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Review of key human factors involved in workplace transport accidents

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Review of key human factors involved in workplace transport accidents

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Workplace transport is the second biggest cause of accidents in the workplace. Although there has been some success in identifying the main types of workplace transport accidents, the people involved, and types of injuries that result, little appears to be known about full influence of a range of human factors on workplace transport accidents. This review therefore seeks to identify pertinent literature in this area. Literature on individual differences and personality, stress, fatigue and demands, training, competencies and selection, and safety culture and management processes was examined, primarily in the context of workplace transport. The literature found relating to these areas would suggest that human factors issues are likely to influence workplace transport accidents on a number of levels. A number of recommendations are made to enable research to be targeted and practice to be improved.

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EXECUTIVE SUMMARY

SUMMARY

This report presents the results of a literature review conducted by Loughborough University for the Health and Safety Executive (HSE). The research was funded by the Injuries Reduction Division. The overall aim of the project was to conduct a comprehensive literature review of key human factors within workplace transport.

The report presents: an introduction to workplace transport; a general review of the literature in relation of workplace transport; specific sections on key human factors within workplace transport; and recommendations for future.

AIMS AND OBJECTIVES

The aims of the research were to conduct a review evaluating:

1. The key human factors involved in workplace transport operations; and
2. The main elements managers and supervisors need to be aware of if they are to manage workers effectively.

Related specific objectives of the work included determining the current state of the literature on workplace transport; highlighting gaps in the research; and making recommendations for future research.

METHOD

Due to the potentially large scope of human factors issues it seemed more effective to concentrate on key issues within workplace transport. To determine these discussions took place with HSE and other workplace transport experts throughout the review process. The key human factors focussed on within this review in addition to the general workplace transport literature are:

- Individual differences and personality
- Stress, fatigue and demands
- Training, competencies and selection
- Safety culture and management processes

Initial searches focussed primarily on workplace transport literature and were only broadened once it had been established that little or no literature was available in relation to specific areas of investigation.

FINDINGS

- Workplace transport in general
  A number of studies and reports were found focussing on workplace transport. The majority of these focussed on lift trucks, design and training issues, and outlining the injuries and causes of injuries/accidents. Only a very small number performed any kind of evaluation of human factors interventions. In terms of accident causation, human factors are likely to contribute to workplace transport safety problems on a number of levels including factor relating to individuals (for example, drivers and pedestrians), the nature of the job (for example, design of the workplace and vehicle), and the organisational (for example, training procedures and management systems).

- Individual differences and personality
  There is a wide ranging literature on demographic differences in general driving behaviour, suggesting that younger males are the most likely to be involved in driving accidents. In terms of personality, no specific literature was found that addressed

personality factors and workplace transport. However, the general literature suggests that aspects of personality which centre on sensations seeking, risk taking, low conscientiousness, neuroticism, and external locus of control are all implicated in accident involvement.

- Stress, fatigue and demands
  In terms of general driving behaviour increased levels of stress is associated with risky driving behaviour and the likelihood of being involved in future vehicle accidents. Fatigue, as a result of the experience of stress or of the demands of irregular working hours has been found to have a link with both driving and workplace accidents.

- Training, competencies and selection
  In line with the findings on age skill levels develop with experience although it is likely that some individuals over estimate their skill in general driving behaviour. There is evidence that lack of training is a factor in some lift truck accidents, and that drivers of other vehicles with less rigorous training regimes are more likely to have accidents. Accordingly, much of the literature identifies training as a key intervention in reducing accidents and incidents in workplace transport, with some suggestion that the awareness of all workers, not just drivers, should be addressed.

- Safety culture and management processes
  Two HSE reports were found which addressed safety culture and management processes in relation to workplace transport. Other HSE documents such as guidance leaflets were also found but they were mainly derivations of other more in depth literature. None of the academic workplace transport literature focused on safety culture, although it has become apparent that safety culture and management processes are a key area of research within accident prevention in every organisational context. It may be through the effective management of safety culture that individuals will develop the competencies required to do the job, and develop appropriate attitudes in relation to safety. In some cases a positive safety culture might impact and interact with the other human factors issues discussed in the review.

RECOMMENDATIONS

Some broad recommendations can be drawn and future directions mapped out as a result of the existing literature. Although there is a general picture, within workplace transport health and safety research still has a number of gaps:

- More research needed in terms of workplace vehicles other than forklift trucks;
- Research needs to establish whether there are sector differences in workplace transport problems;
- The emerging area of Intelligent Transport Systems for workplace transport vehicles merits further investigation;
- There needs to be accurate assessment of accident levels, exposure levels, how accidents are recorded and the impact of changing technologies on accident types;
- Thorough evaluation of the effectiveness of different workplace transport safety interventions needs to take place.

Findings from the literature dealing with the individual would suggest, in terms of workplace transport, that:

- Younger and new drivers receive additional training, or are monitored as they build experience;
- Personality assessment may be most usefully employed for developmental purposes, including the identification of training needs;

- The impact of stress and fatigue on driver performance need to be further investigated in the workplace transport context, allowing the establishment of safe working parameters.

At the organisational level, focus should be on systems of management, including the development of a positive culture for safety. Specifically organisations should be encouraged to:

- Train a wide range of staff, including supervisors and pedestrians in workplace transport operations;
- Establish clear communication processes to help maintain safe working practices and encourage the sharing of information and two-way communication;
- Develop detailed systems and procedures to assess, monitor and evaluate workplace transport risks.

CONTENTS

1 INTRODUCTION

This report presents the results of a literature review conducted by Loughborough University for the Health and Safety Executive (HSE). The research was funded by the Injuries Reduction Division. The overall aim of the project was to conduct a comprehensive literature review of key human factors within workplace transport. In terms of addressing the Workplace Transport Programme of Work the review will add to the available knowledge and the ways in which employers can improve working conditions. The results of the project will help identify gaps in the research and therefore help the Injuries Reduction Division prioritise funding needs. The review will also identify the most effective means for managers to address human factors in the workplace. Another potential benefit of this research lies in the application of the obtained knowledge by inspectors, as it will give them an improved understanding of how human factors impact on workplace transport accidents and enable them to give better guidance to duty holders.

1.1 AIMS

To conduct a review evaluating the extent to which literature is able to inform:

1. The human factors involved in workplace transport operations; and
2. The key elements managers and supervisors need to be aware of if they are to manage workers effectively.

1.1.1 Objectives

1. To determine the current state of the literature on workplace transport.
2. To investigate key human factors which impact on workplace transport and find literature relevant to this.
3. To highlight gaps in the research and make recommendations for future research.

1.2 SEARCH STRATEGY

'Human Factors' is a vast subject area covering a huge array of issues at the individual, job and organisational level (HSE, 1989). The following quotes demonstrate this:

> "Human factors are environmental, organisational and job factors as well as human and individual characteristics which influence behaviour at work and can affect health and safety. A simple way to view human factors is to think about three aspects: the job, the individual and the organisation and how they impact on people's health and safety-related behaviour." (HSE, 2005a)

> "These include the perceptual, mental and physical capabilities of people and the interactions of individuals with their job and working environments, the influence of equipment and system design on human performance, and above all, the organisational characteristics which influence safety related behaviour at work." (HSE, 1989)

Due to the huge scope of human factors issues it seemed more effective to concentrate on key issues within workplace transport. To determine these, discussions took place with HSE and other workplace transport experts throughout the review process. The key human factors focussed on within this review in addition to the general workplace transport literature are:

- Individual differences and personality
- Stress, fatigue and demands
- Training, competencies and selection
- Safety culture and management processes

Initial searches focussed primarily on workplace transport literature. These were only broadened once it had been established that little or no literature was available in relation to specific areas of investigation. Other human factors will be mentioned where relevant but will not be elaborated upon to the same extent.

The area of workplace transport itself also covers an extensive area, consisting of a wide variety of vehicles and work settings. The HSE (2005b) give following explanation of what ‘workplace transport’ includes:

> “Workplace transport means any vehicle that is used in a work setting. It specifically excludes transport on the public highway; air, rail, or water transport, and specialised transport used in underground mining.”

Again, based on the same ongoing discussion process, the literature review focussed mainly on the vehicles which had been more extensively researched, for example lift trucks. It should be noted that since many workplace vehicles share the same issues in terms of accident causation, many of the human factors will transfer.

1.3 WORKPLACE TRANSPORT: THE NATURE OF THE PROBLEM

> “Workplace transport is the second biggest cause of accidents in the workplace, accounting for about 70 fatalities each year. The majority of these accidents are preventable.” (HSE, 2005b)

The importance of this issue has been further highlighted by HSE who have devoted a priority programme to this area of accidents in the workplace.

Although there has been some success in identifying the main types of workplace transport accidents (moving vehicles hitting or running over people, people falling off workplace vehicles, workplace vehicles overturning, objects falling off workplace vehicles), the people involved (pedestrians, drivers, lorry drivers, passengers and mechanics), and types of injuries that result (e.g. crushing injuries to the feet/lower limbs), little appears to be known about the effect of human factors on workplace transport accidents. This review therefore seeks to identify pertinent literature in this area, and highlight how managers and supervisors can manage human factors more effectively.

1.3.1 International problem dating back to the 1960's

Research into workplace transport and more specifically lift trucks can be traced back to the 1960s (Rechnitzer and Larsson, 1992). As far back as 1960 in an annual report by the Chief Inspector of Factories noted that manual handling injuries were being reduced by the introduction of mechanical handling equipment (cited in Astley and Lawton, 1971). However, as Astley and Lawton (1971. p.1) point out "Mechanical handling removes most of the hazards of man-handling but introduces new dangers. Injury to personnel is less frequent but tends to be more severe". Although forklifts have many benefits (e.g. improving productivity or reducing manual handling) they also result in numerous occupational hazards, especially when frequent interaction with pedestrians occurs (Horberry, Larsson, Johnston and Lambert, 2004).

Disappointingly, the problems associated with this type of vehicle seem to have remained relatively unchanged, in terms of the type of people who are involved in accidents and the types of injuries they receive. Horberry et al (2004 p.576) indicate that "many of the hazards associated with forklift truck operation are well known" however "risk controls thus far have been low level interventions, concentrating on operator protection and training. Little has been done to modify the risk environment; instead a culture reliant upon education to prevent the incidence of assumed erroneous behaviour exists."

Research from around the world, including studies from Australia, America, Europe and the UK, show that there is a consistency across countries and time in terms of the numbers and severity of injuries which occur (Horberry et al, 2004). Miller (1988) has indicated that in the US although forklift trucks are involved in one percent of workplace accidents they contribute to ten percent of the physical injuries. In the United States the Bureau of Labour Statistics (2005) indicates that there were 347 fatalities due to workplace transport accidents in 2003. It is estimated that a further 34,000 injuries of varying degrees of severity occur each year (Bureau of Labour Statistics. cited in Collins, Smith, Baker and Warner, 1999) Similar problems are also apparent in Canada where the Ministry of Labour (1999. cited in Horberry et al 2004) statistics indicate that in Ontario 18 fatalities were recorded between 1990 and 1995. Australian researchers indicate that in Victoria, which has a population of 4 million, 46 fatalities occurred between 1985 and 2001 (Horberry et al, 2004). Despite workplace transport covering a wide range of activities, the most widely researched area, at least in terms of the academic literature, is that of forklift truck operations.

1.3.2 Inherent dangers of forklift trucks

Larsson and Rechnitzer (1994) indicate that forklifts have been identified over a number of decades as having a significant impact on serious and fatal injuries. They state that forklifts are inherently high hazard vehicles. A number of authors (Horberry et al., 2004; Larsson and Rechnitzer, 1994; Miller, 1988; and Swartz, 1993) have identified characteristics of forklifts which make them dangerous.

- Forklifts have a high mass (a typical counter-balanced forklift has a mass of over 3 tonnes, making the loaded mass nearly 6 tonnes, four times the weight of the average family car).
- Rigid and unyielding construction.
- Typically involve a large amount of interaction with pedestrian workers.
- Loads are often simply placed on the tynes (not secured to the vehicle, therefore relying on gravity for stability).
- Misleading in terms of potential risks due to compact size.
- They have problems with stability due to having a narrow track and variable centre of gravity.
- The nature of working with a forklift requires drivers to divide there attention. When carrying a load in reverse the driver has to “simultaneously monitor the balance of his load at the back of the truck and watch the direction of travel” driving with their “left hand on the steering wheel and right hand on the load control” and they “must monitor his blind spot." Miller (1988)

1.4 STRUCTURE OF THE REPORT

The remainder of this review will deal with the main issues involved in workplace transport accidents and incidents. The second section includes a general review of the literature in relation of workplace transport incidents and their causes. The third section highlights design issues which may contribute to those incidents. The fourth section provides the main trust of the review and deals with specific key human factors within workplace transport. Recommendations are made based on this review in the final section.

2 THE PROBLEM

This section reviews the literature which addresses the characteristics and causes of workplace transport accidents. Some of it may seem dated, however from review it appears little has changed, in terms of frequency, severity and types of incidents, since the 1960s, although industry experts indicate that there have been some improvements in workplace transport safety, little academic literature was found to support this. Stout-Wiegand (1987) pointed out nearly 20 years ago that the problems associated with forklift trucks were consistent across time and countries:

> "A number of studies have shown that the most frequent accident types reported are ones in which workers are struck by or run over by forklift trucks...it appears that in general characteristics of injuries involving forklifts have not changed substantially over the past 10 to 15 years." (p188).

Larsson and Rechnitzer (1994) indicate that they believe many of the factors noted by Astley and Lawton (1971) are still relevant:

> "Injury causes include body projection outside the trucks; non-standard controls layout; inadequate seating with increased fatigue; and the need to select drivers with the appropriate aptitude...the need for safety devices such as mandatory dead man cutouts which immobilise the forks and traction on the vehicle; the use of rubber flap guards fitted close to the wheels to deflect pedestrian feet." (Astley and Lawton, 1971)

Larsson and Rechnitzer (1994) obtained a unique perspective about workplace transport accidents by using Critical Incident Technique to interview drivers. They use this and accident data analysis to make recommendations about priorities and interventions. They highlight the fact that drivers are conscious of the risks posed by forklift trucks. The factors drivers emphasised depended on the type of environment they were working in, for example, if they work in manufacturing they would come into more frequent contact with pedestrians and this was reflected in their choice of highlighted critical incidents. Overall, the drivers emphasised the same main causes of fatalities and injuries, in relation to forklift trucks, as emphasised throughout the workplace transport literature. Numerous difficulties with pedestrians were mentioned including: people stepping out from behind things and not having enough time to stop; busy areas such as cross over points between pedestrians and vehicles; poor visibility leading to a higher probability of running over someone's foot; break and shift changes when 'operators run like rabbits all over the place'. Visibility problems also lead to drivers pushing their loads or pallets into people, people also took risks around forklifts and a driver complained of people trying to sneak cars under their loads. A number of aspects relating to the working environment were also mentioned, such as, lack of manoeuvrability, poor visibility (for both driver and pedestrian), falling down ramps, driving into the sun, and uneven surfaces. Icy and wet surfaces can also be problematic, particularly once the temperature goes below -25 º centigrade when rubber wheels exert hardly any friction. Instability of loads was frequently mentioned in terms of loads sliding off of the tynes and injuring people and changing the centre of gravity of the forklift and tipping over. One driver also mentioned the discrepancy between different company procedures which meant that obeying one caused another rule to be broken.

The following sub-sections will look in more detail at the various features of workplace transport accidents widely reported in the literature.

2.1 CHARACTERISTICS OF ACCIDENTS

The HSE Specialist Inspectors Report (Male, 2003) “Safety of Industrial Lift Trucks”, which surveyed accidents and incidents between April 1997 and March 2001, gives the most comprehensive recent incite into the problem within the UK.

In terms of all workplace transport accidents, over the four year period investigated within the SIR, lift trucks accounted for 14 -15 % of accidents. What is not clear from this information are the relative exposure levels of the different types of workplace transport vehicles. It could be if the relative exposure to lift trucks in comparison to other vehicles is 30% of the total they have relatively low accident levels, of course the opposite is also true, but without exposure data it is impossible to know. In terms of severity, lift trucks are comparable to all other workplace transport accidents in terms of severity levels, i.e. similar proportions of fatalities, major injuries, and over 3 day accidents.

Male (2003) investigated 1204 accidents/incidents. Of these 53 were fatal, 532 were major, 484 were over 3 day injuries, and 135 were dangerous occurrences. This does not represent the full scale of the problem, because only the most severe and frequent causes of accidents are investigated, and Local Authority data was not included. As it only covers lift trucks, it does not represent the full scope of workplace transport accidents. However, the authors do claim that the report does give a "good indication of the relative numbers of the most serious accidents...and provides useful data to allow the most frequent and serious accidents to be addressed." (p23)

The pattern of accidents shows that the majority of fatalities are likely to occur due to the vehicle overturning (16), being struck by a moving truck (15), being struck by falling loads (9), and trapping/searing/crushing accidents (5). Being struck by a moving truck is by far the biggest problem in terms of fatalities, major injuries, and over tree day injuries, with a total number of accidents nearly five times greater than any other type of accident. This type of accident accounts for nearly half of all the accidents associated with lift trucks. However, in terms of severity although the 110 accidents/incidents of trucks overturning laterally, are much less frequent there is a high chance of the accident being fatal. Table 1, shows the type of accidents which occurred, frequency and severity level.

Similar findings have been found within other research (Ellis, 2003; Miller, 1988; Stout-Wiegand, 1987; and Swartz, 1993). Ellis (2003) found that struck by moving vehicle, falling from vehicle, being struck by object falling from vehicle, vehicle overturning were the most common types of accident. Miller (1988) indicates that the literature points to the two major causes of forklift accidents as (1) struck by forklift, and (2) load dropped or shoved onto employee. Other causes highlighted by Miller (1988) include the driver catching a body part between the truck and another objects and driving off the loading dock. Stout-Wiegand (1987), in her analysis of two US databases, found that the most common types of accident varied between the two databases. However, the two most frequent types of accidents are the same in both databases, consisting of 'struck by an object' and 'caught in, under, or between objects' accidents. 'Struck against an object' accidents were also high. 'Falls' and 'overexertion' accidents were less common.

Inconsistent language within the literature

One of the difficulties when comparing the accident data from different studies and reports is the different ways that researchers describe accidents. Although, it is possible to get an idea of the general trends across the different literature, more clarification in the description of accidents is needed. For example, Stout-Weigand (1987) has a number of categories for assessing the frequency of different accident type (Struck against an object, struck by an object, and caught in, under, or between objects), but she does not say if this object is the truck, the load the truck was carrying or something the truck has knocked onto the injured party. On the other hand, different reports clearly define 'struck by moving vehicle' accidents.

Table 1: Type of accidents, frequency and severity level

		Fatal	Major	Over 3 day	DO	Totals
Collisions	Door lintel		2	1	1	**4**
	Fixed object		28	26	4	**58**
	Moving truck		9	19		**28**
	Overhead object		3		2	**5**
	Object hit person	1	11	32	1	**45**
	Stationary vehicle		5	7		**12**
Contact (o/h electricity)					2	**2**
Ergonomic				7		**7**
Explosion			6	7	1	**14**
Fall from height		3	44	7		**54**
Harmful release			4	9	1	**14**
Loss of control		1	4	4	3	**12**
Mechanical failure		1	5	8	31	**45**
Mechanical fault			3	2	3	**8**
Other				5	1	**6**
Overturn	Not specified	3	5	9	21	**38**
	Forward		5	2	18	**25**
	Lateral	13	28	20	39	**110**
	Rearward		1			**1**
Slip/trip/fall		2	20	16	2	**40**
Steering wheel kickback			2			**2**
Struck-by	Carriage/fork		1	3	1	**5**
	Moving truck	15	257	251	1	**524**
	Falling load	9	48	32	3	**92**
Trapping/shearing/crushing		5	30	17		**52**
Totals		**53**	**532**	**484**	**135**	**1204**

Source: Male (2003)

The different types of accident are examined in more detail below.

2.1.1 Vehicle overturning

Male (2003) found that overturns were the most frequent cause of fatality. If a forklift overturns there is a high probability of death. Forklift accidents made up 14% of all accidents/incidents investigated but accounted for 30% of fatal accidents, making this the most frequent cause of fatal accidents. Together, counterbalance and variable reach trucks accounted for all fatal overturning accidents on trucks over the period of the survey.

A number of causal factors were highlighted in relation to overturns:

- Inspectors found that in 35% of these accidents the driver was untrained.
- “Overload as the boom was extended”
- Wheels sinking into the ground, being driven into excavations, ruts and soft ground
- Operating across gradients
- Dynamic loads – the load shifted while moving
- Being hit by another vehicle
- Non-application of the parking brake on slopes / braking system failure (sometimes

due to lack of maintenance)
- Adverse weather conditions

Collins et al (1999) also found that overturns were the most frequent circumstance leading to forklift-related fatalities.

2.1.2 Struck by moving vehicle

Male (2003) found that being struck by a moving truck was the most frequently investigated type of accident (523) and the second most frequent type of fatal injury (28%). They comprised 49% of fatal, major and over 3 day accidents. Counterbalance trucks made up a significantly disproportionately high number of accidents (76%). Trucks were carrying out virtually every type of possible action when they hit people; they also hit people after being parked on slopes and after being left with their engines running. A number of areas were identified where this type of accident is likely to occur: vehicle routes and production areas; congested areas (vehicles and pedestrian mix); aisle ends, goods-in and goods-out and stock holding areas; and narrow routes where people need to get by e.g. doorways. Pedestrians are the most likely people to be involved in Struck-by accidents, but this varies depending on time of day and activity.

2.1.3 Being struck by object falling from vehicle

This was the third most common type of accident (9 fatal, 48 major), with pedestrians/operatives being most likely to be injured (72%). The activities they were likely to be undertaking include "steadying high, unbalanced or long loads when the trucks were lifting or travelling with them." All accidents involving lorry drivers were due to unstable loads. (Male, 2003)

2.1.4 Trapping/shearing/crushing

Mast/carriage trap - Drivers and operatives climbing between the mast and overhead guard resulted in four fatal accidents in counterbalance trucks. A maintenance operative was also killed when they "reached through the mast of a counterbalance truck and contacted the mast lower control causing the carriage to descend under gravity. (Male, 2003)

Other trapping/sharing/crushing accidents - This type of accident occurred when operatives trapped their hands in lifting mechanisms. "Operatives and drivers also trapped their hands when returning waste disposal skips mounted on trucks to their carrying position after tipping waste." (Male, 2003. p 27)

2.1.5 Fall from height

Falls from height occurred almost exclusively on counterbalance and variable reach trucks, in the majority of cases (93%) when people were lifted on the forks or an object on the forks. Three of these injuries were fatal and 44 were major. (Male, 2003)

2.1.6 Slip/trip/fall

Waste disposal: When operatives fell for less than 2 metres, generally from the fork or object on the forks, while emptying waste into skips etc. Two of these accidents were fatal, nine were major and three were over 3 day. (Male, 2003)

Working on lorry backs/ramps/dock levellers: Occurred when lorries moved while being loaded (e.g. parking brake not applied). Thirteen investigated accidents were of this type. (Male, 2003)

2.1.7 Mechanical failure/fault

This type of accident accounted for 10 fatal or major injuries. Consistent reasons were not established in relation to mechanical failure. However, it was mentioned as a causal factor in 18% of accidents investigated. (Male, 2003)

2.1.8 Collisions with

Fixed object – Seated drivers often injured themselves when they had their limbs outside the vehicle and trapped it against an object. Trapping also occurred when drivers dismounted and the vehicle kept moving. Also common, were trucks striking vertical objects (e.g. columns, walls) when they were moving (often turning). (Male, 2003)
Moving Vehicle – Doorways, aisle ends, congested thoroughfares and vehicle crossings were frequently highlighted as contributing to this type of accident. Lack of workplace rules and poor driver visibility due to workplace layout were also mentioned. Large load obscuring the driver's vision when moving forward was also given as a causal factor. (Male, 2003)
Stationary vehicle – This type of accident usually occurred when trucks were working in congested areas. (Male, 2003)
***Overhead object* –** Usually through truck masts striking roller shutter doors or door lintels. (Male, 2003)
***Object that moved and struck a person* –** Frequently occurred when objects were picked up, deposited or when objects overhung traffic routes and were struck by moving trucks. Pallets, bins and stacks were often involved. (Male, 2003)

2.1.9 Other

A number of other types of accidents were mentioned but occurred at relatively low levels. These include:
Loss of control - Associated with downhill gradients, slippery surfaces and when driver attempted to turn the truck while travelling downhill after control was lost. Lack of maintenance causing to braking or transmission system failures was also mentioned
Harmful release - Such as CO and LPG release and battery fumes
***Battery explosion* -** Occurred in battery charging areas when metal objects fell on top of batteries, on moving trucks due to loose connections and when jump starting trucks.

2.1.10 Ergonomic

Astley and Lawton (1971) called for design changes to trucks. This indicated that poor design was causing poor posture, leading to driver fatigue and spinal and abdominal trauma. Male (2003) found that drivers of counterbalance trucks received back injuries when they ran into potholes while reversing, i.e. with their backs twisted." In terms of overexertions (13%) in half of the cases "driving the vehicle is reported as the harmful exposure." Getting out of the vehicle and handling heavy forklift equipment account for 20% each of the remaining overexertion injuries.

2.1.11 Successful interventions

Steering wheel kickback - has been reduced to only two accidents, which is said to be a significant reduction. The implementation of power steering has eliminated many of these accidents. This has changed since 1980 when Williams and Priestley (1980) drew attention to this type of injury, having found a number of injuries occurred to drivers due to the steering wheel spinning out of control or being hit by the steering knob. (Male, 2003)

Struck by fork while being removed - Only a small number of this type of accident occurred, this is said to be due to now standard requirements for end stops on carriages which prevent the forks from accidentally being pulled off. (Male, 2003)

2.1.12 Speed a contributory factor

The speed at which forklifts travel has been emphasised as a contributory factor to the frequency and severity of accidents (see Horberry et al, 2004). Larson and Rechnitzer (1994) have indicated that as pedestrians are involved in such a high proportion of accidents speed needs to be controlled when they come into contact with vehicles.

2.2 PEOPLE INVOLVED

Male (2003) provides a breakdown of the type of accidents different groups of people are involved in and the severity level of their injuries. The largest group of employees involved in this type of accident are pedestrians/operatives who make of 58% of the total. This is followed by drivers (32%), lorry/visiting drivers (5%), passengers (2%) and maintenance personnel (1%).

It can be seen from tables 2 and 3 that different groups of people experience different types of accidents at different levels of severity e.g. only drivers have overturn accidents and they are the most likely to have a fatal injury. As a group pedestrians are the most likely to be injured as a result of a forklift accident (major and 3 day as a result).

Larsson and Rechnitzer (1994) also comment on the high number of drivers who are killed by being crushed or run over by their own vehicle. Out of 14 employee fatalities 5 were of this nature and 3 occurred when the driver was working alone. In one case a driver was killed by his load and a further two drivers had fatal falls off raised pallets or tynes. Four pedestrians were hit or crushed by a forklift and a further 2 were crushed by cargo.

Table 2 Types of accidents

	Pedestrian / operative	Drivers	Lorry/visiting drivers	Passengers	Maintenance
Struck by moving truck	65%	18%	78%	67%	36%
Struck by falling load	10%	4%	16%		14%
Fall from height	8%				
Struck by object that truck contained	7%				
Trapped by moving part of the truck or between the truck and another object	5%	6%		14%	
Slip, trip, or fall from height less than 2m	2%	7%		14%	
Overturn		24%			
Collision with fixed object or another vehicle		25%			
Trapping/shearing/crushing					29%
Explosion					21%
Other		16%	6%		

Source: Male (2003)

Table 3 Severity of accident

Person	**Fatal**	**Major**	**Over 3 day**	**Total**
Pedestrian/operative	22	322	277	621
Driver	28	156	177	361
Lorry/visiting driver	3	28	18	49
Passenger		13	8	21
Maintenance personnel		10	4	14
Public		2		2
Trainer		1		1
Total	**53**	**532**	**484**	**1069**

Source: Male (2003)

Research carried out in California in 1980 showed that in 31% of accidents a pedestrian was run over by a forklift truck, and in a further 23% of accidents the a worker was caught in, under or between the truck and another object. (California Department of Industrial Relations, 1982. cited in Larsson and Rechnitzer 1994). Larsson and Rechnitzer (1994) also found that 'hit by' injuries to made up a large proportion of injuries (45%). Stout-Wiegand (1987) found that only 12% of injuries were inflicted on forklift operatives and Williams and Priestley (1980) found that 73% of injuries were to pedestrians. Collins et al (1999) also found that the most common incidents involved pedestrians (35%) in struck-by, load carried, or an object struck by the vehicle incidents. Where injuries occurred, 41% of employees needed time off work at an average of 61 days, resulting in a total of 22,730 lost workdays. Although, there are differences in the way researchers have categorised and described injury types, it is clear that a large proportion of accidents occur to pedestrians, or drivers when they are not actually driving the truck (i.e. they are run over / crushed by their own truck) (Williams and Priestley, 1980; Stout-Wiegand; 1987; O'Mara; 1989).

2.3 VEHICLES INVOLVED

Male (2003) found that some vehicles were more likely to be involved in accidents than others. Indicating that counterbalance and variable reach truck were more likely to be involved in accidents than other types of vehicles. They were also more likely to be involved in fatal accidents. All-terrain, reach and side-loader trucks were also involved in relatively higher numbers of fatal or major injuries.

Counterbalance trucks were involved in a large number of fatal overturns 87%. Many of these occurred due to the driver attempting to jump clear of the truck and getting trapped. This seems to point to an additional problem of driver training i.e. the need for the driver to know what action to take when if their vehicle does overturn. Counterbalance trucks were also involved in a disproportionate and significantly higher number of Struck by moving truck accidents (76%), when it is estimated that they make up 49% of powered trucks. However, this does not take account of the actual amount of time the trucks are used and therefore the likely exposure levels.

A large number of overturns in variable reach trucks (22%) resulted in fatal or major injuries, this is less than counterbalance trucks within which overturns result in 43% of fatal and major injuries. However, the risk is still said to be significant, as "2 drivers suffered fatal, 2 major and 3 over 3 day injuries", in addition, 2 pedestrians suffered major injuries when trucks fell on them. (Male, 2003)

2.4 TYPES OF INJURIES

Collins et al. (1999) found that the most frequent injuries were contusions (35%), followed by sprains/strains (28%), lacerations (11%), fractures (10%), burns (4%), foreign bodies in the eye (3%), and abrasions (3%). Combined, these injuries made up more that 94% of injuries. Stout-Wiegand (1987) found a similar picture in her analysis of two databases. The most common types of injury were Contusions/abrasions/crushing/bruises (Database 1 = 42.6%, database 2 = 31.3%). Sprains/strains (Database 1 = 17.9%, database 2 = 18.7%), fractures/dislocations (Database 1 = 17.1%, database 2 = 21.9%) and lacerations (Database 1 = 13%, database 2 = 9.9%) were also common. Amputations were much less frequent (Database 1 = 1.2%, database 2 = 1.2%). However, it should be noted that over one percent of injuries sustained from forklift trucks resulted in amputation.

2.4.1 Body part injured

The literature has consistent findings in terms of the body parts most likely to be injured (See Collins et al, 1999; Larsson and Rechnitzer, 1994; Stout-Wiegand, 1987; Swartz, 1993; and Williams and Priestley, 1980).

Collins et al. (1999) found that the most commonly injured body parts were the foot or ankle (15%), lower leg or knee (14%), and back (13%). Forty-eight percent of all contusions effected the lower extremities (thigh, hip, and toe). The most frequent fractures were to the toes, feet and ankles (51%). The back was injured in almost a third of sprains and strains. Williams and Priestley (1980) found that non-drivers were more likely to receive injuries to their feet and lower legs and drivers were more likely to injure their hands or areas other than feet. Stout-Wiegand (1987) also found that the most injured body part was the foot area (feet, toes, and ankles), the hand area (hands and fingers) were also frequently injured. Larsson and Rechnitzer (1994) found that in hit by injuries (45% of accidents) about nearly two thirds were to lower extremities i.e. legs, knees and feet.

2.5 SEVERITY

The injuries which occur in relation to workplace vehicle incidents appear to be more severe that other forms of work related injuries. This is demonstrated by the amount of time off needed by employees, after a workplace vehicle incident compared to other incidents. Collins et al (1999) found that of the 41% of people who needed time off work after a vehicle incident an average of 61 days were needed to recover. This is much higher than the average of seven days needed for other types of accidents (Collins et al, 1999). Larsson and Rechnitzer (1994. p. 276) also emphasise the severity of forklift truck injuries indicating that "Internationally, forklift trucks have been identified over a number of decades as a significant contributor to the toll of both serious and fatal industrial injuries."

2.6 OCCUPATIONAL INJURY LEVELS

Stout-Wiegand (1987) found that forklift and tow motor operatives were the most frequently injured workers, accounting for 12% of reported injuries. This was followed by warehousemen (10%), miscellaneous labourers (8%), Freight and material handlers (7%), mechanics (7%), and other operatives, except transportation (5%). These figures may be somewhat deceptive because they imply that drivers are more frequently injured. Although, drivers do have high accident rates, pedestrians are generally more likely to be injured. The reason why this is not apparent here is because the pedestrian figures are broken down into different professional groups. If the professional groups are combined this shows that pedestrians are more likely to be injured. Some weak relationships were also found between occupation and type of injury sustained. For craftsmen (including mechanics and other craftsmen) typical forklift injury involved the worker being struck by an object resulting in a cut abrasion, contusion, or bruise to the hand or finger. For forklift operatives, the most frequent injury was a strain or sprain of the upper trunk. For all other occupations, the most frequent injury was being struck by an object and resulting in a cut, abrasion, contusion, or bruise of the foot or toe.

Larsson and Rechnitzer (1994) looked at the number of 'hit by' injuries, average days lost and average compensation, in order to make some speculation about the relative risks of different industry types. They found that 'Manufacturing' had the highest proportion of 'hit by' injuries (50% of total forklift associated accidents within manufacturing). However, when other factors start to be evaluated 'Trade' has the highest average days lost and average compensation pay outs. Again, when different industries are looked at in more detail 'Fruit, veg and grocery wholesale' has the highest proportion of 'hit by' accidents (46% of total forklift associated accidents within this sector) and the highest average days lost and compensation. However, (excluding road freight) 'Storage' has the highest actual number (n = 20) of 'hit by' accidents. Without knowing exposure levels, the amount of time that different employees spend in contact with forklift trucks, it is difficult to determine the relative risks. Larsson and Rechnitzer (1994) do speculate that Manufacturing seems to be the highest risk area, having the most severe accidents and relatively lower levels of exposure than other sectors. It must be emphasised that this is speculation and based on Australian data.

2.7 SUMMARY

This section has outlined the nature of workplace transport accidents. Overall it can be seen that a restricted number of specific types of accidents are more prevalent and cause the most severe of injuries. Overturning accidents and people (drivers and pedestrians) being hit by vehicles produce the highest number fatalities and most severe injuries. Pedestrians are most likely to be injured and are involved in over half of workplace transport accidents/ incidents. Male (2003) has indicated that counterbalance and variable reach trucks are more likely to be involved in accidents/incidents and therefore present a particular problem.

Human factors are likely to contribute to this problem on a number of levels including factor relating to individuals (e.g. drivers and pedestrians), the nature of the job (e.g. design of the workplace and vehicle), and the organisational (e.g. training procedures and management systems). These factors will be addressed in the following sections.

3 DESIGN MEASURES

Miller (1988, p18) indicates that a large proportion of workplace transport accidents are caused by environmental factors (rather than driver error), going on to emphasise that "We can eliminate hazards and design a safe operating environment only when we understand the real cause of forklift incidents." A number of hazards have been highlighted in the literature and recommendations have been made in terms of the vehicle, the workplace and procedures within it (procedures will also be dealt with in Section 4.4 safety culture). This section touches on the wide literature on design issues, much of which is outside the scope of this review, and focuses in particular on issues around vehicle and workplace design that may influence or interact with the human factors issues described elsewhere.

3.1 THE VEHICLE

Rechnitzer and Larsson (1992) indicate that drivers have been relied upon to compensate for design issues with forklift trucks, which has lead to an over reliance on training (discussed in Section 4.3). This is a strategy which they believe will cause high levels of injury to perpetuate:

> "A clearly demonstrated principle of injury risk reduction is the utilisation of sound ergonomic design to reduce the ongoing performance demands made on the operator to avoid accidents. This leads to the need for visibility standards to be adopted for the design of forklifts and, at the very minimum, standardisation of controls for vehicles used at a particular site." (p35).

3.1.1 Controls

Literature, some dating back to the 1960's, has been calling for the standardisation of controls (Robertson, 1969; Larsson and Rechnitzer, 1994). Non-standardisation of controls (i.e. command functions found in different locations on different vehicles) is a 'danger-factor', especially when individual drivers have to operate different trucks. This is said to limit the driver's skill development, speed and accuracy in normal operation. In an emergency situation it could be more problematic as the driver may press the wrong control or hesitate as they search for the correct control. Strange or novel control layouts increase the driver's mental load and could cause fatigue and impairment of abilities. A specific example of control design is the automatic brake. Due to the high number of pedestrian accidents and drivers being hit by their own vehicle "An automatic brake ("dead-man's handle") seems to be an absolute necessity on all forklifts." (Larsson and Rechnitzer, 1994. p.286)

3.1.2 Mounting and dismounting the vehicle

The act of getting in and out of vehicles is said to lead to a significant number of accidents. Bad design leads to drivers jumping from vehicles and twisting their ankle or knee, this problem is exacerbated when they land on wet or greasy patches. Drivers are also said to contort their bodies into and out of the vehicle which can be problematic (Collins et al., 1999).

3.1.3 Load handling

Problems highlighted include awkwardly shaped loads, load slippage from forks, and load stacking. Ratchnitzer and Larsson (1992) again highlight the over reliance on ‘driver care’ to overcome design flaws. Although they do recognise the importance of driver performance, they believe if effective risk and injury reduction is to be achieved these difficulties must be addressed through improved design. They emphasise the need to improve the load handling system (i.e. to prevent slippage from or movement on the tynes). They indicate this would be a good area of future research.

3.1.4 Forklift ballast

Miller (1988) describes forklift trucks like seesaws, indicating that balance between the ballast and load is essential in order for the vehicle not to tip forward. Although this analogy is simple it does serve to demonstrate that the ballast of the truck will in turn effect the stability of the truck and make steering unpredictable (over and under-steer). A number of alterations can effect the ballast and therefore the load bearing capacity of the truck: installation of a taller or heavier mast, adding ballast to the back of the truck to increase lifting capacity, and changing the battery size in electric forklifts (smaller ones are cheaper). It is therefore essential that drivers and employers, and indeed manufacturers, understand the consequences of changing features of lift-trucks.

3.1.5 Visibility

Collins et al. (1999) indicate that it is important to improve workers awareness of times when a vehicle is operating near them. This could be improved by using audible beepers and flashing lights. Alarm systems also need to be fitted. Miller (1988) states that all forklifts must have a horn and that the driver must use it to warn pedestrians who could be in their blind spot. OPERC (2004) has also made a number of practical recommendations to improve the All-Round Awareness (ARA) of plant operators, including mirrors and various intelligent transport systems.

3.1.6 Intelligent transport systems

Horberry et al (2004) indicate that there is a vast array of Intelligent Transport Systems available. However only the two they evaluated are covered here

1. Seatbelt wearing intelligent seatbelt system - the system included sensors in the seatbelt buckle, seat and handbrake. The vehicle would only start if: the handbrake was engaged; the operator was seated; and the seatbelt was connected. To keep the engine running when alighting from the vehicle, the handbrake must be applied and then the seatbelt disconnected. When getting back into the vehicle the seat detector must be activated, the seatbelt connected and then the handbrake released. This intervention was designed to prevent drivers being run over by their own truck, and keep them in the vehicle if it overturned.
2. Load sensing/speed limiting system (Reduces speed especially when loaded) - this consists of a pressure sensor that detects when the vehicle is loaded, this then limits the speed of the vehicle. The appropriate reduction of speed was decided upon by allowing for the deceleration needed to prevent the vehicle from tipping forward. The speed limit was set so that the total stopping distance when loaded was the same as when the vehicle braked hard when empty. This type of intervention could reduce the amount of overturns and hit by accidents.

3.2 WORKPLACE LAYOUT

A number of authors emphasise the role that poor workplace layout has in workplace vehicle accident causation (see Collins et al., 1999; Larson and Rechnitzer, 1994; Miller, 1988; and William and Priestley, 1980). Larsson and Rechnitzer (1994) state that:

> "The important question today is how high a rate of fatalities and severe injuries, associated with the use of forklift trucks, we are prepared to accept against the continual use of ill-designed and dysfunctional industrial environments and lack of long-term investment in new works." (p286).

The need to separate pedestrians and vehicles is a frequently highlighted (Larsson and Rechnitzer, 1994) and long standing issue, as Booth pointed out in 1979, that, one of the major causal factors in forklift truck (and potentially other forms of workplace transport) accidents is inadequate planning of the workplace. Booth (1979) argues that although factors such as training, supervision, maintenance, and compliance with instructions are important, this misses the key factor of workplace layout. Within this the need to separate site transport from pedestrians (as low visibility is often a causal factor in collisions with pedestrians) and the need for adequate manoeuvring space (as numerous problems are encounters through lack of manoeuvrability space) are essential. Williams and Priestley (1980) indicate that because the majority of major injuries occur to non-drivers the poor design and layout of workplaces must be seen as a causal factor. Larsson and Rechnitzer (1992, 1994) recognise, however, the fact that all workplaces differ and indicate that different possible solutions for pedestrian/vehicle separation should be tailored specifically to the organisations.

Miller (1988) points out that in other areas where people and vehicles come into contact e.g. parking lots, we carefully segregate them, but in warehouses the same rules often are not applied. One of Miller’s (1988) recommendations was therefore the use of separate pedestrian routes. Williams and Priestley (1980) indicate that the bulk of the seriously injured are pedestrians. Therefore, workplace layouts, which increase the interaction between people and vehicles, must be classed as a major causal factor.

Horberry et al. (2004) developed a number of traffic engineering interventions based on the notion that vehicles and pedestrians should be separated. This should take place in work areas and when moving to and from work areas (e.g. from the canteen). The traffic engineering changes they recommended include:

- Completely closing off some areas to either forklift or pedestrian traffic.
- Opening up 'pinch point' areas to make it easier to separate people and vehicles.
- Creating safe routes / walkways.
- If pedestrians and vehicles must use the same route put barriers between them.
- Using temporal separation – only allow vehicles into certain areas at specific times.
- Employing grade separation – pedestrians and vehicles operate on different levels e.g. use of pedestrian bridges.

Miller (1988) also makes specific recommendations for reducing workplace transport accidents:

- Lighting levels - in order for drivers to be able to see properly, and distinguish hazards/pedestrians as quickly as possible, good lighting is essential. This becomes even more important as people age and their eyesight deteriorates.
- Noise levels - alternative warning devices may be needed in areas with high noise levels.
- The working surface - "A forklift must operate on a smooth level surface."

- Aisles width - Where an aisle is narrow there is less room for error, therefore increasing the likelihood of trapping injuries.
- Traffic control signs - the use of signs and the use of high visibility lines to indicate edges (e.g. on ramps) is helpful. He draws attention to the use of stop signs, indicating that they can be used when going from areas of different lighting levels, giving the drivers eyes time to adjust.
- Pedestrian Islands – There need to be clear markings in any locations where there is an interaction between pedestrians and vehicles. Ideally, mark zones on the floor for stock storage areas, traffic areas, and pedestrian routes.

Booth (1979) indicates that the prevention of workplace transport accidents by good design of the workplace is not difficult, but once a dangerous layout is created it is much more difficult to correct. It is therefore imperative that more attention is paid to the design stage within the working environment.

Horberry et al. (2004) found a number of difficulties when trying to implement changes within the workplace in relation to workplace transport safety. They found that:

> "...financial, operational and managerial restrictions had a strong influence on which recommended interventions were implemented. Generally the cheaper interventions that required fewer operational changes, less specialised personnel and less effort to put into practice were implemented." p580

Attention to design issues is a reasonable and relatively well-researched method of tackling workplace transport accidents and incidents. A comprehensive approach, however, covers a number of issues relating to individual behaviour and general safety management, which are discussed in the next section.

4 SPECIFIC HUMAN FACTORS ISSUES

Due to the limited literature in relation to human factors in workplace transport it has been necessary to broaden the literature review to cover human factors in relation to more general transport accidents and incidents. Although some of this research is based on work situations other than workplace transport, it may provide a useful understanding of key human factors issues within workplace transport. Male (2003) highlights the potential usefulness of investigating general transport issues:

> "The ratio of fatal, major and over 3 day accidents was similar for both lift trucks and transport in general. This would indicate that the nature of accidents is a major influence on the nature of injuries sustained. Consequently, it is reasonable to suggest that common lessons can be learnt from similar types of accident on different types of works transport" (p29)

Without detailed empirical research, however, it is not possible to say definitively how some human factors issues will manifest in the unique workplace transport setting.

4.1 INDIVIDUAL DIFFERENCES

This section deals specifically with characteristics of the individual and their impact, or potential impact, on workplace transport incidents. In particular demographic and personality differences are addressed here. Other aspects of individual functioning, in particular relating to the experience of stress and skills are dealt with in subsequent sections.

4.1.1 Demographic differences

Individual differences, in terms of age and gender, have been exhaustively examined in relation to general driving behaviour, and less so in relation to workplace transport activities. For example, Rimmö (2002) suggests that variation in age and gender are differently related to aberrant driving behaviour types. As highlighted earlier, it can be argued that behaviour exhibited by particular age groups or gender groups in relation to driving in general can be extrapolated to potential similar behaviour in relation to workplace transport.

Age

In terms of general driving behaviour, the literature consistently shows that younger driversare at a greater risk of involvement in general road traffic crashes than those in older age groups (Pelz & Schuman, 1971; Maxim & Keane, 1992; Brorsson, Rydgren and Ifver, 1993; Elander, West, and French, 1993; Furnham & Saipe, 1993; Szlyk, Seiple, and Viana, 1995; Lawton, Parker, Stradling, and Manstead, 1997; Dobson, Brown, Ball, Powers, and McFadden, 1999; Norris, Matthews, and Riad, 2000). Fatality and injury rates for young drivers is higher than other groups, with teenagers and those in their early 20s, especially young males, having the highest crash involvement rate of any age group (NHTSA, 1995).

Drivers aged 18 and 19 had six times greater than the average risk for a single vehicle crash, whilst, compared to 25-54 year-olds, they had ten times a greater risk of running off the road (Brorsson *et al*, 1993). A recent literature review by Lancaster and Ward (2002) of individual factors and driving behaviour summarised that younger drivers were, amongst other things, at greater risk of crash involvement, showed higher observed speeds, and tended to overestimate driving ability; showing more confidence in their ability (Matthews & Moran, 1986). Older drivers, on the other hand are more likely to suffer from drowsiness (Lancaster & Ward, 2002), and have more problems associated with attention (Rimmö, 2002).

The more recent studies of driver behaviour continue to illustrate the robustness of these findings, with Begg and Langley (2001) suggestion that young drivers, again particularly male drivers, tended to mature out of risky driving behaviour by age 26 years. Similarly Norris *et al* (2000) noted that younger age is one of the predictors of future motor vehicle accidents, with younger adults (ages 19 to 39) being twice as likely to have an accident than older adults (ages 56 to 88).

There is evidence to suggest that age and experience issues relating to general driving are also applicable to workplace transport. Ellson (2002, in Jones and Dickety, 2004) notes that workers under the age of 25 account for approximately 20% of all fork-lift related fatalities. In an analysis of fork lift truck injuries reported in two databases, Stout-Weigand (1987) found that more than 90% of injuries were sustained by younger workers, with workers under 35 years sustaining 71% of the injuries needing treatment.

Gender differences

As is the case with age, the literature on general driving behaviour and gender seems to give a consistent message. Men are more likely than women to be involved in accidents (Evans & Wasielewski, 1983; Alexander, Kallail, Burdsal, and Ege, 1990; Chipman, MacGreagor, Smiley, and Lee-Gosselin, 1992; Maxim & Keane, 1992; West, 1993; Parker, Reason, Manstead, and Stradling, 1995; Lawton *et aI*, 1997; Norris *et aI*, 2000; Waller, Elliott, Shope, Raghunathan, and Little, 2001). The crash rate per 1,000 drivers has been estimated as more than double for men what it is for women (Chipman *et al*, 1992) and men tend to incur their first crash sooner (Waller *et al*, 2001). Norris *et al* (2000) suggested that males' greater accident risk could be at least partially accounted for by their greater tendency to disregard speed limits and traffic rules. This may be a result of males being more optimistic when judging their driving skill, and perceiving their unsafe behaviours as generally less serious and less likely to result in an accident (DeJoy, 1992). Lancaster and Ward (2002) summarised that men were involved in a larger number and more severe accidents than women, whereas women are more likely to be involved in incidents that are the result of perceptual errors. Lourens et al (1999) suggest, however, that gender differences could disappear when controlling for the number of miles travelled annually, or in other words, the exposure to risk.

Begg and Langley (2001) confirm that risky driving behaviour is predominantly a male activity, and a young male activity at that. Indeed the summation of both types of demographic evidence reviewed would suggest that those most at risk are young male drivers. In the workplace, Stout-Weigand (1987) found that around 95% of injured workers in fork-lift truck incidents were male.

In terms of workplace transport activities, where most operatives are male (as indicated by Stout-Weigand (1987), amongst others), these findings have obvious implications for the development of skill levels and training activities (see section 4.3)

4.1.2 Personality

No literature was found which specifically addressed personality and workplace transport accidents. However, literature is available relating to personality and driving behaviour generally, and workplace accidents and safety behaviour.

Chmiel (2000) suggests that personality in the safety context is said to typically refer to a "relatively enduring, stable, disposition." (p. 266). West (1996) also states that investigating personality “will only work if individuals do indeed show consistent levels of accident risk over time which are different from those of other drivers."

Although, numerous studies looking at very specific aspects of personality are available, it seems more prudent to focus on literature that has concentrated on safety issues. Much of this literature utilises the most common approach to personality, which defines an individual’s personality as being made up of a series of traits or dimensions.

Personality and driving behaviour

Lancaster and Ward (2002), in their review of individual factors and driving behaviour, considered a number of personality factors. The relevant findings from their extensive review are summarised in Table 4 below showing the various personality dimensions associated with different driving behaviours.

Table 4 Driving behaviour and personality

Behaviour / outcome	**Associated personality dimensions**
Risky driving	Sensation seeking Thrill-seeking Impulsiveness Hostility/aggression Emotional instability Depression Locus of control
Crash involvement	Sensation seeking Low tension tolerance Immaturity Personality disorder Paranoid conditions Less conformity Impulsivity Problems with authority figures
Driving violations	Psychoticism Neuroticism (negative relationship). Sensation seeking Thrill and adventure seeking Boredom susceptibility
Drug/alcohol usage (drink driving)	Risk-taking 'Ventursomeness' Impulsivity
Seat-belt use	Sensation seeking
Social deviance (relationship with drink driving, violations, speeding, seat-belt use)	Emotional instability Maladjusted
Gender (young males who are more accident prone)	Thrill and adventure seeking Disinhibition Boredom susceptibility Psychoticism Neuroticism (negative relationship) Extraversion Sensation Seeking Risk taking
Risk perception	Internal locus of control associated with lower perceived risk
Fatigue	Extraversion-Boredom linked with falling asleep while driving External locus of control linked to more road departures

Although there is a great deal of variety in terms of the personality dimensions investigated and their relationship with different behavioural outcomes, it can be seen that some dimensions appear more frequently; those dimensions associated with sensation/trill seeking, and risk taking are associated with the likelihood of having an accident.

Dahlen *et al*. (2005) conducted a study investigating anger, sensation seeking, impulsiveness and boredom proneness. They found that these factors predicted behaviours in terms of aggressive driving, risky driving and driving anger expression.

West (1996) conducted a review of individual differences and accident risk. This review did focus on driving behaviour but had more of an emphasis on social deviance, impulsivity, and risk taking rather than a range of more general personality characteristics. However, West's (1996) key findings did indicate that "Drivers exhibit a stable tendency to be higher or lower risk relative to each other". Indicating that drivers who have higher levels of impulsiveness, social deviance and risk taking are more likely to have accidents.

Personality and accidents

Numerous studies and reviews were found which investigated personality and general accident involvement. Lawton and Parker (1998) reviewed the literature on individual differences and accidents, looking at personality traits (Cattell's 16PF), types (Eysenck), and because their involvement in accidents seems plausible, some specific personality characteristics. Similarly, Hansen (1988) conducted a review of the literature in relation to personality and industrial and traffic accidents. The main dimensions of personality reviewed in this work include extroversion, locus of control, impulsivity, aggression, social maladjustment and neurosis. Finally, Clarke and Robertson (in press) have conducted a meta-analysis of the Big Five personality dimensions (Extraversion/Introversion, Agreeableness, Conscientiousness, Emotional stability - low Neuroticism, and Openness to Experience - Intellect/Imagination) and accident involvement for occupational and non-occupational driving accidents. The finding of these reviews on potential impact of personality traits are discussed in terms of the individual traits and/or methods of personality assessment.

Cattell's 16PF

Lawton and Parker (1998) indicate that the results of the different studies they reviewed were inconsistent in terms of the personality traits (measured by Cattell's 16 Personality Factors) which predicted accident involvement in each case. A summary of the studies they reviewed and the predictive personality traits in each case is shown in Table 5

Table 5 16PF dimensions and accident involvement

Study	**16PF personality traits**
Hilakive et al. (1989) - 597 conscripts	Impulsivity, adventurousness, naiveté, excessive trustfulness, poor self control
Suhr (1961) – 60 commercial drivers	Practical concernedness
Quimby and Watts (1981)	No correlations between 16PF and accidents
Booysen and Erasmus (1989) – bus drivers	Dominance, carefreeness, emotional sensitivity, shrewdness
Lardent (1991) – 91 pilots	Trusting, naive, self-sufficient, less tranquil and relaxed

However, it seems important to consider the possibility that predictive personality characteristics may vary depending on the nature of the work being undertaken. As the professional groups being studied perform very different tasks it is likely that people with different personality traits will be more suited to particular jobs.

Extroversion/Introversion

The bipolar personality dimension of introversion-extroversion (as proposed by Eysenck, 1947) is the most frequently investigated aspect of personality in relation to accidents (Hansen, 1988; Lawton and Parker, 1998). Introversion refers to a person's preference for attending to his/her inner world of experience, with an emphasis on reflective, introspective thinking. Introverts are described as quiet, intellectual, organised, and emotionally controlled. (Hansen, 1988). Extroversion refers to a preference for attending to the outer world of objective events with an emphasis upon active involvement in the environment. Extroverts are described as social, lively, novelty-seeking, carefree, and emotionally expressive. (Hansen, 1988)

Eysenck (1962, 1965, and1970) proposed extrovert's who have lower levels of vigilance would be more likely to have accidents. Although, extroverts are said to be more actively involved with the world introverts like to have more control in their interaction with the world and hence are more vigilant and careful. (Hansen, 1988) The evidence for this link between extroversion and accidents is generally supported. However, there are some contradictory findings (Hansen, 1988). Lawton and Parker (1998) found a similar picture, but again they state that it is not conclusive due to methodological reasons. They indicate that because

> “most of the studies rely on self report accident data, it is difficult to dismiss the possibility that what is being predicted is not accident involvement but predisposition to report involvement in accidents." (p. 12)

Clarke and Robertson (in press) indicate that there are differences between traffic accidents and occupational accidents. Extroversion was found to predict traffic accidents but not occupational accidents. Clarke and Robertson (in press) suggest that there are different aspects of Extroversion and they indicate that these may act in different ways:

- The evidence from transport psychology indicates a positive relationship between extroversion and accidents, however, the research from occupational settings is more ambiguous and contradictory. Lajunen (2001) indicates that the effect of extroversion may be situation dependent, and modified by different contexts (occupational, traffic)
- Low vigilance and high sensation seeking – these two aspects of extroversion could lead to an increased likelihood of accident involvement.
- Positive affectivity (PA) or the experiencing of positive mood aspects associated with extroversion (self-efficacy, task engagement, more accurate and systematic decision making) lead to lower levels of accidents.

Neurosis

Eysenck (1970. cited in Hansen 1988)) also proposed that neuroticism would be positively correlated with accident occurrences. Neurotics have low emotional stability and are said to be characterised as anxious, hostile, depressed, self-conscious, and impulsive (Clarke and Robertson, in press). The effect of neurosis is said to be linked with distractibility or lack of attention to task. A neurotics attention will be split between the task they are working on and focussing on their own worries and anxieties, therefore paying less attention to performing safely (Hansen, 1988) and they are less likely to try and control their environment (Clarke and Robertson, in press). Neurotics response to stress is also implicated, as they become more anxious, fatigued and this impacts on their abilities and increased the likelihood of error (Clarke and Robertson, in press)

Lawton and Parker (1998) indicate that evidence for a relationship between neuroticism and accident involvement is contradictory, going on to suggest that it may be specific aspects of the neurotic part of personality that is linked with likelihood of accidents, such as anxiety and distractibility. Or that only people with very high neuroticism scores will demonstrate the relationship. Clarke and Robertson (in press), however, indicate that the link between neuroticism and accident levels is supported and is evident in occupational and non-occupational studies. They do indicate that the greater likelihood of neurotics to report accidents also needed to be investigated further.

Locus of control

Locus of control, or the amount of control that an individual perceives over their environment, has been linked to accident levels. An internal locus of control is where "one has power to achieve mastery over life events" (Hanson, 1988. p.348). An external locus of control, on the other hand refers to the "the belief that one's efforts to effect change are useless…and one cannot have an influence over life happenings" (Hanson, 1988. p.348). In theory locus of control should be strongly linked to prevalence of accidents as a worker who believes they have more control over their environment is more likely to try to actively prevent accidents, where as someone who believes they have little control would believe the activity would be futile (Hansen, 1988). Overall, from the Hansen (1988) review it appears that external locus of control correlates with increased accidents. Lawton and Parker (1998) also indicate that there does seem to be a relationship between locus of control and accidents.

Hostility/Aggression

Research on aggression and accidents has mainly focused on drivers, where a relationship has been found. Only limited research is available about aggression within the workplace, although, logically a link may be assumed. This could be linked to high job demands or stressful events outside work manifesting in aggressive behaviour (Lawton and Parker, 1998).

Renfrew (1997) has indicated that aggression as a concept and a research area is particularly difficult to define. However, in this case Lawton and Parker (1998. p.15) indicates that:

> "The term aggression is used to cover a very broad range of behaviours, from mild hostility witnessed during a disagreement to physical violence. Common to all these behaviours is the tendency to act out anger and frustration, which may be different to and separate from the tendency to become angry and frustrated or irritable. Further investigation of this area is required to address these various issues."

Hansen (1988) found that many studies show a constellation of traits which are linked with aggression which are consistently associated with accidents and injuries.

Social Maladjustment

Hansen (1988) indicates that social maladjustment is a general category of behaviours and personality characteristics which are associated with accidents. These include "sociopathic attitudes and past behaviours, delinquency and law breaking, marital/familial strife, disregard for other people, immaturity, emphasis upon exaggerated masculinity (for males), hostility and anger, irresponsibility, superficial social relationships, self centeredness, problem drinking, and authority problems" (Hansen, 1988. p. 353). Various types of measurement including: objective personality inventories, projective tests, biographical information, interviews and observations. Hansen (1988) indicates that the evidence for the role of social maladjustment in accident causation is overwhelming.

Risk taking and sensation seeking

Risk taking, sensation seeking, and thrill seeking, as with driving behaviour (above section 3.1.2.1) have been linked with accidents. Sensation-seeking, as conceptualised by Zuckerman (1979) has been linked with a range of high risk of activities. There are also age effects as sensation seeking tends to be found in younger people, and may link to the age differences and accident involvement discussed earlier. Lawton and Parker (1998) indicate that relationships have been found between sensation seeking and driving speed. There are also said to be relationships between thrill seeking behaviour and driving accidents (Lawton and Parker, 1998). Hanson (1988) points to a number of studies which have shown a link between risk taking and accidents he does however indicate that the evidence is limited.

Impulsiveness
Hansen (1988) suggests that: "Impulsivity has been implicated in the occurrence of accidents in several ways. One, it is quite logical to assume that a person who acts quickly and without adequate forethought will be at higher risk for error and, presumably, accidents." Hansen (1988) and Lawton and Parker (1998) indicate that a large number of studies have been found linking impulsiveness and accidents and that age effects may also be present, with young people being more impulsive.

Conscientiousness
Conscientious includes a number of characteristics: “competence, order, dutifulness, achievement striving, self-discipline and deliberation”. People with low conscientiousness scores are said to be careless, impulsive, have a lack of self control, and a lack of respect for authority and order. Empirical evidence shows a significant negative correlation between Conscientiousness and accidents (Clarke and Robertson, in press).

Agreeableness
People who score highly on agreeableness are pleasant, tolerant, tactful, helpful, not defensive, and generally easy to get along with. There is mixed evidence about the relationship between agreeableness and accident involvement, however on the whole there is thought to be a negative relationship, that is as agreeableness goes up accidents go down. It is more important in situations were interaction and cooperation with others is needed. People with low agreeableness scores may find it more difficult to cooperate with others and could be more likely to become aggressive (see above for consequences of aggression) (Clarke and Robertson, in press)

Openness
Clark and Robertson (in press) found that openness is the least researched Big Five personality dimension. People with high openness scores are held to be imaginative, unconventional, curious, broad minded and cultured. Mixed evidence has been found in relation to these characteristics. People who have high scores on this dimension may have a more positive disposition towards training therefore reducing accidents, but be more likely to break rules therefore increasing accidents. More evidence is needed before full conclusions can be drawn.

The Interaction of personality traits
Clarke and Robertson (in press) have considered the possibility that different aspects of personality may interact to produce different outcomes in terms of behaviour. They indicate that there is a need to look at the interaction between different personality characteristics to see how different combinations of traits influence accident level.

Hansen (1988) indicates that the confounding effects of age, sex, experience, and risk must also be recognised within research on personality. These issues are dealt within more depth in other sections of this report.

4.2 FATIGUE, STRESS AND DEMANDS

There is quite an extensive range of research on stress and fatigue in the workplace that has well established outcomes and implications for the individual and the organisation. However, there is a paucity of empirical research linking stress and fatigue to workplace transport accidents. Once again reference is made to general transport literature where appropriate.

In the TUC's guide to health and safety (TUC, 2003) they claim that around 3,500 people are killed, and 40,000 people are seriously injured on the roads each year. They estimate that between one-quarter and one-third of all road traffic accidents involved someone who was at work at the time.

4.2.1 Fatigue

In can be common practice for operators in the construction, quarrying and rail industries to work anywhere between 10-15 hours per day in an attempt to maximise their remuneration. As already stated Dickety *et al*. (2004) suggest workplace transport accidents are the second largest cause of fatal accidents in the UK working environment. The authors suggest a need for further research into the relationship between shift work, driver fatigue and workplace transport risk. The Health and Safety Executive (HSE, 1999a) advises that the highest risk for workplace transport accidents where the worker is suffering from fatigue is between 2.00am and 5.00am. Connor and colleagues (2002) concludes that acute sleepiness increases the risk of a car accident in which the occupant is either injured or killed. They suggest, "Reductions in road traffic injuries may be achieved if fewer people drive when they are sleepy or have been deprived of sleep or drive between 2.00am and 5.00am".

With regards to the relationship between fatigue and workplace transport accidents, the Health and Safety Executive (HSE, 1994) believes that

> "fatigue can be insidious. It may develop slowly and may not always be apparent to those concerned or to their supervisors. Nevertheless fatigue can lead to severe accidents. Fatigue may well result in failure to concentrate. This may in turn lead to an employee failing to ensure that they are in a safe position with the result that they are hit by a falling object or struck by a swinging load".

A relationship between fatigue and prolonged driving was discovered by Hakkanen and Summala (2000), they found that heavy-vehicle drivers could experience difficulties in staying alert whilst driving, could fall asleep at the wheel, or could experience a near miss situation on the road. Hakkanen and Summala (2000) also discovered a relationship between health status and sleepiness-related problems whilst driving. They suggest that the interactive nature of prolonged driving, lack of sleep and health problems would increase the difficulties for drivers to remain alert. McCartt, Wright, Rohrbaugh, and Hammer (1999) found that as the frequency of violating the drivers' hours of service regulations increased, so did the frequency of driving whilst drowsy. McCartt *et al*. (1999) also found that experience of prolonged driving limited the effects of driving whilst drowsy.

Dickety *et al*. (2004) suggests that working excessive hours can lead to poor health outcomes, and performance may deteriorate especially if more than 12 hours are worked. Prolonged working hours impose extra demands on individuals and Rosa (1991) has reported decreased performance and increased fatigue after 7 months of 12-hour shift working. Parallels between fatigue and the experience of stress can also be drawn. Sharpe and Wilks (2002) suggest that the cause of fatigue include psychological stresses, such as loss or bereavement; and social stresses, such as problems at work. These two issues are often considered together in the literature.

4.2.2 Stress

The HSE's (2004) definition of stress is "the adverse reaction a person has to excessive pressure or other types of demand placed upon them". These pressures or demands at work can include working long hours, workload demands, and supervisory pressures.

In terms of general driving behaviour, Norris *et al* (2000) observed that job stress was one of the best predictors of future accident involvement. A link between stress and being involved in a motor vehicle accident was also found by Dobson *et al*. (1999). The authors found that there was an increase in the rates of accidents where participants felt rushed and where they exhibited lower life satisfaction scores. Dobson *et al*. (1999) also discovered a relationship between age and driving behaviour in a group of women drivers. They found that poor driving behaviour among women aged 18-33 years, and women aged 45-50 was associated with stress. The factors described as causing the pressure were feeling rushed, more hours of work, and shift and night work.

Dickety et al (2004) suggest that workload demands can impact on the level of compliance with safety procedures in terms of worker compliance, for example, speeding drivers; and supervisory compliance, i.e. turning a blind eye to maintaining safety standards. In a study conducted by Kirkcaldy, van den Eeden, Trimpop, and Martin (1999) partly as a means to provide an insight into the determinants of job-related accidents, they found that,

> "attitudes towards safety serve to moderate the adverse indirect impact of job stress on driving accidents. Safety attitudes in addition to their direct influence on driving accident frequency, also had an indirect effect through 'recklessness'. It is attitude towards risk-taking that is 'critical' in triggering on-site accidents".

The focus on individual attitudes proposed by Kirkcaldy *et al* (1999) suggests that the general atmosphere or culture for safety in an organisation may have a role to play in mitigating the effects of stress. The issue of safety culture is dealt with in detail in Section 4.4.

4.3 TRAINING, COMPETENCE AND SELECTION

The importance of training, competence and selection in workplace safety is highlighted by Male (2003) who found that in 10% of the accidents/incidents investigated the driver was not, or inadequately, trained. This figure rose to 35% in overturning accidents/incidents. The report suggests:

> "This is a substantially higher percentage that was given for any other nature of accident/incident. This emphasises the importance of drivers being trained in the proper control and operation of trucks and understanding the stability limits associate with them." p24

Williams and Priestley (1980) endorse this view and go further to suggest a competent driver should be able to overcome most problems they are faced with, including poor factory layout and unexpected hazards. The role of training in overcoming deficiencies in plant layout is also highlighted by Booth (1979) who sees training as vital. Larsson and Rechnitzer (1994), however, strike a note of caution here, suggesting that "the reliance on training and driver skills to overcome deficiencies in vehicle and workplace design is considered by the authors to be a high risk strategy which will only ensure a continuing high level of accident and injury." (p287)

There are, however, a myriad of awarding bodies certifying driver competence, including National Vocational Qualifications, Scottish National Vocational Qualifications and industry specific bodies. This in itself has the potential to cause great confusion and restricted working practices, for example, one competent worker in one industry may not be able to transfer to using the same machine in similar applications in another industry.

The importance accorded to training and improving competence has led these to be recognised as the main areas for preventing accidents in workplace transport. Accordingly this area has received much attention in the literature. In reviewing the areas of training and competence, related issues of education, skill development and selection of competent operatives have also been considered.

4.3.1 Education and experience

In general driving, levels of overall education do not seem to be related to the experience of motor vehicle accidents, particularly when taking the age of the driver into account (Norris *et al.*, 2000). The issue of driving experience also seems to tie into the findings on age discussed above. Lancaster and Ward (2002) conclude that there seems to be a reduced risk of at-fault accidents with increased experience of the driver. This would seem to point to the importance of experience in addition to formal training, which all road drivers undergo before licensing. Swartz (1993) notes that a similar testing and validation of drivers in the workplace is not always the case in the US.

In terms or workplace transport, Collins et al (1999) reports that 40% of all lift truck incidents involved operators qualified for less than a month. In addition, the evidence presented in Dickety (2001), suggests that limited experience is over represented in industrial vehicle accidents. Collins et al (1999) go on to suggest that a safe area should be established within which new drivers can practice their skills before working in a populated area. The idea of segregating new drivers until they gain enough experience might be developed into a probationary training scheme, or apprenticeship, in organisations where segregation is not possible.

4.3.2 Workplace transport training

There is some evidence from general driving behaviour to endorse the view that training interventions can be beneficial. Several studies have found improvements in driving behaviour (Dorn & Brown, 2003) and reductions in accidents (Gregersen, Nyberg, Hans-yngve berg, 2003) as a result of formal training.

As already mentioned, there is evidence to indicate that many workplace transport accidents are associated with poor training. For example, Steemson (2000) cites a number of case studies where adequate training would have prevented the injuries sustained in lift truck incidents. Collins et al (1999) observe that a number of drivers themselves were critical of their training provision, noting that it had not prepared them for the conditions busy production areas, the very issue that both Booth (1979) and Williams and Priestley (1980) note as one of the main benefits of adequate driver training.

Most of the evidence on the role of training in accidents is centred on the provision of lift truck training. However Collins *et al* (1999) found that drivers of vehicles that receive less comprehensive training (vehicles other than lift trucks) were more likely to have accidents. This again demonstrates the benefit of training and indicates that comprehensive training for all workplace drivers should be considered essential.

Despite the obvious need for comprehensive training, Coleman and colleagues (1978. cited in Stout-Wiegand, 1987) interviewed 162 workers from 12 plants in the US, and found that only 23% had received formal training, and 34% had received no training at all. The status of training may have improved since that study and Fowler (2002) found that all of the 12 organisations that used lift trucks in her UK study required employees to undertake specific training, with 75% providing additional training on safe loading and unloading.

Driver Selection

Rechnitzer and Larsson (1992) conclude that there is little doubt that lift driving is a skilled operation, requiring constant vigilance and alertness. Their review emphasises the need for appropriate training programmes (including site specific instruction) where “Standardisation of driver training and licensing requirements is seen as an important step in ensuring at least minimum aptitude and skill levels are achieved." (p35). Rechnitzer and Larsson (1992) go on to highlight the importance of selecting drivers with the appropriate aptitude for the task. Some of the organisations they interviewed had developed skill and aptitude profiles pertinent to the task of lift truck driving, and this was seen as a sensible and practical element in risk reduction. Kamp and Krause (1997) agree that effective selection can contribute to increasing safe behaviour and decreasing accidents in the workplace in general.

Fowler (2002) reported that 12 of the 20 organisations in her study did not have a specific selection process for drivers, although half of these companies trained drivers in the skills required once appointed. The lack of initial selection process is not necessarily a problem, provided, as Noordzij (1990) suggests, these is targeting of groups of drivers for special programmes once employed. Of the remaining 8 organisations in Fowler’s study, three tested the competency of potential drivers, two based selection on previous driving experience, two only appointed drivers with no previous history of road accidents. The final company in Fowler’s (2002) study only employed drivers from the local area. The literature would suggest that while selection of appropriately skilled drivers is important, appropriate training can mitigate the effects of poor selection.

4.3.3 Non-driver training

The summary of accidents and incidents in Section 2 of this report highlights the number of pedestrians involved in workplace transport incidents. Accordingly, Collins *et al* (1999) suggest that driver training should include emphasis on the differences of operating lift trucks and general vehicles in relation to pedestrians, and that every employee’s safety training should include an awareness of the hazards associated with working near workplace vehicles and pedestrians should be extremely cautious when entering areas that are travelled by lift trucks and other vehicles. Coleman et al (1978), however, found that no pedestrian workers had received any training on how to interact with lift trucks.

Stout-Wiegand (1987) also emphasises the need for inclusive safety training:

> "Forklift accident and prevention efforts should be directed not only towards forklift operators, but also towards pedestrian workers who's tasks involve interaction with or working in close proximity to forklift...It is important that these employees, who interact frequently with lift trucks or who occasionally work in close proximity to fork lifts, are also addressed by injury prevention programs." (p 189-90)

As well as pedestrians Collins et al (1999) suggest that supervisors be encouraged to participate in safety training programmes to help them understand their responsibilities. The recommendations on wider training and awareness can be seen, as with attitudes and stress, to relate to the overall atmosphere, and creating a culture for safety dealt with in the next section (3.4). Rechnitzer and Larsson (1992) endorse this point suggesting that the overall safety system needs to be addressed:

> "The present views on forklift safety - in regulations, workplace information and training - are focused on the behaviour of the driver, not the systems requirements of the work environment. To decrease the number of fatalities and severe injuries associated with the use of forklift trucks, a shift of focus is necessary." (p33)

Overall, training needs to seen as an essential component of the safety management process, with a primary focus on operators and workers, but with the potential to involve a wider constituency.

4.4 SAFETY CULTURE AND MANAGEMENT PROCESSES

This section of the report deals with human factors at the organisational level. Human factors at this level are held to be fundamental to the obtaining the most effective health and safety performance within an organisation. Within this section safety culture will be discussed in terms of the potential impact of effective safety cultures on workplace transport. A number of management systems highlighted within pertinent workplace transport literature and relevant practices raised in other areas will be outlined.

In spite of the ongoing academic wrangling taking place about the definition and nature of safety culture (Cheyne, 2000) it seems more useful to refer to a widely used definition as the basis of this section. This has been provided by the Advisory Committee on Safety in Nuclear Installations (ACSNI) Human Factors Study Group (HSC, 1993)

> "The safety culture of an organisation is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management. Organisations with a positive safety culture and characterised by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures" (p. 23).

4.4.1 Safety culture, safety management systems and workplace transport

A limited amount of literature was found which specifically related to safety culture, safety management and communication within workplace transport. The first is a review by Fowler (2002), the second is a piece of work conducted by HSL (Dickety, Weyman, and Marlow, 2003), and a third is a guidance document produced by HSE titled “Workplace transport safety’.

Fowler (2002) presents the finding from research carried out within 20 companies, which investigated how they dealt with safety issues in relation to workplace transport. In terms of safety culture and management, Fowler covers risk assessment, safety documentation, communication, safety culture and improvement notices.

Risk Assessment is the first system discussed by Fowler (2002). Risk assessment is also the first stage outlined by the HSE (1999b) in their publication “Managing Vehicle Safety at the Workplace” (IDNG199), so it is obviously a key process in the management of health and safety in relation to workplace transport. Fowler (2002) assessed if a risk assessment had been conducted specifically for workplace transport and if this was suitable, sufficient and appropriately documented. It was found that 14 of the 20 companies had conducted risk assessments of these seven were seen as meeting all the criteria needed to be successful, that is that every mode of transport has been assessed, hazard identification had taken place, their consequences analysed, risk evaluated, corrective measures taken, the process had been fully documented and the actions time limited. Some of the reasons why companies were indicated to have not completed this process successfully include: lack of documentation and actions; the use of one generic assessment over a number of sites (did not consider site specific risks); the use of health and safety agencies who did not understand the risks on a daily basis; rigid implementation of the guidance 'Five Steps to Risk Assessment' (the companies only assessed the risks on the guidance and therefore did not cover workplace transport). Of the six companies who had not carried out a risk assessment for workplace transport, three had carried them out generally but did not realise they needed to carry out a specific one for workplace transport. Of the remaining tree companies, two had minimal knowledge of safety and legislation and one did not believe workplace transport was a safety issue within their organisation, however Fowler believed it was a safety issue for them. In the HSE (1999b) document 'Managing vehicle safety at the workplace', they recommend that a risk assessment is the first thing that an organisation should do in terms of managing workplace transport.

Fowler’s (2002) investigations on safety documentation included whether the company had a safety manual, safety procedures, and documented safe working practices. Sixteen companies had a safety manual but only 10 had implemented the procedures into safe working practices. One problem identified by Fowler (2002) in this area was lack of communication to staff, the consequence of which was systems not being integrated in practice. It is of great concern that four companies were found not to be aware of the need to have a safety manual or procedures.

In terms of communication, Fowler (2002) assessed if there was adequate communication, for example through safety committees and forums. Ten companies had adequate systems in place in terms of communication. Safety committees (monthly or quarterly) were used in seven of the companies, from which information trickled down the organisation. Three companies described as having “strong communication links” used strategies including “two-way safety forums, monthly safety briefs, open door policies and daily safety reminders via email."

In an overall evaluation of the organisations’ safety culture, Fowler (2002) determined if the company had a positive safety culture, by assessing: staff attitude, management systems and management commitment to safety and communication. "A subjective assessment was made on the companies’ overall safety culture including issues such as the attitude of staff towards safety, commitment of management to safety, safety management systems and the mechanisms used to communicate safety." (Fowler, 2002. p12). This shows how numerous safety factors come together to create a company’s safety culture. However, Fowler (2002. p12) also indicates that it is possible to have a positive safety culture without these factors being in place but

> "the actions and attitudes of employees and certain managers revealed their concern about safety and enthusiasm to improve. Some of the companies visited have a limited knowledge of safety legislation and risk management but through senior management’s unwillingness to recruit staff with such expertise and allocate adequate resources to safety, the employees were unable to develop solutions to the identified risks. However, the employees were aware of the risks and showed a positive attitude to combating them through unofficial systems."

This demonstrates how the attitude and interest of employees can have a big impact on the safety culture of an organisation and that effective safety subcultures can develop within good teams under good supervision.

Fowler also noted that some companies could be regarded as under achieving within this sample: "The companies without suitable communication mechanisms included the companies that had not conducted risk assessments or implemented safety procedures or systems." (Fowler, 2002. p 12). This indicated that there is a group of companies who do little in terms of protecting their staff or encouraging a positive safety culture.

Dickety et al. (2003. p22) indicate that it is "well established that safety management systems cannot operate effectively unless people believe in them and take them seriously." They also indicate that "Although limited agreement exists between experts over the exact definition of the term 'safety culture', it is generally accepted that it derives the ideas and beliefs that members of the organisation share about hazards, risk, accidents and ill health." These authors pull together information from a variety of sources to suggest that there are a number of elements associated with a positive safety culture, similar, in some respects, to the areas investigated by Fowler (2002):

- **Senior management commitment** – this can be demonstrated by managers getting involved in managing and implementing health and safety within the organisation e.g. conducting safety inspections, attending safety committee meetings, and delivering health and safety training.
- **Participation of the workforce/ownership of health and safety -** key activity is willingness to report near misses, therefore atmosphere of trust (not a blame culture) is essential. This can be enhanced by involving employees in decision making e.g. what PPE / vehicle to purchase or providing ideas about possible solutions to health and safety problems.
- **The learning organisation -** key to safety management and also encourages employee engagement in the health and safety process.
- **Sustained commitment -** appears linked to organisational learning, but includes the notion of continuous improvement.

The HSE (2000a) guidance document "Workplace Transport Safety" has a section titled "Organising for safety". Its aim is to provide "…guidance on establishing responsibilities and relationships with drivers and other employees, including contractors etc. to secure safe working practices and promote a positive safety culture in the workplace." It addresses culture on the following levels:

1. Control -
   Taking responsibility and demonstrating commitment – informal and formal communication channels, such as meetings and safety tours.
   Accident reporting systems – regulatory requirement, and provision of a means of monitoring safety interventions (this must not be a means of apportioning 'blame'!)
   Allocating responsibilities – every employee, contractor, visitor etc. must understand their own responsibilities in terms of safety e.g. through job descriptions, contracts, training, raising safety issues in meetings, and displaying safety notices and bulletins.
   Accountability – appropriate penalties for failure to comply with safety rules.
   Supervision – this is essential especially in high risk areas.
   Authorisation for task – the organisation should control and authorise the performance of high risk tasks.

2. Communication – this helps maintain safe working practices, ensuring people are clear about their individual safety responsibilities. Communications relate to policies, responsibilities, working practices, sources of information and training, and feedback of safety performance. Everyone should feel comfortable expressing their views.

3. Co-operation – this is an essential process as everyone needs to work together to achieve a safe working environment including managers, employees and contractors.

4. Competence – employers need to make sure that all people on the worksite are capable of doing their work in a safe way. Managers and supervisors must be capable of organising safe working practices. The competencies of all the people within this process must be monitored, assessed and appraised of their performance. This will include the selection and training process.

In addition to the Fowler (2002) and Dickety et al (2003) and HSE (2000) literature, aspects relating to culture were discussed by other authors. Ellis (2003) indicates that "Many employers and occupational health and safety professionals have not sufficiently integrated workplace transport risks into their health and safety management system. However, there is enough evidence regarding the number of workplace transport accidents for action to be." (p38). Horberry *et al*. (2004. p. 576) suggest that: "Despite the significant occupational safety problems that the use of such vehicles can create, organisations typically have ill-defined procedures and traffic management policies with respect to forklift truck operations." Although, this research was conducted in Australia it seems to present a similar picture to a number of organisations in the UK.

4.4.2 Safety culture, safety management and the general literature

When attempting to achieve an effective, or positive, safety culture it is important not to focus on one area and address the whole process of developing an effective safety culture (Cox and Cox, 1996). While this refers to general safety management practices, it can be seen from Section 3.3 that this is also applicable to workplace transport.

A number of authors (for example, Cheyne, 2000; Flin, et al, 2000) have drawn up comprehensive lists of the main influences on safety culture and climate within organisations. What now follows is a general discussion of aspects of safety culture indicated as important.

Management commitment and supervision

Flin et al (2000) draw attention to the key role of the supervisor in developing an effective safety culture indicating that the supervisor has the power to dictate the safety climate through the work atmosphere they create. This is generally measured by ascertaining respondent's levels of satisfaction with supervisors, perception of their attitudes, and behaviours in relation to safety. Zohar (2000) found that supervisory or group level safety climate was related to the experience of minor accidents, suggesting that supervisors play an important role in the safety management system. Although there is only a limited understanding of the process by which management influence the safety culture of an organisation, there is recognition that they will "set the tone and tempo for organisational atmosphere, establish priorities and allocate resources." (p. 186)

Gadd and Collins (2002), through reviewing the literature on safety culture, found that management is "the key influence of an organisation's safety culture." They believe that "employees' perceptions of management's attitudes and behaviours towards safety, production and issues such as planning, discipline etc. was the most useful measurement of an organisation's safety climate". They also highlight a number of studies which show that management commitment is essential for the success of safety interventions and influences the likelihood of employees reporting incidents. Management also has responsibility for determining the character of a number of factors which create the culture of an organisation including safety and production, discipline and selection. (Gadd and Collins, 2002)

Safety systems

Flin *et al* (2000) found that safety systems are included in almost every survey of safety culture. Safety systems include components such as safety management systems, safety policies, and safety equipment. Gadd and Collins (2002) indicate that safety systems envelop all facets of safety management systems, including safety committees, safety officers, safety equipment and safety policies.

Risk

Flin et al (2000) indicate that 'risk' arises frequently within the literature pertaining to safety culture but has a number of conceptual forms (i.e. self-reported risk taking, perceptions of risk and attitudes towards risk and safety). Flin et al (2000) demonstrated that workers have relatively accurate perceptions of risk, but this cannot explain why risk taking behaviour by workers occurs. They indicate that some researchers in this area have introduced personality factors into their questionnaires (e.g. optimism and fatalism). These characteristics could influence risk taking behaviour, their willingness to get involved with health and safety issues or raise health and safety issues. It should be noted that this is also tapping into safety at the individual level and shows the importance of addressing safety at different organisational levels.

Research by Van Vuren (2000) demonstrates how risk perceptions may influence employee behaviour in the workplace. The research was carried out in the Dutch steel industry, within which workers were found to not follow safety procedures and have a poor attitude towards following them. High risk behaviour took place and employees did not take the use of PPE seriously. In spite of employees being aware of the risks they were taking, these violations were seen as acceptable by employees and many team leaders. This case study illustrates nicely how perceptions of risk and behaviour and cultural factors interact.

Work pressure

Flin et al (2000) highlight work pressure as a central issue within safety culture. 'Work pressure' tends to include factors relating to work pace and workload. Management and supervision play an important role in this, as they manage the balance between pressure for production or safety.

> "In a global economy of increased competitiveness, cost reduction and organisational restructuring, work pressure is very likely to influence safety climate at the worksite when time and resources become stretched." (Flin, 2000. p187)

Lee and Harrision (2000) found that production before safety messages tended to come from management and that these had the biggest impact in terms of increased accident levels when it was supervisors or middle managers applying the pressure rather than top management. This gives further support for the key role of supervisors in the safety process.

Competence

The competence factor of safety culture relates to workers' perceptions of qualification, skill and knowledge levels. This factor overlaps training and competence standards, assessment and selection. Factors that will impact on this include economic conditions such as the labour market for a particular profession and an organisations ability to spend money on providing these systems (Gadd and Collins, 2002).

Procedures/rules

Procedures and rules are an important part of managing the safety process, as are the attitudes that are engendered towards these procedures and individuals' reactions to/willingness to follow rules. This may, however, be mediated by individual factors, such as personality.

Communication

Cheyne (2000. p. 57-58) indicates that this includes "the nature and efficiency of health and safety communications within the organisation, the appropriateness of information sharing and the dissemination of safety decisions."

The (HSE, 2000b) publication 'Successful health and safety management' (HS(G)65) indicates there are three main ways for managers to communicate with employees:

1. Through visible behaviour – this gives strong messages to employees which can reinforce or undermine safety messages. Examples of positive reinforcing behaviours include participating in: health and safety tours, health and safety committees, investigations of accidents/incidents.
2. Written communication, such as policy statements, safety roles and responsibilities of employees and management, performance standards, findings from risk assessments, and risk control information and practice.
3. Face to face communication and discussions between employees and managers are important as they facilitate employee involvement in the health and safety process. Opportunities for this type of discussion include during safety tours, planned meetings or briefings, and 'tool-box talks'.

4.4.3 The usefulness of safety culture

The notion that assessing safety culture and the ability to predict and therefore minimise risk has been raised by several authors (Flin et al, 2000; Dickety et al 2003). They address it in slightly different ways but the principle appears to be the same. This has obvious advantages in comparison to using retrospective data, for example, assessing accidents that have already happened. They indicate that the movement towards 'leading' or predictive assessments allows the organisation to minimise risk and therefore reduce accident levels of accidents, and example of this would be risk assessment.

It should be noted that aspects of safety culture are going to vary in importance and relevance depending on the industry and organisation (Flin et al 2000). This means that although there is an increasing understanding of the key factors within safety culture benefits would be obtained from assessing it specifically in relation to workplace transport, although this is likely to be problematic give the diversity in industry.

4.5 SUMMARY

Human factors have been outlined at the individual, job, and organisational level and their application to workplace transport has been discussed. At the individual level, age and gender seem impact on the frequency of accidents with young men having a higher probability of workplace transport accident involvement. Personality traits and types have been found which are more likely to be present in individuals who are involved in accidents. Aspects of personality which centre on sensation seeking, risk taking, low conscientiousness, neuroticism, and external locus of control are all implicated in accident involvement. It should be noted that no research has taken place specifically on personality and workplace transport, although they are implicated in both transport and workplace accidents.

Stress, fatigue and demands have been shown to have ramifications in terms of transport and occupational accidents. However, their exact role in workplace transport accidents has not been investigated. It should also be noted that some of these factors are under workplace control as they can dictate, for example, the level of pressure experienced by employees.

Training and competence in relation to workplace transport have been more widely researched and their potential role in accidents and incidents highlighted. While much literature emphasises the importance of training, a common view emerges that provision should extend beyond the driver, and training should be only part of an integrated approach to producing a safe workplace.

It has become apparent that safety culture and management processes are a key area of research within accident prevention in every organisational context. It is through the effective management of safety culture that individuals will develop the competencies required to do the job, and develop appropriate attitudes in relation to safety. In some cases a positive safety culture might impact and interact with the other human factors issues discussed in this section.

Although the human factors outlined are not all extensively researched in terms of their operation within workplace transport, it seems important to acknowledge that they will impact on accident levels in this area. The final section of this report draws together overall conclusions and presents a number of recommendations based on the findings.

5 CONCLUSIONS AND RECOMMENDATIONS

The importance of human factors in workplace accidents is well established within the general health and safety literature. In terms of workplace transport incidents, human factors do seem to play a role in accident causation, although the literature in this specific area is not as extensive.

There exists a large body of literature relating to the design of vehicles and workplaces aimed at the reduction of workplace transport accidents. Although benefits could be gained from new research in this area, priority should perhaps not be given to new research in workplace layout, given the extensive body of research which already exists. However, vehicle modifications which address specific human factors issues (such as awkward or dynamic loads) or intelligent transport systems could provide useful solutions in the future and may warrant further investigation. What is less clear, however, is whether the knowledge gathered from this research has been transferred to the workplace and resultant changes evaluated.

In addition to design issues, and in terms of human factors issues that have been widely researched, training and competence development seems to have been the primary focus of other investigation in the workplace transport field. What is clear from an examination of this literature is that most authors suggest training is only one of the issues that should be addressed. Fowler (2002) suggests that:

> "workplace transport safety can only be achieved through the implementation of an entire system, including safety documentation, risk assessment, accident, incident and near miss reporting and analysis, training and education, communication, risk assessment and the implementation of control measures to reduce identified risks. If one or several elements of the system are omitted, the system becomes less effective."

A review of the wider safety literature has established the importance that human factors play in this safety system.

When considering the individual differences of those involved in accidents, young men are more likely to have vehicle and workplace accidents, and there is a high probability that this will transfer to workplace transport accidents. This does not mean that young men should not be employed in this context, but that this needs to be taken into consideration and addressed, for example through more intensive training, or monitoring. The impact of personality is less clear, although some aspects of personality (specific traits and types, for example sensation seeking) have been associated with accidents; these are often somewhat context specific. Individual stress and fatigue have been found to impact on both occupational and general transport accidents. Therefore it can be concluded that they are likely to have some bearing on workplace transport accident.

Safety culture and associated management systems are currently a major area of enquiry within accident prevention in every organisational context. This is based around the notion of improving the ‘way things are done’ for safety, including communication and levels of safety awareness. For workplace transport the importance of wider training programmes and enhanced levels of awareness have been emphasised. This encompasses a need to address the wider safety system, as described by Fowler (2002). There are additional benefits to using a multi-faceted approach, since different interventions reinforce each other and can increase their efficacy. An example given by Fowler (2002) is that of the introduction of engineering measures and training/education. The training improves the acceptance of the engineering measures, and the engineering measures reinforce the perceived importance of what was learnt through training.

5.1 RECOMMENDATIONS

Although there is a general picture, within workplace transport health and safety research still has a number of gaps:

- More research needed in terms of workplace vehicles other than forklift trucks;
- The research needs to cover the exposure levels of different vehicles in the workplace to ascertain the true level of employee contact.
- Research needs to establish whether particular sectors and operational contexts exhibit more severe workplace transport problems than others. This would enable the more precise targeting of interventions, as well as an evaluation of the role of the environment in accident causation.
- There needs to be accurate assessment of accident levels, including how accidents are recorded and the impact of changing technologies on accident types.
- Thorough evaluation of the effectiveness of different workplace transport safety interventions needs to take place. This would include, for example, examining the impact of different training packages upon the operators safety.

Findings from the literature dealing with the individual would suggest, in terms of workplace transport, that:

- Younger drivers receive additional training, are closely monitored as they build experience;
- New drivers, like younger drivers, should be closely monitored and possibly segregated while building experience;
- Given the inconsistency in the findings relating personality to accidents it is unlikely that a general personality characteristic will be identified that is predictive of accidents in all contexts, rather different characteristics may have a role depending on the nature of the job and organisation. Consequently, personality assessment may be most usefully employed for developmental purposes, including the identification of training needs.
- The impact of stress and fatigue on driver performance need to be further investigated in the workplace transport context, allowing the establishment of safe working parameters.

As already noted, design issues have received wide coverage in terms of workplace transport research. However, as Horberry et al. (2004) have indicated one of the few emerging areas in relation to design is Intelligent Transport Systems for workplace transport vehicles. There are numerous devices worldwide which could have practical implications and benefits for workplace transport safety. Since only a tiny proportion of these have been tested empirically, this is an area which would benefit from additional research. This would establish the most effective systems in terms of accident prevention.

At the organisational level, focus should be on systems of management, including the development of a positive culture for safety. Specifically organisations should be encouraged to:

- Train a wide range of staff, including supervisors and pedestrians in workplace transport operations. This will not only raise individual awareness, but also demonstrate a wider commitment to employee safety.
- Establish clear communication processes to help maintain safe working practices and encourage the sharing of information and two-way communication.

- Develop systems and procedures to assess, monitor and evaluate workplace transport risks.

As Collins et al (1999) suggest: "...a combination of a safe work environment, comprehensive training for all operators, and implementing and enforcing systematic traffic management" may be the best way to reduce the number of workplace transport incidents.

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