

Reducing risky driver behaviour through the implementation of a driver risk management system

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Dates:

Received: 26 May 2014
Accepted: 12 Aug. 2014
Published: 21 Nov. 2014

How to cite this article:

Luke, R. & Heyns, G.J., 2014, 'Reducing risky driver behaviour through the implementation of a driver risk management system', *Journal of Transport and Supply Chain Management* 8(1), Art. #146, 10 pages. <http://dx.doi.org/10.4102/jtscm.v8i1.146>

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South Africa has one of the highest incidences of road accidents in the world. Most accidents are avoidable and are caused by driver behaviour and errors. The purpose of this article was to identify the riskiest driver behaviours in commercial fleets in South Africa, to determine the business impact of such behaviour, to establish a framework for the management of risky driver behaviour and to test the framework by applying a leading commercial driver behaviour management system as a case study. The case study comprised three South African commercial fleets. Using data from these fleets, critical incident triangles were used to determine the ratio data of risky driver behaviour to near-collisions and collisions. Based on managing the riskiest driver behaviours as causes of more serious incidents and accidents, the results indicated that through the implementation of an effective driver risk management system, risky incidents were significantly reduced.

Introduction

South Africa reportedly has one of the worst road accident records in the world. According to the International Transport Forum (Steyn 2013), South Africa is ranked the worst out of 36 countries when considering road fatalities and it is estimated that road crashes cost the country over R300 billion every year. Very few crashes are unavoidable accidents. According to Collins Letsoala, the acting chief executive officer (CEO) of the Road Traffic Management Corporation (RTMC), as quoted by Mbanjwa (2013:1), 'statistics also showed 90% of all road crashes in South Africa were a result of one traffic violation or another'. The majority of vehicle accidents are caused by driver behaviour and errors. Risky driving behaviour can lead to near-collisions, crashes, injuries and fatalities.

Risky driver behaviour in the commercial transport and freight industry has a direct impact on an organisation's fuel costs, tyre costs and other fleet operating costs, as well as its corporate image and performance. Without managing risky driver behaviour, businesses expose themselves to major risks and unnecessary costs. Organisations that focus their management activities on influencing or changing risky driver behaviour through proactive initiatives not only reduce the risk and cost of unsafe driving but can also improve organisational profitability. To improve road safety, it is imperative to understand and influence drivers' behaviour. The ability of drivers to identify risky or hazardous situations is an important skill that allows drivers to overcome the complex cognitive requirements caused by the traffic environment (Borowsky, Shinar & Oron-Gilad 2010).

Research approach

Risky driver behaviour can have a major influence on a business and its bottom line and, in South Africa where the road accident record is one of the worst in the world, the impact can be severe. To mitigate this, it is critical that driver behaviour be analysed and the riskiest behaviours identified and reduced, as far as this is possible. The purpose of this article is thus to identify risky driver behaviour and to determine the business impact of such behaviour, to establish a framework for the management of risky driver behaviour and, finally, to test the framework by applying a widely used driver behaviour management system as a case study.

The research approach that is followed is therefore primarily qualitative, with a case study application. A literature review is firstly used to determine the driver behaviours that are generally considered to be the riskiest and most likely to result in negative business impacts. These are then compared to the South African context, firstly, in terms of the available literature and, secondly, based on an analysis of six fleets comprising in excess of 2450 vehicles, to determine the riskiest driver behaviours in the South African road environment. The literature review is then expanded to determine the typical business impacts of risky driver behaviour and the potential severity thereof.

There are many products available in the market that claim to be capable of providing full or partial solutions to the risks associated with risky driver behaviour. A brief analysis is performed on some of the most commonly used on-board safety monitoring systems to provide the basis for the establishment of a driver risk management framework.

Following the determination of a driver risk management framework, a case study is used to test the framework. As an 'empirical inquiry that investigates a contemporary phenomenon within its real life context' (Yin 2009:18), a case study is intended to focus on a particular feature within an organisation. In this article, a leading on-board safety monitoring system is analysed using data collected from three of the fleets where the system has been implemented. The selection of these fleets was based on the willingness of the organisations to participate in the review and provide information, as well as the size of their respective fleets and therefore the extent of data. Using a ratio data methodology, critical incident triangles were determined for the fleets under review. These data were then used to test the framework.

The riskiest driving behaviours

Risky driver behaviour can cost a business a considerable amount of money, not only in terms of maintenance and insurance charges, but also insurance claims. Zamorski and Kelley (2011) state that there are a broad range of risky behaviours that could lead to incidents, which includes:

alcohol and drug use; speeding; frequent or rapid lane changes; failing to signal; tailgating; failing to wear a seatbelt; driving while drowsy; and engaging in distracting behaviour (e.g. cell phone use). (pp. 1-2)

Klauer *et al.* (2006) describe only four driver behaviours as the riskiest: excessive speed, safety belt use, driver distraction or inattention and driver drowsiness.

When considering driver behaviour in a fleet context, the picture may be somewhat different. In a study conducted in the United Kingdom, the riskiest fleet driver behaviours were identified as harsh braking, followed by, in order, sharp cornering, lane handling, harsh acceleration and speed (Milnes 2012). This is contrary to the situation in North America, where 'speeding is the most dominant unsafe driving behaviour' (Milnes 2012:1). This is followed by sharp cornering, harsh braking, lane handling and harsh acceleration.

The World Health Organization lists the leading causes of road injuries as speed, pedestrians and cyclists, young drivers and riders, alcohol, medicinal and recreational drugs, driver fatigue, hand-held mobile telephones, inadequate visibility, road-related factors and vehicle-related risk factors (Peden *et al.* 2004). Those relating to driver behaviour are speed, alcohol, medicinal and recreational drugs, driver fatigue and hand-held mobile telephones. In a report on road traffic fatalities in Africa (Eshbaugh *et al.* 2012), the authors use the Haddon matrix to group the key reasons for fatalities in

Africa as human factors (licensing, training, driver attitude, impairment, distractions), vehicle factors (braking, vehicle design, maintenance, passengers or loads, safety equipment), environmental factors (regulation, enforcement, hazards, natural hazards, driver distractions, built environment, road design or maintenance) and social factors (enforcement, awareness, insurance incentives, rider peer pressure). Those that are influenced by driver behaviour are driver attitude, impairment, distractions, braking, passengers or loads and driver distractions. Similarly:

The American Transportation Research Institute indicates that a significant portion of collisions are triggered by 'at risk' driver behaviour, which includes such actions as: following too closely, driving too fast for conditions, failing to obey traffic signals or other 'traffic warning' devices. (Zurich 2010:9)

The American Transportation Research Institute, in their 2006 and 2011 studies, identified a number of risky behaviours which would increase the likelihood of an accident. These are: failure to use or improper signal conviction, past crashes, improper passing violation, improper turn conviction, improper or erratic lane change conviction; improper lane or location conviction, failure to obey traffic sign conviction, speeding more than 15 mi/h (24 km/h) over speed limit conviction, any conviction and a reckless, careless, inattentive or negligent driving conviction (American Transportation Research Institute 2011). Key risky driver behaviours are therefore speeding, risky lane changes, failure to obey traffic signals and inattentive or negligent driving.

Stuster, in a Highway Safety Information System report (US Department of Transportation 2004), ranked the criticality of unsafe driving acts as follows (in order): driving inattentively, merging improperly into traffic, failure to stop for a stop sign or light, failure to slow down in a construction zone, unsafe speed, following too closely, failure to slow down in response to environmental conditions, changing lanes abruptly in front of a truck, driving in the 'no zones' (left rear quarter, right front quarter and directly behind), unsafe turning, unsafe passing, pulling into traffic from roadside in front of truck without accelerating sufficiently, driving whilst impaired by alcohol or other drug, changing lanes in front of a truck then braking, unsafe crossing, driving left of centre into opposing traffic, failure to permit a truck to merge, failure to discern that the trailer of a manoeuvring truck is blocking the roadway, nearly striking the front or rear of a truck or trailer whilst changing lanes, manoeuvring to the right of a truck that is making a right turn, operating at dawn or dusk without headlights, crossing a lane line near the side of a truck or trailer whilst passing, driving between large trucks, nearly striking the rear of a truck or trailer that is stopped or moving slowing in traffic, nearly striking an unattended or parked truck at roadside and abandoning vehicle in travel lane or impeding traffic. These primarily relate to inattentive driving, inappropriate lane changes, failure to observe traffic signals, following too closely, unsafe braking and driving under the influence of alcohol or drugs.

The results of the literature review therefore indicate that, globally, the following are the key unsafe driving practices:

- alcohol and drug use
- speeding
- frequent or rapid lane changes
- failing to signal
- following too closely
- safety belt use
- driver fatigue
- sharp cornering
- unsafe braking and acceleration
- driver attitude
- failure to obey traffic signals
- driver distraction or inattention (e.g. mobile phone use or passengers in vehicle).

Leading risky driving behaviours for business fleets

Alcohol and drug use

'The use of alcohol and/or drugs by a truck driver is a common cause of truck accidents' (Starr Austen 2012:1). A study by the US National Transportation Safety Board (NTSB) indicated that, 'of fatally-injured truck drivers, we found that 33 per cent of the drivers tested positive for one or more drugs of abuse' (Hall n.d.:1). Whilst the NTSB's study was conducted in the 1990s, indications are that alcohol and drug abuse is a clear factor in truck-related accidents. Alcohol or drug use affects the ability to drive as a result of:

impaired vision, reduced reaction times, reduced concentration and vigilance, feeling more relaxed and drowsy, which may cause a driver to fall asleep at the wheel, difficulty in understanding sensory information, difficulty doing several tasks at once (e.g. keep in the lane and in the right direction, while concentrating on other traffic), failure to obey road rules and over confidence, which may lead to risk taking. (Drug Info 2012:1)

In South Africa it is estimated that one of the leading causes of road fatalities is driving under the influence of alcohol (Mbanjwa 2013).

Speeding

'Speeding reduces the driver's ability to steer safely around curves, extends the distance to stop a vehicle, and increases the distance a vehicle travels' (Hub Pages 2010:1). As a result, it is a major cause of accidents:

the risk of a casualty crash approximately doubles with each 5 km/h increase in speed on a 60 km/h speed limited road, or with each 10 km/h increase in speed on 110 km/h roads. (Government of South Australia Transport 2012:1)

Speeding also impacts aspects such as fuel consumption and braking ability: 'the faster a vehicle goes, the further it takes to stop' (Land Transport NZ n.d.:4).

Unsafe lane handling

Drivers making inappropriate lane changes can either lose control and crash their vehicles or run the risk of being hit by other vehicles (Canadian News 2013). In order to change lanes safely:

drivers [*need*] to divide their attention between monitoring the forward roadway, their surroundings, steering the vehicle, regulating the vehicle's speed, and using the turn signal. Drivers who are pressed to change lanes may exhibit degraded performance in one or more of these subtasks. (US Department of Transportation 2009:65)

As drivers have an average of two seconds to respond to lane change events, typical responses to these are a combination of steering and braking manoeuvres.

Failing to signal

A study recently published by the Society of Automotive Engineers (Suk 2012) shows that a failure to signal when changing lanes or the failure to turn off a signal after changing lanes happens 48% of the time (in the US). Drivers making a turn fail to signal 25% of the time. The result is an estimated two million crashes per year, which is estimated at more than double the amount of collisions caused by distracted driving (Suk 2012). There is therefore a clear correlation between the failure to signal and the possibility of a collision.

Following too closely

Rear-end crashes are the second most common claim for fleet operators, according to research from Risk Management News. They make up 17 per cent of all claims and cost on average over \$13,000 per claim. (Automotive Fleet 2008:1)

Added to this:

'Rear enders' are the most common type of injury car accidents. Most rear end accidents involve one or both of three key factors: driver inattention by the driver behind, following too closely, or a rapid deceleration by the driver whose car is hit. (Calloway & Wolf n.d.:1)

Typically, the most common reason for rear-end crashes is following too closely.

Non-use of safety belt

'Failure to wear seat belts is responsible for more fatalities than any other single traffic behaviour' (Monahan 2005:1). In Queensland, South Australia, the risk of being killed in a car accident was calculated as being ten times higher if drivers or passengers were not wearing seat belts (Centre for Accident Research and Road Safety – Queensland 2011). 'When used correctly, wearing a seat-belt reduces the risk of fatal injury to front seat passenger car occupants by 45%, and risk of moderate-to-critical injury by 50%' (Edgar Snyder & Associates 2011:1). Seat belts are one of the effective methods of preventing serious injuries and fatalities on the road.

Driver fatigue

'Several studies have shown that fatigue influences driving behaviour in specific ways: slower reaction times ... reduced vigilance ... and reduced information processing' (Jonck 2010:1). Some of the consequences on operational driving aspects include affected steering, speed and following behaviour. 'Fatigue is one of the leading factors contributing to road crashes' (Centre for Accident Research and Road Safety – Queensland 2011:1).

Sharp cornering

A recent study conducted on fleet driver performance indicated that sharp cornering is the second-most common riskiest driver behaviour in both the USA and UK (GreenRoad 2012). The risk of incurring an accident will increase if sharp cornering is combined with speeding and even more so if this risky driving behaviour is performed with an overloaded or improperly loaded truck.

Unsafe braking and acceleration

Harsh braking and acceleration can have a number of effects on vehicle costs. In addition to the danger that it poses to other drivers, particularly drivers behind the vehicle, harsh braking impacts tyre and fuel costs. 'Hard braking will also accelerate tyre wear, along with excessive use of the accelerator and brake' (Tyre Savings 2013:1). In addition:

when the footbrake is used the road speed that has been lost has to be made up by using the accelerator, thereby burning fuel. If it becomes necessary to change down a gear or half gear then even more fuel is used. The load is also more likely to shift under heavy braking. Harsh braking uses more fuel and require an increase in the number of gear changes that you will subsequently have to make. (Department of Transport 2009:12)

Poor driver attitude

Attitude can be defined as a tendency to react positively or negatively towards specific situations, phenomena, objects or persons. A considerable number of research studies indicate that attitude influences behaviour; for example, a study by Iversen (2004) indicated that three attitude dimensions, namely, drivers' attitude towards rule violations and speeding, drivers' attitude towards the careless driving of others and drivers' attitude towards drinking and driving were very successful in predicting risky driving behaviour. Specific interventions designed to change future risky driving behaviour should address driver attitude.

Failure to obey traffic signals

The failure to obey traffic signals is a clear danger to other road users, as well as the driver, the vehicle and the load carried:

The consequences for not obeying traffic laws include personal injury, death, and damage to your vehicle or other property. You may also be ticketed, which may result in a fine or license suspension. (New York Defensive Driving 2013:1)

Driver distraction

There is an important distinction to make between driver inattention and driver distraction:

Driver inattention occurs whenever the operator of a vehicle diverts his or her attention away from the driving task. Driver distraction, on the other hand, has been defined to occur when this inattention leads to a delay in the recognition of information that is necessary to accomplish the driving task safely. Thus, distraction occurs when inattention leads to a critical incident. (Hanowski, Perez & Dingus 2005:442)

Evidence suggests that driver distraction is a primary factor in 12.9% of all crashes (Hanowski *et al.* 2005). Driver distraction includes such elements as talking on cell phones, talking to passengers, reaching to floor or into a pocket et cetera, smoking, eating or drinking, looking outside and so on.

The South African context

Road accident statistics in South Africa are compiled by the RTMC. The last available accident crash statistics report is the March 2011 *Road traffic report* (RTMC 2011). This report states that contributory factors to South African fatal crashes are human, vehicle or road related. The major human contributory factor is 'speed too high for circumstances' (RTMC 2011:55). This is followed by, in order, pedestrian (jay walking), hit-and-run, unlawful or unsafe overtaking, turning in front of oncoming traffic, disregard of traffic signals, following too closely, intoxicated driver, intoxicated pedestrian, intoxicated cyclist, driver fatigue, unsafe or illegal U-turns, unknown factors and illegal or unsafe reversing. Those pertaining to driver behaviour are speed too high for circumstances, unlawful or unsafe overtaking, turning in front of oncoming traffic, disregard of traffic signals, following too closely, intoxicated driver, driver fatigue, unsafe or illegal U-turns and illegal or unsafe reversing. Together, these driver behaviour-related elements accounted for 58.24% of fatal crashes where human factors were the major contributory factor in 2011.

The 2010 road traffic offence survey – one of the primary sources for the 2011 *Road traffic report* (RTMC 2011) – is an independent survey which determines the level of lawlessness with regard to selected critical offences that mostly contribute to the occurrence of road crashes in South Africa. These are identified as speeding, traffic signal offences, overtaking across the barrier line, alcohol levels, driving licences, wearing of seatbelts, vehicle fitness, correlation between vehicle registration plate and licence disk, pedestrian compliance and presence of traffic officers, pedestrians, cyclists and animals on the roads. It is evident that the five of the first six offences are driver behaviour related.

An analysis of selected South African transport organisations¹ revealed the top 10 riskiest driver behaviours as (in order from most to least):

- harsh braking and aggressive accelerating
- driver unbelted and driver distractions
- not looking far enough ahead
- sharp cornering
- following too close
- disregarding traffic signals
- speed policy violation
- judgement errors
- mirrors not checked
- driver fatigue.

1. Six organisations with a total fleet composition in excess of 2450 vehicles were studied over a year period in 2012–2013 by researchers at the Institute of Transport and Logistics Studies (Africa), University of Johannesburg.

It is evident from the above that the riskiest driver behaviours in South Africa demonstrate very similar patterns to driver behaviour elsewhere in the world.

The business impact of risky driver behaviour

It is evident from Table 1 that risky driver behaviour potentially has a major impact on the costs of doing business. 'Researchers have confirmed that drivers with repeated patterns of risky behaviour are more likely to be involved in a collision than those without such behaviour infractions' (Zurich 2010:9). It is therefore imperative that organisations operating fleets need to strictly control and manage risky driver behaviour to ensure that negative impacts on their business's bottom line are minimised.

Systems for managing risky driver behaviour

Organisations are complex systems that have values, principles, attitudes and viewpoints which differentiate them from other organisations. Research indicates that organisations with a well-established safety culture, attitudes and practices have a direct influence on safety performance. Organisations that focus on and develop opportunities to create safer organisations will develop and encourage employees to display safer behaviour (Özkan, Öz & Lajunen 2013).

Many different interventions can be used to change risky driver behaviour to safer and desired driving habits. Risky driving behaviour can be identified through various ways, such as customer or operational complaints, driving observations, drivers receiving fines for any traffic violations, when drivers are involved in accidents or near-misses, or with an on-board safety monitoring (OBSM) system. It has become common practice to utilise sophisticated technologies to improve risky driving behaviour and to reduce the associated risk. An OBSM allows fleet managers to collect detailed information associated with driver behaviour and vehicle performance. In recent years, OBSM devices have become increasingly advanced. Different types of devices exist which vary significantly in terms of complexity, data extraction sources and diverse features.

Some devices gather data directly from the vehicle on-board diagnostics, whilst others have embedded GPS functionality or built-in accelerometers. These devices monitor numerous driver or vehicle parameters and obtain performance data such as vehicle speed, location, braking and acceleration and fuel consumption. Some of the commonly used OBSM systems that are available, with their primary attributes, are described below (Insurance Institute for Highway Safety 2013; Volunteer Fireman's Insurance Services 2012).

Forward collision warnings systems

These systems monitor the roadway in front of a vehicle, by means of vehicle proximity sensors, and warn the driver when the vehicle is getting too close to the vehicle in front of it (i.e. potential collision risk). Some of these systems have the capability to store operational data (e.g. harsh braking events), which can be analysed to determine risky driver profiles and training requirements.

Lane departure warnings systems

These systems monitor the location of a vehicle within the roadway lane and alert the driver if the vehicle inadvertently strays or is about to deviate outside the lane marking. Some systems warn the driver through steering wheel or seat vibrations, whilst others use audible and visual alerts. Some systems even use light braking or minor steering adjustments to actively resist the vehicle moving out of the lane.

Fatigue warning systems

These systems use advanced algorithms to monitor driver behaviour (e.g. driver's eye blink rate and duration) and warn the driver if inattention or drowsiness is detected.

Roll stability control systems

These systems use sensors and a microprocessor to monitor how a vehicle responds to a driver's steering and automatically intervenes to assist the driver to reduce the rollover risk that exists. The system selectively reduces the vehicle speed to keep the vehicle on its course. Often, the intervention takes place before the driver is even aware of the requirement.

TABLE 1: Business impact of risky driver behaviour.

Driver behaviour risk element	Potential impact				
	Fuel	Maintenance	Accident risk	Insurance cost	Penalties
Alcohol and drug use	-	-	✓	✓	✓
Speeding	✓	✓	✓	✓	✓
Unsafe lane handling	-	-	✓	✓	✓
Failing to signal	-	-	✓	✓	✓
Following too closely	-	✓	✓	✓	-
Non-use of safety belt	-	-	✓	✓	✓
Driver distraction	✓	-	✓	✓	-
Driver fatigue	✓	✓	✓	✓	✓
Sharp cornering	-	✓	✓	✓	-
Unsafe braking and acceleration	✓	✓	✓	✓	-
Poor driver attitude	✓	✓	✓	✓	-
Failure to obey traffic signals	-	-	✓	✓	✓

Vehicle tracking

Vehicle tracking can assist asset management and customer service requirements, as well as assist driver safety. A vehicle that has stopped for an excessively long period or is not located in the intended area could indicate that the driver needs assistance.

Combination systems (monitoring driving metrics)

These systems monitor a range of driving metrics such as speed, engine revolutions (RPMs), braking and G-forces. The system can alert the driver if pre-set parameters are exceeded through audible warnings.

On-board video monitoring systems

These systems normally provide continuous video monitoring of the road ahead and interior of the vehicle through a windshield mounted camera. Some systems not only provide warnings to the driver if pre-set parameters are exceeded but also track and tag the information to the video. Some systems require fleet managers to manually download and assess the information, whilst others automatically upload the information, via cellular transmission, to analysis centres where the data are assessed.

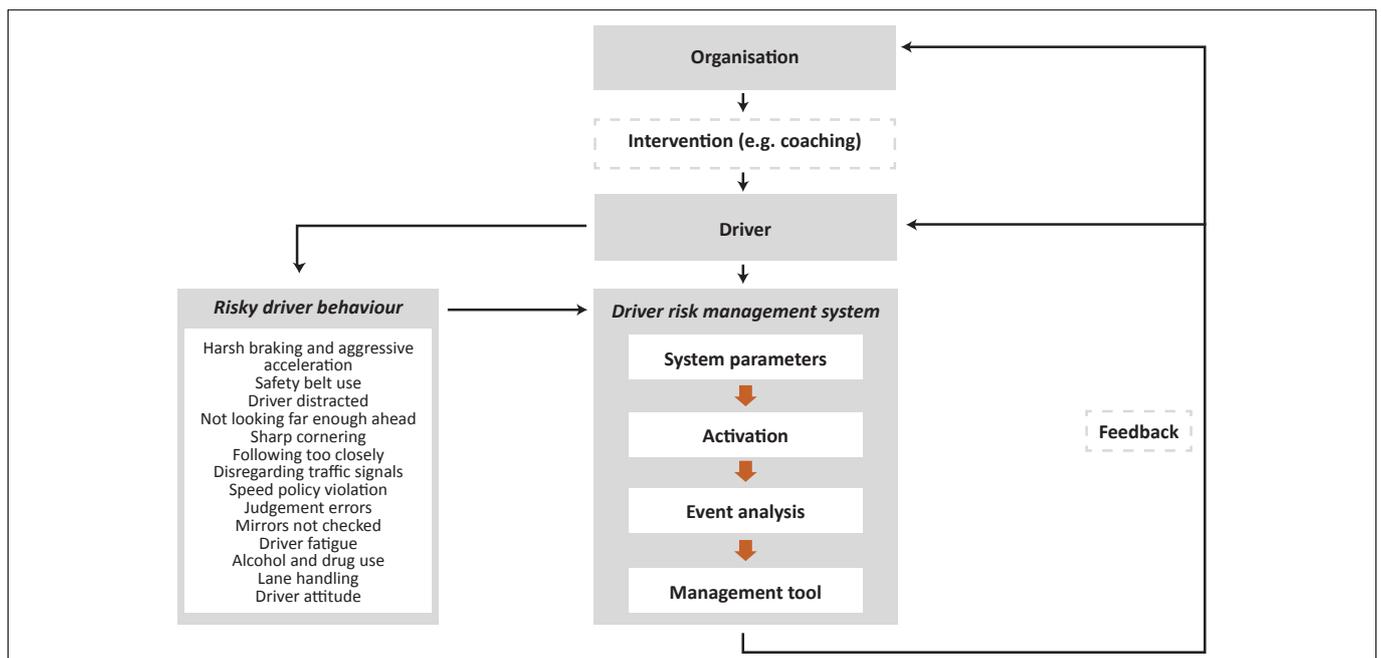
To provide comprehensive and coherent driver risk management, a system should be able to combine the best functionalities of the above listed systems, but must also be extended to provide pertinent and intelligent data so that this information can be used as a management tool. In order to create this type of driver risk management system, relevant information needs collected, filtered, analysed and used to predict and influence risky driver behaviour.

Framework for a driver risk management system

Organisations that place significance emphasis on management activities to influence risky driver behaviour through pre-emptive strategies not only reduce the associated risk and cost of unsafe driving but also improve organisational efficiency. Organisations must be able to identify risky driver behaviour and establish a preventative process to correct and reduce risky driving behaviour before it leads to an accident or injury.

A broad range of risky driver behaviours exist that increases the probability of road traffic accidents and directly impacts organisations fleet operating costs. Organisations need a pre-emptive and comprehensive risk management platform to effectively manage and reduce risky driver behaviour. An effective driver risk management system (DRMS) should contain the following segments: system parameters, activation, event analysis and a management tool (Figure 1).

The DRMS must be able to monitor driver and vehicle performance and through intelligent activation, as well as capture and upload only those risky driving events which matter. The risky driving events must be analysed and scored to determine the most appropriate actions. The DRMS should also provide an uncomplicated and easy accessible management tool that profiles risky drivers with relevant supporting evidence that can be used to provide feedback to the organisation and driver. The individual driver risk profile enables management to initiate appropriate coaching interventions to address risky driving habits and monitor the effectiveness of such coaching interventions. The driver should also however have the ability to identify his own risky actions and modify them. A good DRMS



Source: Authors' own construction

FIGURE 1: Framework for a driver risk management system.

should therefore provide feedback to both the driver as well as the organisation, so that, together, risky driver behaviour is minimised.

Case study: Selected DriveCam implementations in South Africa

Overview of the driver risk management system

Selected DriveCam implementations in South Africa were used to form the basis of a case study to test the framework. The framework requires that the system that must be able to identify risky driver behaviour and proactively manage it so that risky drivers' behaviour is modified to prevent incidents, rather than to identify such behaviour only after an event has occurred. The DriveCam system is a DRMS that combines a number of components which work together to form a comprehensive management system.

System parameters require that a system should be set up so that it is able to monitor vehicle telematics and should thus include aspects such as GPS and accelerometers. The DriveCam system provides this functionality and allows for the system to be parametrised for a specific type of vehicle so that activation is appropriate for the vehicle type. The DriveCam system provides for intelligent activation to ensure that only relevant events are taken into account. It also filters out events caused by road noise so that events triggered by risky driver behaviour can be managed. In addition to the automated activation, the DriveCam system allows for manual activation, so that, should the driver feel that it is warranted, a recording of an event can be uploaded and stored in the system. The driver should also be aware of system activation. As the purpose of the system is modification of risky driver behaviour, consciousness of system activation will assist the driver in awareness of risky driver behaviour and the modification of their own risky behaviour patterns.

The most critical aspect of the framework is the analysis of the events that have triggered the system. DriveCam-recorded events are analysed off-shore by trained DriveCam analysts, which allows for consistency, fairness and impartiality. Based on this, events are scored against a pre-determined scoring system, so that the organisation, as well as the driver, can focus their risky behaviour prevention efforts on only the behaviour that is likely to result in a serious event or incident. Each system trigger could consist of one or more transgressions, each carrying a numerical score ranging from 0 to 10 points. These are added together to give a total event score. For example, a driver may have triggered the system by harsh braking. The analysis of the event may show that the driver jumped a stop street and was then required to brake quickly. In this instance there are at least two events, each of which carries a score of between 0 and 10. When the total event score is calculated, the sum of these two events is used. In general, the higher the total event score, the more risky the event (and the driver's actions).

In the DriveCam system, events that triggered a recording are not viewed in isolation, but are rather used to develop

driver profiles to determine which drivers are most at risk of accidents and which of their behaviours are most likely to result in such events. DriveCam not only performs driver profiling, but also provides a fleet profile dashboard, so that the organisation is able to, at a glance, recognise potential problem areas and manage these accordingly.

Ratio data analysis

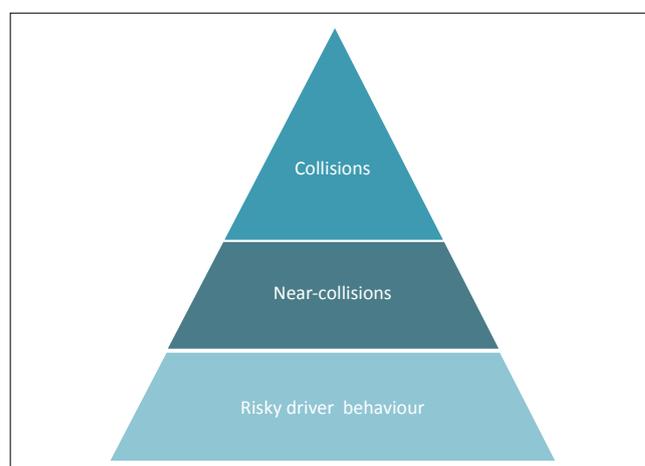
As previously stated, risky driving behaviour can lead to near-collisions, crashes, injuries and fatalities. According to Jones *et al.* in Salmon, Regan and Johnston (2005:51), 'near misses are those hazardous situations, events or unsafe acts that occur when the sequence of events could have caused an accident if it had not been interrupted'. Near-misses are often used as predictors of more serious accidents. This is based on the 'assumption that these near misses and accidents have the same relative causal patterns' (Wright & Van der Schaaf 2004:105).

When considering common cause hypotheses, reference is frequently made to popular ratio data studies such as Bird (1966), Corbett *et al.* (2008), Heinrich (1931), Tye and Pearson, in Rausand (2011) and Salminen *et al.* (1992). Ratio triangles or icebergs are used freely in industry today. Although these are often used to imply a ratio relationship of causes, Heinrich's original triangle was not intended for this purpose, but was rather an attempt to illustrate that:

prevention need not wait until an accident occurred, and that prevention should not only be aimed at the most severe consequences but also to events at the lower levels of the triangle. (Wright & Van der Schaaf 2004:105)

Based on evidence provided by Heinrich (1931), 'reduction of events at the bottom of the triangle should lead to a reduction in the number of events at the top of the triangle' (Wright & Van der Schaaf 2004:106). Figure 2 outlines the methodology that was used to obtain the critical incident triangles for the fleets under review.

For the purposes of the evaluation, the DriveCam scoring system was used to determine the values for the critical incident triangles. DriveCam uses a numerical scoring



Source: Authors' own construction

FIGURE 2: Critical incident triangle methodology.

system, ranging from 0 to 10 points, which indicates the severity of the event. To determine the number of incidents at the base of the triangle, risky driver behaviour was defined as:

- traffic violations (such as not slowing or stopping for stop streets and red lights, speeding, etc.)
- poor awareness (such as not looking far enough ahead, not scanning the roadway or intersection, not checking mirrors, etc.)
- fundamentals (such as following too closely, driving too fast for conditions, unsafe lane changes, etc.)
- distractions (such as using cell phones, eating and drinking, passenger in vehicle, etc.)
- driver conduct (such as judgement errors, aggressive behaviour, reckless driving, etc.)
- driver condition (such as drowsiness or falling asleep)
- custom event detail (as defined by the specific organisation, which may include aspects such as reversing on an active roadway, fast cornering, etc.).

Table 2 provides a summary of the fleets that were analysed. A total of over 160 000 system events were analysed, of which almost 31 300 were considered to constitute risky driver behaviour. Events that received a total event score of zero were excluded from the analysis.

Figure 3 illustrates some of the critical incident triangles obtained from the fleets under review. Although the critical incident triangle ratios differ considerably from fleet to fleet (there is no ideal ratio), managers need to be aware of these ratios, so that these can be monitored over time. The purpose of ratio data analysis is to understand and manage the risky driver behaviours at the base of the triangle that can result in more serious incidents and collisions.

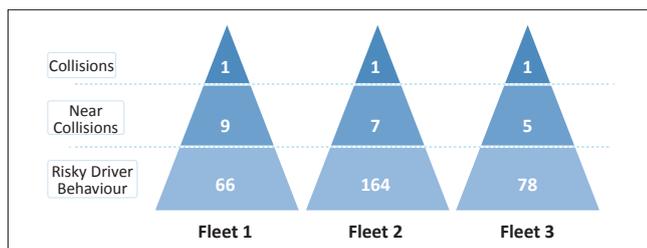
Outcomes

Based on an understanding of the risky driver behaviours that were resulting in serious incidents and collisions in their fleets, the management teams of the fleets under

TABLE 2: Summary of fleets in which risky driver behaviour was assessed.

Description	Fleet 1 (Buses)	Fleet 1 (Buses)	Fleet 3 (Courier)	Total
Fleet size (number of vehicles)	822	609	145	1576
System events (number of event triggers recorded)	98 077	56 648	5653	160 378
Risky behaviour (total event score 1–15)†	26 152	4273	874	31 299

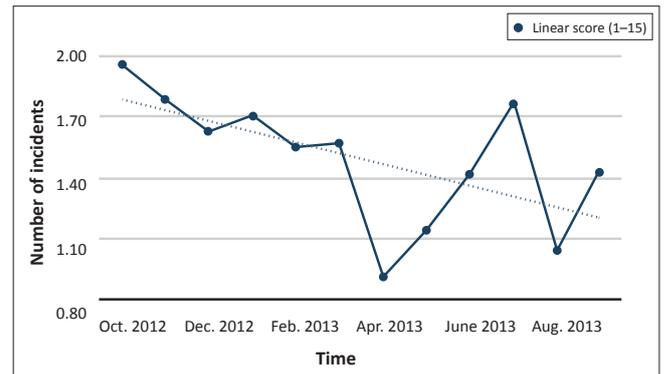
†, Sum of individual transgression scores.



Source: Authors' own construction

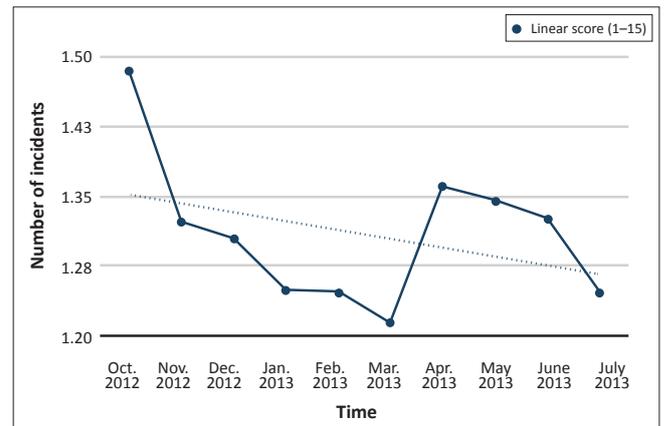
FIGURE 3: Critical incident triangles for Fleets 1–3 in this study.

review used the DriveCam system to manage behaviour at the base of the triangle. Figures 4–6 provide an overview of the results achieved over specific review periods. These Figures show that the implementation of an effective driver risk management framework (such as DriveCam) can result in a clear reduction of risky driver behaviour over time. In the three fleets under review, reductions of between 16% and 33% were achieved over the various review periods, dependent on the extent of implementation and the depth and type of intervention, which ranged from creation of



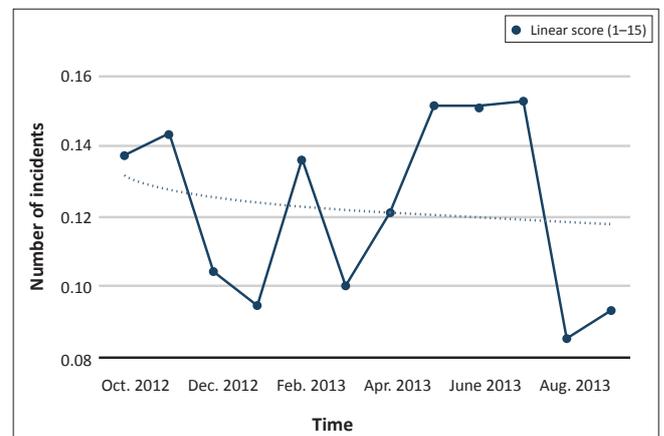
Source: Authors' own construction

FIGURE 4: Fleet 1 – Average number of incidents per vehicle (buses).



Source: Authors' own construction

FIGURE 5: Fleet 2 – Average number of incidents per vehicle (tankers).



Source: Authors' own construction

FIGURE 6: Fleet 3 – Average number of incidents per vehicle (couriers).

awareness, self-coaching and management coaching to disciplinary procedures. From anecdotal evidence obtained from semi-structured interviews with these commercial operators, managers indicated that they had seen significant reductions in the number of incidents, as well as substantial savings in related costs such as insurance. Interviewees also indicated that they had far better control of their fleets and a much better understanding of what their drivers were experiencing on the roads.

Conclusion

Risky driver behaviour not only increases the probability of road traffic accidents, it directly impacts organisations fleet operating costs, its reputation and performance. A literature review of international research studies identified a broad range of risky driver behaviour, which includes: speeding, frequent or rapid lane changes, failing to signal, following too closely, driver distraction or inattention (e.g. mobile phone use or passengers in vehicle), driver fatigue, sharp cornering, unsafe braking and acceleration, driver attitude and failure to obey traffic signals.

Similar characteristics are evident in South African, with the top 10 riskiest driver behaviours being (in order): harsh braking and aggressive accelerating, driver unbelted or driver distractions, not looking far enough ahead, sharp cornering, following too close, disregarding traffic signals, speed policy violation, judgement errors, mirrors not checked and driver fatigue.

The impact of risky driving behaviour on businesses is substantial. Inefficient and unsafe driving habits increase vehicle operating costs (e.g. higher fuel consumption and maintenance costs), insurance costs (i.e. increased risk profile), claims and accident related pay-outs and damage corporate image. Improving driving habits can lead to lower insurance costs, less loss or damage to cargo, increased vehicle fleet reliability and effectiveness and improve driver health, productivity and morale.

A DRMS helps proactively to reduce liability, property damage and workers' compensation costs and reduces a firm's financial exposure in the event of a collision by providing unbiased evidence to assess and manage exposure to risk. Video evidence also protects firms against fraudulent claims, can exonerate drivers and provides them with added security whilst driving. The DRMS also ensures that drivers adhere to corporate driving policies which guarantee a safe and comfortable journey. An effectively managed DRMS can also significantly reduce fleet operating costs by fostering improved driving behaviour that improves fuel efficiency, cuts vehicle maintenance costs and improves operations by ensuring vehicles are kept on the road where they generate revenues.

For implementation to be effective, it is recommended that a DRMS should:

- Be able to monitor driver performance and, through intelligent activation, capture and upload only those risky driving events which matter.
- Create driver awareness of system activation so that driver is able to modify their own risky behaviour patterns.
- Analyse and score risky driving events to determine the extent of the risk.
- Provide the opportunity to identify and reduce the frequency of unsafe driving behaviour by implementing corrective measures (i.e. coaching) before further incidents or collisions occur.

In this research, a case study was used to test a framework for the management of risky driver behaviour. As a case study methodology only focuses on a particular feature within an organisation, it is recommended that future research be expanded to incorporate fleets of varying sizes and complexities to establish the replicability of the framework. Future research should also incorporate return on investment analyses to establish whether system implementation and the resultant reduction in risky driver behaviour lead to quantifiable benefits for the organisation.

Acknowledgements

Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

R.L. (University of Johannesburg) and G.J.H. (University of Johannesburg) were equally responsible for the research and writing of this article.

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