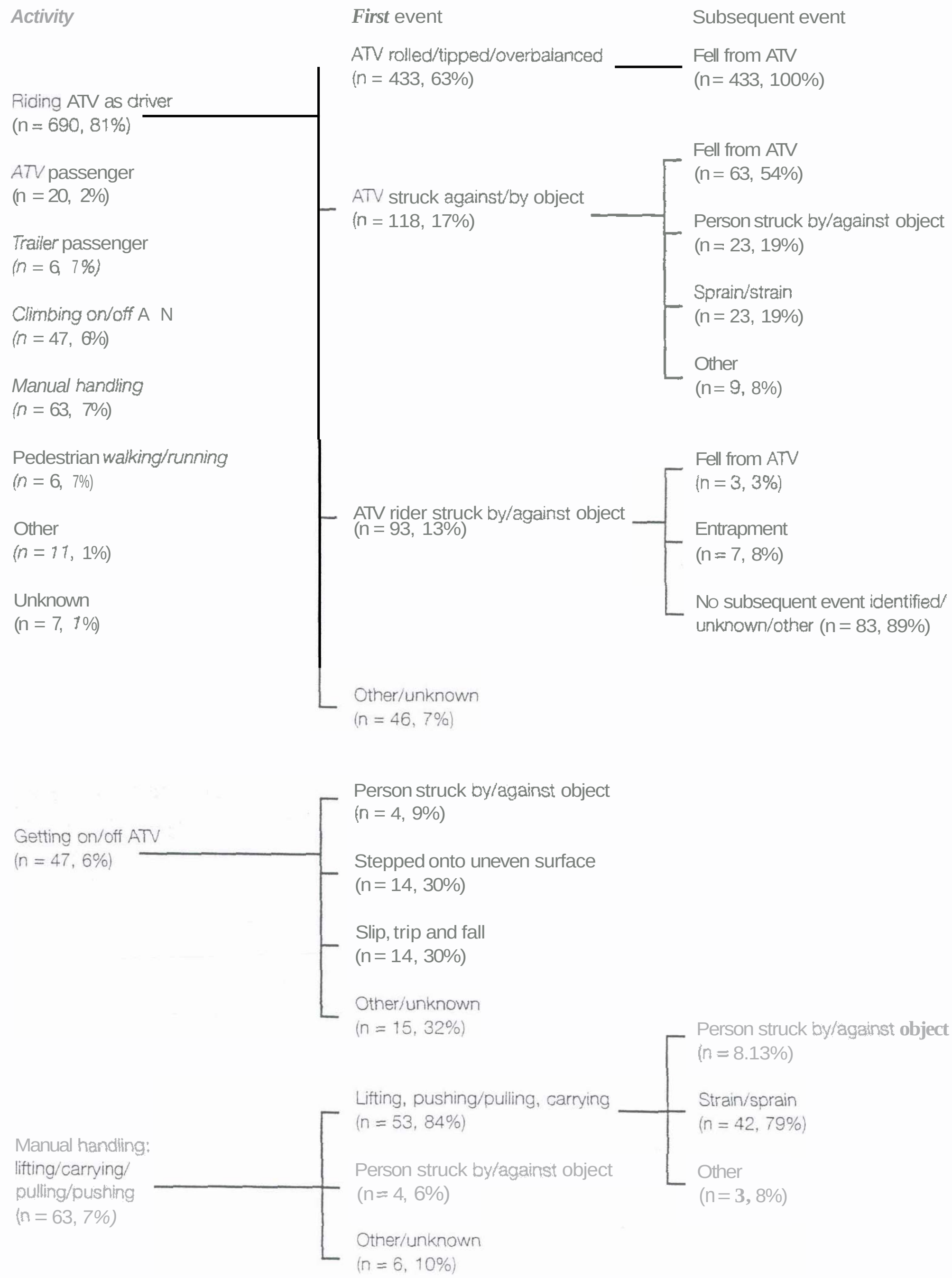
The high rates of injuries and fatalities linked to ATV use in New Zealand and overseas continue to be of concern. This study provides a baseline (with some basic descriptions of the situation in New Zealand in the given year), but with limitations.

TABLE 1
Activities immediately preceding the ATV-related injury

Activity	*n*	*%*
Riding ATV as driver	690	81
Passenger on ATV	20	2
Passenger on trailer (pulled by ATV)	6	1
Getting on/off ATV	47	6
Manual handling (lifting/carrying/pulling/pushing)	63	7
Other/unknown	24	3
Total	850	100

FIGURE 4

ATV-related incident sequences: most frequent activities preceding and subsequent to the event



There are difficulties in positively identifying four-wheeler incidents from the pool of two, three, four and now six-wheeler reported incidents on farms. Two-wheelers, for example, were sometimes also referred to as ATVs in the 1980s —whereas they are not now. Changes in terminology and the sources of available data in New Zealand complicate the process of constructing historical comparisons of incident trends.

The potential to identify incident event sequences and the causal factors through this data source is also limited. Narrative entries to contemporary ACC data are often not explicit enough, and the reliability must be questioned (given that acceptance of an individual claim may well hinge on the wordmg). The findings of this study provide some useful but very general indications of common event scenarios. Since farming is conducted in highly variable contexts, more in-depth ecological or systems-approach studies are required for specific evidence-based interventions to be developed. Such work would also assist in interpreting the epidemiological data.

Acknowledgments

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STAYING ON TOP:
LOSS OF CONTROL EVENTS INVOLVING QUAD BIKES ON NZ FARMS

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ABSTRACT

It is estimated that there around 60,000 quad bikes (aka All-Terrain Vehicle or ATV) in use within the farming community in New Zealand. These have been linked to an average of seven deaths a year since 1997 and over 100 times that number in compensatable claims. This is estimated to cost ACC alone between NZ$500,000 and NZ$1m annually. Surprisingly little research appears to have been done in this area since the 1980s when the machines first appeared and concerns about injury rates were raised.

This paper is in two sections. The first covers an epidemiological analysis of the claims data from the 882 more serious ATV-related injuries lodged with the ACC in the 12 month period to 31st of July 2001. The second consists of a series of 55 on-farm studies from most parts of the country that yielded detailed case material on the design & current use of ATVs, including 156 loss of control incidents.

The findings provide a snapshot of contemporary ATV use in New Zealand, including common causal factors in loss of control events. Further areas worthy of more detailed investigation and potential interventions are discussed.

STUDY 1

A descriptive epidemiological analysis of quadbike-related ACC Escalated Claims data for the period, July 2000-July 2001 was undertaken. The overall objective was to generate basic descriptive statistics which could also guide the more in-depth field-based investigation to follow.

Method

ACC provided the researchers with a database containing 882 cases, representing all escalated ATV-related claims for the period July 2000-July 2001. Escalated claims are those one third judged likely to prove most costly to ACC and hence have narrative entered that allows searches to identify factors such as ATVs being involved. The data were cleaned by COHFE researchers, removing all non-four-wheel quad bikes from the dataset. This left 850 ATV-related claims, believed to involve ATV's.

Having removed all confidential and non-useful information, variables available for analysis were: incident description narrative, date of birth, sex, work-related, accident date, scene (eg. 'farm', 'road'), employment status, serious injury, fatality, diagnosis, injury site (eg. hand, face), location (district), occupational group. Data preparation was included: transforming incident date data to month codes, collapsing location data into 19 District codes, using Statistics NZ regional boundaries, and collapsing occupational group data into a few relevant codes for purposes of clarification.

Limitations

ACC data, whilst useful, should be read with due awareness of it's limitations.

- Not everyone who gets injured whilst using an ATV on NZ farms files a claim with ACC.
- Not everyone who files a claim gives a full and accurate account of what actually happened.
- Narrative is only entered for the third of all claims which ACC staff feel will result in the greatest overall costs. It was noted in later field work [with seriously injured claimants not on the ACC database] that wrong guesses do get made.

Findings

- 81% of claimants were riding/driving the ATV immediately preceding the incident.
- In 75% of cases the ATV rolled sideways, tipped forwards or flipped backwards and the rider fell or was thrown off the ATV.
- 16% of incidents involved activities other than driving (13% getting on/off the ATV or manual handling).
- The most common injury agency was the ground surface or the ATV.
- 15% of incidents involved the ATV being struck by/striking against an object.
- 14% of incidents involved the rider striking against or being struck by an object.
- Airborne debris struck the rider in the eye in 28 cases.
- The largest counts of ATV-related incidents registered in Waikato and the Manawatu/Wanganui regions.
- The highest number of claims per 100,000 of total population as at 1996 census were for Southland followed by the Northland region.
- Incidents were most common during the milder months [September-February].
- Claimants were males in 83% of cases.

STUDY 2

Introduction

As found in the preceding NZ study, the majority of serious injuries and fatalities reported in the literature are linked to overturns of some description. (De Lisle, 1988). DeLisle's team conducted follow-up phone interviews with 624 people presenting in regional Quebec Province hospitals after ATV incidents over a seven month period and noted that two thirds of the incidents involved no external object. They also found that 70% of the incidents reportedly involved overturns, which occurred on either hilly or flat land. They concluded that accident reconstruction studies were needed for possible engineering solutions to be identified as part of an overall intervention package. Whilst there is some pertinent recent overseas literature (eg. Rodgers and Adler, 2001) it is important to note that whilst 90% of quadbike use in NZ is occupational and only 10% recreational – the reverse is true in N.America.

Of the 15 ATV–related fatalities on NZ farms in the two years from June 2000, OSH report that: 1 was from a head injury, 1 from impact with a train, 8 from being crushed / pinned [including resulting in drowning] by quad, and 4 more loosely defined simply as from rollovers.

Hence it was decided in this study to focus on the grouping of incidents which we have collectively termed Loss of Control Events [LCEs]. We also elected to adopt a methodology that would yield a breadth and depth of case detail sufficient for a necessarily broad package of potential interventions to be identified that may address the high number of crushing and/or entrapment injuries.

Method

The subjects for investigation were drawn from a pool comprising ACC database claimants meeting the criteria, and others who had experienced LCEs who came forward from the general public in response to a media campaign by region linked to an 0800 Freephone number.

Primary selection criterion was that the individuals reporting the LCEs had had at least one recent event of the types most frequently associated with serious injury outcomes or fatalities in New Zealand.

In total 55 farm studies were conducted. These included 156 Loss of Control Events (LCEs) in 13 out of the 15 Statistics New Zealand 1996 census regions.

The study schedule comprised four sections:

1 Establishment. Covering farm and terrain descriptors plus induction / familiarisation procedures for new riders,
2 Machine. Details of the quads currently used including condition checks, modifications and tasks

3 People and Tasks. Details on who uses the machines, for what, and ideas they have individually on what could be changed to make ATVs even more effective on their property.
4 LCEs. Models of quadbikes, trailed implements and riders were used to assist interviewees recall and explain the detailed mechanics of the LCEs. Where the movements were complex the explanations were video recorded for later interpretation. The event section included an inspection of terrain in as much detail as logistics and accessibility allowed. The data was collected using an event sequence and factors chart modified from Bentley and Haslam (2001).

Limitations

- As far as we are aware, no one knows exactly how many quads are in use in NZ or how many people ride them. Without a true picture of the total population and its characteristics a representative sample cannot be gauged
- The people taking part in the study were all volunteers. No one was paid for their time. The case studies took between one hour and three hours to complete on site, and so the contribution was significant. As a result the participants may represent the more interested and less fatalistic of the quad using population.
  The data collection was carried out wherever possible on the farms where the incidents took place. In four cases this was not possible as the individuals were no longer working there, but were included in the sampling frame none the less as it was felt important to include contracted workers who have potentially quite different circumstances.
- The CAA and police can conduct investigations where the machinery involved is still lying untouched, and witnesses present. Such recency was not an option in this case. ATV incidents also often happen away from witnesses and in situations where the vehicle must be righted and ridden out if possible to get medical help.

Findings

The database comprises on average 97 separate fields of information for each of the 53 farms in four linked tables. 25 of these fields hold narrative. The potential lines of contextual analysis are many and varied therefore. This paper is a short one and the following represents only the major themes.

'More serious injury' is defined for the purposes of this study as: any head injury, any injury resulting in hospitalisation, and/or any injury resulting in a temporary or permanent loss of function which significantly affects farm performance as stated by the person involved.

<u>Maior activities being; undertaken at the time of the event</u>

- 71 of the 156 LCEs, and over half [n=20] of the 37 LCEs resulting in the more serious injuries took place whilst interacting with stock or going to or from this activity.

- For all activities combined, two-thirds [96] of LCEs and 21 out of the 37 more serious injuries involved ascent, descent or traverse. Therefore over one third of the more serious were on flattish terrain.

The contributing factors in the Loss of Control Events

- Whilst Unpredicted Surface Changes (USCs), and the Use of marginal routes factor in a lot of LCEs, other factors may be a stronger predictor of serious injury from any LCE that does occur. Eg Haste, where nearly half of all the LCEs resulted in one of the **37** more serious injuries reported.

Most common combinations of two factors in all LCEs and those resulting in the more serious injuries

Factor 1	**Factor 2**	**Of all LCEs**	**Of more serious**
Use of marginal routes	Loads – big, shifting, badly placed or unfamiliar	13%	8%
Unpredicted Surface Changes (USCs)	Use of marginal routes	9%	8%
Unpredicted Surface Changes (USCs)	Secondary Visual Tasking (SVT)	8%	9%

Sex and Age

Males represented 76% of the reported rider population on the farms but 92% of the more serious injury cases investigated. The mean age was 42 years for all riders and 43 for those suffering the more serious injuries from LCEs.

Rollovers

26 of the 37 LCEs which resulted in the more serious injuries involved rollovers. Of these 26, nine were to the side, nine backwards, four straight over forwards and four forwards at 45 degrees. Of particular note is that:

- Around half of the rollovers resulting in these more serious injuries occurred on flattish terrain – not hills as one might expect.
- Backward tips are essentially a steep country phenomena, which whilst inherently dangerous as the machines weight may well be directly onto the rider, the chances of entrapment and therefore an even more serious injury outcome may be less than on flatter terrain.
- There are a lot of cases of crushing. 20 of the 26 serious rollovers resulted in crushing to the trunk and shoulders. Crushing as defined here includes broken ribs and vertebral damage of a kind that may imply point loads being applied. Handlebars and racks are most frequently cited as the point of contact.

Entrapment

In half of the fatality cases in NZ from 1998-2000 the victims were trapped/pinned by the quad machine after the event. In this study:

- Entrapment occurred in two thirds of the more serious 37 LCEs resulted.

- 65% of the entrapments were on flat, undulating or rolling land – not steep country.
- All three entrapments where they couldn't eventually get out unassisted, and were waiting several hours for help were on flat land.

Time of Day

- 65% of LCEs occurred between 11am and 4pm.
- 37% occurred during two peak hours of 11am-12 noon, and 3-4pm.

Discussion

As is perhaps inevitable with a exploratory study of this kind, more questions are raised than answered. Further interpretation and analysis of the data will be carried out in the coming year in conjunction with the industry.

There are indications that a group of the riders suffering the more serious injuries normally ride well within the capabilities of the machine. The issue of affordances and error intolerance may be relevant here. Flynn and Stoffregen, (1995) suggest that the tractor driver learns about stability through the system's responses to disturbances. The quadbike on lumpy terrain may offer relatively little opportunity to learn - the line between comfortably stable and irretrievably instable maybe too fine for these riders.

It also needs to be recognised that a matrix of interventions will needed rather than a single layer. Every LCE and rider is also unique and the design must incorporate that (Haslam, 2001). Farmers with a constantly changing set of factors to deal with cannot expect to avoid all risk, and need instead to take a broader approach and stack the odds in their favour.

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Developing interventions to reduce quadbike incidents in New Zealand

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Abstract

The 70,000 quadbikes (also called All-Terrain Vehicles, four-wheelers or ATVs) in use on New Zealand farms were linked to seven deaths and in excess of 2000 injury claims per year between 1997 and 2002. This paper reports on a series of studies that generated practical evidence-based intervention designs. The method comprised two main phases. The first was an epidemiological analysis of the Accident Compensations Corporation (ACC) claims data in the 12 month period to 31st of July 2001. The aims were to provide a basic descriptive overview of injuries being reported nationwide. Phase Two was a series of 156 follow-up investigations at the scene of the Loss of Control Events (LCE) on 55 farms throughout the country. A hybrid event-sequence-factor chart was used to explore and capture the LCE causal factors. The studies provided some surprises for the industry, including the finding that the majority of more serious entrapments occurred not on hills but on flat land - where riders might generally perceive less risk of serious harm.

This paper describes the system-wide spread of potential interventions that were designed in consultation with industry. An intervention subsequently being piloted that addresses inadvertent reversing is described.

Keywords: ATV, farming, quadbike, interventions, off-road

1. Introduction

In 2001 it was estimated by the New Zealand Motorcycle Distributors Association that there were around 70,000 quadbikes (also called All-Terrain Vehicles, four-wheelers or ATVs) in use in this country, with 5000-6000 new machines are sold annually. The country has roughly 80,000 farms in total, indicating a high level of uptake – especially in the dairying, beef and mixed sheep/beef sectors.

28 people died while using quad bikes on New Zealand farms during the 1990s. The incidence increased during that decade however, with 12 of these fatalities in just two years between 1997 and 1999. For historical comparison, in the 12 year period to 1989 a total of 12 fatalities were similarly recorded in the hospitalisation data for all 2,3 and 4 wheeled motorcycles incidents on farms combined [1]

Between 2000 and 2003 the cost of quadbike-related injuries grew markedly. Incidence of new claims rose 63%: average cost of new claims increased from: NZ$1,090 to NZ$1,530, and ongoing claims climbed ffom NZ$4,050 to NZ$9,760. Combined new and ongoing claims costs grew to around NZ$3.5 million. The Occupational Safety & Health unit (OSH) of the Department of Labour identified quadbikes as the most common single factor in traumatic deaths on NZ farms, and quadbike use as their single greatest area of concern in farm safety.

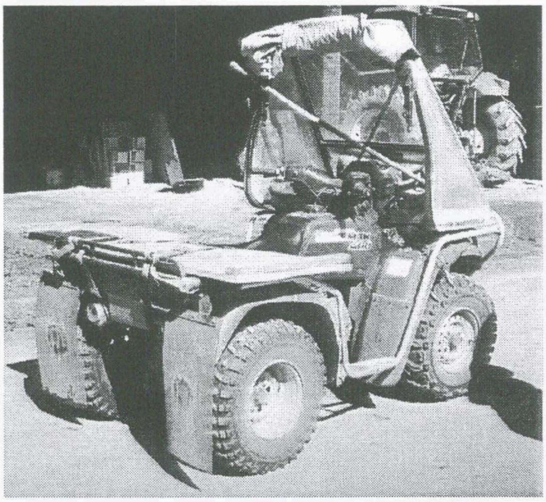


Figure 1. Typical quadbike with South Island sheep station modifications.

Quadbikes fitted out as in figure 1. have to a very large degree replaced light tractors on New Zealand farms, as these cheaper, lighter machines become more powerful and equipped for a wider range of tasks.

The attractions of quadbikes over tractors or utility trucks (also known as pick-up trucks or utes) to farmers include affordability, compactness, speed into remote areas, low impact on plant beds and other sensitive surfaces and the ability to carry loads of more than one third of the vehicles own weight. For the purposes of this study, quadbikes were defined as four-wheeled motorbike-derived vehicles with handlebar steering systems which may or may not require weight-shift in riding.

It has been noted ever since they first appeared that in NZ and elsewhere, the use of quadbikes has been relatively under-regulated [2, 3, 4]. There is no legal requirement to register or gain a warrant of fitness for quadbikes used solely on private land and as quadbikes weigh less than the 700kg limit and younger family members excluded from tractors can legally ride them.

A very limited number of studies on quadbikes, have been undertaken since the initial flurry of publications as concerns were raised about ATVs in the 1980s. Notable exceptions being work in the USA by Rodgers and Adler in conjunction with or through the Consumer Protection organisation CPSC [5]. Unfortunately, the applicability of the North American findings to NZ is questionable despite having similar fatality rates of between 0.8 - 1.0 per 100,000 machines per year. The reason for this is the very different purposes for which the machines are bought. 90% of the ATVs in N.America are believed to be used for recreational riding [6]; whereas in NZ 90% are sold for work. Hence assuming similarities in the circumstances and causal factors is ill-advised.

The overall aim of this study was to gain sufficient understanding of causal mechanisms and context in New Zealand for practical evidence-based interventions to be generated that would work here.

2. Method

2.1. Epidemiology

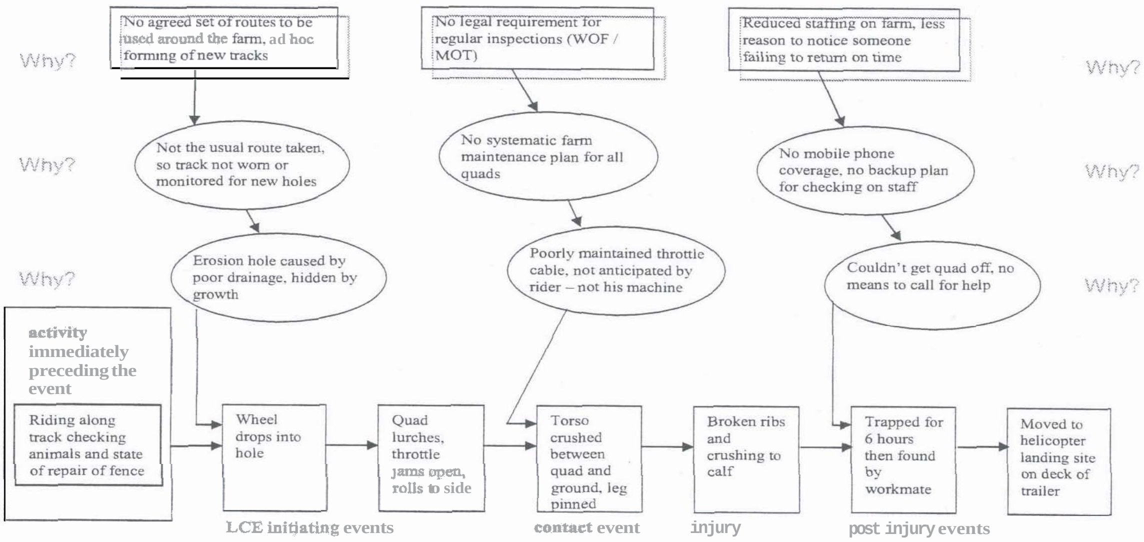
The aim of the first Phase was to provide a basic descriptive overview of injuries being reported nationwide to guide the design of Phase Two – the on-site investigations. It comprised an epidemiological analysis of the ACC claims data ffom the 882 more serious ATV-related injuries ffom the estimated 2500 lodged with the in the 12 month period to 31st of July 2001. This is reported in full by Moore and Bentley elsewhere [7].

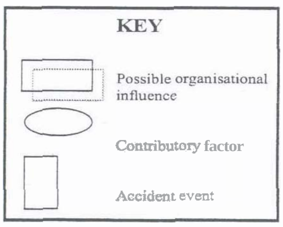
2.2. On-site investigations

These comprised 156 event-specific investigations spread through New Zealand. The objective of the research was to gain a detailed understanding of the most common quadbike-related Loss of Control Event (LCE) scenarios and their key characteristic combinations. Including: employment status, time of day, time of year, ground conditions, terrain, isolation, ancillary implements in use, injury types, activity sequence, injury agencies, serious injury LCE characteristics, entrapment and the effect of Roll Over Protective Structures (ROPS).

The event investigation methodology adopted was centred on analysing and capturing a description of the LCE using a Sequence of Events and Causal Factor chart, based on work by Haslam and Bentley [8], and modified for the purpose.

Figure 1. Sequence of Events and Causal Factor chart (modified from Haslam and Bentley [8])





Graphic representations of the sequence of events and their causal factors have been used for decades in industry [9], but the literature yielded no entirely suitable field-based methodology for investigating civilian off-road vehicle-based injury incidents. The preparation for this aspect of the study therefore included a wider review of potential investigative techniques, via literature and personal interviews with experienced practitioners, notably in the related fields of forensic and air accident investigation.

The Haslam and Bentley chart was selected as the closest fit to the needs of this study. It was modified for the quadbike investigations however in two ways; by extending the sequence of events to cover the post-injury phase, and through the inclusion of prompts to elicit more consistent data on latent and/or distal factors.

Post-event data was critical as quadbike LCE in New Zealand generally occur off-road and sometimes in very remote locations. The rider is in most cases alone at the time without anyone to provide immediate assistance. With the trend towards reduced staffing levels on farms, and partners working to bring in a second income, it may also take longer before they are missed and a search initiated. Due to remoteness and hilliness of terrain, mobile telephone or radio communications may also be unavailable or unaffordable for all or parts of the property. There can therefore be considerable delays in getting help to the event site if the person is trapped or otherwise incapable of getting back without help. These delays can obviously make the outcomes of injury events considerably worse, and/or the rehabilitation period longer.

The second modification was the formal inclusion of the Why? Why? Why? prompts on the chart template used on site. This technique takes the line of enquiry to three stages removed from the immediate causal factor and was identified in the air accident investigation literature as a useful field aid [10]. It was trialed during piloting on three sites in the Bay of Plenty. The device was found helpful as most riders in the pilot volunteered underlying organisational reasons for day to day things going wrong, but only when the causes were within their personal control, not when beyond it. In other words, they saw no point in mentioning things they didn't think could be changed.

Subjects were interested in the event chart recording process though, and the detail of what was being recorded. They generally therefore noticed the gaps at the higher less immediate levels - which they then discussed. In helping to complete the form, critical thinking was prompted about more distal organisational topics normally accepted as 'givens'. This prompting of discussion to reasonably consistent depth allowed underlying factors to be plotted.

The on-site investigations included detailed discussions on potential interventions that would have been effective in preventing or mitigating the effects of the LCE. Potential interventions included evidence-based ideas supported in the literature. Commonly promoted intervention concepts were subsequently peer reviewed at the other farms for robustness and applicability.

2.3. Industry consultation

Following the on-site phase and analysis, the draft intervention lists were circulated in discussion form via the Agricultural Health and Safety Council – a national forum comprising representatives from a wide range of industry groups, commercial bodies, agencies and training providers. Intervention designs were refined accordingly through group and individual discussions, and prioritised for action by the various parties responsible for the intervention types concerned.

3. Interventions

3.1. Approach

In designing the study, and in particular developing the intervention package, local evaluation knowledge was drawn upon extensively. The New Zealand Injury Prevention Strategy (2002 Draft) reflects the experience of a number of key domestic agencies in concluding that injury prevention in NZ will work best when it:

- Addresses the multiple factors that contribute to injury
- Encourages environmental and behavioural changes
- Engages the people who are most at risk
- Involves action across sectors (e.g. Police, health, education)
- Is sustained and reinforced over time."

This list is also consistent with the principles which underpin the WHO Safe Communities Model.

Over-reliance on regulatory measures for quadbikes brings limited success, and so the approach endorsed here is a broad spectrum of interventions that includes the acceptance of supervisory and personal responsibility.

3.2. Organisation and farm management

Although farms are commonly family businesses – a home as well as a workplace, they are still an occupational setting as even without formal employees a hierarchy of control is active. Therefore the three classic categories of injury prevention intervention – the 3Es (engineering, education and enforcement) as used in pedestrian safety for example, were extended to include work organisation. Supervisory decisions and dictates have a high potential for becoming latent failures, as staff commonly work in isolation for long periods – possibly for several days. Key interventions include:

- Avoid the setting of unrealistic work schedules and goal conflicts – especially for new employees.
- Invest more in tracks to reduce exposure time on marginal country.
- Improved track maintenance including keeping grass and undergrowth short so that the surface on commonly used routes across paddocks is revealed for riders and surface water movement managed to minimise erosion
- Plan new fence lines to take quadbike use into account. Guidelines giving minimums for angles and clear path widths may be beneficial.
- Formalise routes to be used each time across untracked areas that avoid marginal terrain.
- Quadbikes with trailers need to stay straight when descending to avoid jack-knifes. Layout routes that

don't attempt changes of direction and offer straight run-outs at the bottom of slopes.

3.3. *Personal awareness*

- Encourage the uptake of basic training to give new riders essential skills, such as effective weight shift techniques.
- Educate riders on the dangers of secondary visual tasks. Watching stock movements whilst riding on an unpredictable surface are very common factors in LCE.
- Educate farm workers on the increased risk through fatigue at physically and mentally demanding times such as lambing.
- Inform farmers on the importance of avoiding goal conflicts and setting realistic work schedules for themselves and others.
- Develop and make available a CD and/or video showing practical strategies for getting out of common difficulties.
- Promote simple good riding practices, e.g. 'don't go down a slope you haven't already been up'.

3.3. *Engineering*

- Long term development of vehicles that don't need modifying or to be operated routinely outside their design parameters.
- Encourage manufacturers to offer machines that don't require weight shift at low speed for that section of the market who don't want, or aren't capable of, Active Riding.
- Transport bulk fluid by a separate vehicle to limit tank volume needed on quad. Minimise fluid movement in tanks and shifting of loose loads such as tools and fencing staples.
- Implement attachment systems that do not afford 'snap roll' leverage of the quad.
- Require throttle protection to be provided to reduce inadvertent operation by animals and the knee when getting on and/or turning hard right.
- Avoid arrangements where trailed implement, rear axle & tyre assembly or load is critically wider than the front of the machine in view of the rider.
- Provide means of reducing entrapment after roll overs – especially on flat country.
- Require all machines imported to have full running boards fitted that do not offer entrapment either when in motion or after tipping.
- Design out point load impact potential on the rider's body.
- Develop personal search and rescue alarm device that is affordable, works in remote country and can be carried comfortably on the person at all times.
- Fit creeper gear and steering head tightener for walking the quad down steep hills, and also useful for feeding-out with both hands free.
- Provide lights that point where you're going – not where you've been i.e. handlebar-mounted not frame.

3.4. Regulation

- Require implements to be tested for use with specific quad types and sold on that basis to avoid overloading.
- Initiate a national WOF-type system for quadbikes to: protect riders better from machine failure and enable owners to demonstrate willingness to maintain equipment responsibly.
- Formalise maintenance and dailylweekly checking on farms using log book system.

3.6. Pilot – reverse gear audible warning

A number of the interventions are being taken up by various agencies, but one that was quickly embraced by individual farmers following media releases on the idea was that of reversing beepers. The way that most quadbikes are designed allows the rider to dismount, at for example a gate, leaving the machine with the engine running and either a forward or reverse gear engaged. A small display light mounted on the handlebar console normally indicates reverse gear engaged but will probably not be noticed in bright sunlight, when covered with dirt or if the rider's attention is ahead down the track as they climb back on. When working with stock around gates it is common for the last movement to be a short reverse. When the rider gets back on, they are generally in a hurry to catch up with the animals and so push the throttle hard, which may well cause damage to either themselves or the machine if they go backwards instead of forwards as expected. In the study over 95% of riders reported having trouble with this latent design weakness. Once a month was typical frequency. A conservative estimate of injury costs from this feature is NZ$750,000 a year to ACC alone. The intervention idea is a simple beeper unit wired into the machine that provides an auditory cue as well a visual one that the machine is in reverse gear. It costs between NZ$25-85 depending on make and model, and has resolved the problem for the three machines so far fitted that we have monitored.

4. Concluding comments

There is currently a mismatch between the tool needed by farmers and what is available. This should be addressed by engineering design in the longer term. However, that will happen slowly, if at all, given the relatively modest size of the NZ market and commensurate influence on design directions taken by the manufacturers.

In the short to medium term there are 70,000 or so machines out there already and intervention plans need to reflect that rather than focus simply on improving the specification of new machines arriving in NZ.

Regulatory controls could well be improved to reduce the risks of for example young employees being given unfit machines to ride, but given that quadbikes are used predominantly on private land where regulations on users are difficult to introduce and very costly, if possible at all, to enforce it is envisaged that a similarly long term sustained intervention approach will be needed. Simplistic Regulations on age and the wearing of helmets for example should certainly not be presented substitutes for informed and careful supervision.

The quadbike injury problem in New Zealand extends beyond the employees of working farms into the families and wider rural community and intervention designs need to reflect this

Acknowledgements

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THE CONTEXT OF QUADBIKE USE ON NZ FARMS

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ABSTRACT

This paper describes one of a series of studies on context of quadbike use on Loss of Control Events (LCE) involving quadbikes on New Zealand farms. The aim of this series of studies was to gain sufficient understanding of the various risk factors and their interactions in a New Zealand farming context for effective evidence-based intervention ideas to be generated. Data was collected through on-farm studies and other consultative methods within industry. The findings include patterns of use indicated that are different to those anticipated by the designers of the quadbikes and also to those seen in North America where most previous studies have been done.

INTRODUCTION

In 2002 there were are approximately 70,000 quadbikes also known as All-Terrain Vehicles (ATV) in use in New Zealand, and a further 7,000 new machines being sold each year. The attractions of quadbikes over tractors or utility trucks include affordability, compactness, speed into remote areas, and low impact on plant beds.

On average there are seven quadbike-related fatalities per year, and the cost to the national Accident Compensation body (ACC) is high. New and ongoing claims costs were NZ$1.5 million in 2000101 climbing to NZ$3.5 million in 2003/4. Attempts in NZ to generate evidence-based interventions to reduce this burden have drawn heavily upon North American research findings which assumes sufficient parallels in usage and hence risk factors. The support for this assumption was untested (Moore and Bentley, 2002).

The objective of this Context study was therefore to present a detailed description of quadbike use by identifying: what tasks are the quadbikes being predominantly used for on the farms where LCE are taking place, what specific risks do the tasks typically present, how well suited are the machines to these tasks, who is using them, and what are the characteristics of the machines in service. In collecting this data the researchers hoped to be able to identify potential interventions that would not only reduce risk of injury, but also improve productivity more directly through reducing any mismatch between tool and task.

METHOD

There were two strands of data collection: structured studies on 53 farms visited as part of the LCE investigation study reported elsewhere, and off-farm industry consultation.

The farm visits comprised a single visit of between 40mins and half a day depending on size of operation, number of staff, time available by subjects and number of quadbikes in use. Initial contact was made by telephone and all quadbike users on the farm were invited, via the LCE subject, to take part in the context study at this point. Subjects to reluctant to commit to prearranged group interviews on farms during working hours and were often scattered geographically for most of the period at work. Once the interview(s) were in progress however, others would join in if they were in the same location. Arrival of the researchers was therefore arranged to coincide with the start of breaks for lunch or morning tea. The data was collected principally in a group setting constructed by the subjects. Individual interviews were arranged if requested or the researcher suspected important subjects were being kept out of the group; for example, an employer not allowing an employee to comment on induction training. There were 119 identified occupational users of the quadbikes on the 53 farms studied of which 21 were unavailable or declined interviews. In these cases basic data on age, sex, employment were obtained from colleagues.

Following the semi-structured interviews and focus group sessions, the machines currently used by the riders were inspected. Basic task analysis of the main tasks being undertaken with the quadbikes was then conducted using walkthrough-talkthrough and participant observations. This sequence of investigation was followed as closely as possible, but had to be adjusted on some sites to fit in with subject availability, weather, tasks in hand on the day, difficulty of terrain, availability of personal transport into remote areas, and work demands.

The state of repair of the quadbikes currently in use on the farms was assessed against a set of factors that were seen by professional quadbike engineers to have significant effect on handling. The test factors were: tyre pressures, tread depth, wheel bearing adjustment, head race adjustment, assessment, suspension wear, and park brake effectiveness. Twisting or cracking of the towbar and attachment structure was also visually checked for.

The second phase of the data collection was off-farm industry consultation to triangulate the findings from phase one. It included analysis of practical training on quadbike use from FarmSafe and private providers and a review of the literature on NZ usage. Semi-structured interviews also were held with: other farmers using quads, other farmers choosing not to use quads, ACC and OSH staff in the regions, Agricultural Health and Safety Council, Federated Farmers spokespeople and manufacturers of quadbike implements and accessories in NZ.

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FINDINGS AND DISCUSSION

The findings were grouped under three headings: *Tasks* (primary purpose of purchase, design for the task, coping without quadbikes); *Quadbike users* (user population, employment status and gender, exposure, age and experience of users, training, adherence to manufacturers guidelines, introducing new riders, use of Personal Protective Equipment; The *quadbikes* (age, state of repair, modifications, makes. 2WD/4WD, usage, trailers and other implements used with the quadbike)

Tasks

The vast majority of machines have multiple uses but the most common primary purpose was mustering and checking stock (54%), the next highest being personal transport (16%). When working with animals high risk scenarios include trying to 'do the dog's job' - chasing animals, which requires fast tight turns on churned-up ground. Bringing the herd in for milking represented 8%, the other nine task groups making up the remaining 16%.

The riders were asked, "what three changes relating to your quadbike, or its use, would help you the most with your tasks on this property". The most common request (n=24, 25%) of the 45 logged was for 'protection for rider and the clocks when quadbike rolls to be built in as standard'. It is interesting to note the fact that counter to the trend of increasing engine sizes on each new model, no riders asked for more power or speed and a number of farmers complained about the demise of the smaller 250-350cc machines. Perceived advantages of these included: cheaper to buy and run, more nimble, more, lighter and easier for older and weaker riders to control.

When asked how they would cope without quadbikes, the cost of replacement vehicles was estimated at between $50,000 and $100,000 (for a secondhand Landrover and small tractor plus a new two-wheeler). This compares to a new quadbike price of approximately $15,000. After twenty years of assimilation there may now be as many as one third of farming enterprises in dairy and sheep&beef who believe themselves to be reliant on having a powerful quadbike covering a wide array of tasks. The financial motivation to try and complete all tasks with just the quadbike is therefore considerable.

Quadbike users

If the study farms are representative, the findings would indicate a rider population of approximately 100,000 people. 70% are farmers (44%) and family members (26%), employees comprise 24%, contractors 3% and others 3%. 61% of NZ riders in this study were over the age of 40. By comparison, North American rider populations appear a lot younger. Studies show 80% of riders in the USA to be under 45 years of age. A Canadian study reported 75% to be between 20-39.

An important finding is that the New Zealand riders on farms say they understand, but almost universally disregard, the user guidelines – written for the predominantly recreational N.American market. "They don't apply to NZ usage – the need to carry passengers etc - it's what we buy them for" (Northland Farmer).

The quadbikes

69 (mean age 4.6 yrs) of the 70 machines used on the 53 farms were given a six point check against the set of factors affecting handling. 60% (41) of all machines failed on one or more of the six tests as described, and 12 of these machines (mean age 6.75 years) failed on three or more tests. The most common failures were due to excessive play - in the head race of the steering and in the wheel bearings. The specific impact of poor maintenance was not assessed, but Moore et al (2006) report that the absence of an effective park brake on the quadbike was specifically cited as the primary factor in 3% of 156 LCE investigated.

96% of the machines were modified from the form in which they were sold. Most were permanent and changed the performance characteristics of the machine in a rollover substantially.

87% of the farms used unbraked trailers behind quadbikes despite their very limited capability to maintain control in descent. Moore & Bentley (2004) found a far greater involvement of either a trailer or trailed implement in LCE than the epidemiological data suggested previously. Just 0.6% of the 200112002 ACC cases of LCE are recorded as involving trailers compared to 21% of 152 LCE they investigated.

CONCLUSIONS

No previous study had established: how quadbikes were being used on New Zealand farms, how well suited the users perceived they were for these applications, and whether there were any system design weaknesses compromising performance and/or health and safety of the users. This paper advances our understanding on these questions and highlights some important mismatches between tool and task. It is clear that the machines are not used as the overseas designers intended. It is also clear that the patterns of use differ sufficiently from those in North America for studies conducted there to be of less relevance to New Zealand than had been assumed. Farm use of quads, as we know it, is unique to NZ.

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