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Applying online fleet driver assessment to help identify, target and reduce occupational road safety risks

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ABSTRACT

Many studies have shown that driver attitude and behaviour are important determinants of the likelihood of collision involvement. Knowledge of the Rules of the Road and the perception of hazards are also associated with collision involvement. The aim of this paper is to review the practical application of an online fleet driver assessment program to help identify, target and reduce occupational road safety risks. A large and unique data set collected from online assessment of drivers employed in a UK telecommunications organisation is analyzed. Data was also collected on driver demographics and their driving and collision history. Analysis of the data revealed that attitude, behaviour, knowledge and hazard perception are highly correlated with self-reported collisions. The influence of these variables on collision involvement was assessed using a Poisson regression model. Both attitude and behaviour scores exhibit a statistically significant association with collision involvement, along with other variables such as mileage driven, driver age and personality. The findings lend support to the need to create a safety culture in which driver assessment and improvement is the norm, as well as reducing exposure to risk wherever possible through better ways of working and travelling.

1. Introduction

This paper reviews the application of online fleet driver assessment to help identify, target and reduce occupational road safety risks. An introductory review of the relationship between behavioural traits and road traffic collisions is presented and discussion is given as to how these traits can be measured. Then, by use of a real-world data set based on more than 16,000 employees from a large UK telecommunications company, a statistical assessment of the efficacy of behavioural assessment is conducted.

Occupational road traffic collisions account for a large portion of killed and seriously injured road traffic casualties around the world. For example, Moser (2001) stated that up to 33% of occupational fatalities are attributable to motor vehicle collisions and Bibbings (1997) estimated that 25% of all road traffic collisions in the UK involved occupational driving. In Queensland, Australia, Meers (2002) reported that 37% of all fatal vehicle crashes between 1997 and 2000 involved a commercial vehicle. Mitchell et al. (2004), reported that around 30% of all occupational deaths in Australia involved injury as a result of a motor vehicle crash on a public road. Lynn and Lockwood (1998) found that, even allowing for exposure, work based company car drivers were 49% more likely to be involved in crashes than the general public. The increased collision involvement of company car drivers was also found by Cartwright et al. (1996) and Dimmer and Parker (1999) who stated that 27% of company car drivers reported involvement in at least one crash in the previous three years compared to 18% reported by non company car drivers. In part, the high representation of company drivers in collision involvement can be explained by increased exposure to risk (Davey et al., 2007), but there is anecdotal as well as the research evidence provided by Dimmer and Parker (1999) of a 'work driver effect', which means that responsible companies must endeavor to reduce the risks to society and their employees.

This has led to a growing view expressed within industry and the road safety literature that creating a proactive 'fleet safety culture', influenced by corporate policies, processes and procedures, is fundamental to improve occupational road safety and reduce the associated costs (see for example Haworth et al., 2000; Moser, 2001; Murray, 2003; Murray and Dubens, 2000). There is some evidence that the influence of a safety culture does indeed have a positive effect on fleet collision reduction, (Murray et al., 2002; Newnam et al., 2004; Wills et al., 2006). Gregersen et al. (1996) applied a quasi-experimental approach in a large Swedish telecommunications company and showed that engaging drivers, for example through group discussions, did lead to safety improvements.

Many organisations have introduced driver training programmes in order to establish a safety culture and improve the safety of employees and society, as well as to comply with insurance company requests to minimise risks. Often these training

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packages are accompanied by driver assessment questionnaires that aim to pre-test driver behavioural attributes, knowledge of driving regulations and perceptions of hazards. The aim of these programmes is to identify and promote desirable traits and eradicate attitudes and behaviours that are associated with higher collision involvement.

There is a belief that identification of these desirable characteristics amongst employees can allow improved recruitment and assignment of staff and the identification of training needs in others. There is, however, debate as to the most effective way to undertake driver and potential driver assessments. Conducting behavioural and skill assessment entails large direct and indirect costs through driver down time to organisations. For this reason, the assessment methods need to be shown to be reliable, valid and effective in reducing collisions.

A degree of validation comes from published literature. For example the work of Beirness (1993), West et al. (1993), Underwood et al. (1999) and Deffenbacher et al. (2003) reveal that drivers with behavioural traits associated with anger, aggression and frustration have a greater tendency for collision involvement than those with low scores in theses traits. Means of detecting this behaviour are often derived from the Manchester Driver Behaviour Questionnaire (DBQ) developed by Reason et al. (1990). Parker et al. (1995a), Meadows et al. (1998), Lajunen and Summala (1995), Lajunen et al. (1998) and Iversen and Rundmo (2002) found scores obtained using this instrument can be used as predictors of collision involvement. In the context of fleet safety Sullman et al. (2002) and Davey et al. (2007) found a positive correlation between DBQ scores and collision involvement. Typically in such studies, however, behavioural scores explain only a small amount of the variation in collision involvement. Sullman et al. (2002) found that a model incorporating the violation score part of the DBQ accounted for 11% of the variation in collision involvement. Parker et al. (1995b) attributed 16% of the variation in road collision involvement to violation scores and Xie et al. (2000) quoted 3.4%.

Clearly other factors need to be incorporated in the models in order to assess collision involvement, such as age (Evans, 2004; Gregersen and Berg, 1994), gender (see Maycock et al., 1991; Hemenway and Solnick's, 1993; Stamatiadis and Deacon, 1995), hazard perception (Deery, 1999), knowledge of driving regulations and organisational factors. These organisational factors include the safe work culture of the organisation, which are described in detail by Newnam et al. (2004), Watson et al. (1996) and Wills et al. (2006). Organisational factors such as management commitment, communication, payment schemes, tight deadlines, sales/productivity targets, work pressures, delivery time slots and other distractions such as mobile phone use can have a major impact on driver safety. Banks et al. (2006) demonstrated that the effectiveness of work-related driver education is dependent on good perceptions of organisational commitment to safety management, appropriate work demands, trusting relationships and good communications.

2. Method and background to case study company

Most of the previous studies described in the literature were based on surveys administered by researchers. The case described in this paper uses company-derived information from a large UK organisation, which was available on an unprecedented scale, and provides a rich source of applied data to help inform road safety research and practice. This unique investigation allows the value of the company's focus on fleet safety training to be evaluated. Employees of the company are given regular safety training, the crux of which is to undertake a compulsory online driver risk assessment to allow risks to be targeted. This assessment is based on the self reporting of attitudes, behaviour and knowledge of the "Rules of the Road" and perception of hazards. The data available was from 16,004 registered car and van driving employees. This assessment, implemented over a four year period, is part of the company's on-going programme of safety improvement and risk reduction, which was informed by the Haddon Matrix (Haddon, 1980) and focused on the driver, the vehicle, the journey, management culture and community engagement. Undergoing the online driver assessment is a pre-requisite to grant employees a "permit to drive" in the case organisation. On detection of poor attitudes and behaviours, employees are referred to a range of interventions including management "one to ones", in-vehicle, classroom and computer-based training, monthly communications on key road safety topics and regular performance reviews. Persistent poor driving performance can ultimately result in re-deployment.

The data collected from this assessment is analysed and used to determine the worth of the company's safety approach and to make recommendations to help improve fleet safety. The data and method used are detailed in the next section.

The case organisation has a fleet of approximately 12,000 cars and 32,000 light commercial vehicles driven mainly by engineers and managers. In total, up to 100,000 employees may be expected to drive while at work. The company's internal health and safety group identified driving as the greatest and most expensive risk faced by its employees, and at the time of the study just over 28,000 people were registered on the risk assessment databases, of whom 16,004 had completed it.

The data for this study was obtained from a web-based multiple choice driver risk assessment, which is the starting point of a process aimed at improving driver safety in participating companies. The online risk assessment tool evolved out of early computer-based training modules that were developed in the UK in the late 1980s. Initially the risk assessment tools were designed on CD-ROM to support the UK government's introduction of the theory test for new drivers (DSA, 2000). After this initial application it was developed with support from the driver training sector (IAM, 2001) and the UK fleet industry. University-based evaluation research based on 120 drivers, and a telephone based survey of the first 20 corporate organisations that used the risk assessment product (Murray and Dubens, 2001; Murray et al., 2002) for occupational drivers helped to develop the risk assessment tool described.

In the participant organisation, the assessment, which was completed in privacy, gathered basic information on driver demographics, driving history and driving behaviour. This is in some ways similar to, but not based on, the Manchester Driving Behaviour Questionnaire (Reason et al., 1990).

Information on knowledge of the Rules of the Road and the perception of the driving hazard were also gathered. Specifically five scores were obtained for each individual participant.

1. Exposure to risk score – was based on twenty six questions including age, type of driving, distance and time on the road.
2. Attitude to safe driving score – was compiled from answers to 10 multiple choice questions.
3. Behavioural score – was formed from the answers to ten order-randomized questions designed to assess behavioural responses to a variety of road situations. Participants were required to provide one or more correct multiple choice answers to each of the 10 questions.
4. Knowledge of the Rules of the Road score – was computed from the answers to 10 order-randomized questions. Again, participants were required to provide one or more correct multiple choice responses to each of the 10 questions.
5. Hazard Perception score is similar to the current UK driver theory test – respondents were shown picture clips of roads with traffic in both urban and rural situations and asked to click on potential hazards in a restricted time and a count of hazards

identified was computed. This was combined with marks obtained in answers to a bank of conventional hazard-based questions. In total there were fifteen picture-based hazard responses and questions.

A typical attitude question was: "Badly designed roads are the main cause of traffic collisions". Participants had to strongly agree, agree, disagree or strongly disagree. A typical knowledge question was: "You are the first vehicle in a line of traffic, what is the main danger when you are about to turn left at a set of traffic lights?" To support this question, participants were given an image and a set of multiple choice answers to choose from.

To assess the reliability of the different items to measure the particular construct Cronbach's alpha was computed. For the attitude and hazard scores satisfactory alphas were obtained (greater than 0.75). For the behaviour and knowledge scores participant responses were order-randomised in the assessment process, making it impossible to measure the Cronbach's alpha. However, the scores were shown to be consistent by examination of the individuals' coefficients of variation.

All information was self-reported, by a group of predominantly male (over 93% of the total employee group) engineers and managers. Crosschecks of the accuracy of the responses suggested some under-reporting of exposure measures such as distance and collision involvement.

The self reporting may lead to biases resulting from impression management and socially desirable answering by participants in an attempt to avoid the need to undertake more detailed risk reduction interventions. Lautenschlager and Flaherty (1990) suggested that the tendency to socially desirable answering would be aggravated by the use of computers. However, Booth-Kewley et al. (1992) did not find any evidence of computers increasing this bias. Lajunen et al. (1997) and Lajunen and Summala (2003) investigated the effect of giving socially desirable responses to questions in the DBQ and found in experimental investigation that aberrant behaviours were reported less frequently in public than in private settings. They concluded that bias caused by giving socially desirable responses was minimal in the DBQ. We can generalise from these findings and accept that in this online questionnaire, completed in privacy amongst respondents who were more computer literate than those in Lautenschlager and Flaherty's study, the bias given by socially desirable responses is reduced. The fact remains that there are some socially desirable answers in all self-reported questionnaire based research. This is understood by the participant organisation, and as a result the outcomes are used conservatively, and where possible cross-checked against actual data and management observations.

3. Findings and discussion

A summary of the findings obtained is shown in Table 1, in which a key variable of interest was the number of collisions that each driver had been involved in over the previous three years. Most drivers (83%) reported no collisions at that time, 14% reported one collision and only 0.8% had reported three or more collisions. Comparisons against actual company collision data suggested that there was some selective honesty and memory loss in the self-reported data, however, the actual insurance claims data, did not prove to be compatible with the analysis used in this paper. The company data available was only partial and if used would lead to many missing cases amongst the variables. For this reason, self-reported data was used for analysis, and the company has since put in place measures to focus the coding of its collision data on more on risk management, as well as the traditional claims process and vehicle repair management.

Table 1
Summary Statistics of the data collected (n = 16 004)

Crash data			
Total crashes	3 438		
Mean crashes per person	0.215		
% crash free drivers	83.0%		
Demographics	Mean	Standard deviations	
Driver Age	44.6	8.6	
Miles per annum	12,421	7 000	
Driving hours per week	10.2	7.4	
Assessment scores			
Attitude score	83.1	11.9	
Behaviour score	85.6	8.4	
Hazard score	77.9	8.2	
Knowledge score	79.3	11.7	
Total score	81.3	6.9	
Other variables	% Yes	Personality trait	% of type
Awareness of safety policy	80.8	Patient	40.8
Passed advanced test	2.4	Mature	26.4
Vehicle service	84.7	Reliable	20.7
Vehicle checks	92.8	Structured	7.5
ABS fitted	32.2	Uncertain	1.2
ABS use	87.2	Aggressive, impulsive, irresponsible	3.4
Car used for work	42.8		
License checked	85.2	Driver type	% of type
Had recent Eyesight test	77.1	Engineer/service	61.7
Had recent health check	56.4	To/from work only	35.0
		Sales/accounts managers	2.3
		Delivery/collection	0.9
		Other	0.2

In the sample, 78% had never received driver training since passing their driving test, 20% had received training over one year ago and 2% had been trained in the last year.

The main demographic information obtained was driver age, with over 70% of participants more than 40 years old. Less than 1% of the respondents were in the 17–20 year age group. No information on gender was available. This had not been captured due to union requests, data protection and the requirements of gender-based anti-discrimination laws. The majority (93%) of the employees in the organisation's participating lines of business were male, suggesting that the data in this study can only be considered to be representative of men.

Respondents were asked to describe their own personality from a choice of eight traits which were identified from the literature and industry experience as influencing driving (Murray, 2002). The majority of drivers described themselves as patient (41%), mature (26%) or reliable (21%). Only 4.5% described themselves as aggressive, impulsive, irresponsible or uncertain when behind the wheel of a motor vehicle.

From the series of questions based on driving experience it was found that 88% of respondents had been driving for seven years or more, in line with their age profiles. Thirty-three percent drove between 5000 and 10,000 miles per annum, and 43% of respondents drove between 10,000 and 20,000 miles each year. Ten percent drove between 20,000 to 30,000, which Bibbings (1997) suggested is one of the most dangerous work activities there is in the UK, on a par with activities like mining and deep sea fishing. Only 1.3% of respondents drove further than 30,000 miles annually. The largest fraction of drivers (32%) spent between one and 5 h per week on the road with only 3.5% driving for more than 25 h. These results were in line with organisation-wide company data.

The initial analysis of the data was in agreement with the majority of the findings in the literature. For example, older drivers

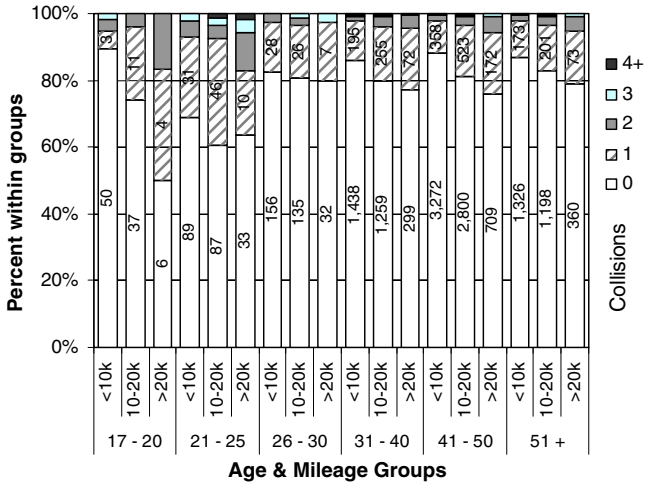

Fig. 1. Number of collisions by age and mileage groups.

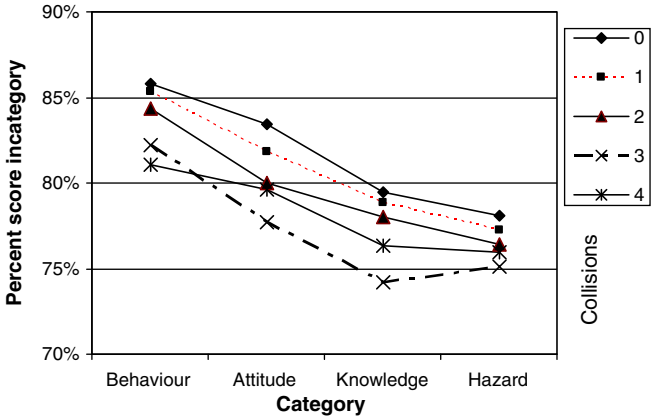

Fig. 2. Collision involvement and test scores.

were involved in fewer self-reported collisions over the last three years, as can be observed from Fig. 1.

The number superimposed on the bar represents the total respondents in that subgroup. Of note is that very young drivers, i.e. 17–20 year olds were involved in fewer collisions than expected. This is most likely because the younger drivers had not been driving on company business for very long and had not entered in to jobs which entailed a lot of vehicle use and consequently they had been exposed to less risk. They may also not have held a driving license for the full three year period over which the collision data was based.

The assessment scores also showed the expected association to the number of collisions. As the assessment scores decrease then the number of collisions increase. This is illustrated in Fig. 2.

Displayed in Table 2 are small but significant correlations between the assessment scores and collision involvement.

From Fig. 3 it can be observed that the personality traits associated with impulsiveness and aggression do appear to be linked to greater collision involvement.

As in other studies (such as Davey et al., 2007), the greater the exposure to risk of collisions the greater the involvement in collisions. The link between exposure, as measured by the amount of driving hours, and collision involvement is displayed in Fig. 4. As would be expected, exposure is also an important variable which the participant company wishes to reduce. The monotonic decline in collision free reports with increasing driving hours is very

Table 2
Pearson correlation coefficient matrix between the assessment scores and the number of reported collisions (all p-values < 0.01)

	Attitude	Behaviour	Knowledge	Hazard	Collisions
Attitude	1	0.243	0.299	0.305	−0.068
Behaviour		1	0.361	0.303	−0.043
Knowledge			1	0.347	−0.035
Hazard				1	−0.048

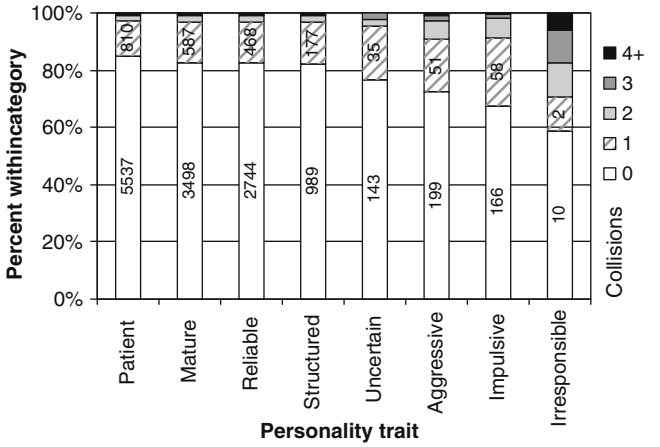

Fig. 3. Personality trait and collision involvement.

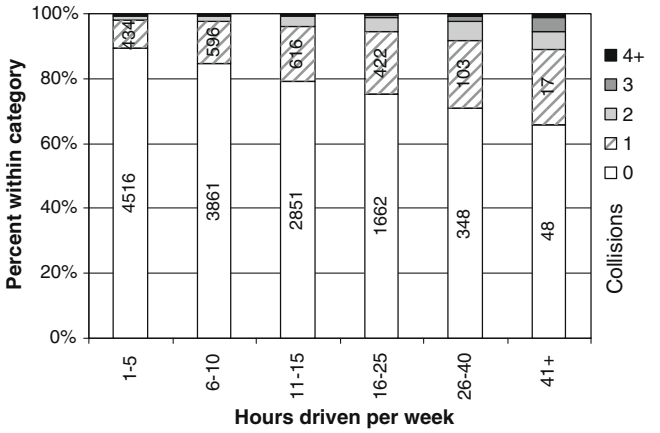

Fig. 4. Average weekly driving hours and collision involvement.

marked. Similar results were obtained using distance traveled. This is particularly important for the case study company because as a telecommunications specialist it has a vested interest in encouraging employees and contractors not to travel and use alternatives ways of working such as video conferencing. This means that the company not only gets a safety benefit as a consequence of reducing exposure, but also a business development benefit in relation to the sale of its products and services.

There are several findings from this initial exploration in addition to the normal dependency of collisions with driver age and distance driven. A relationship has been found between both driver attitude and behaviour scores and collision involvement. It also appears that the association of aggressive, impulsive and impatient traits correlate with the increased likelihood of collisions, confirming the findings from the literature.

To ascertain the degree of increased safety that might result from improvement in participant scores via interventions, models

were computed to allow "what-if" analysis to predict the reduction in collisions that might be expected to result from better scores. Table 4 presents a sensitivity analysis of how collision risk is dependent on variations in the attitude and behaviour scores, derived from the model presented in Table 3.

The last line of Table 4 shows the approximate change in reported collisions across 10,000 drivers. For example an increase in the average scores of 10 would translate into 300 fewer reported collisions. Figures have only been given for a change of −10 and +10 units. Larger changes in score would give a greater change in collisions but extreme changes to the model will be less accurate.

A Poisson regression (Winkelman and Zimmerman, 1995) was computed to model the number of collisions. The coefficients of the model of the likelihood of involvement in one or more road traffic collision are displayed in Table 3. Only statistically significant terms at the 5% level are shown. In the Poisson model, average hours driven per week was used as an offset to help control for exposure, which is also displayed in Table 3. Although this model gives many significant coefficients, it only partially explains the number of collisions, with a pseudo R squared value of 8.9% which is in line with previous studies (e.g. Sullman et al., 2002; Parker et al., 1995b; Xie et al., 2000). The model suffers from slight under dispersion. Although Simonoff (2003) stated that this is not a serious problem, as a correction the scaled deviance is used to inflate the standard errors of the estimates. In developing the model a selection strategy based on the observed drop in the scaled deviance was used as suggested by Maher and Summersgill (1996) and the Pearson χ^2 statistic was used to assess model quality.

From this analysis it can be observed that if personality is categorised as aggressive, impulsive or irresponsible then self-reported behaviour is, as expected, positively associated with collision involvement, as is uncertainty. Maturity is negatively associated with collision involvement. Age groups less than 50 years old, mileage and driving hours are also positively associated with collision involvement. Negative associations are found with having had an eyesight test, having license checks as well as just using the car to travel to work. There were also negative associations with the scores of attitude to safe driving and hazard perception. These assessment scores were found to be significant and had the effect of reducing the likelihood of collision involvement. Surprisingly, safety policy awareness and antilock braking system (ABS) fitted had an increased likelihood of collision involvement. Based on the 'two strikes and get trained' policy of the company, this is most likely a consequence of the actions taken after a company driver has been involved in multiple road collisions in that they are made aware of the company's safety policy. The positive association of ABS supports the findings of Farmer et al. (1997) that many drivers do not know how to use ABS properly. The value and importance of training on braking for drivers of cars fitted without ABS is also made by Petersen et al. (2006). Evans (2004) provides a detailed explanation as to why safety features, such as better brakes, can sometimes be positively correlated with collisions.

Different occupational groups were separately modeled for engineers and service workers with similar results to those discussed. For participants in managerial and accounting jobs, age, exposure, assessment score and personality did not appear to be significant. Only ABS fitted appeared to have a significant positive association with the number of collisions. For participants whose main task was delivery/collection, mileage was the only significant factor. The assessment scores, age and personality ratings were not found to be significant.

Overall, the analysis and modeling process has greatly helped the participant company, and others using the same methodology, to target their safety interventions on the basis of risk in a cost effective way.

Table 3
Model of involvement in one or more road traffic collisions

Variable	Poisson model of number of collisions		
	Estimate	SE	p-Value
Attitude score	−0.007	0.0012	<0.001
Behaviour score	−0.007	0.002	<0.001
Hazard score	−0.006	0.002	0.004
Safety policy	0.127	0.042	0.002
ABS fitted	0.112	0.039	0.004
Car used to travel to work only	−0.479	0.039	<0.001
License checked	−0.195	0.041	<0.001
Had eyesight test	−0.058	0.035	0.099
Age group (compared to 50+)			
17–20	0.366	0.158	0.021
21–25	0.678	0.080	<0.001
26–30	0.166	0.102	0.103
31–40	0.098	0.047	0.038
41–50	0.075	0.040	0.062
Personality traits (compared to patient)			
Reliable	0.009	0.042	0.823
Mature	0.048	0.039	0.217
Uncertain	0.335	0.121	0.006
Structured	−0.014	0.061	0.823
Aggressive impulsive irresponsible'	0.529	0.066	<0.001
Constant	−2.340	0.169	<0.001
Model performance	Deviance		0.784
	Pearson chi square		1.647
	Scaled Pearson chi square		2.101
	McFadden's R^2		8.9%

4. Conclusions

Based on a large and unique sample of data, a model has been produced of the factors which predict involvement in road traffic collisions. From this model it appears that driver personality, behaviour, attitude and personal exposure are important determinants. The fit of these models was of similar magnitude to others of this kind which are given in the literature (e.g. Sullman et al. (2002); Parker et al., 1995b; Xie et al., 2000). It does appear that driver attitudes and behaviours are a predictor of collision involvement, though their impact appears lower than exposure variables such as mileage, hours driven and having an aggressive personality. This suggests that as well as driver improvement, organisations should strive as part of a safety culture to reduce exposure to

Table 4
How the probability of reporting a collision changes with attitude and behaviour scores

Collision model	Collision probability (%)	Significant score	B	Change in score					
				−10	−5	−3	3	5	10
One+	17.0	Attitude	−0.011	1.6%	0.8%	0.5%	−0.5%	−0.8%	−1.5%
Two+	3.3	Attitude	−0.017	0.6%	0.3%	0.2%	−0.2%	−0.3%	−0.5%
Three+	0.8	Behaviour	−0.028	0.3%	0.1%	0.1%	−0.1%	−0.1%	−0.2%
Four+	0.3	Behaviour	−0.036	0.1%	0.1%	0.0%	0.0%	−0.1%	−0.1%
Change in collisions per 10,000 drivers				191	94	56	−55	−91	−180

collisions as far as possible through better journey planning, modal shift, alternative ways of working such as tele- and video-conferencing, home working and trip coordination. Where this is impossible or unpractical, efforts to assess attitudes and behaviours associated with poor driving and to improve these through training and other interventions do appear to be validated as worthwhile. As a low cost mass approach, online assessment can help to measure and detect attitudes and behaviour which are correlated with driving collisions.

Overall, the findings from this research suggest that it is worthwhile for greater effort to be taken by organisations to promote a safety culture and make use of education programmes to improve driver related attitudes and behaviour. Hazard perception and knowledge of the Rules of the Road do not appear to be strong predictors of collision involvement. They are, however, important in underpinning attitude, behaviour, personality and exposure. Certainly, where practical, the attention of safety programmes should be directed to those with aggressive, impulsive and impatient personalities. The findings of this research support those of Deffenbacher et al. (2003) and Lajunen and Parker (2001) that drivers with these personality types have greater involvement in road traffic collisions.

Amongst many stated benefits, the participant organisation has reduced its crash involvement and costs by over 30% during the four years of the programme to date, and is in the process of extending it to include a further 50,000 employees. This study has been particularly useful to the company in relation to the validity of the process, improving the risk assessment tools and providing material to support on-going road safety campaigns. Further research is also in process to explore the relationships identified with wider safety and cultural issues across the organisation.

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