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Provision of telematics research

S Tong, L Lloyd, L Durrell, K McRae-McKee, P Husband, E Delmonte, I Parry, S Buttress

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Quality approved:

Poppy Husband (Project Manager)		Louise Lloyd (Technical Referee)	

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Executive Summary

Background

Young and novice drivers have a high accident risk attributed to risk-taking behaviour and high-risk exposure, such as driving at night and with young passengers. Telematics-based insurance products have the potential to reduce these risks. Several UK insurers now offer policies in which a telematics device is installed in the policyholder's vehicle to collect data to quantify and risk assess driving styles and behaviours. Accompanying policy tools (e.g. feedback, incentives, penalties) are often applied to encourage safer driving and reduce accident risk, although being monitored *per se* may also do this.

Literature review

Evidence of the impact of telematics on accident risk, particularly in young drivers, is currently inconclusive. The growing prevalence of telematics-based insurance in the UK suggests that insurers have confidence that the approach is effective. This study reviewed published literature for evidence to support this assumption.

It found:

- No sufficiently robust direct evidence that telematics affects accident rates of young and novice drivers, but when combined with parental involvement it can influence young novice driver risk (albeit without a direct link to accident rates)
- In commercial fleets, telematics may reduce accident rates in certain supportive environments, especially when combined with feedback and incentives, although behaviour change tends not to be sustained after feedback and incentives are withdrawn
- Methodological constraints were common, such as self-selection bias and insufficient control over factors that could influence the findings. Accounting for these issues requires substantial resources, which may explain why there is limited published evidence

Use of insurance data

It was therefore anticipated that working collaboratively with UK insurers might provide the best opportunity to access data for a robust analysis of the impact of telematics-based insurance on young novice driver accident risk.

An extensive consultation with insurers identified several telematics-based and non-telematics-based insurance products. A subset of these products was discussed extensively with a view to accessing policyholder data to analyse accident risk.

Two research questions were identified, with the first being fundamental to being able to robustly answer the second:

- How do those who choose telematics products differ from those who do not?
- To what extent does telematics-based insurance affect accident risk?

To answer these questions requires a comparative analysis of the accident risk for a 'matched sample' of young and novice drivers with and without telematics-based insurance.

A full range of data measures to answer both research questions was identified, and three methods of data collection and study design were proposed and evaluated. All of the proposed methods would use insurance data as a primary data source.

Methodology – benefits

The core benefits of using insurance data were found to be:

- Claims data are likely to accurately reflect the accident types of interest
- Insurance risk indicators enable matched samples in the treatment and control groups to be recruited to ensure young drivers across the risk spectrum are sampled
- Detailed exposure data (volume and type) for telematics-based policyholders

Methodology - limitiations

However, these core benefits have to be considered against the limitations of insurance data as a primary source for a comparative analysis of accident rates.

Specifically, insurers collect insufficient data to describe the exposure and experiences of control groups using non-telematics insurance products. The methods to overcome this limitation require collecting substantial additional primary data from sources other than insurers, which is complex and requires more resources than anticipated.

In addition, the consultation identified distinct differences in the types of telematics-based insurance products currently available in the UK. A comparative analysis of accident rates would need to consider the effects of different types of telematics-based insurance product, rather than considering them collectively as a single product. To do so robustly would require larger sample sizes and resources than originally envisaged.

Conclusion

It is therefore concluded that it is not feasible to robustly assess the impact of telematics-based insurance on young novice driver accident rates using only insurance data as a primary data source. This is primarily because insurance data do not provide sufficiently comparable and detailed exposure data for a matched sample of telematics and non-telematics policyholders.

Alternative approaches such as a randomised controlled trial (to randomly assign young novice drivers to telematics- or non-telematics-based insurance policies) would also have limitations such as increased expense, longer trial duration, reduced sample sizes and bias associated with self-selecting into the trial itself.

The most desirable study design for a comparative analysis of accident rates for young novice drivers using telematics and non-telematics insurance products would therefore be to supplement insurance data with other primary data sources, particularly to collect exposure data from non-telematics policyholders. To do so robustly and with the necessary accuracy might require a technological solution (e.g. unobtrusive devices to monitor exposure for participants without telematics devices) that would be beyond the scope of activity that was initially expected.

Extended Executive Summary

Introduction

The high accident risk associated with young and novice drivers is due both to their inexperience and youth. Inexperience is associated with developing skills that are essential for safe driving such as hazard perception and situational awareness. Youth is associated with risk-taking behaviour and lifestyle choices that increase situations of high-risk exposure such as driving at night and with young passengers. Reducing the risks of young and novice drivers is of prime importance to governments around the world. One possible approach could be through the use of telematics-based insurance.

In-vehicle telematics use devices to collect data on vehicle movements and control inputs from which it is possible to gather information about driving styles and behaviours. The many telematics systems available record a range of driving data such as speed and accelerations, exposure (e.g. mileage, time of day and types of road used), collisions, and vehicle location (e.g. to enable stolen vehicles to be tracked). Insurance policies that incorporate telematics devices often offer incentives (e.g. reductions in premiums, additional mileage allowances) and feedback on driving style.

When formulating policy in road safety or any other area of public health, it is important to understand the extent to which products may reduce risk factors, and potentially collisions, and the mechanisms underlying these reductions. Telematics-based insurance is assumed to reduce accident rates through reducing the risky driving behaviours mentioned above. This risk reduction is thought to be due to the feedback, incentives and sometimes penalties provided by the insurance companies, but could also include the impact of being monitored. Evidence of the impact of telematics on accident risk in young drivers is therefore currently inconclusive. This is largely due to limitations in existing studies evaluating the effectiveness of telematics. These limitations include insufficient control over innate self-selection bias, lack of control groups and a lack of evaluation of the longer term effects.

The current project looks to fill this knowledge gap by understanding the impact of telematics-based insurance on novice drivers. Its overall aim is to understand the effect of telematics-based insurance products on the accident rates of young novice drivers and the consequential impact on road safety.

Specifically, this report has:

- Reviewed existing evidence of the impact of telematics on accident rates based on a comprehensive review of international research
- Identified the experiences of other countries who have developed and implemented different policies around the use of telematics
- Scoped what primary UK insurance data are available and considered how best the data can be accessed, compiled and used to estimate the likely percentage reduction in road traffic accidents that may result from the wider adoption of telematics-based insurance products
- Scoped and developed a methodology for using the data to create an experimental sample of telematics-based insurance users and a matched sample of non-telematics users to understand the road safety impact of telematics-based insurance on young and novice drivers.

Review of international research literature

A systematic review of the international literature was carried out with the aim of understanding existing evidence of the impact of vehicle telematics on accident rates. The systematic approach used established procedures including defining search terms, inclusion criteria and quality criteria. This method accounted for the strength and quality of the existing research when summarising the evidence.

Effect of telematics on accidents

The review found no studies that directly report the effect of telematics systems on the accident rate of young and novice drivers. Any evidence for the effectiveness of telematics monitoring systems on accident rates that does exist is mainly based on trials in commercial fleets. Such studies noted overall average reductions in accidents of between 0 and 30% when comparing drivers monitored by telematics systems with those who were not, with perhaps the most reliable evidence indicating a reduction of 20%. The authors of these studies acknowledged that their methods and results had limitations, such as evaluations over a short term only, poor control over different levels of driver exposure, poor control over the different levels of intervention from fleet managers (in studies using fleets) and a wide range of safety outcomes (e.g. 'unsafe' vehicle manoeuvres) that were not directly associated with accident risk.

The role of feedback has been shown to be important and the impact of telematics devices is reduced if feedback is not provided. However, the type and frequency of feedback that is associated with the greatest impact could not be determined from the review.

The number of telematics based insurance products available worldwide, and the general trend in published literature to evaluate the effectiveness of telematics devices, suggests that they should offer some reduction in risk. However, the methodological limitations identified in recent studies (and outlined in this report) mean that there remains a lack of independent scientific evidence for the impact of telematics on young and novice driver accidents.

Pay as you drive insurance

With a pay as you drive (PAYD) insurance policy, insurers calculate premiums based on the actual vehicle usage of the policyholder instead of conventional assumptions and lump-sum policy premiums. This approach is seen to improve actuarial risk and incentivise policyholders to contribute to risk mitigation.

Evaluations of data from PAYD insurance policies across Europe have compared risk and exposure of different groups, leading to findings such as:

- Experienced drivers travel more kilometres per day, use urban roads less often, and drive more kilometres in excess of the speed limit than novice drivers
- The risk of accident involvement is lower between 05:00 and 18:00 hours, and higher between 18:00 and 21:00 hours
- Driving exposure accumulated on weekends, including Fridays, is associated with lower risk based on insurance claims data

- Both low (0-20 km/h) and high (90-120 km/h) speeds are associated with higher risk, with the mid-speed range (60-90 km/h) being associated with the lowest risk of accident involvement based on insurance claims data

These findings are potentially useful for understanding risk based on insurance claims data but there are few published studies comparing PAYD policyholders and non-PAYD policyholders. Where this has been achieved using randomised controlled trials, it was found that incentives did not impact on drivers' mileage or times of driving but that PAYD speed-related incentives did reduce overall speeding in the short term. Such methods are constrained by uncertainty over the long term effects, the lack of a control group with matched incentives and self-selection bias.

Based on these findings it is difficult to define the effectiveness of PAYD policies.

The impact of feedback and incentives

Several studies note that the positive impact of telematics on driver behaviour, such as speed choice and headway to the vehicle in front, is heavily influenced by the associated feedback and incentives. These evaluations tend to add telematics into vehicles to collect data 'silently' for an initial period and compare this to a subsequent period where feedback or incentives are offered. These studies also appear to show that driver behaviour is manipulated to adapt to the incentives and feedback rather than instigating a change in behaviour that is sustained after the incentives and feedback are withdrawn.

Evaluations either noted no differences between different types of feedback or incentives, or it was not possible to separate the differences. In addition, no studies were identified which offered an indication of the effect of receiving telematics-based incentives and feedback long term: it is possible that the initial behavioural effects reported by these studies may lead to long term behavioural change over time, although it is just as possible that the behaviour would be maintained for as long as the driver is motivated by the incentive.

Parental engagement

Whilst studies of the impact of different types of feedback and incentives suggest that the impact of telematics may only be short term, studies which evaluate or include the impact of parental engagement in the telematics feedback process suggest that the impact on young drivers could be longer term in these circumstances.

Individuals in these studies noted advantages and disadvantages to parental involvement in young driver telematics policies. These included the parents wanting to know the truth about their child's driving behaviour but not wanting to intrude on their privacy, and children wanting evidence that they are responsible drivers but indicating concern that their parents may use the information to impose restrictions.

In general, evidence suggests that the household safety culture and parental involvement can influence young novice driver risk. When adding a telematics device the studies reviewed suggest that these play a role in influencing young novice driver behaviour, but that it is the role and involvement of the parent that is critical to its success.

Intelligent speed adaptation

Intelligent speed adaptation (ISA) is an alternative form of data recording that identifies the relevant speed limit at each moment in time and usually also alerts the driver when the vehicle's speed exceeds this limit. This information is not necessarily recorded as it would be in a telematics device as the systems often give instant feedback, however previous studies in numerous countries have provided evidence of 'proof of concept' with ISA systems having an impact on drivers' speed choice, when active.

Studies of their effectiveness have shown that both information and incentives separately reduce speeding behaviour, with information only having the greatest impact; there was no additional effect of combining information and the incentive. The main limitations of these studies were identified as self-selection bias where the samples may be motivated to obey speed limits. The system was not found to have any educating effect as the level of speeding returned to previous levels when the feedback and incentives were terminated.

Smartphones as telematics devices

The use of smartphones and associated applications is another possibility for measuring driving behaviour. Utilising a driver's smartphone replaces the need for a telematics device to be installed in a vehicle and instead makes use of smartphone sensors (e.g. GPS and accelerometers). Using smartphones as a telematics device has several advantages: there is no hardware or installation costs, the sensors follow the driver and not the vehicle, apps can be easily downloaded by the user, and the user has control over monitoring. This last advantage is also the primary disadvantage of smartphone telematics. With the user able to choose when to turn the monitoring on and off, there is the opportunity to select to turn it on for advantageous journeys and neglect to turn it on for non-advantageous journeys. It is also possible to turn the monitoring on when travelling as a passenger. Less deliberate acts, such as forgetting to turn the monitoring on, could also misrepresent measures of users' exposure and driving behaviour. In addition, the quality of data from smartphone-based sensors and possible risks associated with use of smartphones when driving could also be counted as potential disadvantages.

One small trial evaluating the use of a smartphone app to record driver behaviour suggested that incentives have short-term impact. The results of this study provide some insight into the challenges that further studies will need to consider, such as the type of feedback issued by smartphone apps, the circulation of feedback to other recipients (e.g. parents), and the type of incentive package offered.

Method constraints

Although many of the studies reviewed have sought to employ fairly rigorous experimental designs, they all have methodological weaknesses. The key weaknesses are summarised below:

- Participants who take part in trials are self-selected and this results in effects that may only be applicable to the population of drivers who accept telematics. The impact on the types of drivers who do not choose to take up telematics-based insurance policies could be different. Self-selection bias is perhaps the most difficult weakness to address in methodological designs.

- Use of small sample sizes which are often homogeneous can reduce the possibility of generalising the results to the whole population.
- Outcome measures are subject to variation that is not robustly controlled.
- Short term trials may assume that the initial impact of installing a device (i.e. the 'installation effect', whereby driver behaviour appears to improve upon installation of telematics) is sustained long term, whereas studies that monitor longer term have actually shown that driver behaviour tends to revert to a baseline.
- There are many different confounding factors influencing the effect of telematics devices. This includes different formats and types of feedback and the impact of parental or manager engagement. If these factors are not controlled or limited in any study the findings are constrained. Such studies should also account for an experimental effect from simply installing telematics that is likely to affect driver behaviour even in control groups without feedback or incentives.
- Measuring baseline and control data is challenging in the context of attempting to evaluate the impact of telematics devices on accident risk, as in theory, the control group should not have a telematics device installed. This makes it difficult to collate compatible data on these drivers, whether the outcome measures are telematics-based measures of risk or insurance claims data (because both rely to varying extents on the detail provided by telematics devices to be truly comparable).

Summary

The following conclusions can be drawn from the literature reviewed:

- There is no sufficiently robust direct evidence of the effectiveness of telematics systems on the accident rates of young and novice drivers.
- Taken as a whole, studies of the use of telematics in commercial fleets suggest potential for telematics to reduce accident rates in certain supportive environments.
- PAYD data can be extremely informative although there are too few published studies comparing PAYD policyholders and non-PAYD policyholders in order to draw any firm conclusions regarding the effectiveness of such policies.
- It has been demonstrated that telematics can influence driver behaviour in a desirable manner when combined with feedback and incentives. However, such studies also appear to suggest that the use of telematics tends to manipulate behaviour whilst being used but does not lead to sustained behaviour change.
- Evidence suggests that a 'household safety culture' and parental involvement can influence young novice driver risk. Telematics systems can be effectively integrated into the parent-young driver relationship to influence behaviour; however, gaining general acceptance and adoption on both sides can be challenging.
- Other forms of telematics such as Intelligent Speed Adaptation can also positively influence driving behaviour but do not appear to provide an educating effect; rather the behaviour change is incentive or feedback driven.

- Methodological constraints such as self-selecting samples and controlling for all of the factors that can affect driver behaviour and accident risk make telematics studies challenging and complex. As a result, high quality studies (particularly when aiming to use accidents as an outcome variable) require substantial resources and commitment. These restrictions may go some way to explaining the limited evidence for the effectiveness of telematics systems to reduce young and novice driver accident rates.

International telematics policies

Few policies relating to the use of telematics were identified during this study. Information was identified and explored for six countries (Australia, Canada, USA, Germany, Italy and Sweden) with further policy information potentially available from Israel, The Netherlands and Denmark but inaccessible in the English language.

In the USA the National Highway Traffic Safety Administration (NHTSA) has implemented rules governing the fitment of Event Data Recorders (EDRs). EDRs are a specific type of telematics device with the sole purpose of detecting and recording collisions. The NHTSA rules govern the minimum data requirements for this activity to ensure that the data are robust.

Australia has produced policy papers discussing measures to implement similar governance over telematics data collection and uses more widely, to reflect widespread fitment among road transport vehicles. Whilst these are not directly relevant to the type of telematics device used for telematics-based insurance policies, data governance may be a desirable consideration in the future to ensure that insurance-related decisions are made by companies using data that meets a minimum standard. The other common theme in the small number of countries with telematics-related guidance is the need to govern data privacy, which is typically subject to local data protection laws.

Italy was the exception, where "Monti's Law" was introduced in 2012 to address the high rate of auto theft and fraudulent whiplash claims (it makes telematics compulsory in new cars and as an insurance option). Telematics-based insurance is required by law to be cheaper than non-telematics insurance. Only location and time data can be used. Italy may be the most mature insurance telematics market with a penetration rate of 4% in 2013.

Availability of primary UK insurance data

A consultation with key stakeholders within the insurance industry was carried out to understand which insurance companies hold claims, policy information and exposure data for telematics and non-telematics policy holders, which insurers are willing to share those data, and what processes and conditions may apply if trying to access these data in the future.

The consultation also aimed to gather views and opinions on how the insurance industry could be supported by government, the EU, and the telematics industry through research and policy. It was guided by a consultation document that included questions for insurers about:

- telematics-based policies offered and any comparative non-telematics policies

- lists of policy and claims data that could potentially be used in the proposed methodology
- questions about data sharing concerns and restrictions
- broader questions to gather information about the opinions of the telematics industry on how research and policy could support the industry

The consultations were conducted through telephone conferences with companies involved in telematics-based insurance, including underwriters, brokers, and service providers.

Telematics products

The range of telematics-based insurance policies on offer is broad, and the policy features vary widely from active feedback with rewards and penalties to a more passive approach, where telematics data are used as an actuarial guide and only acted on at renewal or in extreme cases (e.g. excessive speeding).

Common incentives include discounts on current premiums (e.g. as cashback or as reductions on regular payments for the premium) and on renewals. Penalties cover increases to premiums, and in extreme cases, policy cancellation. A few policies apply mileage restrictions, passenger restrictions or curfews.

Although nearly all the products are targeted towards young and/or novice drivers, the majority of the products have no age restrictions and are available to people of all ages (although the potential savings are typically greater for young novice drivers, with older drivers being less attracted to telematics-based policies once price parity with non-telematics policies occurs). Where age restrictions do apply the most common is 17–25 years.

Feedback methods and types vary with information on mileage and other risk factors such as speeding, acceleration, braking and cornering often received online, by email or text.

Additional features provided by some telematics policies includes collision detection, emergency response and vehicle tracking.

Policyholders

Information on what details insurance companies hold about policyholders was discussed. It can include detailed vehicle information (e.g. type, age and engine size) and basic demographic information about all named drivers on the policy (e.g. age, gender and licensure). Prior experience of telematics insurance is not recorded unless it was obtained with the current insurer.

Total mileage is estimated for each policy, and can disaggregate into subsets such as time of day and business use for telematics-based policies. Claims information is collected but inconsistently across different companies in terms of content and format.

Data sharing

In general, insurers responded positively to sharing the required information. However, there were common concerns:

- Any comparative analysis would need to separate the effects of self-selection bias from the effects of having a telematics policy, using only high-level data.
- High level quote and claims data would provide few meaningful differences within a sample of young drivers to assess self-selection bias issues. Most young drivers appear to be very similar in vehicle and basic lifestyle characteristics.
- If only a few insurers shared their data, it might be easier to identify particular companies and products, leading to commercially sensitive results.
- The outcomes of the proposed research could affect the industry (positively and/or negatively) by identifying the best target groups, telematics technology, or telematics-based policy designs.
- Some insurers were only prepared to share summary claims statistics to protect commercial interests.
- The accuracy of recent retrospective claims data is limited due to many claims being delayed from the point of the incident and hence may not be captured if the data used only look back over the past six months.

Research ideas

A broad range of research that could benefit the telematics insurance industry was put forward by those consulted. Suggested research topics included:

- The effects on driving behaviour of telematics-based insurance compared with other mechanisms for reducing novice driver risk (e.g. graduated driver licensing)
- The effects of different types of feedback from telematics-based insurance
- Evaluating the safety implications of 'app' technology and in-car feedback (linked to telematics data) through infotainment systems
- Quantifying the effect on accident occurrence of curfews
- Understanding why customers move away from telematics insurance policies after one or more years and any impact this has on driving behaviour and safety
- How driver behaviour adjusts after the adoption of telematics and longer term
- How telematics products could be used by driving instructors to facilitate the learning to drive process
- Encouraging telematics uptake
- Methods to reduce the costs of telematics-based insurance
- Research into what telematics devices would be available in vehicles as standard in the future and how this could be influenced to benefit the insurance industry
- Testing the sustainability of telematics products

Government support

The industry was consulted for its suggestions regarding research and policy support that could be provided by Government, the EU or others.

Some insurers suggested that an insurance premium tax (IPT) reduction from the Government was a desirable way of offsetting the high cost of IPT for young drivers. In turn, these insurers felt that this might improve uptake of telematics-based insurance by further undercutting the price of standard insurance products. The industry reported that the cost of the telematics technology was another fundamental constraint and support from the Government or manufacturers to improve affordability of the technology could further develop the market. Improved affordability could also be a by-product of increasing market share.

The telematics insurance industry also thought the Government could offer further support by:

- Strengthening the law around the use of customer data to protect policyholders
- Introducing changes to the learning and licensing process to improve young driver safety

Policy standards and data sharing were key areas of focus for the insurers when asked about standardising the industry. Opinions on these topic areas were split between those of the opinion that the guidelines in place were already sufficient and those who felt that standards need to be introduced.

It was suggested that if standards needed to be put in place, they should focus on making policy features clear to customers and protecting customers' data, leaving the rewards and penalties to be decided by the insurers. Insurers already provide a good level of control over the quality of telematics systems so standardising telematics technology was not considered necessary.

Methodology development

Objectives and research questions for a comparative analysis

Once this research has been completed, the aim of a further study would be a comparative analysis to quantify the expected reduction in accidents and casualties generated by the use of telematics-based insurance for young novice drivers and the consequential impact that telematics could have on road safety.

Two research questions were identified with the first being fundamental to being able to answer the second robustly:

- How do those who choose telematics products differ from those who do not?
- To what extent does telematics-based insurance affect accident risk?

Risk can be defined in a number of ways including behavioural risk indicators, accidents, claims, near-accidents, accident severity and time until first accident.

Implications from the evidence and consultation

Based on the literature review and consultation, a number of themes that could impact on the methodology for a future study were identified.

The importance of exposure data in comparing two groups of policy holders

The outcome measure suggested in the initial study plan was a comparison between a post-risk indicator such as claims. Even with limited prior research comparing telematics and non-telematics policies, other similar comparisons identified the need to control for exposure (how and where policyholders drive) for context and to evaluate risk.

Some studies found that exposure should incorporate more detail than just mileage, such as time of day, journey purpose, road type and even the amount of exposure at speeds in excess of the local limits. Without this information for the control and treatment groups, an underlying assumption must be that there are no differences in the volume and type of exposure experienced by each group.

Self-selection into trials and telematics-based insurance policies

Several evaluations noted the difficulty in comparing pre-existing groups of individuals who select to have different telematics-based insurance policies, or indeed whether to have a telematics policy at all. It was observed that these groups could be fundamentally different types of drivers and any changes in the outcome measure could not be attributed solely to the telematics product. Further differences between people who do and do not select telematics-based insurance could be related to perceptions of risk related to data privacy.

Indeed, insurance companies are aware from their own data analyses that it is difficult to separate the effects on safety of having telematics-based insurance from the effects of self-selection bias (i.e. the personal factors that motivate people to choose telematics policies) if using only high level data.

This suggests that there are more factors than initially identified that could influence whether an individual chooses a telematics or non-telematics insurance policy. If possible, all factors should be considered in forming any study sample comprised of those who have a telematics-based insurance policy (the treatment group) and those who have a non-telematics insurance policy (the control group).

Of course, even when controlling for self-selection bias in choosing insurance, there is the potential for similar bias in opting to participate in a research trial or not. Those who opt to participate in road safety research might be fundamentally different to those who do not, thus any self-selected sample may represent only a part of the full attitudinal and risk spectrum associated with drivers in the subgroup of interest.

The limitations of small numbers and small changes in outcome measures

If the outcome measure is defined to be collisions, especially those that result in an injury, the rate of these outcomes will be extremely small compared to exposure. Small changes potentially influenced by random variation can be reported as large proportional differences. Therefore, trials of this nature should run for a long time on large samples or consider alternative measures of post-risk.

The impact of the initial period of installation of a telematics box

An initial impact of having a telematics device installed in your vehicle was identified in the review. It is unclear whether there is any residual impact of the telematics device on driving behaviour once it has been removed from the car. It is possible that the initial behavioural effects reported by these studies may lead to long term behavioural change over time, although it is equally possible that the behaviour would only be maintained for as long as the driver is motivated by the policy instruments that are in place. Removing incentives, penalties and feedback during a trial (particularly in a controlled, counter-balanced design) is unlikely to be feasible as insurers will be required to keep such policy instruments in place for the duration of the insured period.

These findings impact on the duration of data collection as well as defining different periods of time for analysis after the installation of the telematics device.

The challenges of self-report data

With a comparison between policy holders who have a telematics box installed and those who do not, serious consideration has to be made to collecting comparable data from the second group, given that there is no telematics device to collect those data.

One way of collecting those data is by self-report questionnaires that can be completed by the individuals. However, self-report data on exposure from a control group could not be directly compared to telematics data from the treatment group without an excessive burden of reporting. To overcome this limitation, a technology-based solution for collecting exposure data is mooted as the most viable alternative.

Identifying the impact of telematics on individual drivers within a multi-person policy

Data collected for the treatment group from an insurer could relate to several drivers on the same policy and it is unlikely this can be disaggregated to provide data (e.g. exposure, claims) for only the driver of interest.

Differences between the impact of telematics by feedback and incentives offered

The type, timing and method of feedback could have an impact on the effectiveness of telematics-based insurance in reducing accident risk. It will be important to ensure that policy differences are known in order that the results are not biased towards particular feedback or incentive options.

Accessibility and compatibility of data

Three data sources were identified as important in any future evaluation of the impact of telematics-based insurance on accident risk. These were:

- an early risk indicator to identify differences between individuals in the control and treatment groups;
- a post-risk indicator to identify any differences between the treatment and control groups that occur during the experimental period; and
- a measure of exposure to evaluate differences between the two groups and to put the post-risk indicator into some context.

Consultation with insurers revealed that these data are collected in different ways and may not be universally accessible for research purposes due to data protection.

In addition:

- Some insurers claimed that the difference between young drivers was mostly attitudinal as they tend to drive similar cars, have similar exposure and similar lifestyles. Substantial differences were not anticipated using insurer-only quote data. Additional attitudinal data was considered necessary by some insurers to further quantify differences in a young novice driver sample.
- Insurers' own internal risk ratings (derived from sophisticated actuarial models) might supplement other early risk indicators to provide a better measure of compatibility between control and exposure groups. Not all insurers have such ratings and would defer to premium price otherwise.

- Insurance companies do not generally measure accidents directly, but do measure claims, in various ways.
- Most telematics-based insurance data will not routinely split exposure by day time and night time.
- Insurers are unable to record exact mileage travelled by non-telematics policyholders.

Data collection

Based on the evidence review, consultation findings and subsequent limitations, it is clear that any proposal for a research method to analyse the impact of telematics-based insurance will be challenged to respond adequately to all of the limitations noted.

With this in mind, three possible methods were explored that all have clear and specified limitations and advantages:

- A method using only data from insurance companies for individuals who have preselected their insurance policy (i.e. have self-selected into the treatment or control group)
- A method combining insurance data for individuals who have preselected their insurance policy with further primary data sources including questionnaire measures and technology-based solutions for collecting exposure data
- A randomised controlled trial that matches pairs of individuals and randomly allocates a telematics or non-telematics policy to the individuals within each pair

Each method requires the same three forms of data:

- An **early risk indicator** which includes all factors that could be influential in individuals choosing a telematics or non-telematics policy. This indicator allows self-selection bias to be at least partially controlled by matching the control and treatment groups at the start of the trial. The factors include:
    - Individuals’ characteristics such as age, gender, mileage, licensure, vehicle
    - Where available, the insurers’ own risk rating for each individual
    - Where possible, measures of individuals’ driving attitudes and behaviours
    - Other factors that could be identified in a stated preference experiment
- A set of **post-risk measures** which are the outcome of the trial such as:
    - Number, time and severity of accidents
    - Number and cost of claims
    - Number and time of near-accidents
    - Driver attitude and behavioural scales
- **Exposure measures** such as total and disaggregated mileage to calculate accident risk and understand the different driving styles and characteristics of the two groups. These differences may be influenced by the experimental effect or could be the result of further differences between the control and treatment group that were not controlled for in the early risk indicator.

Recommended method

It is not considered feasible to robustly assess the impact of telematics-based insurance on young novice driver accident rates using only insurance data as a primary data source. This is primarily because insurance data do not provide sufficiently comparable and detailed exposure data for a matched sample of telematics and non-telematics policyholders. A randomised controlled trial (which randomly assigns individuals to telematics-based or non-telematics-based insurance policies) also introduces challenges such as increased expense, longer trial duration, reduced sample sizes and bias associated with self-selecting into the trial itself. It may also be impractical to implement as the insurance policy may need to be funded (at least in part) by the study which removes the direct financial incentives and rewards associated with different insurance policies.

Based on these limitations, it is recommended to use a method combining insurance data for individuals who have preselected their insurance policy with further primary data sources including questionnaire measures and technology-based solutions for collecting exposure data. However, any recommendation to pursue a future study using this method must be issued with the caveat that it is a substantially larger study than originally envisaged. This is because:

- Further primary data sources must be included to obtain sufficient data from both groups on exposure, and factors that could affect self-selection bias
- These additional data sources require self-report methods and potentially some form of technology-based solution for collecting exposure data from the control group
- These methods introduce a level of cost and complexity that exceeds what was originally anticipated
- The consultation identified several distinctly different telematics-based insurance products and a robust comparative analysis might need to consider these products separately which would also more resource and larger samples than was originally envisaged

1 Introduction

1.1 Background

There are several risks associated with novice drivers that have been identified worldwide (e.g. Wells, Tong, Sexton, Grayson & Jones, 2008; Helman et al., 2010). Due to these risks novice drivers are a focus for road safety policies. One promising approach to reducing their risks is telematics-based insurance. Telematics-based insurance policies have the potential to combine the data monitoring capabilities of in-vehicle telematics products (which are now widely used by business fleets to control and mitigate driving risk) with insurance policy instruments to incentivise and/or penalise certain driving behaviours to encourage policyholders to avoid high risk behaviour.

Two main reasons have been identified for novice drivers having an elevated collision risk. First they tend to be young, and second they are (by definition) inexperienced. The behaviours that are associated with these broad characteristics are well suited to being monitored and influenced by telematics-based insurance policies.

The youth of young drivers is associated with risk-taking behaviour and lifestyles that increase high-risk exposure (e.g. late night driving). Telematics-based insurance products can monitor such behaviours and, with appropriate feedback and policy instruments, can seek to modify these behaviours to minimise the associated risk.

The inexperience of novice drivers is associated with a lack of hazard perception skills when compared with more experienced drivers (McKenna & Horswill, 1999; McKenna & Crick, 1994), and acquiring on-road experience is a key factor in reducing risk in early driving (Maycock, Lockwood & Lester, 1991; McCartt, Shabanova & Leaf, 2003; Mayhew, Simpson & Pak, 2003). There are several ways of thinking about the protective effect of on-road experience. One is that on-road experience increases important skills such as hazard perception, known to be associated with lower collision risk (e.g. Boufous et al., 2001; Wells et al., 2008; McKenna & Horswill, 1999; Hull & Christie, 1993; Quimby et al., 1986). The other is that on-road experience may lead to novice drivers becoming better 'calibrated' in terms of actual and perceived levels of driving skill, leading to safer behaviours in certain situations (Kuiken & Twisk, 2001).

Telematics-based insurance policies have the potential to monitor for driving behaviours that are associated with these high-risk behaviours (e.g. speeding, high lateral accelerations representative of driving quickly on bends) and poor hazard perception (e.g. harsh braking, rapid lane changes). Telematics-based insurance policies can therefore seek to constrain certain driver behaviours and activities, whilst encouraging others in an attempt to improve driver safety and reduce the costs and frequency of any claims. By monitoring for such behaviours and applying policy instruments to influence them, telematics insurance could encourage more careful (i.e. slower, less aggressive) driving with a subsequent safety benefit.

When considering new developments that may affect road safety or any other area of public health, it is important to understand the extent to which products may reduce risk factors, and potentially collisions, and the mechanisms underlying these reductions. Telematics-based insurance policies are assumed to affect accident rates through a combination of feedback, penalties and/or incentives. However, other mechanisms may be involved—for example, the effect of being monitored *per se*, and the potential legal implications of unsafe driving behaviour being recorded.

There is a distinct lack of longitudinal research comparing behavioural responses of a range of population groups to different types of vehicle telematics in general, and specifically telematics-based insurance policies[1]. Therefore it is difficult to determine conclusively the extent to which these systems affect accident rates. Any future research based on the recommendations given here should look to fill this knowledge gap by understanding the impact of telematics-based insurance policies on the accident rates of young and novice drivers.

1.2 Objectives

The specific objectives of this research were to:

- Review existing evidence of the impact of telematics-based insurance policies on accident reduction based on a comprehensive review of data from the UK and internationally
- Identify the experiences of other countries who have developed and implemented different policies around the use of telematics products
- Scope what primary UK insurance claims data are, and are not, available and consider how best these data can be accessed, compiled and used to estimate the likely percentage reduction in road traffic accidents that may result from the wider adoption of telematics-based insurance policies
- Scope and develop a methodology for using the data to create an experimental sample of telematics-based insurance users and a matched sample of non-telematics users, from which it would be possible to conduct a comparative analysis of the effect of telematics-based insurance on the accident rates of young novice drivers

This report includes:

- A review of existing evidence of how vehicle telematics can affect accident rates, and how countries across the world have introduced policies regarding the use of telematics (see Section 2).
- A consultation of UK automotive insurers to identify what data were available for two groups of drivers: those with telematics-based policies and those with other policies. It explored what processes and conditions would apply if accessing these data in the future (see Section 3). Research and policy actions recommended by the telematics insurance industry are also outlined (see Section 0).
- Consideration of methodologies for undertaking a comparative analysis of accident rates (see Section 4).

[1] It is important to note that in-vehicle telematics have been used in various guises for several decades, both as research tools and also (primarily) by organisations that seek to monitor their vehicle fleets for various reasons. Such reasons do include a desire to manage and improve risk and therefore such devices may perform similarly to those used by insurance companies for telematics-based insurance policies (indeed, the suppliers to insurers often offer the same product as a commercial system to fleets). The differences arise in the way that feedback, penalties and incentives are applied. Telematics-based insurance differs from the implementation of telematics devices in other contexts by providing drivers with clear instructions on what type of driving is and is not acceptable and subsequently linking such behaviours with changes to the policy itself.

1.3 An initial plan for a future comparative study

Before commencing this research, an initial plan for evaluating the impact of telematics-based insurance policies on young driver behaviour was drafted in order to shape the consultation and the literature review searches in the most appropriate way. This plan takes into account some of the possible challenges with an evaluation of this type, including availability of data and self-selection bias.

The research design initially proposed for any future study was a matched between-groups comparison. A group of young novice drivers comprising individuals who had a telematics-based insurance product would be matched with a group of young novice drivers comprising individuals who did not have such a product. The claims rates of the two groups would then be compared to establish statistically if the use of a telematics-based insurance product is associated with a reduction in claims rate. This research design was predicated on using insurance data as the sole primary data source; as the research progressed, it became evident that other primary data sources would be required for a robust analysis.

2 Evidence review

2.1 Aim

The primary purpose of this chapter is to review existing evidence of how vehicle telematics can affect accident rates.

When reviewing the evidence the overarching objectives of the project were also considered. For example, the sample under study is young and novice drivers, therefore studies of telematics in corporate fleets may be informative, but not entirely applicable to the population under investigation. The review considers evidence of different types of telematics systems, how telematics data are utilised to provide feedback to drivers, and how associated incentives or penalties impact on driver behaviour and accident rates where possible. It also explores evidence of policy measures that have been introduced to in other countries to help guide the use of telematics in vehicles.

2.2 Method

The evidence review in this report used a systematic approach, utilising procedures from systematic reviews seen in other evidence-based domains (e.g. medicine) and carried out by such organisations as the Cochrane Collaboration (www.cochrane.org). Such reviews are generally accepted as the best way of establishing the level of support for a given intervention or treatment.

Systematic reviews are critical reviews, and studies are not simply accepted at face value. A systematic review permits a judgement as to the quality of evidence available, and therefore the strength of the evidence base overall to support or refute claims of effectiveness. Evidence from lower quality sources (for example anecdotal accounts or studies that do not adequately control for self-selection bias or confounding factors) are not considered to be satisfactory or appropriate for drawing formal conclusions of this nature.

In any systematic approach to a review, it is important to define search terms, the databases used, inclusion criteria, and quality criteria. Such definitions permit others working in the same field to scrutinise what was done by the review authors, and also to repeat it at a later date when more literature becomes available.

2.2.1 Search terms

Three searches were performed to ensure that as much relevant literature was found as possible. The search terms detailed in Table 1 were defined and agreed by the authors, the technical reviewer and DfT. The search terms were applied to the TRID database (Transport Research International Documentation), Science Direct, PubMed, Google Scholar and Google. In addition to the search, the project team and technical advisors provided literature from their personal networks of contacts.

The search was restricted to literature published from January 1995 to January 2015 and to English language articles only.

Table 1: Search terms

Search 1	Search 2	Search 3
(index term: Event data recorders, Telemetry, Data collection **OR** keywords: telem* OR "data recorder" OR "data recorders" OR tracking OR monitoring OR logging) **AND** (keywords: "new driver" OR "new drivers" OR "novice driver" OR "novice drivers" OR "young driver" OR "young drivers" OR "inexperienced driver" OR "inexperienced drivers" **OR** keywords: (young OR new OR novice OR graduat*) AND Driver*) Restrictions: Dates from/to :1995-2015 English language abstracts	Keywords: Black box OR Black box recorder*, OR black-box recorder* **AND** Keywords: Study OR studies OR review* OR case-study OR case studies* **AND** Keywords: "Driver safety" OR (driv* AND safe*) Restrictions: Dates from/to :1995-2015 English language abstracts	Keywords: "in vehicle data recorders" OR IVDR OR "IVDR systems" (IVDR OR "in vehicle data recorders" AND record*) **AND** Keywords: Driver* **AND** Keywords: Insur* Restrictions: Dates from/to :1995-2015 English language abstracts
No. Abstracts = 160	No. Abstracts = 30	No. Abstracts = 54
Notes Quotation marks "" indicate a phrase search Asterisks * indicate a wildcard search for alternate word endings Keywords: 'free-text' unrestricted search terms Index term: controlled vocabulary used by database indexers.		

2.2.2 *Inclusion criteria*

Literature returned from the search was assessed against the quality criteria only if it met the inclusion criteria for the review. The inclusion criteria for the review are detailed in Table 2.

Table 2: Inclusion criteria

	Inclusion criteria
Population	Primary: Young and novice drivers Secondary: Drivers of all ages if study meets remaining inclusion criteria
Intervention	Telematics-based product to capture driver behaviour and/or provide feedback in some form
Outcome	Safety-related metrics such as changes in accident rates, claims rates or values, unsafe driver behaviour

2.2.3 Quality criteria

Table 3 shows the quality criteria applied to studies that passed the inclusion criteria. Studies were rated on the outcome measures they use, their controls, and their analysis. Any study that attracted a minimum grade in one or more of the categories (see shaded boxes in the table) was excluded from the review for the purpose of establishing evidence for effectiveness. The reasoning behind this decision is that formally it is not possible to draw firm conclusions from any such study with regard to effectiveness. However, it should be noted that the criteria in Table 3 were applied within the overall project context of seeking to establish the wider impact of telematics on driver behaviour.

For areas of interest to the wider project objectives (beyond merely establishing effectiveness for reducing accidents) and research questions that might be answered using non-effectiveness or non-statistical evidence (for example qualitative data on the acceptability of telematics feedback) the criteria were still applied but appropriate adjustments were made. For example when grading qualitative work or pilot studies, it would not be expected to see formal control groups or inferential statistical tests, however, it would be expected that an appropriate sampling of participants and some established methods of analysis were implemented and reported.

Where existing reviews are referred to, only those that are reported in peer-reviewed studies or were graded as applying similarly robust criteria for inclusion and quality assessment were included.

The grading of quality and the focus only on the highest quality evidence available is a crucial step in using evidence reviews to answer questions about the effectiveness of interventions. Without an assessment of quality, erroneous conclusions can be drawn from studies flawed by design. By carrying out a quality assessment, the review can rule out such studies from consideration.

Table 3: Quality criteria

Grade	Outcome measures	Controls	Analysis
A	Recorded accidents	Adequate methods (e.g. control or comparison groups) or statistical procedures (e.g. multivariate modelling) to control confounding variables and bias	Appropriate statistical methods to state confidence limits of statistical significance of any effects found
B	Self-reported accidents	Incomplete control of confounding variables or bias but some attempt made	Inappropriate or no statistical methods used, but some attempt to assess the likely confidence limits or significance of effects
C	Observed (e.g. telematics recorded 'events') risk-related behaviour	No controls	No attempt made to address this
D	Attitudes or behaviours that have been reliably linked with accident risk as measured through appropriate self-report methods		
E	Self-reported data with no reliable link to accident risk (e.g. 'I think the telematics product makes me safer') or not measured appropriately		

2.3 Results

A summary of studies reporting experimental trials of telematics systems is presented in Table 4. The table is designed to give an overview of the quality of these studies as well as an indicative overview of whether they provide evidence for the impact of telematics on:

- Types of feedback
- Driver behaviour
- Accident rates

This overview highlights that there are a number of studies within the domain that meet the quality criteria imposed here and from which conclusions can be drawn. The table also highlights that of the studies reviewed here, only one experimental study addresses the impact of a telematics system on accident rates directly, and that was in commercial fleets. While other studies report using accident claims data, these do not necessarily measure the impact of the telematics system and focus on other aspects such as profiling accident involved drivers' exposure. There are however a number of studies that provide evidence of the impact of telematics systems on driver behaviour, and some that provide evidence for the impact of various forms of feedback.

It should be noted that there are case-study examples of telematics and the impact on accident rates in a commercial environment that are cited in the literature and noted in Section 2.3.1 for their anecdotal value but were not directly appraised for inclusion in Table 4 as they did not meet the overall inclusion criteria.

2.3.1 The effect of telematics on accidents

The review found no studies that directly report the effect of telematics systems on the accident rate of young or novice drivers. Evidence for the effectiveness of telematics monitoring systems on accident rates is largely based on trials in commercial fleets with a more diverse range of drivers.

Using some earlier forms of telematics (variably referred to as Accident Data Recorders and Journey or Event Data Recorders), Wouters and Bos (2000) conducted a trial with fleets in the Netherlands to test the impact of telematics on accident rates. The study attempted to establish comparison non-telematics fleets to those that had volunteered to take part in the trial. The intervention was simply based on the drivers in the experimental fleets being told that their driving behaviour was being monitored. The average overall reduction in accidents in the experimental fleets compared with the comparison fleets was 20%, although the safety effect varied considerably between the fleets in the study. The authors note that the 20% figure cannot be taken as an expected assessment of potential accident reduction as factors such as the engagement of the fleet managers and the types of vehicle exposure were difficult to control for fully. The authors note that small sample sizes, previous accident records and variations in feedback all played a part in delivering diverse results from individual fleets.

There are other reports of commercial fleets apparently showing reductions in accident rates and events assumed to be related to safety resulting from telematics monitoring systems. For example, Lehmann and Cheale (1998) report case-studies showing accident reductions in commercial fleets fitted with telematics systems, although there is a lack of detail to fully evaluate the validity of these. Hickman and Hanowski (2011) report changes in 'safety-related events' following the introduction of fleet monitoring systems in three US short and long haul heavy goods vehicle fleets. While this study is more detailed, there were reported technical difficulties and a lack of control over fleet manager feedback. An early study of event data recorders cited by Toledo, Musicant and Lotan (2008) apparently had no significant impact on the behaviour or crash rates of young males (Heinzmann & Schade, 2003)[2].

Toledo et al. (2008), Toledo and Lotan (2006) and Musicant, Lotan and Toledo (2007) validated behavioural measures from a telematics monitoring system against historical accident records of drivers from commercial fleets in Israel. Monitoring and feedback of these experimental fleets using this risk measure suggested a reduction in risk, and therefore predicted crash rate, could be achieved; the results are limited to fairly short term data collection though.

[2] Heinzmann & Shade (2003) is not available as an English language publication and was not reviewed directly.

The Israeli studies also report that the behavioural and safety benefits, and engagement with the feedback system (e.g. web portal logins), reduce over time if not supported and return towards baseline levels. This suggests that the role of feedback is important, although the most appropriate form, or forms, of feedback are largely unknown (Horrey, Lesch, Dainoff, Robertson & Noy, 2012).

Table 4: Summary of experimental studies of telematics systems

Reference (shortened)	Summary of paper	Publication type	Peer-reviewed	Control or comparison group	Quality criteria rating Outcome	Quality criteria rating Control	Quality criteria rating Analysis	Evidence of the impact of different types of feedback	Evidence of the impact on driver behaviour	Evidence of the impact on accident rates
Albert et al. (2011)	See Albert et al. (2014)	Conference proceedings								
Albert et al. (2013)	See Albert et al. (2014)	Conference proceedings								
Albert et al. (2014)	Comparison of telematics and self-report data from newly licensed drivers	Journal paper	Yes	No	C	B	B	No	Yes	No
Ayuso et al. (2014)	Comparison of young-novice and young-experienced drivers' PAYD insurance data	Journal paper	Yes	No	A	B	A	No	No	No
Bolderdijk et al. (2011)	Randomised control trial of PAYD monitoring on speed choice and exposure	Journal paper	Yes	Yes	A	B	A	No	Yes	No

Reference (shortened)	Summary of paper	Publication type	Peer-reviewed	Control or comparison group	Quality criteria rating Outcome	Quality criteria rating Control	Quality criteria rating Analysis	Evidence of the impact of different types of feedback	Evidence of the impact on driver behaviour	Evidence of the impact on accident rates
Carney et al. (2010)	Experimental trial of event-triggered video feedback intervention to young drivers and their parents	Journal paper	Yes	No	C	B	A	Yes	Yes	No
Donmez et al. (2008)	Simulator experiment testing concurrent and retrospective feedback	Journal paper	Yes	Yes	C	A	A	Yes	No	No
Farah et al. (2013)	See Farah et al. (2014)	Conference proceedings								
Farah et al. (2014)	Randomised Control Trial of telematics feedback and parental input to reduce male young novice	Journal paper	Yes	Yes	C	A	A	Yes	Yes	No

Reference (shortened)	Summary of paper	Publication type	Peer-reviewed	Control or comparison group	Quality criteria rating Outcome	Quality criteria rating Control	Quality criteria rating Analysis	Evidence of the impact of different types of feedback	Evidence of the impact on driver behaviour	Evidence of the impact on accident rates
	driver risk									
Farmer et al. (2010)	Randomised control trial of telematics with young-novice drivers	Journal paper	Yes	Yes	C	A	A	Yes	Yes	No
Hickman & Hanowski (2011)	Telematics study of three short and long haul commercial fleets	Journal paper	Yes	No	C	B	A	No	Yes	No
Lahrmann et al. (2012b)	Results of a Danish Intelligent Speed Adaptation project 'Pay as you Speed'	Journal article	Yes	Yes	C	A	A	Yes	Yes	No
Lerner et al. (2010)	Review, trial and recommended use of telematics with novice	Government agency Report	No	No	C	B	B	No	Yes	No

Reference (shortened)	Summary of paper	Publication type	Peer-reviewed	Control or comparison group	Quality criteria rating Outcome	Quality criteria rating Control	Quality criteria rating Analysis	Evidence of the impact of different types of feedback	Evidence of the impact on driver behaviour	Evidence of the impact on accident rates
	drivers									
Lotan et al. (2009)	Modelling of young driver behaviour from telematics data collected during 1st year post-licence	Conference proceedings	No	No	C	B	B	No	Yes	No
Lotan et al. (2014)	Pilot study of smartphone based telematics	Conference proceedings	No	No	C	C	C	Yes	Yes	No
Mazureck & van Hattem (2006)	Experimental trial of a following distance and speed related feedback system in The Netherlands	Conference proceedings	No	Yes	C	B	B	Yes	Yes	No
Musicant et al. (2007)	Correlation of telematics data and historical	Conference proceedings	No	No	C	B	A	No	Yes	No

Reference (shortened)	Summary of paper	Publication type	Peer-reviewed	Control or comparison group	Quality criteria rating Outcome	Quality criteria rating Control	Quality criteria rating Analysis	Evidence of the impact of different types of feedback	Evidence of the impact on driver behaviour	Evidence of the impact on accident rates
	claims data from a sample of fleet drivers									
Paefgen et al. (2014)	Case-control study modelling exposure and accident risk from PAYD insurance data	Journal paper	Yes	Yes	A	A	A	No	No	No
Prato et al. (2009)	Study of family relationships and young driver risk using telematics in family cars	Conference proceedings	No	No	C	B	A	No	Yes	No
Prato et al. (2010)	Study of telematics data collected through the first year of licensed driving in Israel	Journal paper	Yes	No	C	B	A	No	Yes	No
Reese & Pash-	Insurance led analysis of	Book chapter	Edited	No	C	B	B	No	Yes	No

Reference (shortened)	Summary of paper	Publication type	Peer-reviewed	Control or comparison group	Quality criteria rating Outcome	Quality criteria rating Control	Quality criteria rating Analysis	Evidence of the impact of different types of feedback	Evidence of the impact on driver behaviour	Evidence of the impact on accident rates
Brimmer (2009)	exposure and claims with an incentivised trial to reduce mileage									
Taubman-Ben-Ari et al. (2014)	Seemingly related to the Farah et al. (2014) study, this extends the findings focusing on parents and the 'family climate for road safety'	Journal paper	Yes	Yes	C	A	A	Yes	Yes	No
Toledo & Lotan (2006)	Description of a telematics monitoring system and validation of its data capture with historical crash records	Conference proceedings	No	No	C	B	A	No	Yes	No

Reference (shortened)	Summary of paper	Publication type	Peer-reviewed	Control or comparison group	Quality criteria rating Outcome	Quality criteria rating Control	Quality criteria rating Analysis	Evidence of the impact of different types of feedback	Evidence of the impact on driver behaviour	Evidence of the impact on accident rates
Toledo et al. (2008)	Validation of a telematics monitoring system in an Israeli fleet with historical crash records	Journal paper	Yes	No	C	B	A	No	Yes	No
Wouters & Bos (2000)	Quasi-experimental study of early telematics impact on accidents in fleets	Journal paper	Yes	Yes	A	A	A	No	No	Yes
Zantema et a. (2008)	Transportation modelling of the impact of different PAYD strategies on network performance and safety. Statistical simulation only	Journal paper	Yes	Yes	A	A	A	No	No	No

In summarising literature from the commercial fleet domain, Horrey et al. (2012) note that there may be a bias to publish studies showing improvements only. In reviewing the evidence, Horrey et al. conclude that the results of published telematics evaluation studies are generally favourable towards improving variables of interest: incidence of crashes, events assumed to relate to safety, productivity, or other derived proxy measures of risk. They caveat that despite this general trend, the overall evidence base is not entirely clear as not all studies are published and research syntheses to support meta-analyses are limited.

With respect to the evidence for telematics having a direct impact on accidents for young and novice drivers, the evidence is almost non-existent. It is likely that commercial operations such as insurance companies have conducted analysis of telematics insurance products and claims (some of which is reported in the next section) but much of this analysis has probably never been publicly released. Fifer (2008) suggests that the number of telematics insurance products available worldwide should offer some reduction in risk. However, it is not possible to establish whether these products are designed to attract a specific self-selected (inherently safer) subset of the consumer population from which there is the potential for commercial profit, or whether this is a product for the young and novice driver population as a whole.

From a public policy perspective there remains a lack of independent scientific evidence for the impact of telematics on young and novice driver accidents.

2.3.2 Pay as you drive insurance

One common form of telematics insurance is known as pay as you drive (PAYD) insurance. With PAYD insurance policies, insurers calculate premiums based on the actual vehicle usage of the policyholder instead of conventional assumptions and lump-sum payments. This approach is seen to improve actuarial risk and incentivise risk mitigation by policyholders (Bolderdijk, Knockaert, Steg and Verhoef, 2011; Desyllas & Sako, 2013).

Ayuso, Guillén and Peréz-Marín (2014) analysed PAYD insurance data from policy holders of a major Spanish insurance company. They compared the GPS data of young inexperienced drivers (<1 year since licensure) with young experienced drivers (>1 year since licensure). Analysis of the GPS data with insurance claims data suggested that in their sample of almost 16,000 drivers:

- Experienced drivers travel more kilometres per day, use urban roads less often (and thereby use highways more often), and drive more kilometres in excess of the speed limit than novice drivers.
- Men are riskier than women (more km/day, higher night time and urban driving, more kilometres over the speed limit).
- Policy holders who drove more than 10% of their kilometres over the speed limit were *less* likely to be involved in an accident than those who drove less than 10% of their kilometres over the speed limit. This result, which appears contrary to previous studies of speed and accident risk (e.g. Ayuso, Guillén & Alcañiz, 2010), is explained by these drivers spending more of their driving kilometres on highways; a road type where crash risk is typically lower and driving in excess of the speed limit may be more common.

While this study is informative with regard to highlighting the heterogeneity of young drivers, it does not afford the opportunity to establish the effect of the telematics or PAYD insurance product. Unfortunately there were no comparison groups with young drivers of vehicles who had not opted for PAYD insurance in order to evaluate the impact of the PAYD insurance product itself.

Using a large dataset from European PAYD insurance consumers, Paefgen, Staake and Fleisch (2014) modelled the relationship of exposure type and accident risk. The traditional perspective has been that increased exposure results in increased crash risk, with little investigation regarding the impact of types of exposure. Reese and Pash-Brimmer (2009) for example note the simplistic relationship between exposure and crash risk with the conclusion that "In general, vehicles driven fewer miles have fewer insurance claims than vehicles driven more miles" (p43). The size of the datasets permitted by PAYD products, however, allows for in-depth analysis of exposure on insurance recorded accident risk. Using a case-control study design, Paefgen et al. (2014) report that:

- The risk of accident involvement is lower between 05:00 and 18:00 hours, while higher between 18:00 and 21:00 hours.
- Driving exposure accumulated on weekends, including Fridays, is associated with lower risk.
- Urban driving is associated with higher risk and highways have the lowest per/mileage risk.
- Both low (0-20 km/h) and high (90-120 km/h) speeds are associated with higher risk with the mid-speed range (60-90 km/h) being associated with the lowest risk of accident involvement.

Similar to Ayuso et al. (2014), this study provides important insight into accident risk through detailed analysis of PAYD data, but does little to inform the current study of the impact of PAYD insurance products on risk. While a comparison group was used during the analysis, this involved data selected from existing PAYD customers who had not been accident involved (rather than non-PAYD consumers).

Bolderdijk et al. (2011) meanwhile implemented a randomised control trial (RCT) methodology to test PAYD insurance incentives. In this study a sample of 141 self-selected car insurance policy holders in the Netherlands took part in the PAYD trial; participants were presumably previously standard policy holders although this is not stated. All participants' vehicles were fitted with telematics systems although as the methodology indicates, participants were randomly allocated to either the experimental or control group. The experimental group participants were offered 30 Euros for keeping to the speed limit, 15 Euros for reducing their mileage, and 5 euros for avoiding driving at night during the weekends. A total incentive of 200 Euros over the four months of study was therefore possible. Some of the experimental group were offered the incentive as a gain (i.e. incentive payments were seen to increase) while others were offered the incentive as a refund (i.e. the cost of their policy was reduced). There were no behavioural differences found between these two experimental sub-groups. The control group participants were meanwhile paid 200 Euros at the end of the intervention period simply for taking part in the trial without any driving behaviour requirements.

Participants in the experimental group also had the opportunity to log into a web portal to receive feedback on their driving performance. The report authors note that the website was rarely accessed by the majority of participants and therefore any effects found are more likely to have been the result of the financial incentives than the driver performance feedback.

The study found that the incentives did not impact on drivers' mileage or times of driving (i.e. weekend night-time driving). Reported feedback from the participants suggests that changing journey habits was difficult; it is also possible that the smaller incentives for reducing exposure and the short length of study were not sufficient to result in active modal shift by participants. Bolderdijk et al. (2011) did find modest but statistically significant effects for speeding (measured as 'the total distance travelled at 6% over the posted speed limit') whereby the experimental group reduced their speeding more than the control group during the intervention stage of the study. However, the experimental group were found to increase their speeding back to previous levels at the end of the experimental stage when the incentives were removed.

The results therefore suggest that PAYD speed-related incentives can reduce overall speeding in the short term, although the long term effect is unknown with the data suggesting that the behaviour is incentive driven rather than the result of attitudinal and longer term behavioural change.

Reese and Pash-Brimmer (2009) meanwhile report a PAYD insurance incentive programme in Texas, USA whereby customers were financially encouraged to reduce their overall mileage more generally. Similar to Bolderdijk et al. (2011), it was also found that participants see driving as 'necessary' and some journeys cannot easily be replaced. Reese and Pash-Brimmer do however report that the insurance-based financial incentives resulted in a statistically significant reduction in mileage when compared with mileage before the incentives were offered. The results must be viewed with caution though as the study did not appear to involve a control or comparison group and the participant group was made up of a motivated self-selecting sample.

Zantema, van Amelsfort, Bliemer and Bovy (2008) modelled the impact of different forms of PAYD insurance at a whole driving population level. The model is largely based on the predicted effects of obligatory or optional PAYD insurance incentivised with variations of mileage and road type. The results in general suggest that a flat rate per mile PAYD insurance for all drivers would improve network performance the most; this arrangement with additional charging by road type would improve safety the most. The safety effect of mandatory PAYD insurance on young drivers was estimated to result in a reduction in crashes of 2%. The speculative nature of this paper is a major limitation to utilising such estimates to inform policy however. Numerous assumptions are necessary when modelling such scenarios, for example, that young drivers will be more likely to be price sensitive and shift transport mode; while this is a logical assumption, it nevertheless proposes that young drivers are a homogeneous group. The authors note that obligatory PAYD insurance is likely to lack public acceptability due to penalising those who drive more.

In summary, studies from PAYD insurance products offer a valuable source of data from those who sign up to it. Bolderdijk et al.'s (2011) study is notable for its methodology and use of non-PAYD policyholders, albeit these drivers still self-selected. Nevertheless, this study provides insight into the role of incentives for improving safety-related behaviour, and the critical nature of ongoing engagement and motivation to maintain any incentive-led change. The studies reviewed offer an in-depth insight into the types of exposure and risk of young and novice drivers which may inform the method for a future study. However, in the context of this review the information does little to enable definitive conclusions to be drawn regarding the effectiveness of PAYD policies.

2.3.3 The effect of telematics on behaviour

Albert et al. (2014) report a study of recently licensed drivers in Israel comparing self-report and telematics data. The family cars of 32 participants (who had been involved in a previous telematics study) were equipped with telematics systems. The young drivers (average age 20.5 years) were given a personal identification key to scan whenever they drove the car to differentiate their driving from other family members. For 2.5 months after telematics installation there was no feedback to participants while telematics data were collected (stage 1). In stage 2, participants received feedback by way of a web based portal and in-vehicle display; this lasted for 3.5 months. In the final stage (stage 3) the feedback was stopped but telematics data continued to be collected for 2 months. During stage 1 and stage 3 participants also completed a self-report questionnaire and travel diary. Results indicated a good association between participants' reported exposure and that recorded by the telematics; a result contrary to other studies comparing self-report and telematics data (Forrest & Pearson, 2005; Lotan & Toledo, 2007).

Drivers self-reported risk ratings at stage 1 and stage 3 were also compared to red, yellow and green risk ratings[3] ('event' scores) from the telematics data. The comparison of self-reported risk ratings and the telematics-based ratings indicated that at stage 1 and stage 3, drivers were likely to perceive themselves as somewhat safer than the telematics data suggested. It is also reported that self-reported and telematics risk indices were lower in stage 3 than in stage 1, suggestive of an influence of the feedback as an intervention at stage 2. Unfortunately the lack of a control or comparison group in this study means that it cannot be determined if the change at stage 3 was a result of the feedback in stage 2, experimental effect or some other factor, such as a natural calibration of risk awareness resulting from on-road experience.

The lack of control or comparison group is not the only limitation of this study. The study sample is small, and a large proportion of the 32 participants were engaged with military service at the time, which would have influenced their exposure patterns. The authors also note that the sample is likely to be biased as the participants had already taken part in a previous driver safety telematics study. It is also necessary to consider the validity of quantified risk from the algorithms used by the telematics devices to determine 'events'; there is no detail regarding the validity of these values or how 'events' related to crash risk. While the system may have been previously validated, it is feasible that drivers' self-reported ratings of risk were in fact more indicative of the risk they experienced when driving and may not have been an underestimate.

Mazureck and van Hattem (2006) report a study for the Dutch Department of Transport (DoT) to test the feasibility of in-vehicle technology to influence following distance and speed. The equipment in this study involved a GPS monitor to measure speed and a device to measure the car's following distance to the vehicle in front. The data were fed back to a dashboard display showing a green light for conforming with desired speed (up to the speed limit) and a yellow light for breaking the speed limit. The same feedback

[3] 'Green' drivers perform fewer than 20 'events' per 10 driving hours; 'yellow' drivers perform between 20 and 50 'events' per 10 driving hours; 'red' drivers perform more than 50 'events' per 10 driving hours

showed the driver when they were within a defined safe following distance to the vehicle in front or not. A lease car company installed the equipment in 62 cars.

Following a baseline monitoring phase where there was no feedback to the driver, the feedback equipment was turned on and participants were able to earn reward points for maintaining a green light for both speed and following distance for each continuous 15 second period. Reward points could therefore be accumulated and then used to purchase items or experiences from a dedicated website. The reward rate offered was highest for the first two weeks of the trial to entice participant engagement; the reward rate halved after two weeks and then halved again after 5 weeks.

Results of this study suggest that the instant driver feedback and rewards, even when reduced, were sufficient to encourage desirable behaviour change. Drivers spent a greater percentage of their driving within the speed limit and with the defined safe distance from the vehicle in front. Due to the study design, it is not possible to determine how much of the change in behaviour is a result of feedback or the incentive. However, the results also found that the immediate positive shifts at the start of the trial faded as the trial progressed and when the system was turned off speeding and following distance behaviour lapsed to pre-trial levels. Similar to other studies (e.g. Farmer, Kirley & McCartt, 2010; Toledo & Lotan, 2006) this study suggests that feedback and sustaining driver interest in the system is a crucial aspect of using telematics devices to improve safety related driving behaviours.

Additional potentially useful insights provided by Mazureck and van Hattem's (2006) study include:

- Drivers' level of fault acceptance, even in a voluntary trial, was very low and drivers became frustrated when the system's speed map data was incongruent with the posted speed limit.
- Participants reported that the fixed safe headway of 1.3 seconds was reportedly difficult to achieve in real traffic as other road users would often move into the headway gaps.
- The study tried to further incentivise drivers to engage with the system through a competition of online behaviour scores. The success of this appears to have been variable with participants reporting it to be just as frustrating as much as it was motivating.

An experimental simulator study sought to explore feedback type further. Donmez, Boyle and Lee (2008) tested participants in a simulated driving environment to test whether concurrent in-vehicle feedback or retrospective feedback was effective at improving driver performance; in this case the focus of the study was improving safety by mitigating driver distraction. Donmez et al. (2008) report that both forms of driver feedback improved driver performance over time compared to a control group with no feedback. Using both concurrent in-vehicle feedback and retrospective feedback was considered to provide the most promise for improving driver performance (in this case improving safety by mitigating the effects of secondary task distraction).

In summary, the studies reviewed all suggest that telematics has the potential to affect driver behaviour in a desirable manner when combined with feedback and incentives. However, studies also appear to show some consistency that this use of telematics manipulates behaviour rather than leading to behaviour change, and therefore lasts for as long as the incentive.

No studies offer an indication of the effect of using telematics long term: it is possible that the initial behavioural effects reported by these studies may lead to long term behavioural change over time, although it is equally possible that the behaviour would be maintained for as long as the driver is motivated by the incentive.

With or without long term behaviour change, the use of incentives to influence post-licence behaviour may be sufficient to influence the critical period following licensure when novice drivers are most at risk of being involved in an accident.

2.3.4 Parental engagement

Previous work has related various aspects of parental monitoring and the family safety climate as being influential on young drivers' risky behaviours (Simons-Morton, Zhang, Jackson & Albert, 2012); a finding not dissimilar to the important role of fleet managers and corporate safety culture on fleet safety. On this basis some studies have sought to combine parental input with telematics feedback to reduce young drivers' risk on the road.

The dynamic between parents, young drivers and telematics monitoring systems is not straight-forward, with studies citing various perceived advantages and disadvantages from each group respectively (Guttman & Gesser-Edelsburg 2011; Lerner et al., 2010; Lotan, Musicant & Grimberg, 2014). A summary of these can be seen in Table 5.

Table 5: Parents' and young drivers' views of parental monitoring using telematics

	Advantages	Disadvantages
Parents	Want the truth about their child's driving	Impact on parent-child relationship
	Contributes to supervision	Data security
	Can help to moderate risky driving	Internet dependency
	Provides the opportunity for open dialogue with the young driver	Lack of ability to influence child's behaviour anyway
	Provides objective data to support parental authority	Invasion of child's privacy
		Cost
		Erosion of trust
		Privacy intrusion
Young drivers	'Objective' indicator of driving behaviour accepted by parents	Concern that parents' will use feedback to impose restrictions
	Can show they are responsible drivers	Ridicule by peers
	Can provide evidence to improve their parents' driving	Feedback not accurate or detailed enough to explain context
	Tool for self-monitoring and	

	Advantages	Disadvantages
	improvement	

Summary based on Guttman and Gesser-Edelsburg (2011), Lerner et al. (2010) and Lotan et al. (2014)

Farah et al. (2014) used a randomised controlled trial (RCT) design with 217 volunteer families to test the effect of different forms of feedback involving young male novice drivers and their parents. A telematics system was installed in the family car and the families were randomly allocated to the following groups:

- Individual feedback: Telematics feedback to each family member about their own driving but not that of any other family member.
- Family feedback: Telematics feedback to the whole family about all family members.
- Parental training: As with the Family feedback group but parents also received training on how to exercise vigilant care regarding their son's driving.
- Control group: No feedback or training.

Driving behaviour was measured in terms of the number of triggered 'events' (e.g. hard acceleration, braking, cornering). Only the difference between the parental training group and the control group was statistically significant, whereby young drivers in the parental training group recorded significantly fewer events. The other two groups were not statistically different from the control group suggesting that the presence of parental training was an important factor in the lower event scores for the parental training group's young drivers; statistically it was not possible to determine the contribution of feedback or training separately within this group.

It was also found that parents' event rates were correlated highly with their sons' event rates, suggesting that young drivers imitate their parents' driving (Farah et al., 2014). However, more detailed analysis from a previous Israeli study using telematics in family cars suggests that while the recorded profile between parents and their young driver offspring (male and female participants) is similar during early licensure (and the 'accompanied stage' in Israel's graduated driver licensing programme), it begins to depart during the early months of solo driving whereby the young drivers record higher risk indices, particularly for males (Prato, Lotan & Toledo, 2009).

Further analysis of telematics data across the first year after licensure for Israeli young drivers also appears to support the importance of the parent (Prato, Toledo, Lotan & Taubman-Ben-Ari, 2010). This study suggests that the telematics data can be used to determine which young male drivers and sensation seekers[4] record the highest risk indices. Lower risk indices within the young driver sample were correlated with active involvement and monitoring of driver behaviour from the parents (Prato et al., 2010).

Similarly, Taubman-Ben-Ari, Musicant, Lotan and Farah (2014) emphasise the role of the 'family climate for road safety', in a report based on what appears to be the same experiment as Farah et al. (2014). They surmise that higher risky driving events among young drivers are associated with parents who have low levels of commitment to safety and low levels of parental monitoring.

[4] 'Sensation seeking' is a personaility trait characterised by thrill-seeking behaviour, inhibition and risk-taking.

Farmer et al. (2010) sought to determine if young novice drivers' behaviour improves following the installation of telematics and various forms of feedback with parental engagement. Young recently licensed drivers (n=85) and their parents volunteered to take part in the study and were randomly assigned to one of three experimental groups or the control group. Group 1 drivers (n=22) received immediate in-car auditory alerts for sudden braking events, sudden acceleration events, non-seatbelt use and speeding. These events were also immediately posted to a parent-accessed web portal. Group 2 drivers (n=20) were treated the same as Group 1 except that the website notification was only made if the behaviour was not corrected. Group 3 drivers (n=21) had no in-vehicle auditory alert and events were posted to the parent web-portal only. Group 4 drivers (n=21) simply had a telematics system installed with no intervention (the control group).

The largest impact of the intervention appeared to be an increase in seat belt use in experimental groups; albeit non-use was rare with seatbelts worn 94% of the time at baseline. It is proposed that the continuous auditory in-car feedback and parental concern led to this effect. There were no statistically significant differences between the experimental groups and the control group with regard to the number of sudden braking or acceleration events. The impact of the intervention on speeding behaviour (10 mph over the limit) was mixed when compared with the control group with notable trends over time. The web-only group had the same speeding profile as the control group, suggesting that this form of feedback had little effect. Post-study interviews with parents revealed that they very rarely engaged with the website reports. Of the two experimental groups with in-vehicle feedback, only the group with concurrent immediate web-notification demonstrated reductions in speed at the start of the trial. Over the period of the trial, however, their speeding behaviour increased and by the end of the trial their speeding behaviour was what might be expected had there been no intervention.

Toledo and Lotan (2006) similarly report finding that driver engagement with monitoring feedback fades over time and that short term positive effects are not sustained if follow-up is not maintained. In contrast, Carney, McGehee, Lee, Reyes & Raby (2010) found that beneficial effects (a reduction in high g-force 'events') of parental feedback of young drivers' video-based driving events did last beyond the experimental stage when monitoring was terminated. However, the study had a small sample (18 drivers) and did not employ a control group; the effects cannot therefore be attributed solely to the intervention.

The evidence suggests that the household safety culture and parental involvement can influence young novice driver risk. The studies reviewed suggest that telematics systems can play a role in influencing young novice driver behaviour, but that it is the role and involvement of the parent that is critical to its success. While parents and young drivers acknowledge the relevance and potential utility of telematics for monitoring and improving safety, considerable barriers and obstacles to general acceptance remain (Lotan et al., 2014).

2.3.5 Intelligent Speed Adaptation

Intelligent speed adaptation (ISA) is a form of Advanced Driver Assistance System (ADAS). ISA essentially informs the driver of the relevant speed limit for the road they are driving on and usually also alerts the driver when the vehicle's speed exceeds this limit. The technical specifics of ISA devices are not considered here; the system is of interest for the general telematics properties and for measuring driver behaviour and providing feedback among the cohort of interest (i.e. young and novice drivers).

It has been suggested that full ISA implementation into the car pool could be effective at reducing road accidents (Carsten & Tate, 2005; Regan et al., 2006; Vlassenroot et al., 2007). Previous studies in numerous countries have provided evidence of 'proof of concept' with ISA systems having an impact on drivers' speed choice, when active (e.g. Biding & Lind, 2002; Carsten & Tate, 2005; Lahrmann et al., 2012b; Peltola et al., 2004; Regan et al., 2006; Vlassenroot et al., 2007; Warner & Åberg, 2007) [5].

Lahrmann et al. (2012a) and Lahrmann et al. (2012b) report on the extensive recruitment and results of an Intelligent Speed Adaptation study in Denmark. It is detailed that despite the positive impact of ISA on speed choice, and reasonably positive feedback from drivers who experience the system, ISA has not made its way into the mainstream market. Furthermore, despite partnering with an insurance company, recruitment and retention of participants in this particular trial proved difficult (albeit the original recruitment strategy unusually required the participant to pay for taking part); instead of a study of 300 young drivers (18-24 years), a study of 153 drivers of all ages was completed.

The system that participants received gave them information about the speed limit for the road they were travelling and warned them via a voice message when they had exceeded the limit by more than 5 km/h. It was hypothesised that if young drivers' speeding behaviour could be shaped then it would have a lasting positive effect, even when there was no ISA system in the vehicle. To test the hypothesis four participant groups were formed:

- Control - system installed but not active (i.e. no information or warning). Full discount received regardless of behaviour.
- Incentive only group – No information, no warning but could lose discount if speeding.
- Information only group – No discount incentive, information and warning only.
- Combination – Information, warning and discount incentive.

The results were suggestive of both information and the incentive reducing speeding behaviour, with 'information only' having the greatest impact; there was no additional effect of combining information and the incentive. It was considered that a self-selecting sample may have been motivated to obey speed limits; therefore the incentive was not as effective as originally hypothesised. The system was not found to have any educating effect as the level of speeding returned to previous levels when the feedback and incentives were terminated. Lahrmann et al. (2012b) report that their overall results are similar to other ISA trials (e.g. Regan et al., 2006; Vlassenroot et al., 2007) and conclude that while ISA has a convincing effect on motivated drivers' speeding behaviour, there is no evidence of an educating effect of the system, or that the 30% insurance discount offered in the study would be sufficient to support ISA as a market driven product.

[5] These studies of ISA are discussed here to provide context and background but did not form part of the core literature found during the literature search and do not therefore appear in Table 4.

2.3.6 Smartphones as telematics

The use of smartphones and associated applications is another possibility for measuring driving behaviour. Utilising a driver's smartphone replaces the need for a telematics device to be installed in a vehicle and instead makes use of smartphone sensors (e.g. GPS and accelerometers).

Using smartphones as a telematics device has several advantages: there is no hardware or installation costs, the sensors follow the driver and not the vehicle, apps can be easily downloaded by the user, and the user has control over monitoring.

This last advantage is also the primary disadvantage of smartphone telematics. With the user able to choose when to turn the monitoring on and off, there is the opportunity to select to turn it on for advantageous journeys and neglect to turn it on for non-advantageous journeys. It is also possible to turn the monitoring on when travelling as a passenger. Less deliberate acts, such as forgetting to turn the monitoring on, could also misrepresent measures of users' exposure and driving behaviour. Further disadvantages of using smartphones rather than fixed telematics devices is that different phones can use different sensors and the placement of the phone in the vehicle is likely to affect measurement (e.g. phone sliding around on the passenger seat versus upright in a cradle).

For an overview of the opportunities and challenges of smartphone based insurance telematics see Händel et al. (2014).

Lotan et al. (2014) claim to be the only scientific study of the usability of a smartphone based driver telematics system at the time of publication; no other smartphone publications were found during the current search. The study was a pilot with only 21 participants and cannot be regarded as providing evidence of effectiveness. Nevertheless, the aim of the pilot was to trial the use of the technology rather than validate its influence on behaviour or safety. The trial utilised an existing iPhone application that monitored driving behaviour via GPS and accelerometer readings.

A focus group with young drivers initially suggested that they were intrigued with the concept but did not see a need for the app to provide feedback to parents and would not seek financial incentive from their parents (one of the possible features of the app). Participants appeared to prefer vouchers and fuel discounts over cash rewards or insurance discounts. The sample was taken from a scout group, which is likely to have influenced the agreement that working towards a group benefit was beneficial compared with working towards a personal benefit.

A group benefit was used in the trial (good driving behaviour was rewarded with up to five t-shirts for a scout summer camp) and appeared to be a successful short-term incentive. The overall results suggested that drivers stopped using the app as soon as the incentive was achieved, and many admitted to not using the app all of the time. Some also admitted using the app when travelling as a passenger to accrue safe driving mileage quicker to gain the incentives.

As noted, the results of this study are indicative only, nevertheless they provide some insight into the challenges that further studies will need to consider.

2.3.7 Methodological constraints

Both Horrey et al. (2012) and Carsten, Kircher and Jamson (2013) note that despite the benefits of the data recorded by telematics devices, methodological limitations have constrained telematics studies. For example, while sample sizes are often acceptable, the outcome variables being measured (particularly accidents) can be subject to random variation and are small in number. As a result, small changes (such as those observed in commercial fleets) can be reported as large proportional differences. Measuring baseline and control data is also difficult.

Another consideration is that even when no feedback is given to drivers, a change in behaviour is noted following installation of a telematics monitoring system. This effect usually drifts back to 'normal' levels and studies often employ a 'baseline period' to account for it, although behaviour prior to installation cannot be compared with behaviour post-installation using objective, high-resolution telematics data. This experimental effect (i.e. the mere presence of the device) makes it more difficult to establish causal effects of the technology and types of feedback. Using control or comparison groups is one way of mitigating the effect of this experimental bias, although these can be difficult to establish. Often the control groups are of the same self-selecting sample as the experimental groups (e.g. those who have opted for PAYD insurance). These can be useful to determine differences in the system (for example, types of feedback) but it does not allow for determination of the effect of the system as a whole on the wider population (e.g. those who do not choose to have PAYD insurance). Even when using matched comparison groups, Horrey et al. (2012) note the large number of extraneous factors that will always cause doubt over other possible explanations for any results found.

The practicalities of telematics studies also limit the ability to measure the effect on accident rates. As Paefgen et al. (2014) point out, research using telematics devices still requires substantial resources to account for study personnel, equipment, information processing systems, IT support, data coding and analysis, and administration of and incentives for participants. They estimate that a recent naturalistic driving study cost more than US$20,000 per vehicle.

As noted in Section 2.3.5, Lahrmann et al. (2012a) provide a detailed overview of the difficulties recruiting participants for a Pay as You Speed study in Denmark. Another study similarly reports to have required a whole year to recruit just 10% of participant families who had initially shown willingness to take part in a telematics trial, despite the offer of a large monetary incentive (Farah et al., 2014).

2.3.8 Summary

A previous review of telematics concluded that the key limitations of the research at that time were as follows (note that 'IVDR' in this context refers to in-vehicle data recorders, or telematics in broader terms):

- "Several reviewed studies used small, homogeneous samples and short periods of data collection.
- The context of the installation, feedback and any external reference to the IVDR system may exert its own distinct influences on driver behaviour.
- Some IVDR systems claimed to measure risk without robustly demonstrating predictive validity.

- Several studies may have been subject to a regression to mean effect if IVDR systems were fitted in response to an atypically high accident rate, thus over-estimating the safety effects of IVDR.
- Future applications of IVDR systems for research or policy purposes will need to address the public acceptability of IVDR and the extent to which the people who accept IVDR differ from those who do not in terms of their driving behaviour.
- The potential for widespread use of IVDR systems is likely to depend on a number of issues associated with data ownership rights and data privacy."

(Tong & Felstead, 2008, piii)

All of these limitations are still valid today. However, the body of evidence from which to draw conclusions has developed and while the overall quality of studies is reasonable even if methodological limitations remain (most notably the issue of self-selecting samples and a reliance on measures of driver behaviour that are assumed to be indicative of safety but have no validated association with accident risk).

There are now a number of studies that have evaluated driver monitoring systems for young and novice drivers. Although there have only been a few published reports with rigorous experimental designs and analyses, it appears that monitoring can reduce the occurrence of assumed risk related behaviours, especially when parental engagement is fostered.

While initial findings show promise, there is currently no evidence that the behavioural changes reduce crashes directly for this cohort of drivers. While the mechanisms of effect would suggest that they should (e.g. reduced exposure to risky scenarios) there is not enough current evidence to support widespread development and implementation of young and novice driver monitoring systems and programs. Young and novice driver monitoring is a complex application that requires careful consideration of required functions, technologies, interfaces, implementation strategies, and stakeholder concerns (see RoSPA, 2013 for a more detailed overview of these concerns).

Studies have shown that telematics data is more reliable and of higher resolution than conventional self-reported driving data, thus increasing the validity and quality of data used for analysis and reporting (e.g. Forrest & Pearson, 2005; Lotan & Toledo, 2007). Furthermore, telematics offer a way to objectively study the behaviour of motorists in a minimally intrusive manner. Rosomer, Deschamps, Wilson and Fisher (2012) note that even low-cost in-vehicle data recorders are able to differentiate between novice and experienced drivers.

However, there is little clarity regarding the best form of reward or punishment for incentivising drivers. The PAYD studies demonstrate that desired driver behaviour can be incentivised successfully in the short term but the most efficient and cost-effective method for doing this, particularly for young and novice drivers, is largely unknown. Furthermore, there is very limited evidence of longer term educating effects beyond the monitoring phase. Nevertheless, encouraging desired behaviours during the critical post-licence stage (e.g. reducing driving at night and speeding) would be theoretically beneficial; the most appropriate way to incentivise this for all novice drivers is not clear though.

In summarising the state of the evidence for telematics and young drivers, Lotan et al. (2014) note that studies have shown promise for telematics to reduce behaviours associated with risky driving (e.g. Carney et al., 2010; Farah et al. 2014; Farmer et al., 2010; Farmer et al., 2010; McGehee, Raby, Carney, Lee & Reyes, 2007; Prato et al., 2010). However, some of these studies also suggest that the benefits are lost when monitoring and feedback are terminated, and may be entirely dependent on parental engagement.

Paefgen et al. (2014) note that research using such devices for research still requires substantial resources. To overcome some of the financial barriers, research often relies on market driven applications of telematics, such as in commercial fleets, and insurance data. Such compromises can impact on control of study variables and although many of the studies reviewed have employed fairly rigorous methodological designs, they all have methodological weaknesses.

2.3.9 Conclusions

The following conclusions can be drawn from the literature reviewed:

- There is no direct evidence of the effectiveness of telematics systems on the accident rates of young and novice drivers.
- Taken as a whole, studies of the use of telematics in commercial fleets are suggestive of the potential for telematics to reduce accident rates in certain supportive environments (e.g. high initial accident rates, implementation of strong safety culture governance, fleet manager support and driver feedback).
- PAYD data can be extremely informative although there are too few published studies comparing PAYD policyholders and non-PAYD policyholders in order to draw any firm conclusions regarding the effectiveness of such policies.
- It has been demonstrated that telematics can influence driver behaviour in a desirable manner when combined with feedback and incentives. However, such studies also appear to show some consistency that the use of telematics manipulates behaviour rather than leading to behaviour change, and therefore lasts only for as long as the feedback and/or incentive are in place.
- Evidence suggests that a ‘household safety culture’ and parental involvement can influence young novice driver risk. Telematics systems can be effectively integrated into the parent-young driver relationship to influence behaviour, but the barriers to general acceptance and adoption on both sides are considerable.
- Other forms of telematics such as Intelligent Speed Adaptation can also positively influence driving behaviour but do not appear to provide an educating effect; rather the behaviour change is incentive or feedback driven.
- Methodological constraints such as self-selecting samples and controlling for all of the factors that can affect driver behaviour and accident risk make telematics studies challenging and complex. As a result, high quality studies (particularly when aiming to use accidents as an outcome variable) require substantial resources and commitment. These restrictions may go some way to explaining the limited evidence for the effectiveness of telematics systems to reduce young and novice driver accident rates.

2.4 International policy measures related to telematics

The aim of this task was to identify countries with policies concerning the use of telematics, and to consider how those policies are intended to direct the development and implementation of the technology. Key issues such as the impact on road safety and data privacy in relation to policies were also explored.

2.4.1 Method

Online searches were conducted using Google. Search terms included telematics; black box; in-vehicle monitoring, vehicle data logging and policy / policies.

In addition to Google searches, country-specific versions of Google were also interrogated. All searches were in English and searched English language results.

Official Government transport department websites were also explored, and enquiries were made using contacts in transport research institutions and ministries in the relevant countries, to assist with identifying relevant policies.

The countries of interest were:

- Australia
- Canada
- Denmark
- Germany
- Israel
- Italy
- The Netherlands
- Sweden
- USA

2.4.2 Results

The majority of the results of the online searches were articles relating to insurance companies offering telematics devices fitted to vehicles to reduce insurance premiums, product details for specific systems, or informational articles discussing the implementation of policies for companies considering in-vehicle monitoring programs. These results were not relevant to the task aim.

Searches of the various government websites revealed an apparent lack of telematics policy information online. In the case of non-English speaking countries such as Israel, The Netherlands, Denmark and Italy there was a language barrier that prevented a full exploration of the websites. Whilst many of the government pages have English equivalents there is limited English language content.

Feedback from the contacts in transport research institutions provided the most leads. However, even here the results were mixed. They can be summarised on a country-by-country basis as follows:

2.4.2.1 Australia

Road freight and bus industries in Australia have long used a system of in-vehicle telematics with the purpose of improving road safety, managing the use of the road network (and thereby avoiding congestion) and increasing business efficiency. The system is known as the Intelligent Access Program and uses heavy vehicle telematics (such as location and time) to monitor where, when and how heavy vehicles are being operated and can be used to confirm compliance with jurisdiction. A policy paper was produced in 2014 (National Transport Commission, 2014) discussing the introduction of a national framework to provide consistency in compliance and management of these systems. The purpose of the policy was to establish the uses for telematics data and the boundaries regarding data privacy. Key functions of the policy were to provide a resource to improve compliance and enforcement outcomes, maintain a common dataset based on international standards, and to establish framework principles relating to privacy, enforcement, and use of the collected data.

2.4.2.2 Canada

In Canada, telematics equipment that is already fitted to the vehicle when first sold is subject to federal jurisdiction. However there are no federal requirements for allowing or requiring telematics systems, and no specific federal motor vehicle safety policies for devices or applications that record vehicle or driving parameters for the purposes of insurance, fleet management or eco-driving feedback. Such devices tend to be retro-fitted and are therefore more likely to be subject to provincial requirements; however, no such requirements were known. There have been recent discussions about the requirement for electronic logging devices (ELDs) in commercial vehicles, but these have not yet become policy. There are also some provincial requirements to limit distraction while driving, but these refer primarily to the use of hand held cell phones or other electronic communication devices.

2.4.2.3 Germany

Information was found regarding the Intelligent Transport Systems Act, which entered into force on 20 June 2013. The purpose of this act was to comply with the specifications adopted by the European Commission (Intelligent Transport Systems Act Directive 2010/40) regarding the use of information and communication technologies in managing traffic flow. It was not possible to find further information in English.

2.4.2.4 Italy

In Italy, "Monti's Law" was introduced in 2012 to address the high rate of auto theft and in response to the number of fraudulent whiplash claims. The legislation makes it compulsory for telematics boxes to be installed in new cars. Insurance companies in Italy have to provide a telematics option for customers. All insurance companies are required by law to offer lower premiums to drivers with telematics devices installed in their cars. The only data in Italy that is allowed to be used from telematics is location and time. It is suggested that Italy is the most mature insurance telematics market with a penetration rate of 4% by the end of 2013 (Eliot & Moss, 2013).

2.4.2.5 USA

Several rules were found on the Federal Register of the United States Government concerning event data recorders (EDRs). The final rule was produced in response to the growing number of light vehicles equipped with EDRs, and was intended to encourage standardisation of data obtained through EDRs (Code of Federal Regulations, 49 CFR Part 563[6]). The National Highway Traffic Safety Administration (NHTSA) was found to have dedicated website pages[7] regarding research into EDRs. It also has created a policy to govern the data collected by EDRs, which are a type of telematics device used to record high resolution collision data for the purposes of accident investigation and reconstruction. Such devices have been integrated by most automotive manufacturers producing vehicles for the US market and are sometimes retrofitted to vehicles. The policy sought to standardise the frequency of data collection and the range of parameters recorded so that the data were sufficient for understanding accidents and potentially assisting with any legal proceedings following a collision.

Such policy measures are not directly relevant to the current study, which is interested in the use of telematics devices as a way of managing driver behaviour as part of an insurance policy. It is possible that such devices may also incorporate collision detection and recording (in which case, the precedents set by NHTSA would be of interest in that respect); however, the focus of this work is on telematics devices that can be used to change behaviour to reduce accidents rather than record them if they do occur. In this context, the policy measures are not directly relevant although it does indicate that if important decisions are to be made on the basis of telematics data, minimum requirements for data quality may be required to ensure that the market is treated fairly.

2.4.2.6 Sweden

A National Strategy and action plan for the use of Intelligent Transport Systems (ITS) was published by the Swedish Transport Administration in 2014[8]. An English language version could not be found. Information on the privacy rules regarding vehicle positioning systems was published by the Swedish Data Inspection Authority in 2011 which provides key points for both employers and employees regarding the requirements for storage and use of vehicle positioning systems[9]. However, this is a guidance document rather than policy.

2.4.3 Summary

Online searches for policies relating to the use of telematics did not identify any documents; however, information from contacts in other transport research institutions and ministries provided five country-specific leads. These were investigated further and only in the USA was there a telematics-related policy (albeit specifications for accident

[6] http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title49/49cfr563_main_02.tpl

[7] http://www.nhtsa.gov/EDR

[8] http://www.trafikverket.se/contentassets/e45f594e1cab49fa952f77ba55bb4ed4/strategi_handlingsplan_its_140430_ts.pdf

[9] http://www.datainspektionen.se/Documents/faktablad-positioneringsteknik-eng.pdf

data recording functions). Australia has produced policy papers discussing measures to implement similar governance over telematics data collection and uses, particularly given widespread fitment among road transport vehicles. The other common theme in the small number of countries with telematics-related guidance is the need to govern data privacy, which is typically subject to local data protection laws. The exception is Italy, which has mandated the fitment of telematics in new vehicles and also requires insurers to offer telematics-based policies to customers as an option.

2.5 Implications for a future study

Based on the literature review, a number of themes that could impact on a future methodology were identified. These included:

- The importance of exposure data in comparing two groups of policy holders
- Self-selection into trials and telematics insurance policies
- The limitations of small numbers and small changes in outcome measures
- The impact of the initial period of installation of a telematics device
- The challenges of self-report data
- Identifying the impact of telematics-based policies for individual drivers within a multi-driver policy
- Differences between the impact of telematics by feedback and incentives offered

2.5.1 The importance of exposure

In the initial study plan, a comparison between a post-risk indicator such as claims was suggested as the outcome measure. Even though there was limited research into comparing telematics and non-telematics policies, other similar comparisons identified the need for controlling for exposure measures, both in terms of how and where policy holders drive, but also in evaluating risk. The findings from these studies, and the implications for the proposed analysis, are as follows:

- Drivers differ in the distance that they travel, the use of urban roads, and their speeding behaviour. These all impact on rates of accident involvement and therefore the comparative analysis would need to collect exposure by road type and possibly speed.
- Men generally are exposed to more risk than women in that they tend to drive further per day, drive more at night and in urban areas, and drive more miles over the speed limit[10]. Gender would need to be accounted for in the comparative analysis, alongside time of day for different types of exposure and compliance with the posted speed limit.
- The risk of accident involvement is lower between 05:00 and 18:00 hours, during the weekend and on highways, while higher between 18:00 and 21:00 hours and

[10] In one study, policyholders who drove more than 10% of their kilometres over the speed limit were less likely to be involved in an accident than those who drove less than 10% of their kilometres over the speed limit. Apparently contradictory results similar to these can be explained (and therefore controlled for) by understanding what type of roads they travel on.

on urban roads. As stated above, time of day for exposure would need to be accounted for in any comparative analysis.

- Speed data is also important exposure information as studies found that both low (0-20 km/h) and high (90-120 km/h) speeds are associated with higher risk.

These comments suggest that exposure information in the comparative analysis should incorporate more detailed information than mileage alone. Exposure data must be combined with time of day, road type, road speed limit, and speed limit compliance to account for differences in risk. Without this information for the control and treatment groups, an underlying (and unlikely) assumption must be that there are no differences in the exposure experienced by each group.

It is likely that these detailed exposure data will exist in samples using telematics-based insurance products; it is non-telematics policyholders for whom these data will not be readily available from insurers. This will require some additional data collection which could either be self-reported (with associated difficulties in achieving the required detailed) or provided by a smartphone-based application provided to either both or solely the control group to unobtrusively monitor and report exposure directly to TRL.

2.5.2 Self-report data

With a comparison between policy holders who have a telematics box installed and those who do not, serious consideration has to be given to collecting comparable data from the second group, given that, by definition, there is no telematics device to collect that data. It is anticipated that while raw telematics data would not be collected, insurers would have the capability to provide summary statistics covering different types of exposure and driving style (e.g. time of day, type of road, speeding) for each telematics policyholder. Such data could be collected via self-report measures or a smartphone-based application.

A further alternative could be a controlled trial (discussed in Section 2.5.3) where all participants have a telematics box installed in their vehicle which records their driving behaviour but the participants in the control group receive no feedback and could be told that it has no influence over their policy. This only achieves the objective of the study to evaluate the impact of installing telematics devices in young drivers' cars if it can be assumed that having a telematics box installed with no feedback and no impact on their insurance policy is equivalent to their driving behaviour if no box had been installed. One study suggests that once an initial period of impact is over, driver behaviour does return back to a normal level but it is difficult to use this as a baseline as some driving experience will have been gained over this period of time. The use of less intrusive smartphone technology is expected to have far less impact on behaviour and also not substantially affect the cost of the proposed study, whilst still collecting sufficient data with a similar level of accuracy (albeit with some limitations as discussed in section 2.3.6).

2.5.3 Self-selection bias

Several evaluations noted the difficulty in comparing pre-existing groups of individuals who select to have different telematics products, or indeed whether to have a telematics product at all. It was observed that these groups could be fundamentally different types of drivers and any differences found in the outcome measure could not be assumed to be related to the telematics product above fundamental differences between the groups in the first place. No study appeared to control for this bias successfully.

- One study commented that future applications of telematics systems for research needed to consider the extent to which the people who accept telematics differ from those who do not in terms of their driving behaviour.

Another possible source of bias is the impact that being involved in a trial can have (and such demand characteristics are not exclusive to studies where there is an obvious intervention, e.g. a telematics box). In some controlled trials a baseline control group comprised drivers who had a telematics box fitted but received no feedback as suggested above.

- These trials noted that the installation of a telematics system impacts on driving behaviour.
- It was noted that the effect usually drifts back to 'normal' levels after a period of time.

These types of trial design appear to identify differences in different systems and different types of feedback but do not allow the evaluation of these types of systems on a population as a whole.

2.5.4 Understanding small numbers and small changes

If the key outcome measure is defined to be collisions, especially those that result in an injury, the rate of these outcomes will be extremely small compared to exposure. One commentary noted that small changes potentially influenced by random variation can be reported as large proportional differences. Therefore, trials of this nature should run for a long time or consider alternative measures of post-risk.

Given the challenges involved in producing a valid and robust result it is also important to run a trial or evaluation on a large group. If trials are run on small groups due to practical, budget or time restraints then generalising the results to the whole population will be a challenge.

It was also noted in the review that several studies may have been subject to a regression to mean effect if telematics systems were fitted in response to an atypically high accident rate, thus over-estimating the safety effects of telematics. This risk should be considered if data are to be collected from insurance policy information, as high risk individuals could gain more financially by taking out a telematics insurance policy.

2.5.5 The impact of time on evaluation of telematics

Two impacts relating to time were identified in the literature review. Firstly, there is an initial impact of having a telematics device installed in your vehicle. One study reported safer driving in the first period of the trial after a telematics box had been installed which returned to a more natural driving style after a period of time when no feedback was received.

Secondly, it is unclear whether there is any residual impact of the telematics device on driving behaviour once it has been removed from the car. It is possible that the initial behavioural effects reported by these studies may lead to long term behavioural change over time, although it is just as possible that the behaviour would be maintained for only as long as the driver is motivated by the incentive and/or aware that their driving is being monitored.

These findings impact on duration of the data collection trial and may require splitting the analysis into different periods of time before and after the installation of the telematics device. Consideration should also be given to only including drivers on their first insurance policy so as not to be affected by previous experience.

2.5.6 Identification of individual drivers in claims data

One controlled trial reported the difficulty in identifying the driving behaviour of the young driver when a car is shared between different drivers. This was controlled for by providing a personal identification key to the driver of interest.

This could be a potential confounding factor in our telematics group if data collected for this group are based on the data collected from the telematics system which could contain information from several drivers.

2.5.7 The impact of incentives and feedback

Several studies compared different telematics systems in terms of incentives offered and feedback provided. No differences in behavioural change were observed between different incentive packages unless large incentives were offered, however feedback did appear to affect driver behaviour with studies reporting a reduction in safe driving behaviours once feedback had been removed. The timing and method of feedback could also have an impact. An assessment which compared young drivers' driving behaviour with their parents' driving behaviour showed that low levels of parental monitoring and low levels of commitment to safety were directly related to risky driving behaviours in young drivers.

This suggests that any differences between telematics and non-telematics users could be dependent on different incentive, feedback and parental involvement. It will be important to ensure that differences in the individual policies are known in order that the results are not biased towards a small number of different policy options. However, even when differences in policy types are known, it will not be possible to know how the feedback is used once it is delivered to the policyholder(s). For example, parents may have direct access to the telematics feedback provided by an insurer but the extent to which they act upon this and discuss it with their children will remain largely unknown. Several studies have emphasised the importance of parental feedback so this could be a limitation of any further study.

2.5.8 Data privacy

Whilst it was appreciated that data sharing would be a primary concern for insurance companies, one evaluation commented on the take up of telematics systems being dependent on the public understanding and agreeing to make their journeys identifiable to their insurance companies.

This suggests that a further difference between people who select to take up telematics policies and those who do not could be related to people's risk levels of data privacy and this should be considered in devising control and treatment groups.

This suggests that there are more factors than initially identified that could influence whether an individual chooses a telematics or non-telematics insurance policy. If possible, all factors should at least be identified to ensure that the research can detail the limitations in matching the control and treatment groups. This could be achieved with an initial questionnaire or choice experiment to identify as many factors as possible.

3 Consultation

3.1 Aim

The consultation sought to engage with UK insurers to explore what claims data were held for policyholders using telematics and non-telematics products, the level of comparability between insurance data for telematics and non-telematics policies, and whether such data could be made available for future research and analysis.

In addition to claims data, the consultation with insurers also identified supplementary data measures that could be made available for selecting and categorising samples of telematics and non-telematics users. This would determine whether insurers alone hold sufficient data for a comparative accident analysis, or whether supplementary data are required from policyholders. Obtaining insurance claims data direct from insurers for both groups would provide the most accurate data for comparative statistical analyses. Some insurance companies offer both telematics-based policies and non-telematics-based policies, so initial efforts focused on obtaining data on both groups from the same companies.

The consultation process also gathered views and opinions on how the UK Government, the EU, the manufacturing industry and the insurance industry could support telematics insurance through research and policy.

3.2 Method

A consultation document was developed to structure the discussions and was provided to insurers prior to the consultations, allowing time to prepare responses in advance. An internal workshop was held by the project team to generate the content of this document. Some of the questions included were provided by DfT, which approved the document prior to the consultation commencing.

The document includes questions about telematics policies on offer and any comparative non-telematics policies, lists of policy and claims data that could potentially be used in the proposed methodology, questions about data sharing concerns and restrictions, and broader questions to gather information about the opinions of the telematics industry on how research and policy could support the industry.

Prior to participating, each consulted party received a summary of the research background, the consultation goals, a document outlining TRL's data security processes and experience, the consultation document, and a consent form. The consultations were conducted by telephone with each lasting approximately 90 minutes. Notes were taken during each discussion and were supported by a digital recording of each call.

3.3 Results

TRL consulted companies involved in telematics insurance including underwriters, brokers, and service providers. In these talks, telematics-based policies and non-telematics-based policies were discussed, including three provisional driver policies.

3.3.1 Telematics product information

It was important for this project to understand the conditions that apply to each type of policy, the data that are collected via telematics and how those data are processed to provide driver feedback and incentives. An understanding of the range of telematics-based policies on offer was important for determining the breadth of the sample required in order to generalise to the wider population. It would also provide further variables for discriminating between different types of telematics-based insurance to explore whether accident rates vary for different types of telematics policies once differences in the target population are controlled for (e.g. policies that control exposure may have a different effect on accident rates when compared with policies that aim to moderate vehicle control behaviours).

The approaches taken by insurers with regards to policy features vary widely. Some have taken an interventionist approach providing active feedback with rewards and penalties, with most insurers in this category tending to describe their policy features as either 'carrot' or 'stick' orientated. Other insurers have taken a more passive role, offering products similar to traditional policies where the telematics data is used as a guide and only acted on at renewal or in extreme cases. As the telematics-based insurance industry is relatively new, the average length of time that the products discussed have been available on the market is approximately 2.8 years, ranging from over eight years to a couple of months.

Although nearly all the products are targeted towards young and/or novice drivers, the majority of the products have no age restrictions and are available to people of all ages who may be incurring high premiums (e.g. people with more experience but are offered a high premium due to other risk factors such as a small or non-existent no claims bonus (NCB)). However, some insurers do implement age restrictions, the most common being 17–25 years (with variations including 17–24 years, 17–30 years, and over 19 years of age).

Table 6 shows the policy features referred to during the consultations, whether at least one of the insurers in the consultation offered this feature, and specific comments from insurers as appropriate. Overall, a wide range of features are offered across the telematics-based insurance market, which highlights the diversity that is currently available to customers. The only items that were not represented among the sampled products were mileage-based penalties for poor driving, restrictions on carrying passengers and in-car feedback systems linked to telematics.

Table 6: Telematics policy features represented in at least one of the products offered by the sample of insurers[11] (features highlighted in orange were not represented in this sample but might still exist in the market)

Policy features	Details
Incentives	**Discounts or benefits in current year**
	Discounts or benefits on renewal
Penalties for poor driving	**Increase to current premium**
	Increases to current premium
	Increases at renewal
	Cancellation
	Restrictions on mileage
	Curfews on time of day
	Other
Restrictions	**No. of passengers**
	Mileage
	Time of day/curfew
	Other
Feedback methods	**In-car**
	Online
	Mobile application
	Telephone call
	Email
	Text
	Other
Feedback details	Feedback is typically tailored for a journey or incident and is generally in the form of generic information and tips. More tailored approaches can talk drivers though their behaviours and offer advice or online courses. Feedback can be at regular intervals or triggered automatically. Feedback can be immediate if a serious incident is thought to have occurred.

[11] 15 separate policies were discussed within this section of the consultation. Not all questions were asked for all 15 polices.

Policy features	Details
Other features	**Event data recorder**
	Collision detection and first notification of loss
	Emergency response/E-Call
	Fraud detection
	Customer vehicle tracking
	Stolen vehicle tracking
	Other

3.3.2 Policyholder information

One of the main aims of the consultation was to gain an understanding of the types of data collected by insurers about their customers. The insurers were asked about which data could be used to characterise samples, and whether comparable groups of telematics and non-telematics users form part of their customer base. The type and format of variables that are used to define each group would need to be matched across different insurers so data consistency was a focal point for the consultation.

Table 7 includes a list of the policyholder and claims information required to create matched samples between the telematics and non-telematics customers, an indication of whether the sample of insurers could provide this information for telematics and/or non-telematics customers, and any comments from the consultations about the detail and format of the data.

Table 7: Policy holder and claims information represented in at least one of the products offered by the sample of insurers (split by telematics and non-telematics products)

Information	Telematic	Non-telematic	Comments
Vehicle information			
Vehicle type (car, van, etc)	Y	Y	
Vehicle age or VRM	Y	Y	
Engine size	Y	Y	
Vehicle insurance group? (matching samples)	Y	Y	Industry-wide ABI (Association of British Insurers) vehicle insurance group codes as well as insurer-specific internal risk ratings
Vehicle purpose (social, commuting, business)	Y	Y	
Policy information			
First 4-5 digits of the customer's postcode	Y	Y	

Information	Telematic	Non-telematic	Comments
How many drivers on the policy?	Y	Y	
Which is the main policyholder?	Y	Y	
The demographics of all named drivers?	Y	Y	Other named drivers typically have fewer details recorded compared to the main policyholder
Main policyholder - Age	Y	Y	
Main policyholder - Sex	Y	Y	
Main policyholder - Licensure	Y	Y	
Main policyholder - Auto/manual	Y	Y	
Main policyholder - Socioeconomic status	Y	Y	May use marital status and/or credit rating as an indirect measure
Main policyholder - Employment status	Y	Y	
Main policyholder - Job title	Y	Y	
Estimated total mileage	Y	Y	
Estimated daytime mileage	Y	N	Detailed exposure data for non-telematics policyholders is not collected. For telematics-based insurance, some additional analyses might be required to provide the different types of exposure.
Estimated night-time mileage	Y	N	
Actual total mileage (business/other)	Y	N	
Actual daytime mileage	Y	N	
Actual night-time mileage (if this is known, how is 'night-time' defined?)	Y	N	
Number of policy cancellations	Y	Y	
The reason for policy cancellations (by points, due to telematics, etc.)	Y	Y	May not be completed accurately or in a consistent format for analysis
Who cancelled the policy	Y	Y	
Offences/points history	Y	Y	May only be accurate at the time of a quote being offered or at renewal
Number of years a telematics policyholder	N	N	Historical use of telematics-based insurance would only be available if the previous policy was with the same insurer
Internal rating of risk	Y	Y	Will be specific to each insurer and not shared with third parties. Not consistent for matching between insurers.

Information	Telematic	Non-telematic	Comments
Frequency of communication regarding policy conditions (incentives, restrictions, etc).	Y	Y	Data may be unavailable in a usable format. More data would be available for telematics than non-telematics customers, hence unsuitable sample-matching (but useful for providing a broad sample of telematics-based policyholders).
First notification of loss (FNOL) events over time	Y	N	
Extended mileage over time (beyond a single policy)	Y	N	
Historical information on feedback given to policyholders based on telematics (extent of contact, agreed actions etc)	Y	N	Records may only apply to certain types of communication
Other	Y	Y	These include premium price, method of payment (monthly/ annual – where annual implies safer), time of day of purchase (where daytime implies safer), criminal convictions, bankruptcy history, and how often the vehicle is parked at policyholder address
No claims bonus	Y	Y	
Claims information			
Value	Y	Y	
Liability/fault	Y	Y	
Number of parties involved	Y	Y	Might be a grouped classification
Injury severity	Y	Y	Might be grouped or free text and based on injury cost, which may not correspond directly to severity
Type of accident	Y	Y	Might be grouped or in free text format
Number of claims	Y	Y	The number of claims may include no fault claims and window claims and may vary by insurer
Other	Y	Y	Summary telematics data for claim and property damage may be available
Claims are associated with specific drivers (for policies with multiple drivers)	Y	Y	
Are there any other data that could be provided in addition to the items listed above?	-	-	Can include difference between telematics and the non-telematics policy price and how the policy was purchased (through aggregator, direct, etc.)

The consultation found that information captured by insurers for both telematics and non-telematics policyholders was sufficiently comparable across policy type in the following key areas:

- Vehicle information (e.g. vehicle make, model, insurance group)
- Policyholder demographics
- Policyholder risk (actuarial classifications)
- Policyholder driving offences
- Claims (e.g. frequency, cost, fault)

However, information to describe exposure (actual mileage and the conditions in which mileage was accrued) was not sufficiently comparable across the two policy types as it was not collected for non-telematics policyholders.

3.3.3 Data issues and limitations

3.3.3.1 Policyholder data limitations

Policyholder data were collected in a way that was apparently consistent across insurers and could be made available for analysis, with some exceptions for:

- **Insurance history.** General insurance histories were not collected routinely and historic policy information would probably only be available if it was from the same insurer. This would make it difficult to identify previous experience of telematics-based insurance from insurance data alone.
- **Exposure.** Exposure data deemed important for matching and comparing samples with and without telematics would be limited, primarily for the non-telematics customers. No insurers were able to gather exact mileage information for non-telematics customers due to validation issues, although mileage estimates were gathered for nearly all policies with the exception of some insurers that do not believe mileage is a risk factor. Customers' estimates were generally reported by insurers to be inaccurate. Other forms of exposure data were not available for non-telematics policyholders but might be for telematics policyholders (e.g. mileage by road type, journey durations).
- **Claims data.** Claim injury severity is not always recorded and a named driver is not always associated with the incident meaning that, for policies with multiple named drivers, it may not be possible to differentiate incidents associated with a young novice driver from those associated with older more experienced drivers. Furthermore, claims data appear to be inputted, formatted and stored inconsistently, with free text descriptions used that are difficult to categorise for analysis. Claims data can also include glass repairs and replacements, and no fault claims, which are of less interest for the proposed comparative analysis. The types of claims can depend on the type of cover purchased.

  Insurers might be more willing to share summary rather than individual claims data. Such aggregated data might reveal few meaningful differences within a sample of young drivers due to most having similar vehicles and lifestyles. Claims are also often subject to a reporting delay and may not appear on file until they are resolved, which can be several months after the incident. Any prospective or retrospective incident analysis would need to account for this delay in the methodology.

- **Socioeconomic classification.** Common socioeconomic classifications are not always calculated for policyholders. Proxy measures used can include marital status and credit rating. Sharing such data might be restricted by data protection issues and commercial restrictions associated with tools for calculating credit ratings and socioeconomic status. Comparability of such metrics between insurers is unlikely.

In addition, policyholder data does not include any attitudinal measures that can be used to further define drivers and their behaviour.

Insurance companies evaluate their own and others' policy options regularly to ensure that they are competitive. In doing so, insurers are aware that it is difficult to separate the effects on safety of having telematics-based insurance from the effects of self-selection bias (i.e. the personal factors that motivate people to choose telematics policies) if using only high level data. The implications of these limitations are discussed further in Section 3.4.

3.3.3.2 Data sharing concerns

In general insurers responded positively about sharing information but raised common concerns: the methodology for the comparative analysis would need to separate the effects of self-selection bias from the effects of having a telematics policy, using only high-level data.

If the findings were subject to bias, the exercise would not enhance the industry's knowledge. Secondly, if only a limited number of insurers shared their data, it might become easier to identify particular companies and products, leading to commercially sensitive results. This could include identifying the most receptive customer groups, and the most effective telematics technology and policy types. This could undermine the investments and market positions of existing insurers in the telematics market and provide competitors and new entrants an easy route to market. Thirdly, collating and sharing the required data anonymously and in an appropriate format for comparative analyses could have a high associated cost.

3.3.4 Supporting telematics with research and policy

A further aim of the consultation was to gather insurers' ideas for how future research and policy could support the telematics industry. Fifteen insurers responded.

3.3.4.1 Research

A broad range of research that could benefit the industry was discussed. The main area of interest was the effect of telematics-based insurance on driving behaviour. Consultees' suggested research topics around driving behaviour and safety included:

- The effects on driving behaviour of telematics-based insurance compared with other mechanisms for reducing novice driver risk (e.g. graduated driver licensing)
- The effects of different types of feedback from telematics-based insurance

- The safety implications of mobile apps and in-car feedback through infotainment systems
- The lifespan of any effects of telematics-based insurance on driving behaviour and the difference in accident rates between those who stay with a telematics product and those who do not
- The impact of curfews, including the effect on accident rates
- Why customers move away from telematics-based insurance after one or more years, the subsequent impact on driver behaviour and safety, and approaches to reverse this trend
- How driver behaviour adjusts after the adoption of telematics and longer term
- How telematics products could be used by driving instructors to facilitate the learning to drive process
- How to encourage telematics uptake
- How to reduce the costs of telematics-based insurance (e.g. by examining benefits and savings)
- How telematics data can be used by government agencies, research institutes, and courts to understand accident liability and the effect this may have on customers (including how to overcome negative public perceptions about this application)
- How telematics might be incorporated in vehicles by automotive manufacturers in the future, and how the insurance industry might steer such developments to better support telematics-based insurance
- The sustainability of telematics products and the full extent to which telematics data can be exploited
- How to present to the public a balanced, robust picture of the benefits of telematics
- Create an evidence base to test that telematics-based insurance is not inadvertently encouraging dangerous or unsafe driving practices

3.3.4.2 Government, EU, and manufacturer support

An apparent theme from the consultation was the high cost of insurance premium tax (IPT) for young drivers. It was suggested by consultees that an IPT reduction for those choosing telematics-based insurance may lead to a higher uptake by providing a greater reduction in policy cost when compared with standard insurance products. It was clear that insurers felt the market for telematics-based insurance products was hampered by cost – for telematics to be more desirable to more people, it needed to undercut standard insurance policies by a greater margin. The cost of the telematics technology was another fundamental constraint and support from the Government or manufacturers to improve affordability of the technology could further develop the market.

Other areas identified where the Government could support the telematics insurance industry were strengthening the law around the use of customer data to protect policyholders (e.g. by having minimum standards for policy cancellation), introducing a graduated driving licence to improve confidence and exposure, and introducing a stricter driving test. Insurers also suggested learning from the experiences of the telematics industry in the EU and particularly Italy, where uptake of telematics-based insurance is highest.

Very little was said about how the EU could support the telematics industry; however, an EU directive was not desirable as the industry believed that it should be governed by the demands of local markets.

Consultees suggested that two ways in which manufacturers could support telematics-based insurance were to standardise telematics devices to enable easier installation, and fit such standard systems in all new vehicles. This would reduce the purchase and installation costs associated with telematics-based insurance thus making premiums more competitive for a wider population.

It was also suggested that insurance aggregators could do more to support telematics-based insurance by showing quotes for all insurance types together instead of only showing telematics-based policies if this option is selected by the customer. This would increase the visibility of the price benefit and enable customers to make a fair choice. It was also suggested that aggregators could make clear any safety benefits of telematics products to customers as well as the ongoing insurance saving.

3.3.4.3 Adopting consistent approaches and industry standardisation

Opinion was split between insurers that felt existing guidelines for the telematics-based insurance industry were sufficient and those that felt further standards were needed. It was reported that the introduction of new standards for telematics-based insurance might stifle innovation in a market where high levels of variation are achievable, and thus could be detrimental to market competition. Some insurers were also concerned that standardisation of data use and how risk is analysed could lead to some drivers being uninsurable. If standards are needed, it was suggested that they should focus on communicating policy features clearly to customers whilst enabling insurers to tailor incentives or penalties to different target populations. It was also suggested that standards relating to data collection should set minimum requirements to enable different insurers to develop competitive insurance products yet ensure that new market entrants meet a certain standard to protect customers.

Insurers reported there was a good quality of telematics systems across the industry so standardisation in this area was not necessary.

Although this group of insurers did not think standards were necessary for the industry at the present time, several areas were highlighted where consistent approaches could benefit the industry. These included introducing greater consistency in:

- How telematics data can be used to justify policy cancellation
- How telematics data can be used in claim scenarios and cases that involve the courts (especially so that no insurer gains a competitive edge by being more ‘lenient’)
- How telematics can be used to enforce curfews
- How transparent insurers are with customers over how data are collected and used to calculate risk scores, incentives and penalties

- How much scope insurers have to change their policies and the situations where this is acceptable

Those insurers that believe standardisation within the industry is required suggested that standards should be in the customers' interest to protect against 'aggressive' measures from some companies that may damage the reputation of the wider industry. Standards might also encompass data sharing procedures so that these are clear, at least at a commercial level.

The creation of an industry standard for using and sharing telematics risk data was also mentioned as a way to replace or validate the existing no claims bonus. It was felt that this could encourage the uptake of telematics by increasing the benefit to the customer.

Many insurers agreed that it would be hard to get the industry's support and agreement on standard codes of practice. Some insurers suggested that if they were to be developed they should be done through involved organisations such as brokers and insurers, and not through separate organisations.

3.4 Implications of the consultation process on a future study

Prior to the consultation and literature review, three sources of data were believed to be crucial to the success of a future study:

- An early risk indicator to identify differences between individuals in the control and treatment groups
- A post-risk indicator to identify any differences between the treatment and control groups that occur during the experimental period
- An exposure measure to evaluate both differences in driving patterns and styles between the two groups, but also to put the post-risk indicator into some context.

The results of the consultation suggest that there may be challenges to sourcing these data in a comparable and consistent way.

3.4.1 An early risk indicator

Initially a selection of variables was identified to compare and match the control and treatment groups. Comments from the consultation were received regarding this:

- Most early risk indicators were generally viewed by the consulted insurers to be standard information collected prior to a quote being offered, appeared relatively consistent across the sample that was consulted and were sufficiently high-level to ensure customer anonymity even if shared. Exceptions were insurance histories, exposure, some claims data, and socioeconomic status.
- Some insurers claimed that the difference between young drivers was mostly attitudinal as they tend to drive similar cars, have similar exposure and similar lifestyles. Substantial differences were not anticipated using insurer-only quote data. Additional attitudinal data was considered necessary by some insurers to further quantify differences in a young novice driver sample.
- Insurers own internal risk ratings (derived from sophisticated actuarial models) might supplement other early risk indicators to provide a better measure of compatibility between control and exposure groups. Not all insurers have such ratings and would defer to premium price otherwise.

The initial study plan proposed that the control group should have no prior experience of telematics-based insurance; however, such information is not likely to be available unless a customer has stayed with the same insurer.

3.4.2 A post-risk indicator

Standard outcome measures of risk in road safety studies tend to be accidents of different severities, near-accidents and driver behaviour measures. It was clear that insurance companies do not directly measure accidents but rather claims. In summary:

- Claim injury severity is not always recorded or may be grouped
- Insurers may include no fault and glass claims in the total number of claims
- Claims data are often stored in free text or recorded inconsistently and may be subject to errors
- Not all claims are allocated to a named driver so attributing claims specifically to young novice drivers may not be possible
- Some insurers might not share claims data for individuals, only summary data
- Any claims data collected would need to account for the time delay in processing claims, which can be several months

3.4.3 An exposure measure

In order to compare differences in accident rates between a control and treatment group some measure of exposure is required. At its most basic level this is usually some measure of mileage driven. The initial study plan proposed separating mileage by time of day, type of road and other risk factors. Limitations to using insurers as a primary source for exposure data included:

- Not all telematics-based insurance will split exposure by day- and night-time and other factors
- No objective exposure data is available for non-telematics customers.

4 Methodology for a future study

In this research, as reported in earlier sections of this report, the existing evidence on the impact of telematics on accident reduction was reviewed, experiences of other countries who have developed and implemented different policies around the use of telematics were identified and UK insurance companies were consulted on the availability and comparability of appropriate data and their views on possible methods, limitations and further research.

Multiple possible limitations were identified throughout the research (detailed in Sections 2.5, 3.3.3 and 3.4). These are:

- The importance of comparable exposure data when comparing different policyholder groups
- Self-selection into trials and telematics insurance policies introduces bias
- Small samples and small changes in outcome measures
- A possible initial behavioural impact following installation of a telematics device
- The challenges of self-report data
- Identifying the impact of telematics on individual drivers within a multi-driver policy
- Differences between the impact of telematics by feedback and incentives offered
- Accessibility, compatibility and comparability of data from insurers

The main objective of a future study would be to quantify the expected reduction in accidents and casualties generated by the use of telematics-based insurance by young novice drivers whilst taking into account as many of these limitations as possible.

Developing evidence for an intervention which has already been shown to be difficult to evaluate and has no current significant evidence base is challenging and substantial resources are likely to be required. With this in mind, three methods of data collection are proposed:

- A method evaluating insurance data only
- A method evaluating insurance data supplemented by additional data sources such as self-report and technology-based measures for collecting data based on groups who had preselected their policy type
- A randomised controlled trial which randomly assigns individuals to the treatment or control group (i.e. to telematics-based or non-telematics-based insurance policies).

Given the limitations identified by the insurance companies and by the research team during the consultation, it is not considered feasible to robustly assess the impact of telematics-based insurance on young novice driver accident rates using only insurance data as a primary data source. However, a randomised controlled trial also introduces challenges such as increased expense, longer trial duration, reduced sample sizes and self-selection into the trial itself. Random assignment of participants to a telematics or non-telematics policy may also be highly impractical to implement and if any cost differential is paid for by the study then it may remove one of the key incentives that appears to generate interest in, and engagement with, telematics-based insurance.

The recommended method for a future study is therefore to use insurance data for groups who had preselected their policy type and supplement this with self-report measures and technology-based solutions for collecting exposure data. This overcomes the key methodological constraints of prior research that has failed to a) provide a control group for comparison and, b) collect sufficient data on the wide range of factors that can affect decisions regarding the selection of telematics products so that appropriate statistical comparisons can be made.

However, any recommendation to pursue this study using the proposed method must be issued with the caveat that it is a substantially larger study than originally envisaged. This research has shown that it is not possible to use insurance claims data as the only primary data source for a robust comparative analysis of the accidents rates of young novice drivers using telematics- and non-telematics-based insurance policies. Moreover, it is evident that detailed exposure data is required for both treatment and control groups and, whilst such exposure data is readily provided by telematics for the treatment group, a similar level of detail does not exist for the control group. Whilst some exposure data could be collected using self-report methods, it is unlikely to be sufficiently detailed for comparison unless frequent and burdensome survey measures are introduced (which exceeds the anticipated scope of for a future study). Alternatively, a technology-based solution could be used to automate the collection of detailed exposure data from the control group that was comparable with the treatment group. However, the development and introduction of such a solution (even if it does appear feasible) introduces a level of cost and complexity that again exceeds what was originally anticipated.

In addition, the consultation identified distinct differences in the types of telematics-based insurance products currently available in the UK. A robust comparative analysis of accident rates would consider whether these different types of telematics-based insurance policy have different impacts on accident rates, rather than considering them collectively. To conduct a robust, comparative analysis for these different policy types (without compromising the commercial interests of particular insurers) which includes primary data collection would require larger samples and more resource than was originally envisaged. The design of such a project would also need to engage with a range of wider practical and methodological challenges which it is beyond the scope of this project to consider.

5 Discussion

This study has explored whether there is potential within the telematics-based insurance industry to reduce the accident rate of young novice drivers. It set out to do so using a combination of existing evidence and industry consultation to establish whether an answer to this question already exists, or whether there is scope to work with the insurance industry to develop a research plan that would ultimately provide the answer.

There is mixed but encouraging evidence from the existing literature that telematics-based insurance has the potential to affect accident rates among young novice drivers. Many of the elements of feedback, incentives and penalties have been explored separately (albeit not in studies using the most robust research methods). Collectively there are indications that feedback and incentives are effective in certain applications (e.g. the influence of parental feedback on young drivers using telematics data has produced encouraging changes in driving behaviour). Prior research has not yet been able to determine which feedback mechanisms are the most effective tools for modifying behaviour, nor has it been able to determine the format, type, duration and frequency of feedback or incentive that is most effective. There is some evidence that the effects of such tools also persist only for the time they are applied, with no prevailing change in behaviour after they are withdrawn.

As a consequence of these findings, the existing literature cannot be relied upon as a firm evidence base for future decisions regarding the telematics-based insurance industry. Methodological constraints are associated with all of the studies reviewed. The constraints of earlier work have been summarised in the current study. They have also been used as a way of learning how to correct for (some) of the methodological errors of previous work when constructing a research method for a future study.

There was limited evidence of policy existing in other countries to govern the use of telematics in road transport. It would appear that the efforts have primarily concentrated on setting minimum standards for data quality when using telematics, especially for collision detection and recording. During the industry consultation, it became clear that if regulation and control of the telematics-based insurance market was to be considered, the consensus was to follow the lead of the few other countries that have introduced governance and ensure that it only applies minimum data standards to ensure a necessary level of data quality (because such data may be used to make important and influential decisions about a driver’s insurance policy). However, more excessive governance was not favoured by industry as it might stifle innovation and competition across the telematics-based insurance market.

Consultation with insurers that currently provide telematics-based policies has shown that the market is relatively new but maturing rapidly. Telematics-based insurance products are primarily targeted at young novice drivers aged 17–25 years. While insurers may not restrict their products to this age group, most acknowledge that uptake is greatest in this demographic because the potential cost savings are greatest for young novice drivers. The cost of telematics policies for drivers outside of this demographic is typically higher or on par with non-telematics insurance products and therefore the attractiveness of telematics-based insurance is reduced for other drivers.

A wide range of telematics-based insurance products are currently offered to the UK market, with key differences in how incentives, penalties and feedback are used as policy instruments. These differences would present some challenges if pooling data from multiple insurers for analysis; however, insurers clearly document the way in which such tools are applied so notwithstanding the challenges in comparing customer data across insurance companies it should be feasible to account for these factors when analysing insurance data from different companies. It also provides a unique opportunity to explore the potential for different mechanisms to affect young novice driver accident rates (subject to suitable sample sizes being acquired and any methodological or commercial constraints being overcome).

More broadly, the industry collectively sought further research to: compare the effectiveness of telematics-based insurance with other potential interventions for young novice drivers, such as graduated driver licences; understand the impact of different feedback types used in telematics-based insurance; and, explore how sustainable telematics-based insurance could be in the future, especially in light of predictions for how the technology and market may develop further. Market support or intervention from the UK Government was not particularly desirable except in the areas of insurance premium tax reductions for young drivers (which was felt to be excessive given the overall high cost of insurance for this population) and the affordability of telematics technology for insurance purposes. The industry recognises that it has a role to play in improving the safety of young drivers and it felt that if some of the cost of providing telematics-based insurance policies could be reduced, this would encourage greater market uptake (especially for longer than the first year of insurance) as well as providing insurers with more scope to invest in data exploration and analysis so that telematics-based insurance products could be further refined to employ policy instruments that are effective at generating substantial, long term behaviour change.

The potential telematics-based and non-telematics-based insurance data available from insurers were considered alongside the methodological constraints highlighted by the evidence review. Collectively these were combined to produce three potential methods, each with associated advantages and disadvantages. The three proposed methods were: using insurance company data only; combining insurance company data with self-report and technology-based measures for collecting exposure data based on groups who had preselected their policy type; or a randomised controlled trial which randomly assigns individuals to the treatment or control group (i.e. to telematics-based or non-telematics-based insurance policies).

On balance, the recommended method for a future study is to use insurance data for groups who had preselected their policy type and supplement this with self-report measures and technology-based solutions for collecting exposure data. This overcomes the key methodological constraints of prior research that have failed to a) provide a control group for comparison and b) collect sufficient data on the wide range of factors that can affect decisions regarding the selection of telematics products so that appropriate statistical comparisons can be made.

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