Innovative Strategies for the Road Ahead

Traffic Safety in Organisations; Intervention Effects

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EXECUTIVE SUMMARY

Work-Related Road Safety has long been identified as a special concern in safety, due to the high percentage of crashes where professional drivers are involved, and the different environment in which they are operating compared with private road users.

This review focuses on investigating what evidence there is for the effectiveness of various kinds of interventions which organisations can use to increase their road safety. It was found that there is surprisingly little scientifically reliable evidence concerning such evaluations available, as almost all evaluations suffer from faults such as lack of control groups and valid outcome variables. However, a few recommendations can be made for organisations operating their own fleets, especially those in countries with high accident rates.

This includes using group discussions, telematics with feedback (although special care is needed in the selection of a provider), larger trucks, seatbelt interventions, and restrictions on driving times. Other possible methods include coaching, company safety climate and improved selection of drivers, although there is even less evidence available for the effects of these method. Due to the poor quality of the available evidence, it is also recommended that great care is taken by organisations with the implementation of such interventions.

Designing the intervention so that it can be evaluated in a scientifically meaningful way would not only benefit the larger community, but also the organisation doing the intervention. It is likely that excessive resources including financial, are currently spent on road safety interventions which are not effective, such as skills training. Funnelling resources to more effective interventions would be more cost-effective.

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INTRODUCTION

Since its inception in 2003, Fleet Forum has focused on reducing the road traffic deaths and injuries of humanitarian vehicle fleets. In 2007 Fleet Forum developed a Road Safety Toolkit that supports fleet operating organisations in implementing mitigation measures, trained over 2,100 fleet managers world-wide on road safety, partnered with the United Nations High Commissioner for Refugees (UNHCR) to manage and implement its corporate road safety strategy and developed the Driver Recognition Pro-gramme which focuses on safe and clean driving. To date over 3,500 drivers have participated in the training and recognition programmes. Fleet Forum has also been recognised by the United Nations Department of Safety and Security (UNDSS), the lead agency for the UN Road Safety Strategy, to assist in the launch of the strategy in January 2019. Fleet Forum, with the support the UPS Foundation, wishes to continue to support the aid and development sector with the realisation of the ambitious targets in the SDGs for road safety.

The impact of road accidents is not well understood in aid and development organisations. Where in many organisations the data of the direct impact (damage costs, insurance costs) is captured, the indirect impact of road traffic crashes on organisational performance, impact on staff members in the short and long term and economic impact considering direct and indirect costs remains hidden. This often means that personnel responsible for road safety are struggling to secure long-term senior management buy in for road safety improvement projects.

Aid and development organisations are often managing road safety in solitude and on a case-by-case basis operating in a decentralised model, where headquarters have challenges to make relevant impact and performance data from individual countries visible. Vice versa, country operations find it difficult to make the business case for road safety investments with senior management. There is anecdotal evidence that road crashes hinder access of UN agencies and (I)NGOs to beneficiaries. Fleet Forum members report that being involved in road traffic crashes can lead to the fact that their organisation is not accepted by the local community anymore and can result in the postponement of life-saving aid delivery. On the positive side, there is also anecdotal evidence of organisations that measure the impact of crashes and use their findings to strengthen their fleet safety culture. The International Committee of the Red Cross & Red Crescent for example, captures data around road safety interventions and how that relates to crash severity and crash costs. They use this information to convince senior management to continue to invest in safety interventions.

BACKGROUND

The driving for work context is complex and dynamic, involving different entities and decision makers. Not only do at-work drivers have to safely operate within the road environment, but they also must perform within the occupational context. However, at-work driving safety management typically focuses on on-road context, with little to no regard on how organisations could manage road safety risks. Driving for work may involve irregular driving times, unrealistic work demands, driving seen as secondary or not part of one's job and may involve remote work without direct supervision.

Current fleet risk management approaches promote a strong focus on compliance with standard rules and regulations, traffic laws and organisations' safety policies and procedures. While compliance with safety policies reduces the risk of accidents and injuries at work, incidents continue to occur even when workers comply with rules and regulations because compliance differs between fleet drivers and not all standards and procedures in place are appropriate to work activities. Management of work-related driving are often based on the 'carrots-and-stick' approach, usually with a focus on applying some form of punishment when workers become involved in road traffic incidents due to non-compliance. It could be argued that under these circumstances, at work drivers are even more likely to under-report crashes and traffic violations during working hours due to the potential negative repercussions from their organisations.

RISKS OF DRIVING FOR WORK

Many authors have noted that many road crashes happen to drivers who are either driving a company vehicle or are driving their private vehicle for work purposes. The estimates of how large a part of road incidents fall into this category vary between countries and definitions (for example whether commuting accidents are included), but researchers seem to agree that it is at least ten percent, and probably more than twenty percent.

Despite the obvious conclusion that company drivers are at a greater risk of being involved in a road accident simply due to their increased mileage, research has proven that there are other factors at work. In a study reported by Lynn and Lockwood (1998), the accident liability of a sample of 4,479 company drivers was investigated and compared with that of a sample of 5,226 non-company randomly sampled drivers.

Comparing a three-year accident history of the two groups of drivers, Lynn and Lockwood found that even when differences in annual mileage and demographic variables were controlled for, drivers of company owned or financed cars had an accident liability 29% greater than that of 'ordinary' motorists. Furthermore, once Lynn and Lockwood removed 'perk' drivers from their sample, thus focusing only on those motorists who 'regularly drove their car for work purposes', they found that the excess in accident liability increased to between 40 and 50%.

With the rising number of vehicles and road mishaps in the world, and the increasing importance of this in terms of cause of death, research into work-related road safety (WRRS) is becoming ever more essential. Furthermore, in contrast to most private drivers, those who drive for work can be influenced not only by state authorities, but also by the employer. This opens the opportunity for quite different types of interventions. However, it is important that the interventions are effective for improving safety when driving for work to achieve positive results.

IMPACT OF ROAD TRAFFIC COLLISIONS

Organisations typically count the cost of crashes in terms of the direct costs of repairing the vehicle. However, this fails to acknowledge the many hidden costs involved, especially for aid and development organisations including:

- Impact on (service) delivery
- Not being able to operate in certain areas because of hostility from host communities,
- Personal impact for victims
- Financial impact (including hidden costs)
- Reputational impact

OUR APPROACH

Knowing whether a certain type of intervention reduces the number of crashes is very difficult to ascertain. There is a published body of research including somewhat academically minded case studies, but many can be regarded as misleading due to weak methodology. One very important facet of reviewing the WRRS published literature therefore consists of reporting on the many methodological and statistical problems encountered and sifting out the reliable evidence.

Many researchers and other authors have taken an interest in road safety for those who drive for work purposes, and the published literature is vast. Several reviews of different aspects of WRRS have been published. The report by Grayson and Helman (2011) is acknowledged as an important forerunner to the present review. These authors lamented the (lack of) quality of most studies of interventions in WRRS. They pointed out that they could only find two studies which had used a random allocation of subjects in an experimental design with crashes as the outcome variable, the golden standard of quality. They also noted a shift in the literature over time towards studies on behaviour and attitudes, and case studies without control groups, i.e., a decline in quality. Finally, they also pointed out that WRRS is a term which covers a very heterogeneous environment of vehicles, drivers, and tasks.

Lancaster and Ward (2002) wrote a review on WRRS which concentrated upon individual differences, amongst other themes, with the argument that the differences between drivers in terms of safety, and what predicts these, have long been neglected. We agree with this general statement, but the topic as such will not be covered in depth in the present report, as it mainly focusses on what works in terms of driver interventions. Individual differences can be said to be a possibility in terms of selection of drivers, but this type of intervention is so poorly developed that no recommendations can be given.

OUR APPROACH

The present review adds some new features to the existing knowledge from previous synthesis of the scientific literature. First, it is of course more up to date than previous works, and given the fast pace of publication of today, and the increased possibilities of finding and accessing publications, it does contain material that was not covered before.

Second, this review takes a closer look on the methodology of published studies on work-related road safety. As will be described, there are vast differences in quality between studies, and although we do not exclude papers on the grounds of methodology, we do take a critical stance, putting more weight on the studies we believe are superior in quality and therefore more dependable.

RESEARCH SYNTHESIS

Today, there are several conventional ways of summarizing available scientific results, and some of the differences between these should be explained. The classic review simply takes whatever comes along and supplies a subjective opinion about the state of the art. The aim of many such reviews is simply to argue a specific point, which may mean that the conclusions could be rather biased.

In the last decade, the classic review has largely been replaced by the systematic review and meta-analysis. These two share the features of having the aim of being more objective and comprehensive than the classic review. The aim of a systematic review is to summarize all known knowledge on a certain topic and providing a transparent process of how the literature was found and how it is reported upon. The difference between the systematic review and the meta-analysis is that the latter is quantitative instead of qualitative, and therefore more objective. A meta-analysis usually involves an estimated population effect size, i.e., a number derived from the average of effects from all included studies. This is usually considered to be the best guess we can make about how strong an effect truly is. Meta-analysis also has the advantage of various methods for identifying and controlling for biases in the included data, making it even more exact. The downside of the systematic review and meta-analysis is that they only cover very specific topics.

The present review qualifies as a systematic review, although the wide scope of the topics of interest necessitates a less than perfect cover of all known studies.

AIM

The present review aims to present the soundest available evidence concerning effectiveness of various WWRS interventions for increased traffic safety which are possible to use in fleet-based organisations. In general, an intervention is usually seen as a response to an existing problem, i.e., deploying a new method aiming to reduce the size of the problem. However, not all rules, regulations and habits are of this type, although they might have an impact on road safety. Therefore, the current review will also include a few aspects of road safety that are normally not seen as interventions.

We aim to extend the work of Grayson and Helman (2011) by:

- Including such aspects as considering whether the evidence indicated that the interventions were culture bound in some way, or if the evidence was simply not clear on this point.
- Reviewing publications after 2011 to May 2022. Given the fast pace of publication in the last decade and better access to publications, the present review will also include previous studies that have not been covered before.
- Providing a closer look at the methodology of published WRRS studies given the vast differences in quality between studies. Whilst we do not exclude papers on the grounds of methodology, we do take a critical stance, putting more weight on the studies we believe are superior in quality and therefore reporting results that are more dependable.
- Drawing on and relating to many previous attempts to synthesise the available academic knowledge about WRRS.
- Including research published on data drawn from non-commercial public sector organisations such as the emergency services.

METHOD

This section will discuss two very different aspects of methodology of research; 1) how the current review was undertaken, and 2) how the methodology of the studies included in the review should be interpreted. Several different broad methods of intervention which can be used in organisations have been identified.

REVIEW METHODOLOGY

Types of interventions and other safety approaches included in the review agree with Grayson and Helman (2011). We have included evaluations of interventions in the general area of driver training (including simulators), group discussions, incentive schemes, publicity, in-vehicle data recorders and organisational approaches (including safety climate and management). However, we also discuss factors which employers can use as safety interventions including driver selection and self-selection of drivers, drugs, fatigue, medical conditions, the size of vehicles.

DATABASES AND SEARCH TERMS USED

A general string of terms used to search databases was (occupational OR work OR fleet) AND (driver) AND (evaluation) AND (crash OR accident OR incident) AND intervention AND safety AND road. However, as different databases have different logics and content, the search string was slightly adapted at times. The databases used were Scopus, ScienceOpen, IEEE Explore, Google Scholar, ACM Digital and PubMed. All in all, 429 papers were returned by these searches, not including Google Scholar, which does not feature Boolean search operators.

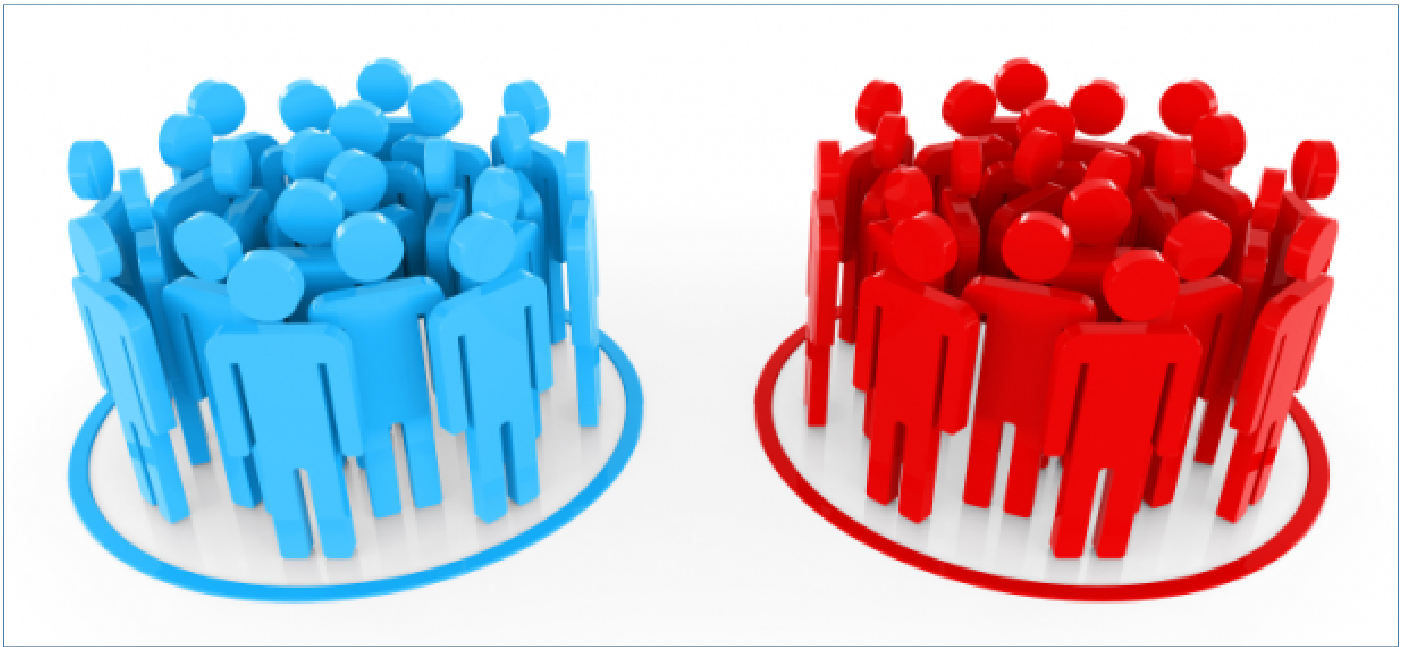
Very few of the papers included were found by this type of search. Instead, most papers were identified from other reviews on similar topics, which had used different search strings and databases. Apparently, the evidence concerning WRRS interventions is scattered over many areas of research, and the keywords and terminology used differ much between papers.

INCLUSION CRITERIA

We included studies and meta-analyses of evaluations of various safety interventions using crashes as the dependent variable (thus excluding for example self-reports and simulator studies). Case studies and quasi-experiments using such an outcome variable were accepted. If no such evaluation could be found for a certain subject, other relevant research was used to describe the case in question but noting that no intervention evidence is available. Although this was not a formal criterion, in practice, only English language papers were included. All types of publications were accepted.

EXPERIMENTAL FEATURES

As for all research, the use of an experimental setup should be the golden standard in road safety. This includes the random allocation of subjects into experimental and control groups. First, control groups are always needed when interventions are to be evaluated. Without a comparable group which has not experienced the intervention, it is impossible to say whether an effect in the experimental group is due to the intervention or something else. Most case studies are therefore excluded as a source of evidence for the effectiveness of an intervention but nonetheless are included in various sections as illustrative examples. Practitioners readily point to case studies as clear examples of how the organisational approach to fleet safety can achieve positive results. However, only positive outcomes tend to be reported in case studies and anecdotally, many organisations have implemented programmes without achieving any benefits. Case studies may demonstrate some interesting findings but provide limited information on how these results can be transferred for other organizations given the disparate nature of commercial fleets.



The only viable alternative method to a true experiment for evaluating an intervention is by statistical control of many variables which might, or might not, influence crash risk. Such variables are for example exposure, previous crash involvement etc. This method is not as reliable as the true experiment, as there is always the possibility of unknown factors, but is often used in field settings where random allocation of subjects and other experimental controls are not possible (see for example af Wåhlberg, 2007).

One important feature of experiments is that they do not vary more than one variable at a time. As pointed out by Grayson and Helman (2011), this contrasts with the standard procedure within organisations, where several different interventions and procedures are often implemented simultaneously. Added to this problem is the fact that these interventions are seldom well-documented. It is therefore very difficult to try to evaluate any specific intervention. An example of a case study suffering from these problems is that reported by Murray, Ison, Gallemore and Nijjar (2009).

LIMITED STUDY TIME PERIODS

One of the problems involved in many evaluations of interventions, but seldom noted by researchers or practitioners, is that the time periods used, especially after the intervention, are rather short. In essence, many studies might be able to ascertain that, for example, behaviour has changed, but if the change is not studied for more than a few months, any conclusion about a lasting effect is premature. An extreme case of this problem is eco-driving training, where trainers often claim effects of 10-20 percent fuel reduction. Such figures, however, are based on the difference achieved during training, rather than on follow-up after training. As will be described in more detail below, the effects of training in eco-driving are probably less than five percent fuel reduction over a twelve-month period.

OUTCOME VARIABLE

As noted by Grayson and Helman (2011), proxy variables have increasingly been used in WRRS research. This means that a dependent variable has been used which is thought to be closely associated with crash involvement instead of real crashes. Speed is a good example of this, but various other telematics-based variables are increasingly being used as proxies for crashes, with only face value validity e.g., harsh braking. In general, it can be said that there is currently no evidence available which indicates that any proxy variable has a strong enough correlation with crashes to be acceptable as a valid replacement for crashes. However, this is mainly true for individual differences (i.e., between individuals' comparisons), where correlations with crashes are usually around 0.1 (this means that only 1% of the variance is explained). Traffic offences, a commonly used safety proxy, has a mean correlation of 0.2 with crashes (Barraclough, af Wåhlberg, Freeman, Watson & Watson, 2016).

Intervention evaluations, on the other hand, are within individuals' comparisons, which might be different to between individuals. Unfortunately, there are extremely few studies which have tested whether a reduction in, for example, number of 'safety critical events' leads to a similar reduction in number of crashes. This type of research would seem to be limited to speed, often studied in relation to number of crashes and traffic offences. For the latter, some studies that reported that offences have decreased while crashes have remained at the same level (Lund & Williams, 1985), or even increased (Janke, 1994; see further the analysis in Masten & Peck, 2004). Other proxy variables would seem to draw their validity from studies on individual differences, with the strong limitations already noted.

SELF-REPORTS AS A PROXY VARIABLE

The use of self-reports would seem to be increasing in WRRS investigations as a method of evaluating fleet safety interventions, just as in traffic safety research in general. This is probably due to it being a cheap and deceptively easy method to use. Validity problems are not apparent unless specifically investigated, and most researchers choose not to do this, either in their own data or in the vast literature on this topic.

Briefly described, the problems of self-reports arise when they are used as both independent and dependent variables, which opens the door for what is called common method variance. This term refers to artefactual associations in data which are due to systematic measurement biases. For example, a badly calibrated tachometer which overestimates high speed more than low speeds, and from which acceleration values are calculated, would lead to an exaggerated association between speed and acceleration behaviour. For self-reports, several types of response biases can have this sort of effect.

Common method variance is a feature of between-individuals' investigations and are thus not relevant for evaluations. However, one of the most important self-report biases, social desirability, can create artefactual results in within-individuals designs too, although this has not been investigated to the same degree as common method variance. The point is that if people know the aim of the investigation (checking whether a training session led to changes), many people may feel compelled to respond positively (see af Wåhlberg, 2010, for a reverse effect of this mechanism). They might even believe this is the case, but as the connection between self-reports and actual behaviour is rather weak, this belief is not proof of any real change. Therefore, in WRRS evaluations, little weight should be attached to results which rely solely on a self-reported change in behaviour.

CULPABILITY FOR CRASHES: WHO IS TO BLAME?

One problem with using crash data in intervention studies is that the total number of crashes happening to drivers within a company is not a good dependent variable. This is because a fair percentage of these have not been caused by the drivers themselves, i.e., the crashes are not related to behaviour which is under their control. Therefore, changing the behaviour of the drivers within a company does not reduce their number of crashes to zero.

The percentage of culpable crashes in a group of drivers differs depending upon the exact definition used (see the review in af Wåhlberg, 2009), but an attempt to validate a definition of culpability yielded the estimate that about three quarters of all crashes within a company or organization have some element of culpability (af Wåhlberg & Dorn, 2007, see also Dorn & af Wåhlberg, 2018; af Wåhlberg, 2009a). These findings therefore question the extent to which organizations can claim that most crashes are beyond their control. Indeed, it appears that organizations have an opportunity can improve fleet safety to a large degree.

DISSEMINATION BIAS

In research synthesis studies (reviews, meta-analysis) it has long been known that some results are not published (the file drawer problem), delayed in publication, published in less well-known outlets, and less cited, due to their negative results. Grayson and Helman (2011) pointed out this problem for WRRS, especially concerning case studies and similar internal reports of companies or grey literature. Most companies would not like to make public a report which indicates lack of safety at any time, even if the intervention documents a WRRS improvement.

The problem involved is largely due to a lack of knowledge about statistics, as most people do not understand how much results may vary between studies due to factors which have nothing to do with the topic studied. Thus, two evaluations of the same intervention in the same company might yield very different results, although the true effect might be the same. This might be due to factors such as being undertaken in different departments, with personnel with different jobs and qualities, differences in timing (right before or after holidays) etc. It is very likely that the negative report will simply be buried and never referred to. The present authors know of several such cases, both in industry and in academia.

The cumulative effect of dissemination bias will be to paint an overly positive picture of interventions which might have little impact, or even are harmful. As it is usually impossible to find all the negative results on a topic, more weight should be put on results which carry less of this risk (independent researcher, large samples, experimental design, randomly allocated subjects etc). Within medicine, trial protocols and treatment of results are now being recorded with an official central organisation before they are undertaken, to prevent the suppression of certain results after the fact. Certain countries mandate registration of trials, while several funding agencies and official bodies strongly recommend it.

LITERATURE REVIEW: DRIVER TRAINING AND EDUCATION

There are many types of driver training, and the only apparent commonality between them is the presence of a (professional) teacher. They are often skills-based (i.e., vehicle handling), but have over time come to include more and more higher-order skills (defensive driving), knowledge and attitudes, thus becoming more like traditional school education.

This section is rather brief, because we agree with previous authors of reviews and meta-analyses that there is no good evidence supporting driver training and/or education as a useful intervention for improving WRRS (Grayson & Helman, 2011). On the contrary, the evidence suggests that there is no safety effect at all. This has been the general conclusion within the research community for several decades (e.g., Christie, 2001; Klein, 1966), and the evidence is very strong. Due to the many existing meta-analyses and reviews on driver training (licensing, post-licensing and remedial), we chose to only describe those, instead of all the available material.

Ker et al., (2005) meta-analysed twenty-one studies with more than 300,000 participants, comparing advanced and remedial driver education to controls, and found virtually no effect at all. Masten and Peck (2004) meta-analysed thirty-five studies on different interventions for drivers with bad driving records (crashes/violations). Some of these included a weak educational content (written information), which had no effect on crashes. Apparently, all these studies were from the US.

DRIVER TRAINING AND EDUCATION

Systematic reviews on driver education and training have also been published. Roberts and Kwan (2008) reviewed three studies on school-based driver training and concluded that there were no positive safety effects of this type of intervention compared with schools that had not implemented classroom-based education. On the contrary, there was a possibility that driver education in schools lead to earlier licensing and an increased risk as participants were able to drive at a lower age and this increased their exposure to risk. Scientific studies specifically on training within a fleet context have also been reviewed by Downs, Keigan, Maycock and Grayson (1999). They came to the same conclusion as other reviewers; driver training has no safety effect. No updated review or meta-analysis of this topic has been found.

A few studies have found that (professional) driver training might even have negative effects, at least if it focuses on sheer mechanical skills (Gregersen, 1996; Katila, Keskinen, Hatakka & Laapotti, 2004; see also Ferdun, Peck & Coppin, 1967). Also, the effect for educational content was found to have a negative sign in the meta-analysis by Masten and Peck (2004), meaning an increase in crashes, although this was not significant. This type of perverse effect cannot be said to be proven, but neither has it been well researched, and the possibility remains that some drivers are negatively influenced by developing over confidence in their driving skills and taking more risks, thus cancelling out the possible positive effects for other drivers.

For recommendations about truck driver training, based upon other evidence than crash reduction studies, see Staplin, Lococo, Decina and Berghoffen (2004). Similarly, Unsworth and Baker (2014) reviewed evidence concerning the effectiveness of skills-based driver training for traffic offenders led by occupational therapists. The researchers claimed that this form of training was effective, based on whether the clients passed a driving test as opposed to some apparent change in behaviour (e.g., lower offending rates, reduce crash involvement post-training). However, no evidence of the validity of driving test as a method to determine safety was presented. Still today, skills-based driver training continues to be used in organisations (Lancaster & Ward, 2002, reported training as the most common safety intervention in organisations) and recommended by authorities as a way of improving fleet safety.

GROUP DISCUSSIONS

One of the most well-known interventions in driving safety was undertaken in Sweden in the national telephone company (Gregersen, Brehmer & Morén, 1996). Apart from comparing four different interventions, being large and long-term, it is also one of the most scientifically rigorous intervention evaluations within traffic safety. The most successful type of intervention was found to be group discussions.
This included a 60-minute 'warm-up' period of free discussion; a 40-minute discussion to identify problems at the workplace; a 20-minute meeting to discuss results of the previous stage; a small group discussion of the problems and how to resolve them and a 60-minute plenary session to plan and commit to future action. Compared with the control group and other interventions (including skills-based driver training), the group discussion intervention reduced crash involvement by more than half (before/after periods of two years). This result can be contrasted with that of Masten and Peck (2004), who meta-analysed studies of state-run interventions for problem drivers. In this analysis, group discussions had a minimal effect (d = 0.023, 5% reduction in crashes). The difference between these two results can probably be explained with reference to the difference in settings: work improvement versus a sort of punishment. Also, the drivers in the Gregersen study were colleagues who would have expected to work together for a long time (and thus being accountable to each other), while the problem drivers in Masten and Peck would expect never to meet again.

The intervention evaluated by Gregersen et al. was modelled after the results from Japan reported by Misumi (1989), who reported impressive results for the discussion method for bus drivers. However, this paper is a short summary of many studies undertaken over the decades, and little information is available concerning possible threats to validity. Also, a paper by Salminen (2008) is often mentioned in reviews of WRRS. This was a replication of the Gregersen study in a similar setting (electricians) and reported a strong reduction in crashes. In contrast to the Gregersen study, however, it did not feature a control group, and many details of the methodology are vague. It is therefore not considered fully reliable here.

In summary, the group discussion approach has a sound theoretical basis, there is at least one empirical study that attests to its effectiveness and is financially beneficial compared with other types of interventions. However, no properly controlled investigations have been carried out to take forward or even replicate this study.

COACHING

Coaching is a method of instruction which has similarities to teaching, supervision, and mentoring. What sets it slightly apart from these other methods is the emphasis on one-to-one work, that the coach does not have authority over the coachee, and that performance, not knowledge, is the usual content. Coaching is an international industry, with professional coaches teaching (coaching) any kind of subject. However, this is not a pre-requisite, and other approaches exist, for example peer-to-peer coaching (which in many ways is simply more experienced workers instructing newcomers although in a more formalized way). As with all kinds of professional teaching and similar services, professional coaches claim large successes for their work. Evaluations, however, are scant. We have found none for driving safety.

ECODRIVING TRAINING

One interesting sub-class of interventions, which has apparently not been covered before in WRRS reviews is training in ecodriving with the objective of saving fuel as many drivers' waste fuel due to behaviours such strong acceleration and braking, which have no positive effect on mean speed. From a WRRS perspective, what is interesting is that fuel consumption is rather easily and objectively measured, and fuel has statistical properties which are very superior to those of crashes (as it can be measured continuously). Therefore, if there is a strong association between fuel consumption and crashes, the former should make an excellent safety proxy, apart from the fact that it is important for both economy and the environment. Somewhat strangely, no study which calculates if fuel-wasting drivers are also dangerous has been found.

Only af Wåhlberg (2007) seems to have included a measure of crashes in an evaluation of ecodriving training. This study was set in a bus company, with a post-training period of 12 months and a total of some 350 drivers. Unfortunately, the control group was neither randomly assigned, nor equal in size to the intervention groups. Furthermore, fuel and acceleration data indicated that the effect was only about two percent. It is therefore not surprising that no significant effect of training on crashes was found. Such a small effect could not possibly be reliably detected with this size of sample and mean level of crashes.

There are several studies which have reported positive effects of ecodriving training on fuel consumption, but all of them would seem to have some sort of methodological shortcoming, notably that comparisons between pre- and post-training time periods have not held differences in temperature constant (e.g., Beusen et al., 2009; Sullman, Dorn & Niemi, 2015). This bias can strongly influence the results (Degraeuwe & Beusen, 2013). Pinchasik, Hovi, Bø and Mjøsund (2021) used a randomized and in general well-controlled design in testing the effects of ecodriving training (including incentives etc) and reported an effect of 5-9 percent. However, despite the design, it is still possible that the analysis did not fully control for differences in temperature. Other methodological shortcomings of ecodriving studies are lack of control groups, very short time periods for evaluation and artificial testing (simulator or test route). It is also very common that companies with commercial interests in this area publish reports. These usually lack all details concerning the methodology used and are thus not possible to evaluate. In summary, no reliable studies on safety effects of ecodriving training and similar techniques have been found. Furthermore, even if fuel consumption is accepted as a proxy for safety, there are very few reliable studies available anyway.

TRAINING SIMULATORS

Simulators have for long been very popular for training within aviation, and this trend has to some degree been imported into the ground transportation industry (e.g., Staplin, Lococo, Decina & Berghoffen, 2004). However, no published evaluations using crashes as criteria have been found. In our own experience, we have evaluated one simulator, used for training of bus drivers. This report is still unpublished due to lack of approval from the organisation. We were not able to design a proper experiment, instead we were called in after the simulator had been used for several years. We were able to isolate two comparable samples with and without training, under the assumption, and as assured by the company, that allocation to the simulator-based training had been random. The results indicated that drivers who had been trained in the simulator caused more crashes than those that had not taken part in the simulator-based training. It is our belief that there was really no effect of the simulator on crash involvement and that the peculiar result was due to the subjects not being randomly allocated as previously thought.

SAFETY CLIMATE/CULTURE AND ORGANISATIONAL FACTORS

Organisations have many opportunities to influence traffic safety among their employees, and most seem to take this seriously and try to implement rules and interventions for this end (Lancaster & Ward, 2002). However, this has never been an easy undertaking. For example, organisations may be very large, and experiences, beliefs and knowledge may differ a lot between different people at different levels in the hierarchies. Therefore, what would seem to be a straightforward method at one level may be resisted by others.

Apparently, safety in general is usually measured in proxy form in organisational research, for example rule compliance (e.g., Pilbeam, Doherty, Davidson & Denyer, 2016) instead of in terms of accidents. For a previous review on organisational factors, see Mooren, Grzebieta, Williamson, Olivier and Friswell (2014). We agree with these authors that there is very little reliable evidence concerning organisational factors and traffic safety. In fact, no experimental interventions have been found, and the only relevant evidence would seem to be comparisons between different companies. For an overview of organisational factors which can be used to improve safety in the trucking industry based upon case studies, see Camden, Hanowski and Hickman (2019) and for a similar approach see Knipling, Hickman and Berghoffen (2003).

The concept of companies having a general attitude or thinking about safety, which differs between firms and correspond to their safety level, has gained much popularity in recent decades. Indeed, it has become so well established that it is commonly used as a proxy safety variable, i.e., it replaces actual safety as dependent variable in some studies (e.g., the review by Nævestad, Hesjevoll, & Phillips, 2018). However, apart from being a somewhat elusive concept which is difficult to measure, it is very weakly related to safety records. Furthermore, no evaluations have been found of interventions where safety climate has been manipulated and the expected resulting safety increase (in terms of crashes) has been measured. The concept of safety culture must therefore currently be seen as speculative and not a proven factor in organisational safety. However, this lack of evidence should not be seen as proof that the concept is unimportant, but rather of the immaturity of the measurement methods involved.

SAFETY CLIMATE/CULTURE AND ORGANISATIONAL FACTORS

Turning to case studies, Wallington, Murray, Darby, Raeside and Ison (2014) reported on a multi-intervention in a large company over ten years' time. It included dozens of different attempts to increase safety, covering all levels of employees, vehicles, and even the surrounding community. With all these interventions in place and controlling for the general safety trend in Britain at the time, effects can be estimated to about 2-3 percent per year. Similarly, Murray, Ison, Gallemore and Nijjar (2009) reported on an intervention in another large British company, with similar results. However, the lack of a control group makes the results difficult to evaluate. During the latter part of the time of these studies, a British bus company experienced a much stronger decline in number of crashes (af Wåhlberg & Dorn, 2019), without any comprehensive safety program but apparently due to the economic recession.

Yet another study which can be said to fall under the safety climate heading is that of Goettee, Spiegel, Tarr, Campanian and Grill (2015). In this project, new truck carriers were trained in the applicable regulations and inspections to foster a good safety culture, and their number of crashes were compared to controls from other states. This would thus seem to be at least a quasi-experimental study. However, participation was voluntary and not very high, which opens the possibility of bias due to self-selection, which could explain the better performance of the trained carriers versus controls in the first part of the project. In the second part, carriers who declined being trained were safer than those who were trained. All in all, this study cannot be deemed to present any evidence which indicates that safety in companies can be increased by increasing knowledge of safety regulations.

Benchmarking is a systematic approach to measuring various indicators within an organization and establishing a baseline so that a company's safety performance can be compared with others. This approach has been recommended for driving safety too by Mooren, Searles, Benc, Creef and Wall (2012). However, no evidence was forwarded concerning whether this had worked in any company, and no evaluation of such an intervention has been found except for the Wallington et al case study reported in this section. However, the effects of benchmarking are difficult to disentangle from other interventions and the effects reported overall were extremely small.

All the factors described above have been identified in meta-analyses of studies on crash risk, not proxy variables. In the Lancaster and Ward (2002) review of such factors all kinds of proxy variables were included, and the review was not systematic. Their factors/recommendations therefore differ from the present ones.

INCENTIVE PROGRAMMES

Safety incentive programmes are rewards for adhering to fleet safety standards and regulations and are expected to motivate fleet drivers to commit to safer behaviour. Motivation is one of the key elements for a behavioural safety approach and safety incentives have been used widely in the industry to achieve and sustain an improved level of safety performance. However, for traffic safety, the focus is on punishing bad behaviour whilst good behaviour goes unrewarded. A bonus system was one of the four measures studied in the Gregersen et al (1996) study showing a significant 23% reduction in crash rate for the two-years post intervention. Many organisations operate incentive and reward systems, but there is no published evidence on the effectiveness of such schemes.

From an organizational perspective, Downing (et al, 2004) explained that the effectiveness of the incentive scheme depends on the focus of the safety programme. Highlighting further that punishment, also referred to as negative incentive (reprimands, fines, dismissals etc.), are ineffective ways of preventing unsafe behaviour instead, will encourage non/under-reporting of incidents, leading to a riskier environment and likely incidents. Even the best safety incentive scheme cannot make a bad fleet risk management programme any better.

IN-VEHICLE RECORDERS/TELEMATICS/ OTHER TECHNOLOGICAL INTERVENTIONS

The use of electronic surveillance of professional drivers has skyrocketed in the transportation industry in the last twenty years. Research on its safety effects, on the other hand, was largely carried out before this sharp increase in use. We thus agree with Grayson and Helman (2011) that evidence for this type of intervention is scant and weak. Here, what little is known with regards the results of well-designed studies will be described, partitioned into different sections. One important feature of telematics systems is whether they provide immediate feedback while driving, or a summary after the journey, or both. Thereafter, the type of measurement that is used can be placed into some broad factors

There are two ways in which telematic systems can be used to improve driver behaviour; by giving specific feedback about what is happening in real time, and by summaries of behaviour over trip, day, week etc. The advantage of the former is that it is easier for the drivers to associate their behaviour with the outcomes, but the disadvantage is that it might distract the drivers. Furthermore, these two kinds of feedback can be used in two main ways: as feedback directly to the drivers, or by sending the information to someone in charge (parent or supervisor).

TELEMATICS AND DETECTING RISK

There are any number of systems being designed and tested which purports to detect some aspect of driving risk, for example monitoring of driver health (Hayashi, Kamezaki & Sugano, 2016). Most of these use accelerometers and try to detect 'risky events' or similar features of driving, i.e., certain moments in time when the designers believe risk of crash is higher than at other times. This kind of system has been developed many times for both smartphones (e.g., Sasidhar & Upasini, 2019) and specific in-vehicle recorders. What is a common thread amongst these systems is that the designers believe that they can subjectively decide which type of manoeuvre (event) is dangerous, and therefore do not even try to validate the measurements against crashes (for the only known exceptions, see Guo, Klauer, Hankey & Dingus, 2010; Khorram, af Wåhlberg & Tavakoli, 2020).

Furthermore, few of these systems have been implemented in a behaviour change design (although many companies claim that they do change behaviour, as described above). However, no evaluations seem to have been published.

EVALUATIONS OF TELEMATIC FEEDBACK INTERVENTIONS

At least thirty evaluations of interventions based in technological feedback have been published. However, most of them suffer from one or several deficits in methodology and/or reporting. The only well-conducted study would seem to be that of Wouters and Bos (2000) in the Netherlands. Featuring some 800 vehicles of different kinds, randomisation and matching procedures, several control groups and 1 year before and after time periods, the validity of the study would seem to be unrivalled. The results are also impressive with 20-30 percent reduction in crashes. This is even more so considering that there was no real feedback; the study was designed only to test whether surveillance as such would alter behaviour. Similar results for fuel consumption have been reported by Liimatainen (2011) and af Wåhlberg (2007).

CASE STUDY: Telematics Feedback

The Floow, is a UK based data analytics company working with major insurers around the world to provide telematics-based apps for scoring driver behaviour. After each journey, a score is generated to indicate driver risk across a number of key driver behaviour components including Contextual Speed, Time of Day, Smooth Driving, Road Risk and Distraction. Distraction is measured according to active mobile phone engagement levels including call state throughout a journey. The resulting driver score allows feedback to the driver immediately after every journey.

FloowCoach is a twelve-week four call phone-based coaching programme for those drivers scoring in the bottom decile to develop safer coping strategies and reinforce new behaviours over subsequent phone calls. An action plan with specific goals is also agreed based on behavioural strategies to improve driver score. FloowCoach was evaluated in December 2019 with 482 drivers received 1 call, 235 drivers received 2 calls, 219 drivers received 3 calls and 276 drivers graduated from the programme and received all four calls. 2,190 drivers were in the control group constructed from those customers that could not becontacted. The groups were compared according to the insurance claims frequency Vs the control group. The findings showed that compared with the control group, drivers in call 1 group made 10% fewer claims than expected, for call 2 group there were 24% fewer claims, for call 3 group there were 3% more claims and for call 4 group there were 20% fewer claims than expected. Overall, it was found that compared with the control group, the experimental group made 12.5% fewer claims. This suggests that longer term behavioural changes using telematics in conjunction with telephone-based coaching can be achieved.

EVALUATIONS OF TELEMATIC FEEDBACK INTERVENTIONS

There is only one other evaluation study using crashes as outcome variable which is considered reliable. Larson et al. (1980) evaluated an intervention among police drivers, where tachograph data was given to supervisors and used as basis for (positive and negative) feedback to the drivers. Crashes and costs for these were reduced by 40-50 percent over up to 1.5 years. The drawback of this study is the lack of a control group. Although the crash rate for the police department before the intervention had been monitored for at least 1.5 years, the possibility of a regression to the mean effect is still viable.

Other evaluation studies of technologically based feedback, which are not considered reliable here, although they did use crashes as a dependent variable, include Lehmann and Cheale (1998), Levick (2009), Levick and Swanson (2005), McGehee et al. (2007), Musicant, Lotan and Toledo (2007), Simons-Morton et al. (2013), and Toledo, Musicant and Lotan (2008). More than a dozen other studies have used various proxy safety outcomes instead of crashes and are not considered here.

However, after having studied the commercial information provided by dozens of companies offering solutions, the present authors can conclude that not even one of them have provided any meaningful data which can be used to evaluate their product in a fleet setting. In an insurance setting however, with access to claims, insurance companies can regress the telematics scores on to claims data over a reasonably long period and confirm that scores are predictive of crash involvement. The results of such pilots have never been published due to commercial sensitivities. The implications are that companies should seek the advice from insurance companies about which telematic systems might be most accurate and effective.

INTELLIGENT SPEED ADAPTATION

Intelligent Speed Adaptation (ISA) was really the first kind of telematics safety system in driving. However, it differs in several ways from most current systems, which are based upon event detection, as described above. While event-based systems usually do not take the driving environment into account (which is a serious weakness of these systems), ISA is connected to a road database and GPS, and works by comparing the speed limit to the actual speed. It is important to point out the basic assumption of ISA; that risk of crashing is mainly due to speed in excess of the speed limit. This assumption has not really been proven, as most research measures speed, not speeding. If the limit is exceeded, some different actions might result (i.e., feedback). In the most prohibitive variant, the ISA system controls the engine and simply cuts the throttle, while in others, there is feedback from an active accelerator or just a display or auditory signal. All of these constitute immediate feedback. It does not try to detect 'risky events' or similar in terms of deceleration profiles etc. Most evaluation trials of ISA systems have focused on usability, subjective perceptions and speed behaviour (e.g., Wall et al., 2009). There is therefore surprisingly little information available about whether ISA systems do reduce collision involvement. We have found no such evaluations.

CASE STUDY: Intelligent Speed Adaptation

In 2015, Transport for London (TfL) launched a trial of intelligent speed assistance (ISA) technology in London with the installation of ISA devices on all buses travelling on two of its major London bus routes. The ISA devices used a digital speed limit map of London, developed by TfL, and GPS data to identify the prevailing speed limits throughout each vehicle's journey. The device then limited acceleration of the bus beyond the posted speed limit. Data collected before the trial indicated that speed compliance issues mostly took place during the late evening; on off-route sections of the journey (e.g., between the bus depot and the start/end of the bus journey); and on 20mph roads. The trials were adapted to take this information into account. It was made clear to drivers that ISA is only a driver aid, and that they were responsible for control of their vehicle at all times and ensuring that they did not travel above the posted speed limit.

The results of the trial were largely positive. TfL bus drivers demonstrated increased compliance with local speed limits, although this compliance was less common on downhill stretches of road. There were no adverse effects on driver behaviour reported after the technology was fitted. Although there was no significant effect on fuel usage during the ISA trial, there was some evidence of improved emissions in 20mph zones and data-modelling indicated that there would be marginal safety improvements if ISA was installed within the TfL bus fleet. Some drivers reported experiencing an increase in negative attention from passengers and other road users who felt that the installation of ISA caused unnecessary delays; however, passengers were generally more accepting of the system once its purpose had been explained. TfL has now begun roll out of ISA on all new buses.

SEAT BELT COMPLIANCE

Seat belt use is in some ways is slightly outside the bounds of the present review. In theory, such an intervention should not influence the frequency of crashes at all but reduce the number of injuries. Therefore, it is of some interest in the context of WRRS, and some material concerning this has been located.

Mainly, interested readers are recommended the summary of interventions for increased safety belt use by Geller, Rudd Kalshner Streef and Lehman (1987). This paper concerned the use of various behaviourist methods and found that most studies had reported strong increases in use over periods of several years, notably a method without any rewards. However, none of the studies used a control group.

Mortimer, Goldsteen, Armstrong and Macrina (1990) reported weak effects of incentives on seatbelt wearing, using a city-wide approach with similar cities as controls. However, the incentive used was designed to increase belt-wearing among occasional wearers rather than habitual non-wearers. Better evidence was presented in Ludvig and Geller (1991), where several control groups were used. Seatbelt wearing was influenced by a sort of discussion group, somewhat like the format used by Gregersen et al. (1996). The effect was well above a 100 percent increase.

VEHICLE SIZE

One aspect of WRRS which has not been discussed much in the scientific literature is the safety effect of how large and heavy the vehicle is. What little information exists about this feature is largely from the US and concern heavy trucks. In contrast to the intuitive beliefs of many people, this evidence suggests that heavier trucks are slightly safer than lighter ones (af Wåhlberg, 2008). If the effect of less exposure due to fewer vehicles on the road is added, heavier vehicles at fleet level are much safer, to a degree that corresponds to the increased amount of goods they can carry and more. It is important to note that heavy vehicles are especially safer on low-risk highways and motorways and that it is used to its full capacity to improve sustainability.

However, a heavy vehicle entering a built-up environment may increase the risks for vulnerable road users such as pedestrians and cyclists. This principle can also be applied to vans, although no research has been found on this topic.

TIME OF DAY

Humans have circadian rhythms which make us sleepy at certain times of the day. There is fair evidence that this increases risk when driving. The most reported result is an elevated risk during the night, peaking strongly somewhere between 02-05 am (Folkard, 1997; Hamelin, 1987; Langlois, Smolensky, Hsi & Weir, 1985). Also, a lower peak sometime after noon has also been reported, but studies disagree about exactly when this happens.

These results are based on rather large, aggregated crash datasets, and they are in that sense reliable. However, there is some variation between studies, probably due to exposure factors which have not been held constant, and especially the influence of different cultures is unknown. For example, the effect of different sleep habits has not been studied. Differences could be expected between cold countries, where few people sleep during the day, and hotter countries, where some sort of siesta during the hottest hours of the day would seem to be common.

These results are mainly based upon private car drivers, while results for professional drivers are somewhat different (Pokorny, Blom & van Leeuwen, 1987; af Wåhlberg, 2009b). One of the possible explanations for this is that time for driving is to some degree under voluntary control for private drivers, i.e., day and night-time drivers are to some degree self-selected and therefore not directly comparable.

The scientific literature thus agrees upon the fact that there are strong (up to about five-fold risk) fluctuations in crash risk over time of day, but not exactly when these happen. The probable explanation for this is that this is not a universal phenomenon in terms of exact time, but dependent upon local and individual sleep and work habits etc.

No intervention to improve fleet safety based upon time-of-day risk differences has been found.

FATIGUE, SLEEPINESS AND TIME ON TASK

In a case-control design to investigate the risk factors associated with occupational road accidents, Fort et al (2010) identified several factors relating to scheduling and fatigue management as contributing to increased risk of crash involvement. Fatigue and the commonly resulting sleepiness have been found to be risk factors in driving (Tregear, Reston, Schoelles & Phillips, 2009 (sleep apnoea); Bioulac et al, 2017 (sleepiness while driving). Professional drivers often drive for many hours per day, and this might lead to fatigue and generally reduced driving performance.

Several studies have found an increased risk of crash as the day progresses, i.e., increased fatigue with increased hours of service, although this is not a simple linear function. Most industrialized nations have therefore introduced rules for how much professionals are allowed to drive, per day and week. For organisations who have drivers in countries without such rules, or lax enforcement, it could probably pay off to implement policies for hours of driving, although no intervention of this type has been found.

DRUGS

The high risk of road crashes resulting from use of alcohol and illegal drugs is well known (Li et al., 2011; Rapoport, Lanctot, Streiner & Herrmann, 2009; Rogeberg & Elvik, 2016; Taylor et al, 2010), but no studies specifically evaluating an intervention to reduce drugged driving behaviour in an organizational setting has been found. For a review on interventions for non-occupational populations, see Razaghizad et al. (2021).

DRIVER SELECTION

It is well known that drivers differ in their tendency to cause crashes. What is less well known, and accepted, within the research community, is that this tendency is stable over decades (af Wåhlberg, 2009a). This means that there is much to gain in trying to select the right drivers from the start. This can be done by applying some rather well established facts about what increases crash risk; illegal drugs and alcohol (Rapoport, Lanctot, Streiner & Herrmann, 2009; Rogeberg & Elvik, 2016; Taylor et al., 2010), medical conditions and medication (Elvik, 2013; Rapoport et al., 2019; Vaa, 2013), in-experience (Bruning, 1989; see also Duke, Guest & Boggess, 2010 about the confounded effects of age) and driving offences (Barraclough, af Wåhlberg, Freeman, Watson & Watson, 2016). On the other hand, some factors only show a very slight elevation of risk such as ADHD (Vaa, 2014), and self-reported personality (af Wåhlberg, Barraclough & Freeman, 2016).

In terms of current practise with regards the selection of drivers, some companies use profiling tools that can be used to highlight those individuals that may represent a greater risk when driving for work. The intention is to use the driver profiles in the induction period to address the risks identified. Below are two case studies to highlight current practise in the use of profiling tools. Whilst these results may be compelling, the studies have not been peer-reviewed.

CASE STUDY: Driver Selection

Nottingham City Transport (NCT) is the principal bus service operation in the city of Nottingham in the UK. Prior to 2009, NCT took a largely traditional approach to bus driver recruitment, whereby driver skills and knowledge were evaluated during a short period of instructor-supervised driving. However, this approach was highly subjective, limited in scope and not consistent with real-world driver behaviour. Using a validated profiling tool, the new recruitment process included assessments of driver attitude and behavioural risk factors that were subsequently addressed during the induction training period.

Between 2009 and 2016, NCT assessed 1,100 potential freight drivers using the new selection method and recruited 600 new drivers. In the first six years the organisation saw more than 20% decrease in the frequency of 'at fault' crashes among its drivers.

DRIVER SELECTION

CASE STUDY: Driver Selection

The iconic Greyhound Lines US Bus Company noted a link between its new-hire drivers and high crash frequency with 33% of all vehicle collisions involved new-hire drivers between 2013 and 2014. Greyhound had a well-established and evidence-based training process that centred on driver knowledge and skills and post-recruitment induction and training was carried out in a 'sterile' training environment under the supervision of an experienced driver.

The training environment neglected to consider the significant operating pressures that often influence drivers within bus fleets, including service scheduling; passenger interaction; and stressful driving conditions. To assess how its new drivers would react to these pressures, Greyhound introduced a validated profiling tool in 2014 to target the training of new-hire drivers; to improve drivers' awareness of their driving behaviour; and to enable drivers to self-mitigate risk factors by developing effective coping strategies. In the first year that the assessment was implemented, the percentage of vehicle collisions involving new-hire drivers reduced by 57%, and between 2014 and 2016 the number of crashes involving new hire drivers fell from 33% to 19%.

Following the introduction of the assessments, the worst performing area of the fleet (Northeastern USA), which experiences adverse weather conditions and high congestion levels, experienced a 51% reduction in collisions between 2014 and 2016. In New York City the number of collisions involving new-hire drivers fell from 40% to 7% over the same period.

There are some driver risk profiling instruments being offered by commercial companies, but it has not been possible to find any sound evidence for any of these. Similarly, several studies have been published about the development and testing of various types of testing instruments, but few have been evaluated against crashes. One exception is Wang et al. (2016), who put together several different measures of perception and cognition into a test battery and validated this against samples of Chinese bus drivers with and without culpable crashes in the last three years. The resulting effect sizes were quite strong.

DRIVER SELECTION

The results indicated that drivers with accident history within three years performed overwhelmingly worse ($p < 0.001$) on dark adaptation, dynamic visual acuity, depth perception, attention concentration, attention span, and significantly worse ($p < 0.05$) on reaction to complex tasks compared with drivers with clear accident records. Although no summary analysis of the total predictive power of all variables was presented, the results are interesting. However, it should also be remembered that several studies on cognitive factors and crash involvement have been published, with very small effects reported (e.g., Brown & Ghiselli, 1948; Goode et al., 1998; Legree, Heffner, Psotka, Martin & Medsker, 2003; Marcotte et al., 2006; Stutts, Stewart & Martell, 1998). In general, cognitive factors have therefore not been shown to be strongly predictive of crash involvement, and although the Wang study probably profited from using culpable crashes only and high variation in the accident variable, a systematic meta-analysis of the available evidence on cognition would be needed to resolve this discrepancy. No evaluation of an intervention based upon selection of drivers has been found.

DRIVER TURNOVER

There is little research on the relationship between professional drivers' tendency to change jobs and their accident risk, but a few studies indicate that a correlation may exist (Bruning, 1989; Cantor, Corsi, Grimm, & Özpolat, 2010; Staplin & Gish, 2005; af Wåhlberg & Dorn, 2018, but see also Häkkinen, 1979 for contrary results). This means that the drivers with more crashes on record tend to leave their employ.

As the tendency to cause crashes is highly stable over time (af Wåhlberg, 2009a), allowing such people to leave instead of re-training them or using some other type of remedial intervention is probably good for WRRS.

COMMUNICATION CAMPAIGNS

The Swedish Televerket study by Gregersen et al (1996) included what they termed a 'campaign' group comprising of five staff meetings during the year. Here, seasonal problems for driving were discussed, videos were shown, and publicity material was distributed. The results of the experiment indicated that this was the only one of the four intervention groups not to show a decrease in crash rate. Community road safety campaigns in an organisational setting were also reported in the review by Ludvig & Geller (1999) of behavioural change interventions over a 10-year period. Their review covered a range of procedures, such as promise cards, performance feedback, pledge cards, and safety reminders. However, only behavioural outcome measures were assessed. There is no hard evidence in the literature that the interventions described above are effective in improving WRRS.

CASE STUDY: Communication Campaigns

Arriva Bus UK were involved in eight collisions with pedestrians in Leicester city centre in 2018, and a further five in the following five months – including one death. Leicestershire Police confirmed that this issue was not isolated to Arriva but all bus companies across the city. Analysis showed more than 65% of bus collisions with pedestrians in Leicester city centre involved the pedestrian being distracted. In 2019 Arriva created an awareness campaign with physical branding, social media, and pedestrian interaction days, to highlight the dangers of being distracted while crossing the road. The campaign had two main slogans: "Don't play games with your life", and "Don't let that song be your last".

To get other stakeholders on board, Arriva approached the city council, Leicestershire Police, and another bus company, to ask for their support. It was agreed that all buses would have campaign branding, as well as every bus shelter in the city centre. A joint social media campaign was launched, and a pedestrian awareness day, where all four stakeholders came together to publicise the campaign reaching over 300,000 people. A reduction of 60% in bus/pedestrian collisions in Leicestershire city centre was reported but without a control group and randomization, it cannot be known with any certainty that the communication campaign was responsible for this reduction.

OTHER TYPES OF INTERVENTIONS

During the literature searches, we found some evaluations which are not specific to WRRS, but which could in principle be implemented within organisations. In France, a type of motivational intervention for young drivers was delivered for several years. The drivers signed a contract on safe driving, which also gave them some financial benefits. This intervention was evaluated using crash data from the geographical county where the experiment was taking place. This evaluation used crashes as dependent variable, three control groups (other counties), a two-year follow-up period and large samples (about 1600 drivers in the experimental group), and the results indicated a lower risk in the county, although this was not significant (Carcallion, Rachid Salmi & Atout-Route Evaluation Group, 2005). Methodologically, the study can still not be said to be good evidence, due to the self-selection of the intervention group, but also because crashes could not be specifically tied to the drivers participating in the study. Also, several other interventions were implemented simultaneously in the county, and although the authors tried to disentangle these effects, this was not possible for all of them. Motivational contracting may therefore be a possibility for improving WRRS, but there is no proven effect.

LOW- AND MIDDLE-INCOME COUNTRIES

Most of the research reviewed here has been conducted in high income countries yet most of the world's traffic deaths occur in low- and middle-income countries and the share is rising (WHO 2015). Fatality rates are also high at the city level in developing countries (Welle et al, 2015). Low- and middle-income countries also have higher levels of traffic deaths among pedestrians, bicyclists, and motorcyclists. Most of the road safety measures instituted in high-income countries are focused on vehicles and vehicle occupants. However, in developing countries, motorcycles dominate the road along with human powered vehicles, pedestrians and even animal driven carts. Even if all the measures implemented in high-income countries, including its infrastructure, are effectively transferred to developing countries, the result are unlikely to be comparable with that seen in high-income countries, mainly because of a differing traffic mix.

One of the key points in bringing down the road fatalities and injuries in high-income countries is the availability of vehicles that provide greater safety to the occupants in crashes. In contrast, many low- income countries do not have such regulations. By introducing new car assessment programmes (NCAP) and legislating minimum acceptable rating in these, vehicle standards has been greatly improved in high-income countries. In high-income countries, an established set of interventions have contributed to significant reductions in the incidence and impact of road traffic injuries. These include the enforcement of legislation to control speed and alcohol consumption, mandating the use of seatbelts and crash helmets and safer design of roads and vehicles (WHO, 2004). Despite traffic growth in developed countries (for example Australia, France, Sweden, Canada etc.), the frequency of road fatalities is declining. This can be mainly attributed to the improvements in vehicle standards, road design, modern traffic management, effective law enforcement, driver licensing procedures, duly supported by emergency services and medical treatment in case of crashes taking place. Only 28 countries, representing 416 million people (7% of the world's population), have adequate laws that address all 5 risk behavioural factors (speed, drink driving, crash helmets, seatbelts and child restraints) (Ruikar, 2013).

There also appears to be differences in how road users perceive risk according to a nation's wealth. A cross cultural study (Nordfjærn, Şimşekoğlu and Rundmo, 2014) assessed road traffic risk perception, risk sensitivity and risk willingness across low income countries in Africa (Ghana, Tanzania and Uganda) and middle income countries (India, Russia) and in a high income country (Norway). The study showed that individuals in sub-Saharan Africa perceive higher levels of road traffic risk and were more willing to take risks than middle- and high-income country participants. the study also showed that Norwegians reported safer road traffic behaviour particularly with drink driving, speeding and use of seatbelts. The detailed country analysis showed that Ghana reported safer behaviour, suggesting that Ghana has progressed further in their road safety journey compared with Tanzania and Uganda. More importantly, the study highlighted that the model using perceptions of risk, demographic characteristics, and road traffic attitudes to predict driver behaviour did not fit for the three low-income countries in Africa. Other studies have evaluated cultural differences in hazard perception skills (Lim, Sheppard & Crundall, 2013) showing that both experienced and novice drivers from a developing country (Malaysia) were slower than developed country drivers (United Kingdom) in reacting to hazards. It therefore cannot be ascertained using the existing evidence whether interventions that are effective in high income countries will also be effective in low- and middle-income countries.

CONCLUSIONS

We conclude that there are several interventions that have some evidence to suggest that they may be effective for improving fleet safety. Grayson and Helman (2011) concluded from their review of six main are as: driver training, group discussions, incentive schemes, publicity, in- vehicle recorders, and organisational approaches that only four interventions were found to be scientifically acceptable and showed statistically significant reductions in crash risk. Three were in the same investigation (Gregersen et al, 1996), and the fourth was the use of IVDR in a fleet setting (Wouters and Bos, 2000). Here, we confirm these findings and note several other factors that could be taken into account to improve fleet safety including size of vehicle, coding for blameworthiness in a crash in a more valid way, and as the tendency to cause crashes is highly stable over time (af Wåhlberg, 2009a), allowing drivers with many crashes to leave instead of re-training them or using some other type of remedial intervention is probably good for WRRS.

We also note that for aid and development organisations working in low and middle-income countries risk perception, risk sensitivity, risk willingness and hazard perception may differ Nordfjærn et al (2014; Lim, Sheppard and Crundall, 2013). Risk perception and hazard perception training may therefore be particularly beneficial for traffic safety in low to middle-income countries.

As mentioned, many reviews and meta-analyses of WRRS have been published, with somewhat different aims, and especially very different views on what is acceptable evidence. Furthermore, there are many reviews on interventions for other driving populations. The material in these have mainly not been included in the present review. However, there is a possibility that some sort of method that has been applied to other driver groups can also be used for drivers at work (older drivers: see Castellucci, Bravo, Arezes & Lavallière, 2020; Truck drivers: see Mooren, Grzebieta, Williamson, Olivier &Friswell, 2014).

Safety culture is highly determined by the management and leadership within an organisation and the key to organisational safety lies in demonstrated commitment to safety. How managers and supervisor's trade-off the need for productivity, while ensuring safety policies and procedures are still being implement ed, presents a message to employees on which work-related behaviours are most important. If productivity is favoured over safety, employees are more likely to prioritise production to the detriment of safety. Whilst no studies presented here could be sourced that meet the standard criteria of an experiment, the degree to which management are observed or perceived to be committed and involved in safety initiatives could be the primary factor that affects individual employee 'safe behaviours'. Further research using well-controlled quasi-experimental methods in the field are required to confirm that a positive safety culture can improve WRRS as measured by a reduction in the number of crashes.

Based on the personal experience of the authors working for several decades in the field, it can be said that organisations with an interest in WRRS often make decisions on how to construct a fleet risk management programme based upon a very limited amount of information, even when there is a good source of knowledge available (e.g., Brake the road safety charity, Fleet Forum, ETSC etc). This is a variant of the dissemination problem, but here, it is the end user, which is creating the problem, possibly due to the need for quick fixes, lack of resources, lack of understanding about the heterogeneity of results that could emerge and the difficulty of developing an effective intervention.

LIMITATIONS OF REAL-WORLD RESEARCH

As should be evident from this review, there are many possible interventions available for organisations that want to increase traffic safety. The available evidence for their effectiveness, however, is scant. It should also be noted that companies operate in the real world, and it is extremely difficult to set up experimental studies in this context. Randomised allocation of participants to specific intervention groups which is the gold standard experimental method is very difficult to achieve in the wild, particularly in a commercial setting.

The kinds of interventions discussed here would be challenging to study with the level of scientific quality outlined in the present review for many reasons. For example, companies would not want their operations disrupted due to the study requirements and it would be difficult to organise a control group with no exposure to the intervention when all drivers are working for the same organization. Based on the authors experience, crash data may not be collected in a reliable way, and this would have a major impact on how the results of any statistical analysis can be interpreted. There is also the added problem of collecting sufficient data to be able to detect a difference in crash rate as an outcome of the intervention. The participating company would need to employ several thousands of drivers and observe the effects of the intervention on crash involvement for up to 6 months. This is especially difficult in current economies that typically outsource vehicles and drivers where managers have little control over knowing who is driving for them at any one time.

RECOMMENDATIONS

- We recommend a more thorough investigation of WRRS interventions before applying them including taking the advice of a traffic safety researcher on any specific system/principle being considered.

- We recommend setting up an internal pilot study to see whether the initial effects of the intervention can be seen.

- We recommend contacting other organizations with experience of using interventions rather than rely on information from sales personnel.

- In most cases, we recommend that driver training should not be used as a general safety intervention (only as requirement to pass a driving licence), unless it is the group discussion variant described by Gregersen et al (1996).

- We recommend the use of telematics for managing WRRS with feedback loops delivered automatically or via a coach.

- Given that low- and middle-income countries have a lower set of requirements for driver training and licencing compared with high income countries, it is recommended that new drivers are assessed for skills to identify whether skills-based training is necessary.

- We recommend that organization implement the group discussion approach as an effective behavioural intervention to improve fleet safety.

- We recommend that number of driving hours are strictly controlled and preferably allow for some flexibility in choice of hours worked.

- We recommend that for organisations who have drivers in countries without good working hour regulations or lax enforcement that they implement policies for a maximum number of hours spent driving.

- It is possible that hazard perception training may be beneficial in the context of organisations operating in low- and middle-income countries and we recommend a pilot study to assess its effectiveness for improving fleet safety.

- We recommend that organisations ask telematics providers for hard evidence, evaluating any reports according to the information in this report. For example, has the research been carried out by an independent researcher? Has a control group and random allocation of subjects' been part of the design? Most importantly, are crashes the outcome variable?

RECOMMENDATIONS

- We recommend that organizations focus on retention of drivers, for example through driver recognition and career development programmes.

- We recommend that organizations work with insurance-based telematics providers as insurers have access to claims data and can ascertain whether scores are predictive of crash involvement.

- We recommend that an incentive scheme can be used but is unlikely to be effective in managing risks in the absence of a good fleet risk management programme.

- We recommend that if an organization must choose between two differently sized trucks, the larger one should be chosen on the proviso that the heavy vehicle is used on low-risk highways and motorways. This assumes that the larger vehicle can be used to its full capacity, and this will also improve sustainability. However, a heavy vehicle entering a built-up environment may increase the risks for vulnerable road users such as pedestrians and cyclists.

- Given the lack of evidence for the effectiveness of WRRS interventions, we recommend that when organizations decide to implement fleet risk management programme that they should also commit to undertaking an evaluation, preferably by independent researchers.

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