

Towards Zero

Study on fatal collisions
on the SRN during 2014

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Executive Summary

This project has determined and analysed the root causes of 159 fatal collisions that occurred on the strategic road network (SRN) in 2014 and identified the potential countermeasures that could either avoid or reduce the injury severity of these collisions. This allows prioritisation of possible solutions to take pre-emptive action and influence the outcome of future collisions on the SRN that have similar characteristics. This analysis produces valuable information that can be used to inform all five pillars of the ‘safe systems’ approach: Road Safety Management (pillar 1), Safer Roads and Mobility (pillar 2), Safer Vehicles (pillar 3), Safer Road Users (pillar 4) and Post-crash Response (pillar 5).

TRL created a bespoke, in-depth database for the investigation which was hosted securely within the DfT’s RAIDS¹ database. TRL received outstanding co-operation from police forces in the supply of fatal collision files. These were coded into the Highways England Fatality Study Database and analysed by TRL.

A ‘safe systems’ approach was used to identify the causation factors that led to the fatal outcome of the collisions and identified the countermeasures that could have prevented or mitigated the fatal road collisions on the SRN in 2014.

Known causation factors were found to always involve a human (‘people’) component. However, nearly all of these collisions could potentially have been prevented or the injury outcome mitigated by solutions in other areas. Forty percent had countermeasures in ‘vehicle’ or ‘road’ only, approximately one-third had countermeasures in all three domains, and overall in 96.2% of collisions ‘vehicle’ or ‘road’ countermeasures may have prevented the fatality.

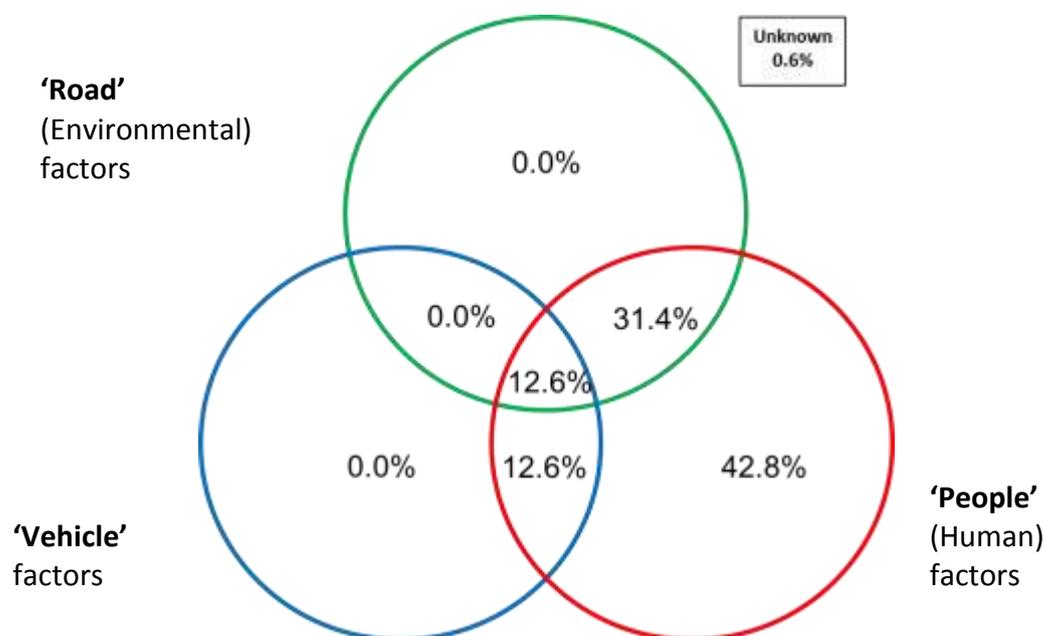


Figure 1: Collision causation factors by category (n=159)

¹ Road Accident In-Depth Study

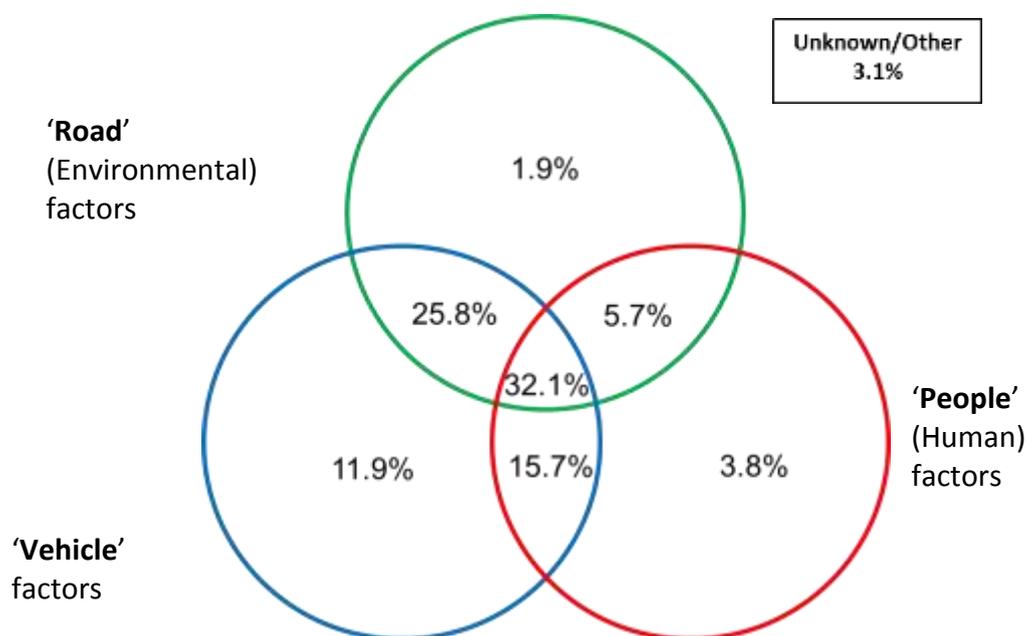


Figure 2: Collision countermeasures by category (n=159)

Countermeasures were assessed in terms of the frequency with which they were estimated to be applicable for the 159 fatal collisions and categorised with respect to the level of confidence that they would prevent the fatality. These led to the prioritisation of specific countermeasures in each of the safe systems domains of 'people', 'vehicle', and 'road; these could be used to identify candidates for future action. It should be noted that TRL did not assess countermeasure cost or implementation feasibility.

The 'people' countermeasures that were rated most highly in terms of confidence that they would avoid or reduce the fatality were:

- Improved VRU² conspicuity;
- Use of seat belt;
- Driver/rider training³;
- Better maintenance; and
- Better licencing.

'Vehicle' countermeasures were twice as frequently assigned compared with other safe system categories, indicating that more fatalities could be influenced with these countermeasures. The target group for these was typically young males. Those measures

² Vulnerable Road User (i.e. pedestrian, pedal cyclist or motorcyclist)

³ e.g. Hazard perception or risk avoidance training, not driver skill

rated most highly in terms of confidence that they would avoid or reduce the fatality and should be considered future priorities were:

- Autonomous Emergency Braking System (AEBS);
- Driver alert for approaching hazard;
- Intelligent Speed Assist (ISA);
- Lane keep assist; and
- Fatigue monitoring.

New Advanced Driver Assistance Systems (ADAS) on cars (and other vehicles) have the potential to have a significant effect on casualty targets, but the very low prevalence of features in the fleet means that only negligible contribution to the Highways England 2020 target is expected to be delivered by these features. In the longer term, ADAS will prevent a proportion of fatalities and, with the appropriate actions from consumer testing programmes, for example Euro NCAP, and type approval safety regulation, they will deliver significant fatality reductions by 2030 with the acceleration of fitment to the fleet. Action should be taken to encourage uptake of key technologies on cars. Larger benefits are achievable by ADAS by the 2030 time horizon (e.g. up to 19%-34% of annual fatalities for AEBS with combined functionality). Other countermeasures might achieve fatality reductions over a more immediate timeframe and would be complemented by efforts to increase fitment of vehicle safety systems.

The 'road' countermeasures that were rated most highly in terms of confidence that they would avoid or reduce the fatality were:

- Add street lighting;
- Add appropriate barrier;
- Remove hazard;
- More effective barrier type;
- More effective drainage; and
- Shield hazard.

These results should be treated as initial indicators for ways in which to reduce fatalities on the SRN and seen as the first step in understanding what the evidence says about how to prevent or reduce fatalities.

The overall recommendations made by the project were:

- An on-going assessment of fatal collisions on the SRN should be implemented. This will allow a stronger evidence base to determine countermeasures, enable the monitoring of collision causation trends over time, and – in the longer term – evaluate the effectiveness of implemented countermeasures.
- Prior to implementing any countermeasures on the SRN, a cost benefit study should be carried out to develop a cost effective implementation strategy for those measures which can be directly implemented by Highways England.

- A strategy should be developed to influence implementation of countermeasures not under Highways England's direct control.

A range of more detailed recommendations have also been made following on from these high-level recommendations, focussing on practical actions that could be made to improve the outcome of fatal collisions on the Strategic Road Network based on the 2014 sample.

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1 Introduction

1.1 Purpose of the study

The government's road investment strategy⁴ and the Highways England strategic business plan⁵ set out the plan and targets for major roads and motorways over the period 2015 to 2020. This includes a target of reducing killed and seriously injured (KSI) Road Casualties 40% by 2020 and a focus on safety with a vision that 'no one should be harmed when travelling or working on our network.'

In response, this project aims to determine and analyse the causes of fatal collisions on the strategic road network (SRN) to assess the potential countermeasures that could have been deployed to either avoid or reduce the severity of these collisions, such that pre-emptive action can be determined to influence the outcome of future collisions on the SRN that have similar characteristics.

In reviewing and analysing existing fatal collision information to understand the causes of fatal collisions and predictively assessing ways in which the collision could have been avoided or mitigated, this project aims to:

- Populate an in-depth database for fatal road collisions on the SRN for the year 2014 and identify the causation factors that led to the fatal outcome of the collisions;
- Identify the countermeasures that could have prevented or mitigated the fatal road collisions on the SRN in 2014, to:
 - Inform on how the adoption of technologies might be expected to influence future casualties.
 - To begin to prioritise, based on real world data, future collision prevention strategies where Highways England could directly and indirectly influence the outcome.
- Determine how an ongoing data collection system should be designed and managed to provide Highways England with a cost-effective, in-depth evidence base and understanding of the factors contributing to fatal collisions that occur on the Strategic Road Network (SRN).

⁴ <https://www.gov.uk/government/collections/road-investment-strategy>

⁵ <https://www.gov.uk/government/publications/highways-england-strategic-business-plan-2015-to-2020>

1.2 Information sources

The project used existing collision information collected by the Police and Highways England in order to retrospectively review and assess the circumstances of fatal collisions on the SRN in 2014. As described in Section 1.1, one of the aims of this work was to carry out a holistic assessment of the collision, enabling a broad and detailed assessment to determine causation factors. This information was used to identify countermeasures that could avoid or mitigate each collision, with a view to using this as leading information to affect future collision outcomes.

The information sources considered by the project are described in the following sections. No new information was collected as part of this work, but the TRL team reviewed the existing information in the context of the aims of this project.

1.2.1 *Police ‘fatal files’*

The main information used to inform on collision causation factors was police ‘fatal files’. These files can be extensive and contain information collected by Police forces at the scene and after the collision. The main purpose of these files is to support prosecution under the Road Traffic Act (1988), and therefore the conclusions of the report are those which can be supported in court and the likelihood of conviction is an element in the decision. In some cases therefore, information relevant to the causation for the collision may not be included in the Collision Investigation Unit report, because there was not sufficient evidence to present to a court.

1.2.2 *Highways England Reports*

Information collected by Highways England was also reviewed from 29 fatal collisions that occurred in the North West region and also supplementary information from other regions. This information was used to consider to what extent it could be used to inform on collision contributory factors and causation.

Upon review, it was clear that the purpose of the Highways England information was to provide detailed information on the legislative compliance of highways design and maintenance. It was found that the level of detail of the reports varied greatly depending on the circumstances of the collision; these were very detailed in the cases where the highways features might have been relevant to the collision and therefore the subsequent inquest.

This information was very detailed information on the highways structures and design and useful in gaining a full understanding of the road/infrastructure related causation factors.

1.2.3 *Scope of information*

Existing information sources are designed to collect data for specific purposes. For example, the police and Highways England investigations can differ greatly in their approaches and analysis, despite looking at the same collision information. While some, or much, of the information recorded is relevant to a holistic assessment of collision contributory factors or causation, existing sources omit specific aspects or record the information to a different burden of proof, meaning that an accurate and complete assessment cannot be made

effectively without re-analysing the base information. The following table provides a summary of the information sources available and their intended purpose.

Table 1: Information sources and their purpose

Comparison aspects	Highways England System	STATS 19	Police Files	HEFDB
Purpose	Examination of the Legislative compliance of structures and maintenance for which Highways England is responsible	High-level national statistics completed by attending police officers	Investigative report that prevents evidence and opinions of experts	<i>Focused in-depth collision investigation; examines evidence on causation and countermeasures</i>
Causation information	May provide some understanding on road causation factors	Contributory factors with no evidence or explanation	Can provide in depth understanding of causation factors in all areas, but varies greatly depending on circumstances of the collision	<i>Standardised and analysable assessment of causation factors in all areas, coding of evidence and pertinent info that accompanies assessment</i>
Counter-measures	None	None	Sometimes provides some evidence of what may have influenced the occurrence or outcome of the collision	<i>Standardised and analysable assessment of possible countermeasures in all areas</i>
Specifics (in terms of additional benefits)	Not in format easily analysed	Not in format easily analysed	Not in format easily analysed	<i>Analysable format; data can be accessed electronically and analysed using queries</i>

1.2.4 Highways England Fatalities Database (HEFDB)

Table 1 highlights the purpose and characteristics of the existing collision data against the objectives of the HEFDB study. Thus, the objectives of this project, namely to determine the causation factors/cause and related countermeasures considering ‘people, vehicle, and road’ aspects, demand that the full picture of the collision circumstances are considered. Although this project used the same collision information as the police and Highways England, it analysed aspects of ‘people’ and ‘vehicle’ typically absent from Highways England information, and assessed the fatal file information to provide an evidence base for understanding why collisions are occurring and what can be done to prevent them, rather than focussing on aspects that meet the higher burden of proof for legal enforcement.

1.3 Collision causation

Collision causation is a complex topic; there are typically many factors that contribute to the occurrence and severity of a collision. In many instances, particular combinations of circumstance combine in time and space to cause a collision. Without any one of the contributing factors, the collision would not happen. Indeed, most drivers have experienced first-hand, circumstances that have not led to a collision, but could have done so had the situation been only slightly different.

Another way to visualise this issue is by considering the ‘Swiss cheese model’ of hazards first proposed by Reason (1990), whereby failures (in this case collisions) occur only when all specific risks align to result in a collision. If one aspect is not conducive to the occurrence of the collision, it is prevented (see Figure 3, below).

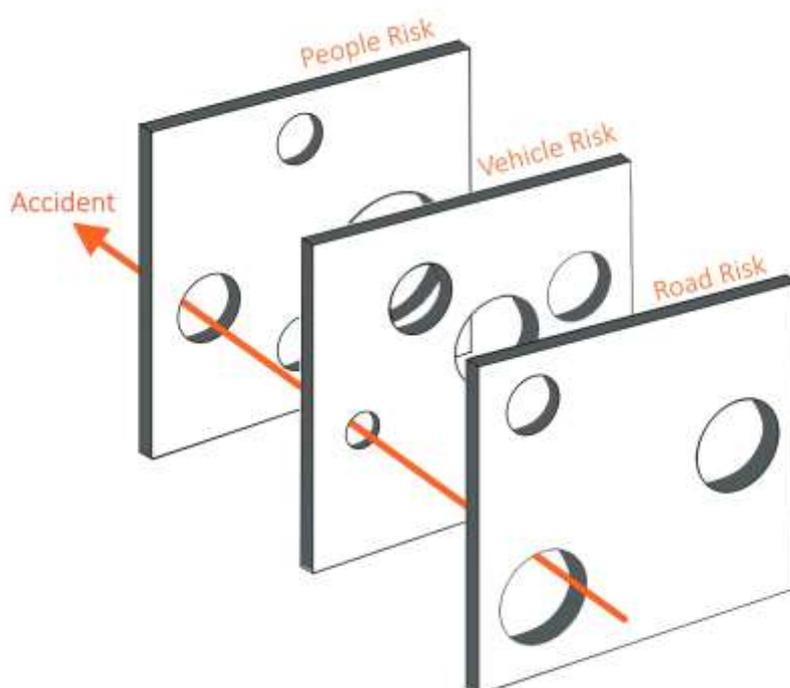


Figure 3: Swiss cheese model of collision causation (adapted from Reason, 1990)

1.3.1 Causation factors

The majority of collisions have multiple causation factors. These causation factors can be grouped according to whether they relate to the people (driver), vehicle or road as displayed in Figure 4 and provide a useful way to analyse the high-level causation factors associated with a collision.

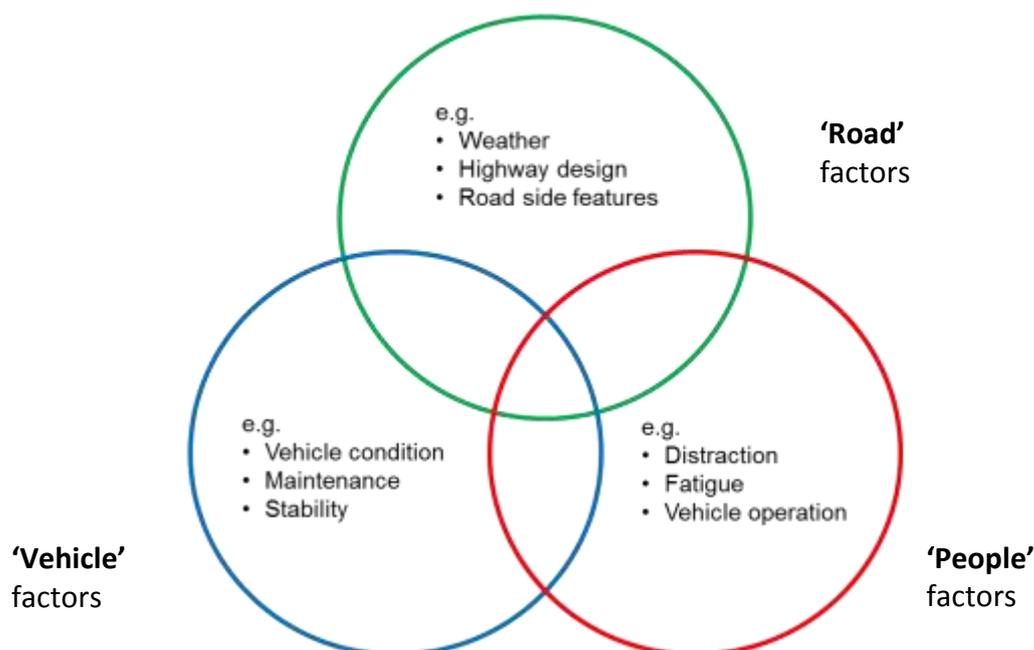


Figure 4: Causation factor Venn diagram

Road users are continually subjected to a combination of these people, vehicle or road factors. A collision occurs when a factor, or combination of factors in any category, influence a road user (or group of users) with the result that a collision occurs.

The **occurrence** of a collision and the **severity and outcome** of that collision can be influenced by any number of factors at any stage during the collision. Therefore, changing any element of the collision circumstances, or the factors influencing the road users, can completely change the outcome of a collision and even prevent it from occurring.

For example, consider a collision in which a fatigued driver drifts across the centre-line and into the adjacent lane, striking an oncoming vehicle and resulting in a fatal collision. If identical circumstances occur but there was no oncoming vehicle before the driver corrected the lane departure, the collision would not occur. If the vehicle was equipped with a lane departure warning system, the collision may have been prevented despite the oncoming car, or the severity of the contact reduced as the driver reacted to the warning.

1.3.2 *Highways England fatality study: causation factors and the potential for analysis*

Therefore, fatal road traffic collisions, like other collisions, result from a complex combination of causation factors. Consequently, the approach to investigating and understanding the factors relating to fatal collisions must reflect this complex interaction to capture all aspects of the factors influencing the collision. In this study, we have used existing information collected by the Police to reassess the evidence to the specific scope and aims of this study, namely to determine the causation factors and potential countermeasures.

In order to assess trends and patterns in the causation factors, the information collected by TRL can be analysed in different ways and at different levels of detail, from individual case by case examination to high level overview. At the most detailed level, each event is due to a unique and individual combination of factors and the highest level only a summary overview. Therefore, in order to learn most from the analysis, a strategic approach is required, optimising the breadth and depth of information so that conclusions are not specific to individual events and not so broad that they are unfocused and do not lead to implementable solutions.

The Highways England database has been structured in such a way as to allow the information to be examined in a range of ways and at a range of different levels of detail, thereby offering flexible analysis options to respond to varied research questions. The causation factors have been assigned at a number of levels (i.e. path, vehicle, occupant) and are therefore adaptable depending on the type and design of the analysis being carried out.

1.4 Collision countermeasures and safe system approach

The Haddon Matrix is the most frequently used concept in the injury prevention domain (see Figure 5). This shows how countermeasures can be assigned according to the stage of the collision and the category of the countermeasure.

The holistic recording of collision causation factors results in a strong evidence base with which to determine collision countermeasures: actions that can avoid the collision itself, or mitigate its injury outcome. These can be directly linked to the safe systems approach to provide an evidence base for the design of a safer overall transport system and provide an understanding of specific countermeasures and in which categories of ‘people, vehicle, road’ the countermeasures lie. This information can inform ways in which Highways England could most effectively meet their strategic plan for a reduction in network KSIs of at least 40% by the end of 2020 against the 2005-09 baseline.

	People	Vehicle	Road
Pre-crash	Improved driver training Driver awareness	Better maintenance Primary safety (e.g. AEBS, ESC, Alco-lock)	Improved road surface Improved highway layout/design
Crash	Use of safety systems (e.g. helmet or seatbelt)	Secondary safety Presence and performance of safety systems	Remove road side hazards Barrier performance
Post-crash	Incident response eCall systems	Fuel system Safety pyrotechnics Vehicle design standards	Infrastructure performance (e.g. access for emergency services)

Figure 5: The Haddon matrix (with example countermeasures)

2 Method

2.1 Data sources

TRL requested 192 fatal collision files from collisions on the Strategic Road Network (SRN) in 2014. Positive and helpful collaboration with Central Motorway Police Group (CMPG) meant that the response from police forces was excellent (see Table 2). In total a sample of 83% of the 192 collisions requested were coded into the Highways England Fatality Database.

The size and content of a police fatal file varies with the complexity and type of collision. TRL requested specific parts of the 'fatal file' to support our review of fatal SRN collisions in 2014; these were:

- CIU fatal report:
 - This is the Collision Investigation Unit fatal report and provides a summary of the collision and an evidenced conclusion at the level demanded for a prosecution.
- Case photographs:
 - These provide information about the collision scene and circumstances and often include elements not included in the CIU which can be important to determining appropriate causation factors or countermeasures.
- Scene plan:
 - This provides a scale diagram of the scene and is essential as part of the case reconstruction, but can also be used to assess aspects relevant to countermeasures: for example, was there sufficient sightline for a radar system to detect the hazard?
- 'Collision booklet' front page – STATS19⁶ :
 - This comprises information collected by the police for inclusion in the mandatory STATS19 dataset. This information includes data on occupant age, gender, and position in vehicle that might be omitted from other sections, and also includes useful ancillary information that can help fill in other information gaps.

⁶ Road accidents reported to the police – see <https://www.gov.uk/government/collections/road-accidents-and-safety-statistics>

Table 2: Police cases obtained for analysis

Cases requested	Cases received (of those requested)	Cases available (of those requested)	not (of requested)	Additional cases received (not requested)	Total cases received	Number of cases coded
192	147	16		19	166	159

We received, via secure data transfer or other secure means, 166 cases, of which 19 were not requested. These included six cases from five English police forces and six cases from police forces in Wales. Where the road environment was consistent with the SRN (for 12 cases), we coded the additional files to partially compensate for the fact that 16 of the files requested were unavailable because they were active cases.

The TRL team coded 159 files and also received information from 29 cases from the North-west region held by Highways England, as well as supplementary Highways England information from fatal collisions elsewhere on the SRN that followed the same format. Data was stored according to the Road Accident In-Depth Studies (RAIDS) security protocols, with electronic data stored on secure systems and hard copies in a dedicated, access controlled room.

2.2 Data coding and storage

A team of experienced collision investigators reviewed each fatal file and coded the information into the Highways England Fatality Database. With agreement with Highways England and the UK Department for Transport, this database was housed within the Road Accident In-Depth Studies (RAIDS) database⁷ which brings together different types of collision investigation into a single, compatible, and comprehensive database.

On receipt, cases were logged and stored securely. The case files were reviewed and photographs that contained disturbing content were reviewed only by staff trained, experienced, and willing to review such content.

After completion of coding, the case was signed-off by the investigator in the database. The data was then subject to a quality review by a senior member of the team to ensure that the case had been coded completely and appropriately. Once any amendments had been made to the case, it was released into the database and available for analysis.

2.3 Data analysis

The investigation team reviewed and coded over 1,000 data fields for each case which records a multitude of information on the collision and outcomes, including information about the:

- Collision (weather conditions, contribution of the environment, road type/layout);

⁷ <https://www.gov.uk/government/publications/road-accident-investigation-road-accident-in-depth-studies/road-accident-in-depth-studies-raids>

- Vehicles (number and type involved, defects/condition of components, safety system fitment);
- Occupants (characteristics, injury severity);
- Infrastructure (road condition, barrier type/condition, lighting type);
- Impact (Collision Deformation Classification (CDC), speed);
- Road environment (junction, sightlines, visibility, signs);
- Human factors (distraction, experience);
- 'Paths' (the point of view of each participant through the collision); and
- Causation factors and countermeasures.

In this process, the TRL team used the same base information as the police, but interpreted information from evidence (e.g. case photographs) and other sources using different aims and focus to that of the police investigation.

During the coding process, and after studying the case file information described in 2.1, the investigators identified the collision causation factors in each level of the database of people, vehicle and road. These assessments used the opinion of the TRL investigators.

The TRL investigators also assigned countermeasures within each category of people, vehicle, road so that these are aligned with the safe systems approach. Using the evidence from the police file, we made an assessment of confidence that the countermeasure would influence both collision avoidance and mitigation using a scale of high and low confidence. This acknowledges, in line with the safe systems approach, that the collision cannot always be avoided and in these circumstances the next preferred outcome is to reduce the severity of the outcome. Primary countermeasures were also coded, providing the investigators 'best estimate' of the most appropriate measure. In terms of identification of the ways in which to address future fatal collisions on the SRN, this provides a key evidence base to determine priorities.

2.4 ADAS roadmap

The fitment of Advanced Driver Assistance Systems (ADAS) has the potential to prevent a proportion of SRN fatalities and these technologies will penetrate into the fleet, contributing to future casualty targets. However, predicting the future penetration of safety technologies is both difficult and subject to errors of unknown magnitude. Fundamentally, predicting the future where there are many complex factors that can influence the fitment rate of systems to vehicles means that any estimate should be suitably caveated; the indicative predictions made here should therefore be considered with caution and used as a guide to how future fatalities might be influenced by changes in ADAS fitment.

Future penetration rates of ADAS into the fleet are dependent on a range of factors and it is important to identify and understand the main ones that affect the fitment rate. These include the following, many of which are interrelated; for example the:

- Regulation of ADAS;
- Inclusion and testing of systems in consumer testing schemes such as Euro NCAP;

- Strategy of the car manufacturer to the fitment of safety systems and the cost of integrating the system into a new model version;
- Level of additional technical complexity/feasibility required above existing hardware already fitted to the vehicle; and
- The consumer's willingness to pay for optional systems.

To assist with the formulation of estimates for future system fitment, the proliferation of safety systems over recent years was considered and judgements made about how the fitment rate might be likely to change in the future. We have taken a simplified approach to this assessment and have not considered differences in penetration for different vehicle segments (which can have quite different fitment rates) because this was considered beyond the scope of this project.

Most of the vehicle systems assessed as countermeasures in this study are already offered as optional extras to current cars, or in some cases, as standard. In the case of other ADAS, these are expected to begin to be offered in the near future fitment (see Figure 6). These active technologies will penetrate into the vehicle parc⁸ with the result that a proportion of the countermeasures identified will be implemented without any additional action.

Some systems are already the subject of mandatory fitment for certain categories of vehicles entering the vehicle parc. For example, EC Regulation 661/2009 (the 'General Safety Regulation') introduced mandatory fitment of a number of advanced safety features to vehicles, including Electronic Stability Control (ESC) all new types of cars (M1) and small commercial vehicle (N1) sold in the EU from 2011, with all new M1 and N1 vehicles being equipped from 1st November 2014. As a result, the proportion of the fleet equipped with this technology has shown a large increase from 2009 to date. Extrapolating this forward, we would expect that by 2020, approximately 95%-100% of the fleet would be equipped with ESC.

The same regulation (EC 661/2009 made fitment Advanced Emergency Braking Systems (AEBS) and Lane Departure Warning Systems (LDWS) mandatory to medium and heavy commercial vehicles. Regulation 347/2012 sets out the specific procedures and due to the complexity of braking and axle technology the introduction of AEBS was made in stages. From 1 November 2013, new type approvals must comply with the requirements set out in the regulation, with the exception of the approval level 2 requirements and vehicles not equipped with pneumatic rear axle suspension. These requirements apply to all vehicles registered from 1 November 2015. As a result, we would expect the proportion of equipped vehicles to increase as new registrations penetrate into the fleet, although full fleet fitment is not predicted to occur until post 2020.

Figure 6 shows the estimated roadmap for the vehicle systems we considered as vehicle ADAS countermeasures. This provides an indication of the time at which we expect most new registrations to be offered with a system as an option (hatched bar) and as standard (solid bar).

Note that Lane Departure Warning is not predicted to be available as an option beyond 2020. Lane Keep Assist is a more effective system for preventing unintended lane departure

⁸ Vehicles on the road

collision types because it actively prevents the vehicle from drifting out of the lane, rather than only providing a warning. Lane Keep Assist is therefore predicted to supersede Lane Departure Warning systems and will integrate the warning into its improved functionality.

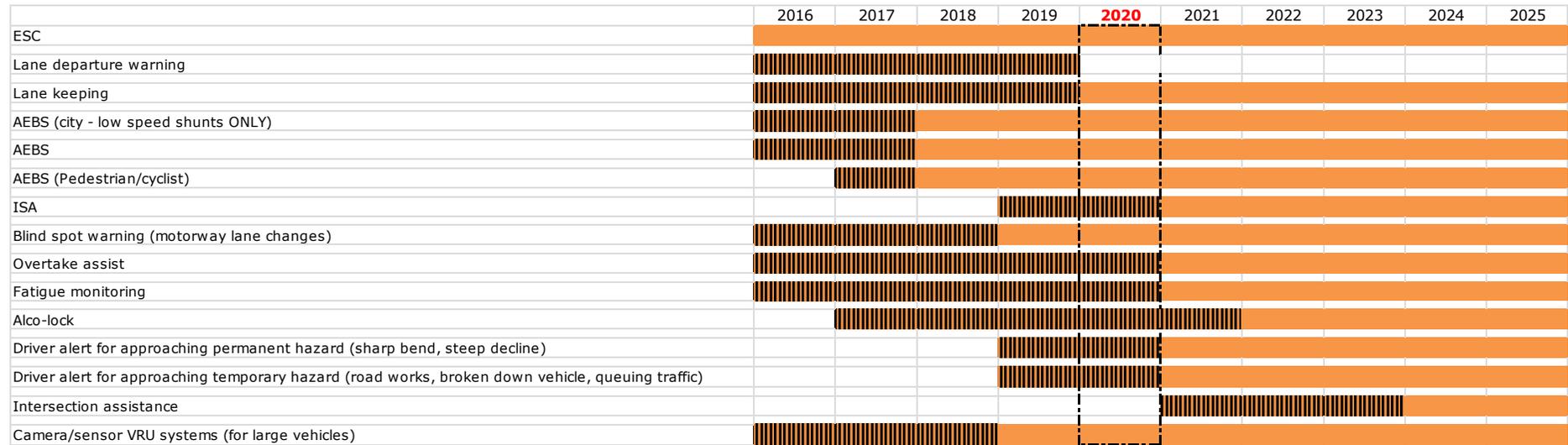


Figure 6: ADAS roadmap showing estimated introduction of ADAS (hatched = generally optional system, solid colour = generally standard system)

3 Results

This section provides an overview of the sample, causation factors and countermeasures based on the sample of 159 fatal collisions.

3.1 Sample description

Considering the entire sample of collisions (n = 159) in the Highways England Fatalities Database (HEFDB), Table 3 shows that the majority of the collisions involved multiple road users (vehicles and vulnerable road users (VRU)). The proportion of single vehicle fatal collisions (27%) in the sample is much lower than the proportion across Great Britain in 2014 (46%)⁹. Table 3 also shows the number of collisions that were probable suicides in each collision type. In addition to the 5 probable suicide collisions shown in Table 3, there were another two potential suicides or deliberate acts. However, there was not enough evidence from the collision to confidently confirm if these were in fact deliberate acts and therefore, these were coded as normal accidental incidents.

Table 3: Number of collisions in the HEFDB 2014 sample

Collisions	n = 159
Single road user	43
(Suicide/Deliberate act)	(2)
Multi road user	116
(Suicide/Deliberate act)	(3)

The distribution of vehicles and road users involved in the 159 fatal collisions is presented in Figure 7. Some key observations can be made from this table:

- The sample is dominated by passenger cars.
- There is a high number of pedestrians for the road types that constitute the SRN.

It should be noted that not all road users/vehicles were always coded into the database if the investigator deemed that their inclusion added little or no value to the collision investigation, but the following tables include all those people and vehicles relevant to the collision causation and countermeasures.

⁹ Reported Road Casualties Great Britain: 2014 Annual Report

(https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/467465/rrcgb-2014.pdf)

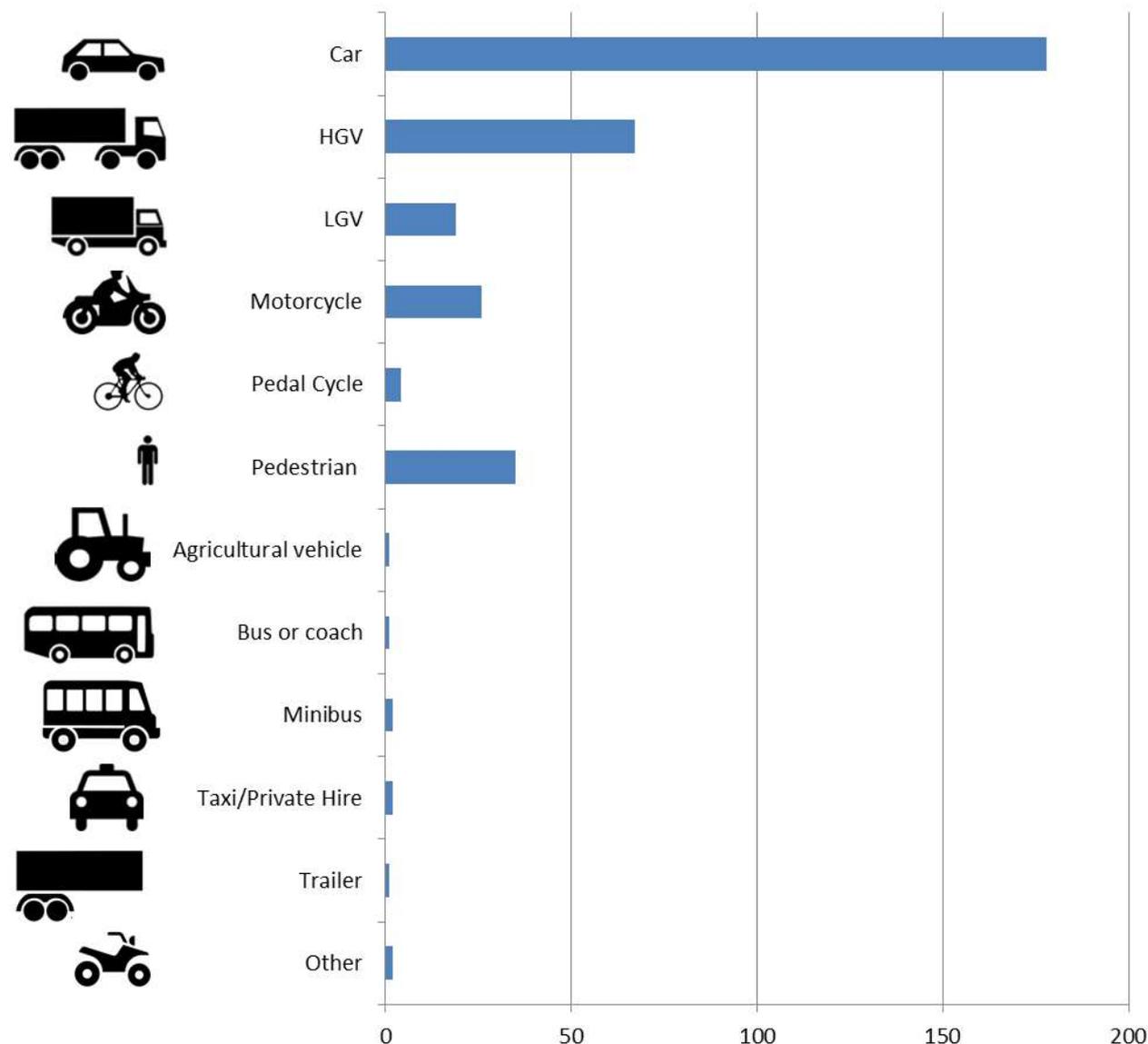


Figure 7: Number of vehicles/road users present in the HEFDB (n = 338)

Within the 338 vehicles involved in the HEFDB sample, a total of 449 people were involved, of these 176 were fatally injured. Table 4 provides the distribution of all occupants and road users and the distribution of fatalities within each road user class.

An initial finding when examining the data in this way is that a large proportion of fatal road users had alighted from their vehicles on the carriageway before being struck and killed. These people have been grouped into the road user type ‘Alighted.’ This group was devised to:

- Avoid confusion about which road users were genuinely pedestrians on the carriageway and which were originally vehicle occupants. Similarly, those road users who are in the process of alighting or have recently alighted from their vehicles and entered the carriageway but were not perceived as pedestrians by the other road users.

- This also avoids discrepancies when coding a person as either an occupant or a pedestrian.

Clearly, passenger car occupants are the most frequently killed people on the SRN. However, the proportion of vulnerable users (motorcycles, pedal cycles, and pedestrians) who are killed is substantially greater than any other road user class. HGV occupants have the lowest proportion of fatally injured occupants.

Over 95% of the entire sample of people was travelling in either:

- Passenger cars
- Heavy Goods Vehicles
- Light Goods Vehicles
- Motorcycles
- Pedal cycles
- Pedestrians

All of the fatalities occurred within these vehicle groups apart from one coded as 'Other'. This fatality was driving an on-road quadbike which does not meet the criteria for any of the other road user types.

Table 4: Number of all people and fatalities in each road user class

Vehicles and road user class	Total number of people	Number of fatalities	% fatalities
	256	92	35.9%
	69	7	10.1%
	29	12	41.4%
	23	18	78.3%
	3	3	100.0%
	30	28	93.3%
	1	0	0.0%
	3	0	0.0%
	12	0	0.0%
	4	0	0.0%
	2	1	50.0%
  Alighted	17	15	88.2%
Total	449	176	

3.2 Fatality demographic information

The demographic information of the 176 fatalities is presented in this section. Figure 8 presents the fatalities in their road user class (see Table 4) by their gender and shows:

- Approximately 80% of all fatalities in the sample are males from all road user classes.
- Females were primarily killed in passenger cars (82% of all female fatalities) and account for 30% of all passenger car fatalities.
- Some females were also killed on motorcycles (n = 2) and as pedestrians (n = 4).

The gender of one car occupant fatality and one alighted occupant fatality were not reported in the source information and as a result they have been coded as an unknown gender.

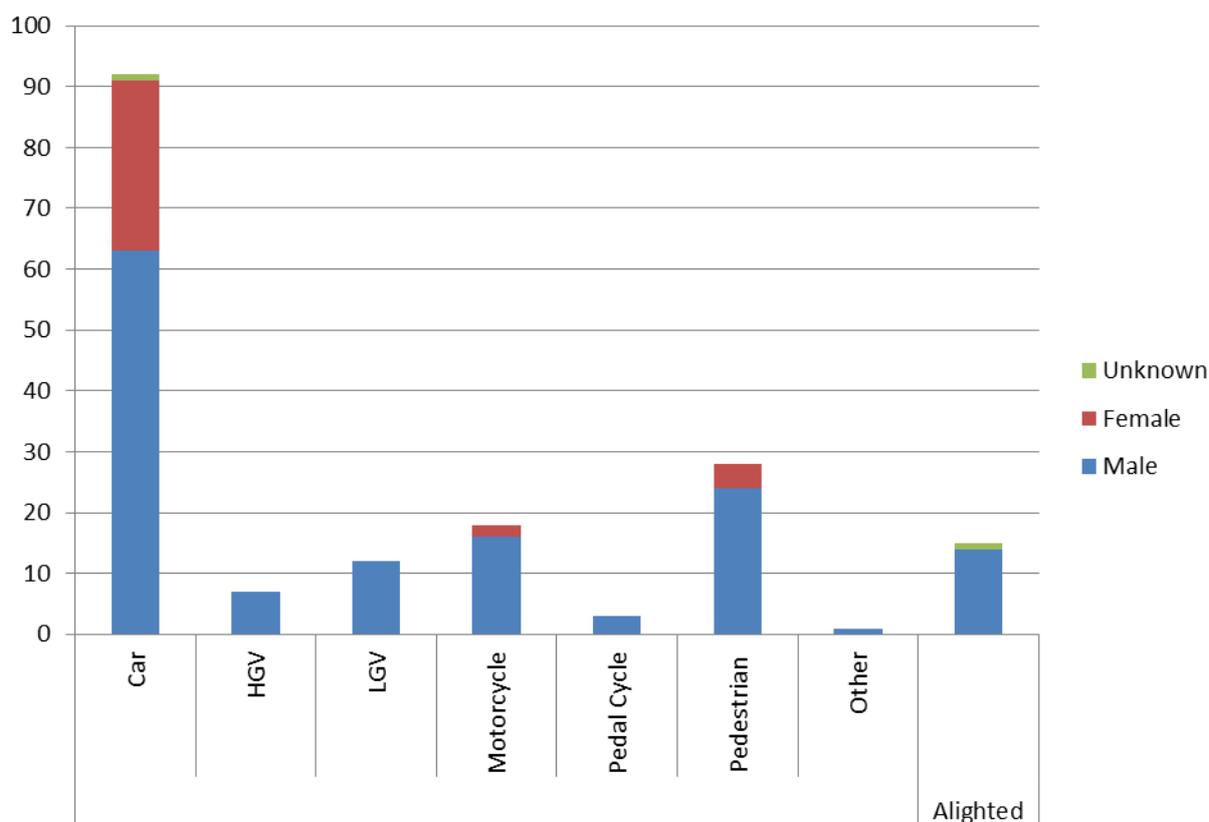


Figure 8: Vehicle type and gender of all fatalities (n = 176)

The age distribution of all fatalities by their road user class is presented in Figure 9:

- There is a large proportion (18.8%) of fatalities had no reported age in the source information and have been coded as 'unknown'. This is recognised as a limitation of this work and it is recommended that future studies collate the STATS19 info with the police fatal files to address this and other unknowns.
- The largest proportion of fatalities with a known age are between 35 and 44 years old (16.5%) followed by fatalities between 25 and 34 years (14.8%).
- People of all ages are killed, including three children aged under 16 years.

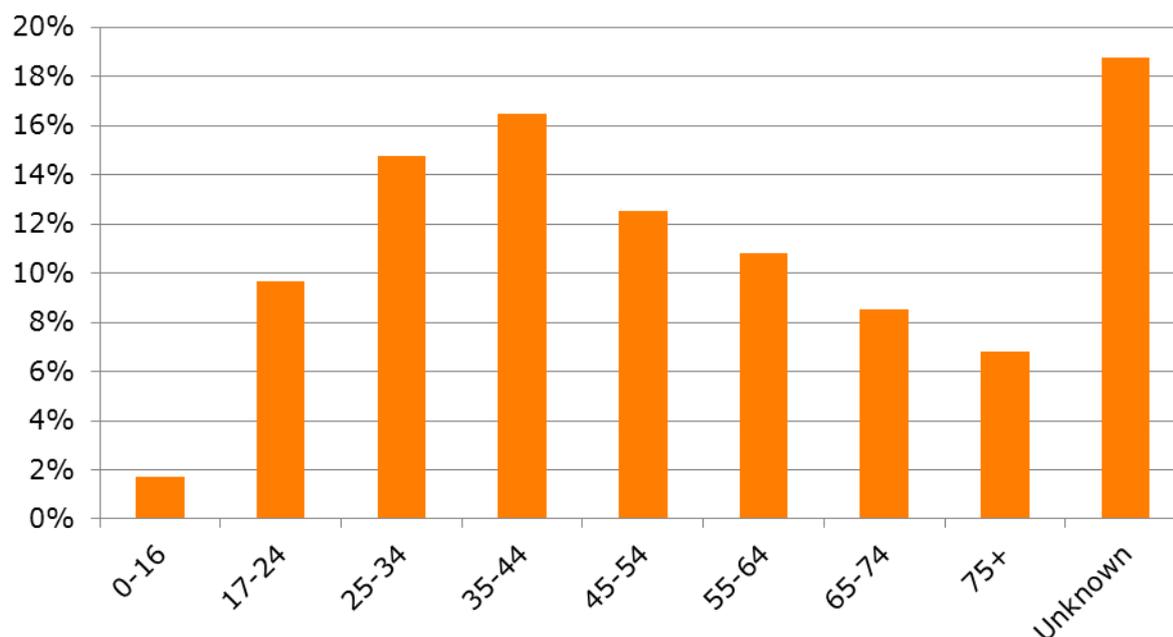


Figure 9: Age group distribution of all fatalities (n = 176)

A further breakdown of the fatalities in Figure 9 showing road user class as well as age group is presented in Table 5:

- Of the three child fatalities (0 – 16 years old) two were killed in cars in separate incidents. The third child was killed as a pedestrian, however, this was believed to be a suicide as the person climbed over the side of a pedestrian bridge and fell backwards into the carriageway before being struck by a car.
- Killed occupants who alighted from their vehicles and entered the carriageway were from all age bands. Similarly, pedestrians killed in the carriageway were from all age bands except 45 to 54.

Practical recommendation:

Consider an education/awareness campaign on advice to road users should they be forced to alight their vehicle on, or next to, a live carriageway.

Table 5 vehicle type and age of all fatalities (n = 176)

	0 - 16	17-24	25-34	35-44	45-54	55-64	65-74	75+	Unknown	Total
Car	2	10	12	16	12	7	12	8	13	92
HGV	0	0	0	1	2	0	0	0	4	7
LGV	0	0	4	5	1	0	1	0	1	12
Motorcycle	0	3	2	0	6	4	0	0	3	18
Pedal Cycle	0	0	0	1	0	2	0	0	0	3
Pedestrian	1	2	5	5	0	3	1	4	7	28
Other	0	1	0	0	0	0	0	0	0	1
Alighted	0	1	3	1	1	3	1	0	5	15
Total	3	17	26	29	22	19	15	12	33	176

The number of fatalities who were the primary occupants in charge of their vehicles (i.e. drivers and riders) and passengers is shown in Figure 10. Pedestrians and alighted occupants in the carriageway are shown as a separate group.

- More than 62% of fatalities were the primary road users and in charge of the vehicles they were travelling in (i.e. drivers and riders).
- Passengers and pedestrians account for 19% of fatalities each.
- The majority (79%) of passenger fatalities occurred in passenger cars.

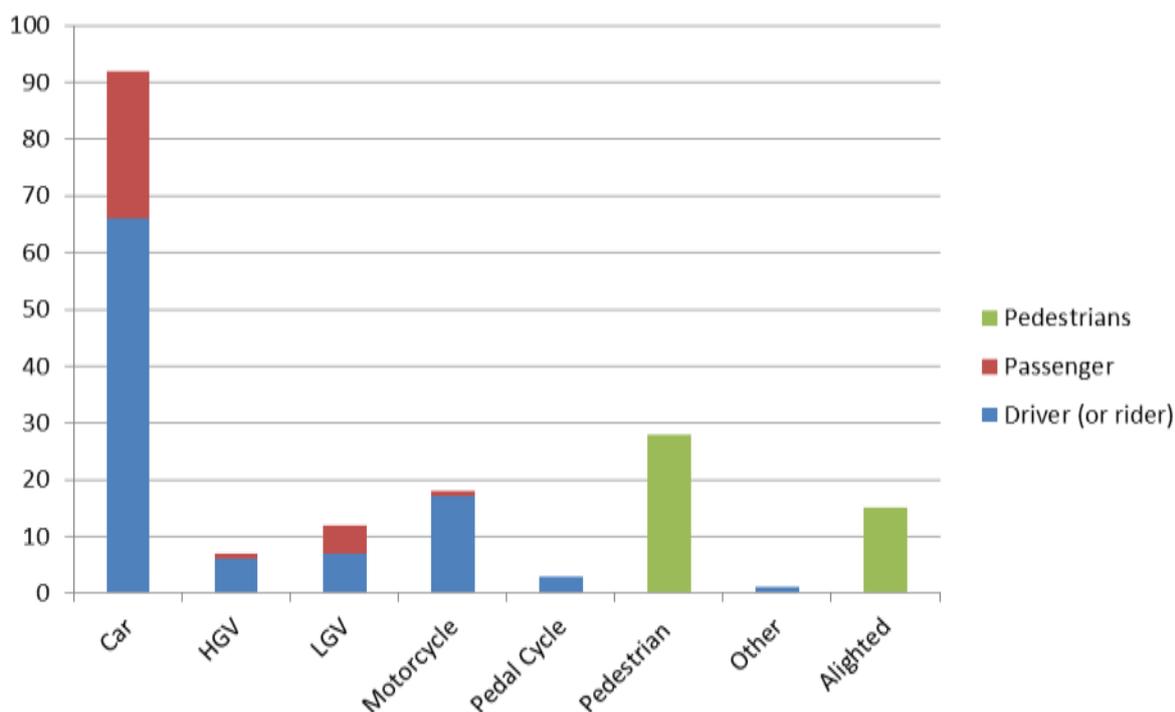


Figure 10: vehicle type by position in vehicle of all fatalities (n = 176)

3.3 Number of collisions by type:

The following graphs describe the types of collisions that occurred in the HEFDB sample and count the number of individual collisions (n = 159).

Figure 11 considers the 43 fatal collisions that involved a single road user type and is dominated by loss of control collisions. These collisions include vehicles that lost control on straight roads or corners. The collisions are categorised into the collision type that best summarises the key dynamics of the collision as per the collision type matrix for this study (see Appendix A). However, the inclusion of a collision type does not necessarily exclude it from the other collision types. For example, the three collisions that were categorised as Overtake/Lane change collisions all involved a vehicle that lost control but the overtaking or lane change was the pertinent manoeuvre in those collisions.

The only collision in the HEFDB that was categorised as a single road user 'Pedestrian/Pedal cycle' collision type involved an electric vehicle that depleted its batteries and came to rest in the carriageway. The driver exited the vehicle and attempted to push the vehicle to safety but was crushed by the vehicle as it rolled backwards. All other 'Pedestrian/Pedal cycle' collisions involved another vehicle with the VRU.

The two collisions in the 'Miscellaneous' category are the two probable suicides from Table 3. The drivers committed suicide by self-immolation while driving, which cannot be coded into any other collision type.

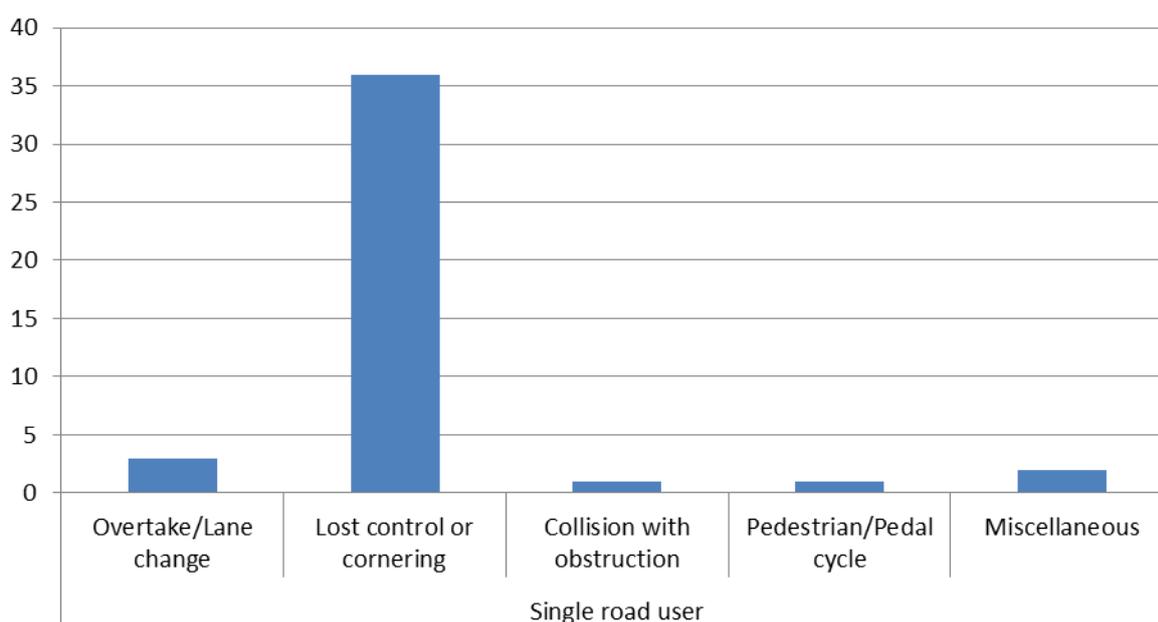


Figure 11: Single road user collisions by collision type (n = 43)

Figure 12 presents the collisions which involved at least two road user types and shows that the most frequent type of fatal collisions involved pedestrians or pedal cycles. Collisions involving pedestrians or pedal cycles are grouped together as the collision dynamics are generally similar between these two types of VRU.

'Rear end' collisions involving a vehicle impacting the rear of another vehicle in front are the second most frequent collision type, accounting for approximately 21% of all multi road user

impacts. The high frequency of this collision type is related to the road types that make up the SRN.

‘Collisions with an obstruction’ represent approximately 11% of the multi road user collisions and can include impacting vehicles that are parked or unattended. For example, impacting parked vehicles or trailers in lay-bys can be categorised as ‘Collision with an obstruction’. Similarly, any object, debris or other obstruction in the carriageway is also categorised into this collision type.

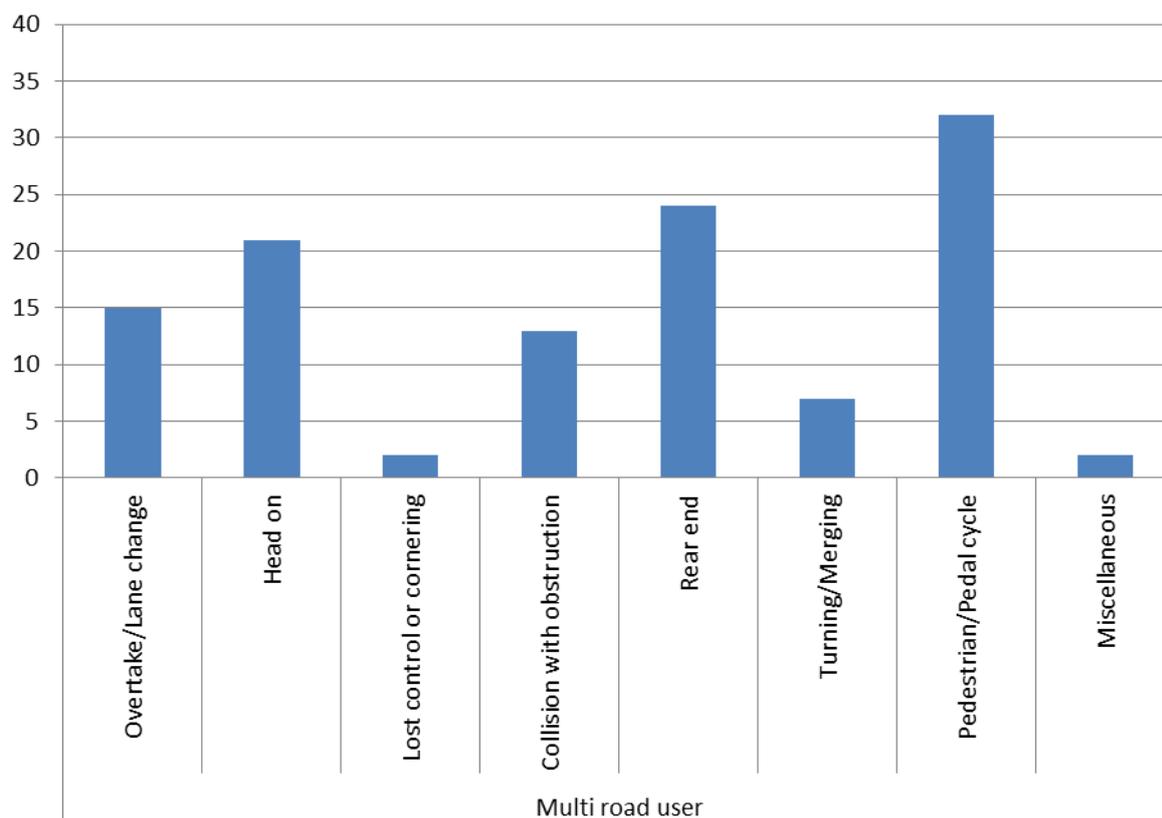


Figure 12: Multiple road user collisions by collision type (n = 116)

Practical recommendation:

Consider an education/awareness campaign on improving driver behaviour and selecting a following distance appropriate to the conditions to reduce rear end collisions.

The carriageway class of all 159 collisions by the collision type is represented in Figure 13. Notably, all of the ‘Head on’ collisions occurred on A-roads, indicating that no motorway crossovers occurred in this sample. The majority of the ‘Head on’ collisions occurred on single carriageways (81%) where no central median or barrier was present. Excluding ‘Head on’ collisions, the distribution of collisions between Motorway (n = 65) and A class (N = 118) carriageways is reasonably consistent, with approximately 63% occurring on A class carriageways. Approximately half collisions (55%) on A class roads were on dual

carriageways; with 42% on single carriageway and 3% on slip roads. None of the collisions occurring on slip roads included vehicles travelling the wrong way down the carriageway.

Turning and merging collisions were grouped together as the number of collisions in the individual collision types (see Appendix A) were very low compared to the other types.

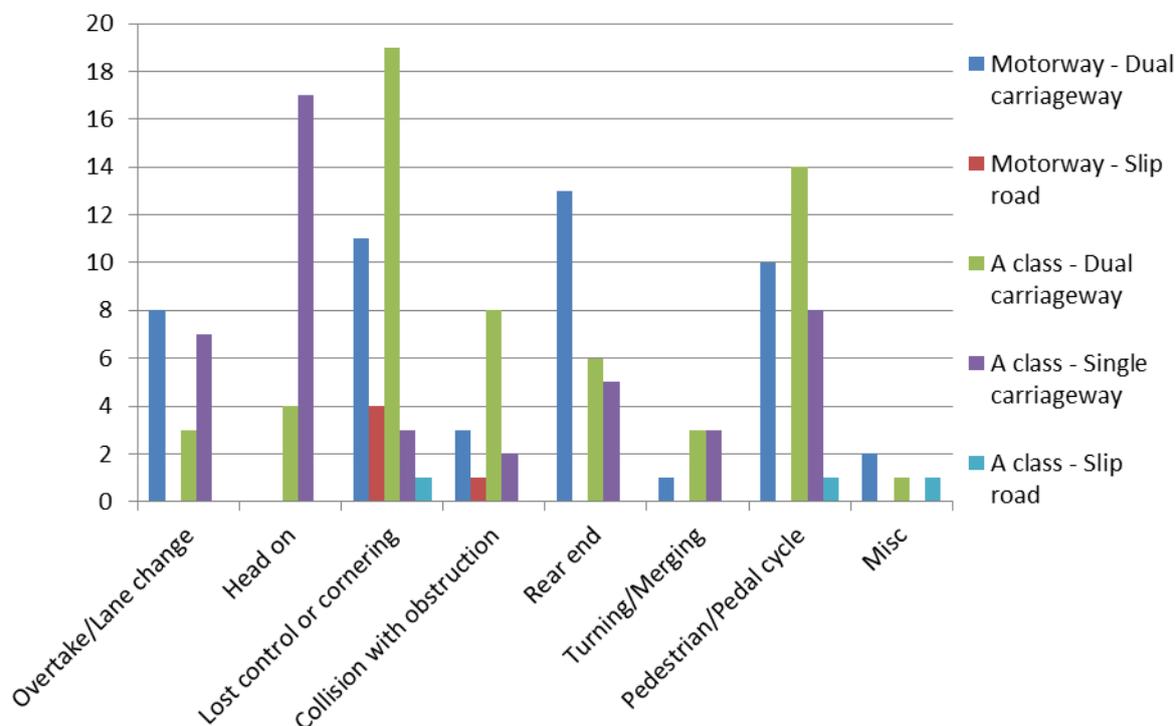


Figure 13: Collision types by carriageway class (n = 159)

The weather conditions at the time of the collision are recorded in the same format as STATS19 and are plotted against collision type in Figure 14. 76.7% of all collisions in the HEFDB occurred in fair weather conditions, including the vast majority of ‘Lost control or cornering’ collisions. However, of these collisions (n = 120) 26 had wet or damp road surface conditions and 3 collisions were described as having frost or ice on the road.

‘Pedestrian/Pedal cycle’ collisions (n = 21) that occurred in rain, were slightly more represented than other collisions. Some of the source material did not report the necessary information and so those collisions have been coded as unknown. It is reasonable to assume that the weather conditions in these cases were not pertinent to the collision circumstances.

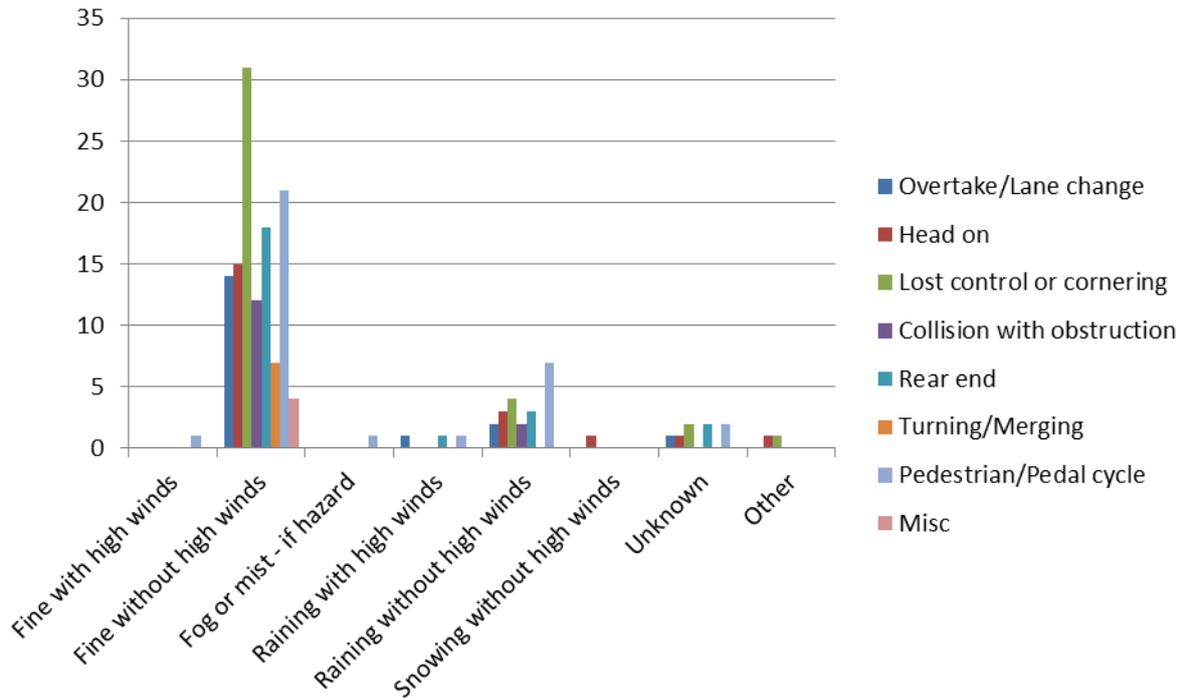


Figure 14: Environmental conditions by collision type (n = 159)

The lighting conditions at the collision locus and the ambient lighting are represented in Figure 15 with collision type. The distribution of collisions in the HEFDB between light and dark conditions is almost even (51% in light conditions; 49% in dark conditions). However, collisions in darkness with no street lighting were found to be over-represented (75.6% of all collisions in the darkness). Within this group of collisions, ‘Pedestrian/Pedal cycle’ collisions were the most frequent.

The majority of collisions occurring in light conditions were described as Daylight (86.4%).

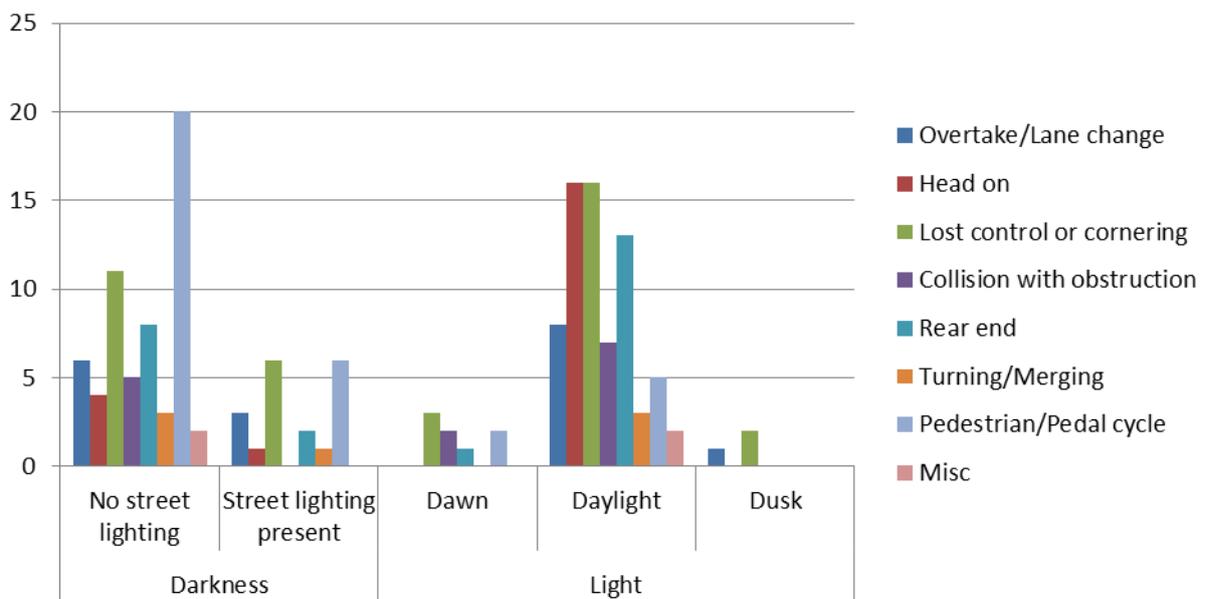


Figure 15: Light conditions by collision type (n = 159)

3.4 Causation

Considering the entire sample of 159 fatal collisions, the database was analysed to show the distribution of causation factors by the categories of: people, vehicle, and road. Figure 16 shows that that causation factors attributable to ‘people’ dominate; Over 40% of collisions were due to these causation factors only. The majority of collisions had causation factors from multiple categories, with ‘people’ combining with ‘roads’ (31.4% of collisions) and ‘vehicle’ (12.6%), and with all categories in 12.6% of cases. The causation factors were unable to be determined for one case due to a lack of available evidence from the collision (see Appendix B for a detailed summary of this collision).

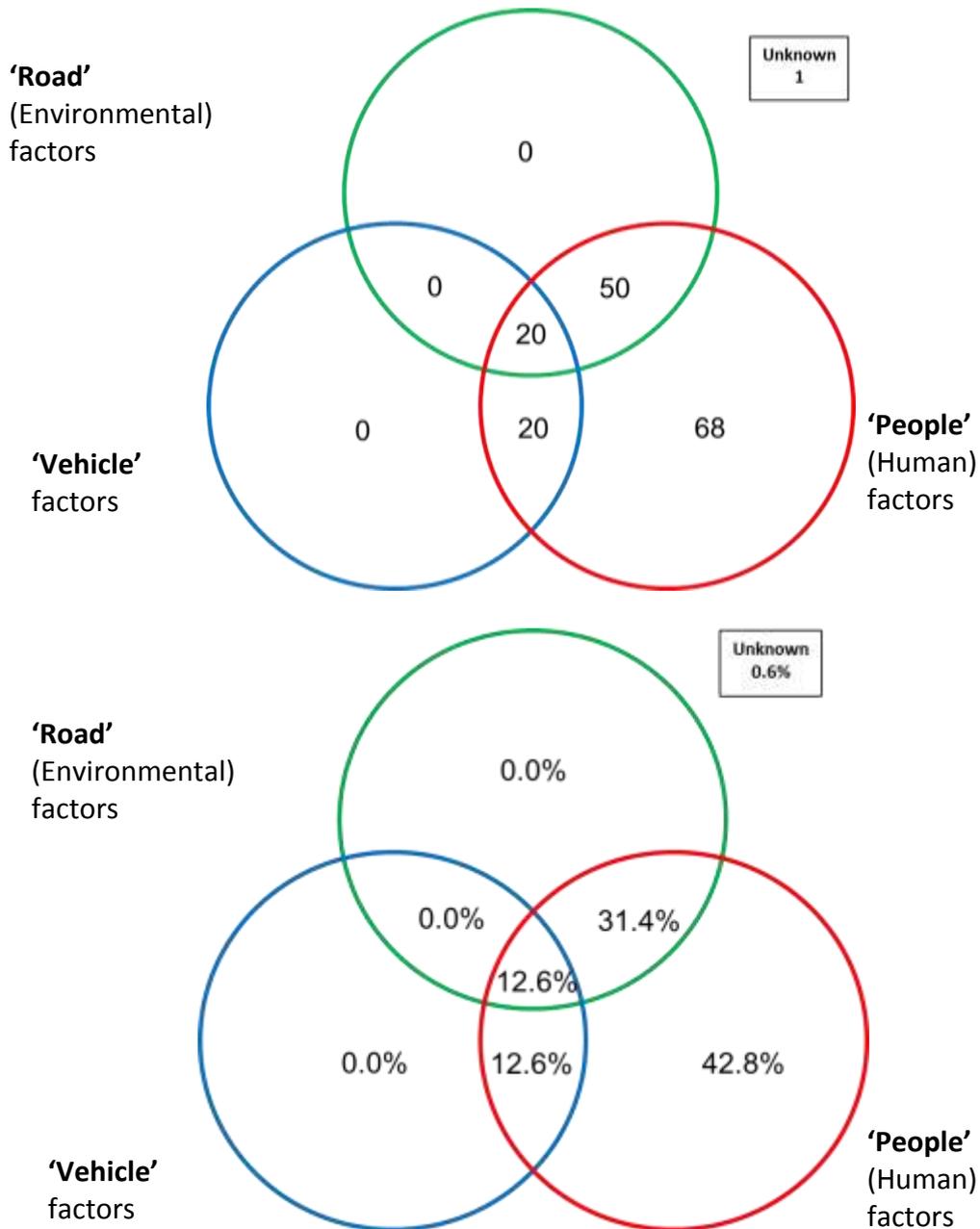


Figure 16: Collision causation factors by category (n=159)

3.4.1 *Precipitating actions*

Precipitating actions (actions that led to the collision) were assigned to occupants who contributed to the collision via their behaviour or actions. The collision investigators selected a single action from a list of predefined actions that best described the occupant's contribution to the collision.

Analysing the precipitating actions provides further insight into the precise actions of road users that contributed to the fatal collision. One action is assigned per person if they were deemed to have contributed to the collision and this is restricted to only one action per person. Therefore, the action that best represents the person's actions in the collisions is selected.

The following graphs describe the precipitating actions of the people involved in the fatal collisions that induced the events that lead to the fatality occurring. The following figures count the number of individuals to whom a precipitating action was attributed (n = 183) and excludes the remaining people who did not have a precipitating action attributed to them (n = 266).

Figure 17 shows all of the people to whom a precipitating action by their road user class. Considering the precipitating event (the event that led to the collision) by the road user type, this shows that trends can be identified for particular road user groups. For cars, 'loss of control', 'failure to avoid an object in the carriageway', and 'poor turn or manoeuvre' are the main groups. For pedestrian collisions, entering the carriageway without due care is the main precipitating event. Note that this comprises 183 road users who were assigned a precipitating event; 266 occupants who were not assigned a precipitating event are not included in the data presented in Figure 17.

The precipitating action for fatalities only is shown in Figure 18 with their road class. Fatalities that had no precipitating action are also shown; these primarily include 32 passengers of vehicles with 18 drivers. The 126 fatalities demonstrate that the majority (71.6%) of all people killed on the SRN had a precipitating action that contributed in some respect to the collision in which they were killed.

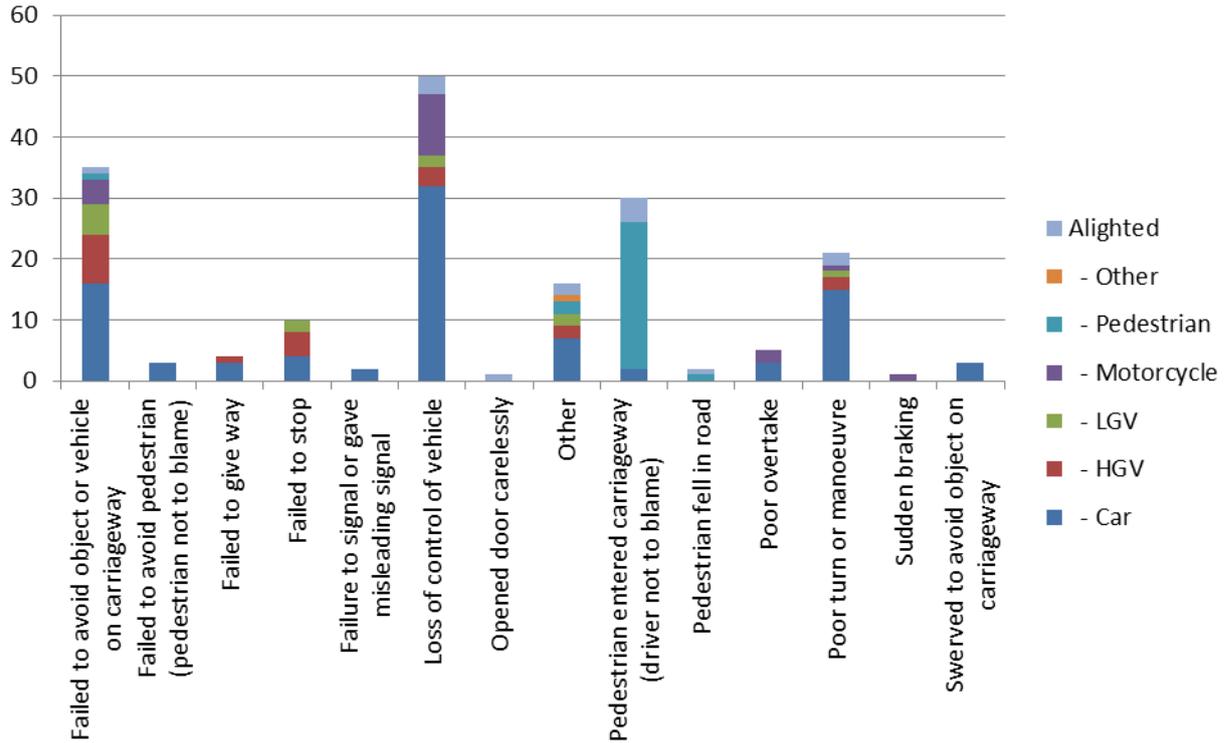


Figure 17: Precipitating action for all road users (excludes occupants without any precipitating action attributed to them), (n=183)

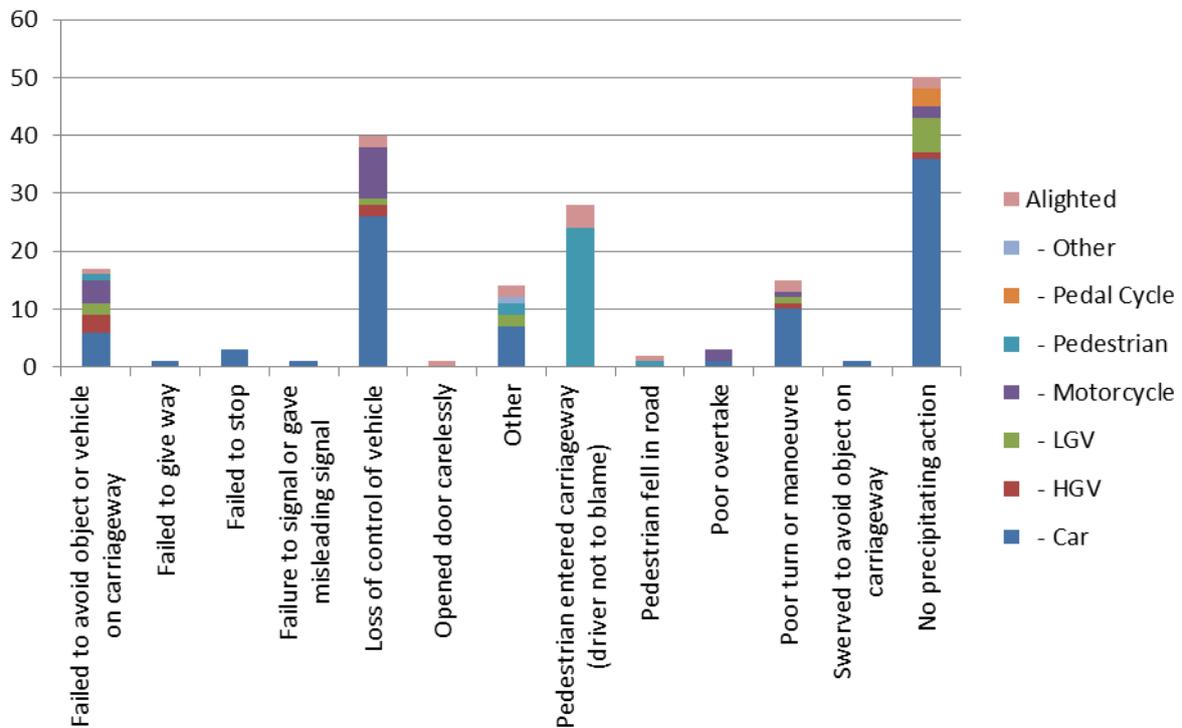


Figure 18: Precipitating action for all fatalities only (n=176)

3.4.2 Causation Factors

The frequencies of all causation factors attributed to people in the HEFDB are presented in Figure 13. The 158 cases where causation factors were attributed to people involved 183 individuals. Multiple causation factors can be attributed to a person and are not mutually exclusive (apart from 'Failed to look' and 'Looked but did not see'). The investigator could attribute a level of confidence to each causation factor and only the highest confidence factors are presented for analysis in Figure 19.

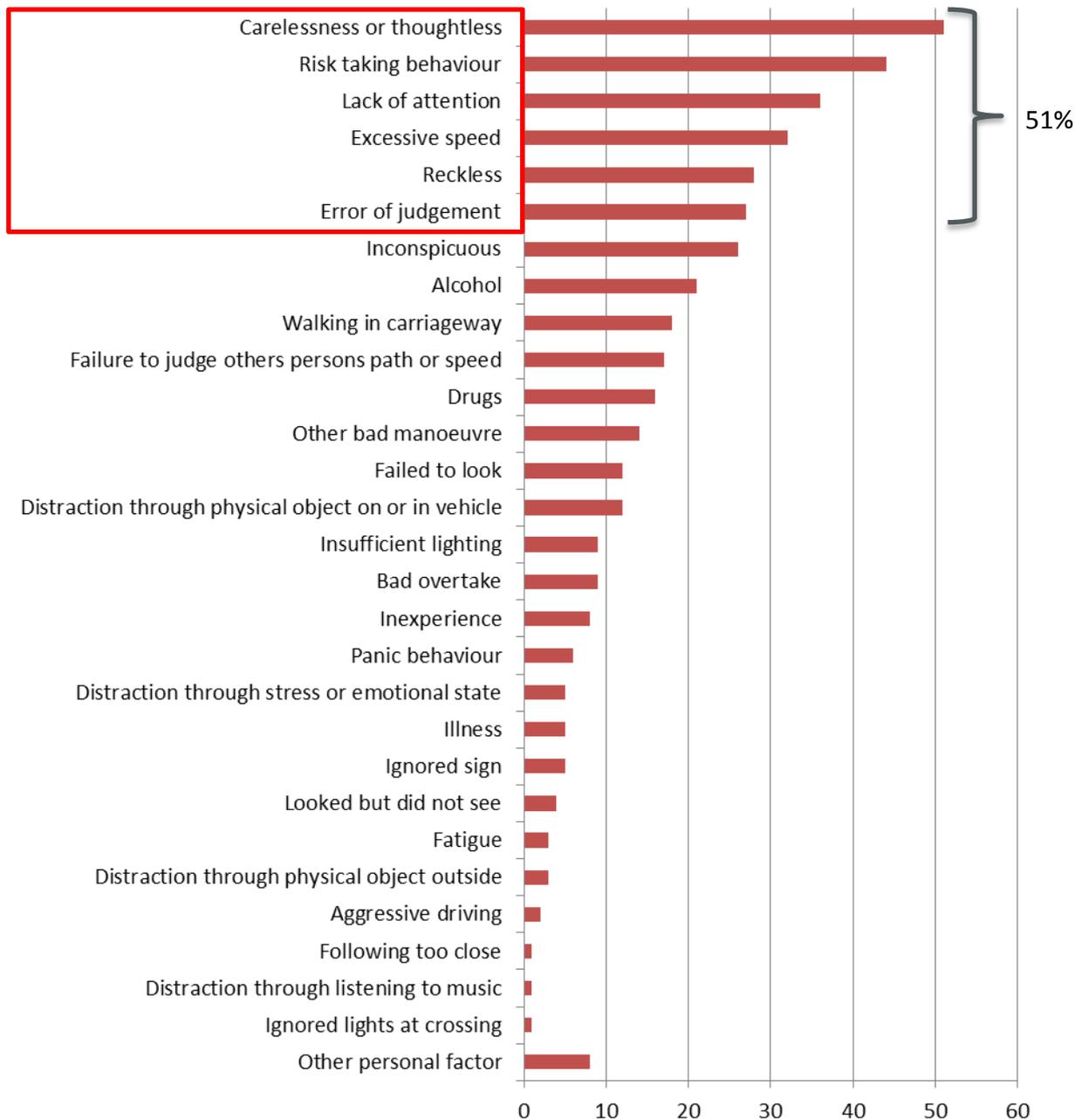


Figure 19: Frequency of specific people causation factors

The six most frequent causation factors ‘Carelessness or thoughtless’; ‘Risk taking behaviour’; ‘Lack of attention’; ‘Excessive speed’; ‘Reckless’ and ‘Error of judgement’ account for more than half (51%) of all human factors. Multiple causation factors were attributed to a person if there was evidence to support the behaviour and they were not mutually exclusive.

Eight people were attributed with the causation factor ‘Other personal factor’ where the investigator believed a significant factor was not captured in the list of causation factors. Five of these people were probable suicides, two had medical episodes, and one was a deliberate act involving a pedestrian pushing another pedestrian into the carriageway resulting in both of their deaths.

The frequency of specific vehicle related causation factors is presented in Figure 20. This shows that the modal category was defective tyres (25). Other main categories were ‘other’ defects (10) and defective brake systems (7).

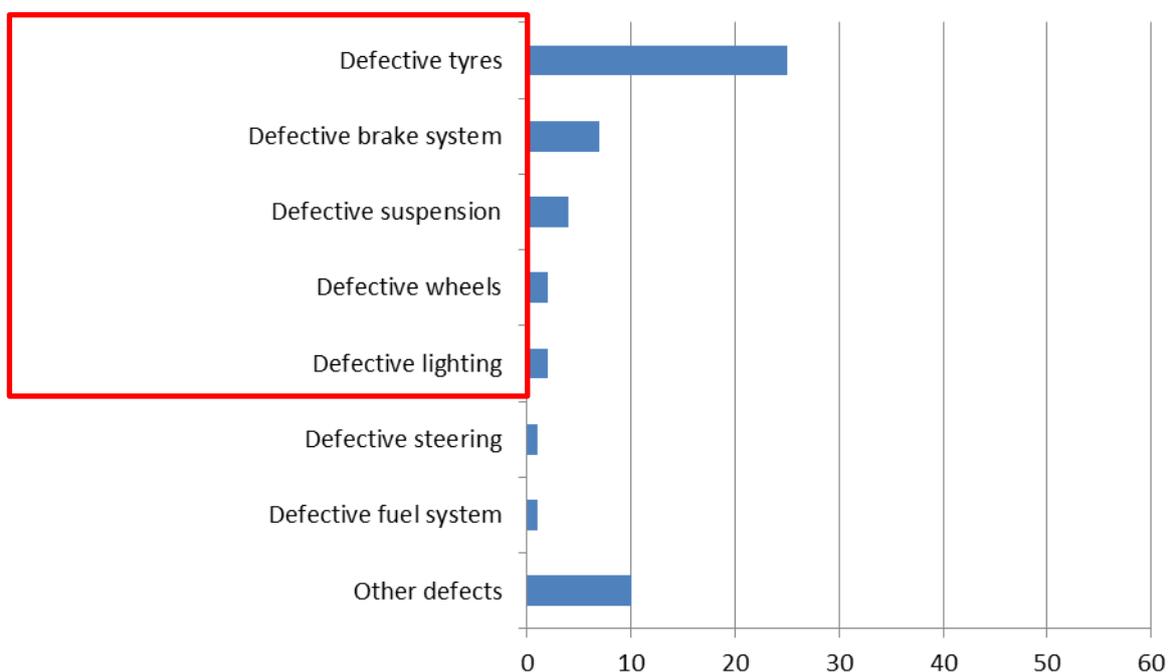


Figure 20: Frequency of specific vehicle related causation factors

The ‘other’ defect category included various defects that were not coded into the main categories, such as:

- A significant failure in the maintenance system - the cab tilting pump being left in the up or open position prior to the collision.

- The bonnet became detached from latch during journey.
- Lift axle on trailer in raised position whilst full load carried; this led to instabilities.

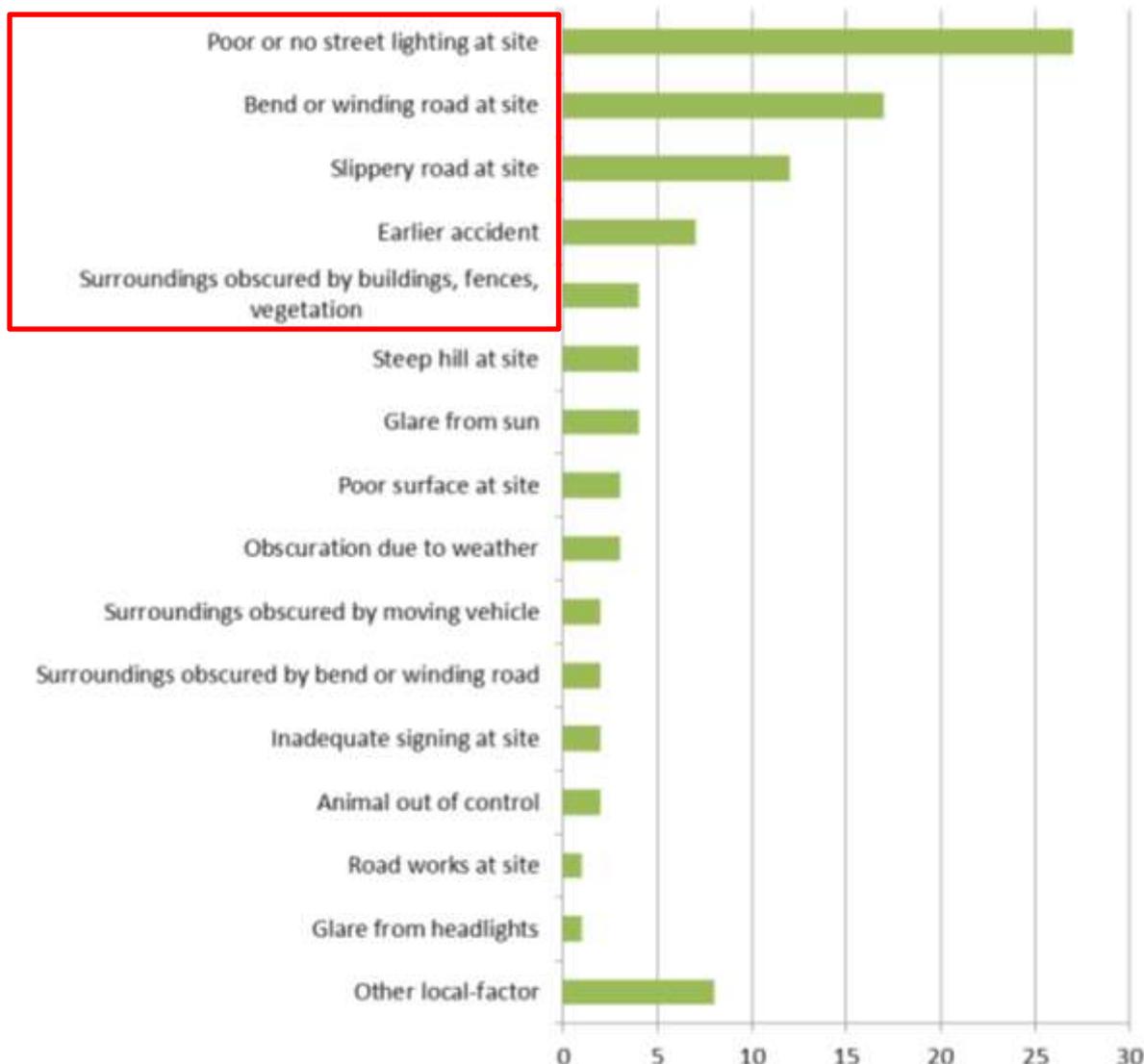


Figure 21: Frequency of specific road related causation factors

For ‘road’ causation factors, Figure 21 shows the frequency of assigned factors.

The main categories can be seen to be related to poor or no street lighting at site, bend or winding road at site, slippery road at site and other local factor at site.

This latter group comprised factors such as:

- Other local-factor: A pedestrian was in the carriageway tending to another pedestrian who had jumped from a footbridge.
- Other local-factor: Queuing traffic on lead up to slip road.
- Other local-factor: Tarpaulin found on north bound carriageway.
- Other local-factor: Water on carriageway - approximately 3 mm deep.

3.5 Countermeasures

Figure 22 illustrates how countermeasures can change the risks that road users are exposed to, by influencing elements of the safe systems approach. This can alter both the occurrence and the severity of the outcome of a collision.

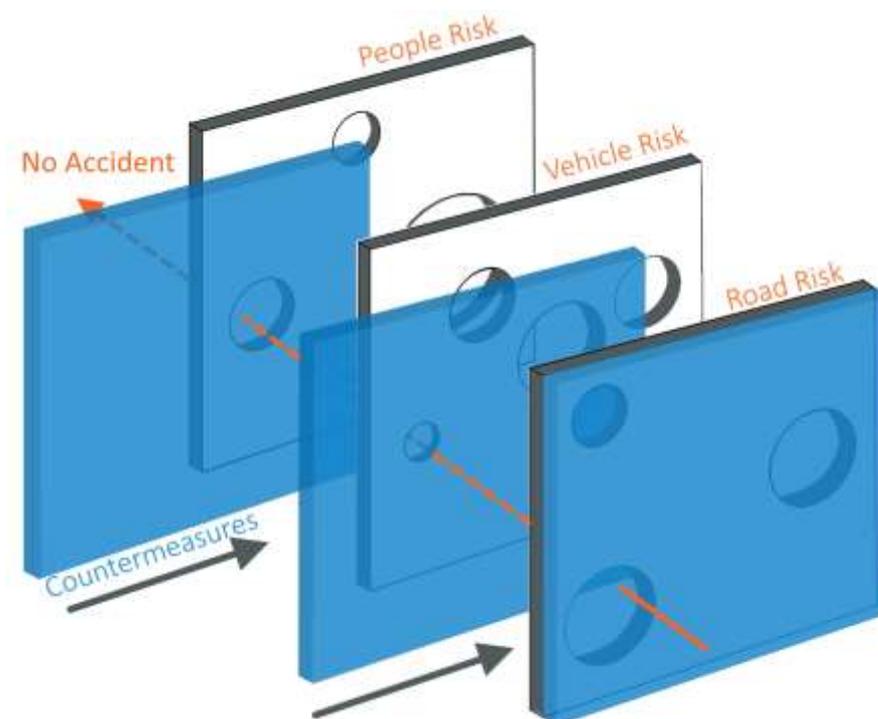


Figure 22: Countermeasure intervention in the Swiss cheese model of collision causation (adapted from Reason, 1990)

For the entire sample (159 collisions), Figure 23 shows the countermeasures that were assigned by the high level groups of people, vehicle, road. More than one countermeasure could be assigned per case.

This shows that vehicle-based countermeasures are the main group overall, followed by road and then people. Therefore, despite the fact that the human element was always involved in the collision cause, the countermeasures to address this were judged to lie mainly in the vehicle group. Indeed only 6 of the 159 collisions had countermeasures that were only in the 'people' category. This shows that there are a range of potential solutions to address causation factors in the 'people' domain.

Unknown countermeasure were coded where there was no reasonable countermeasure that could influence the outcome or occurrence of the collision (e.g. for suicides).

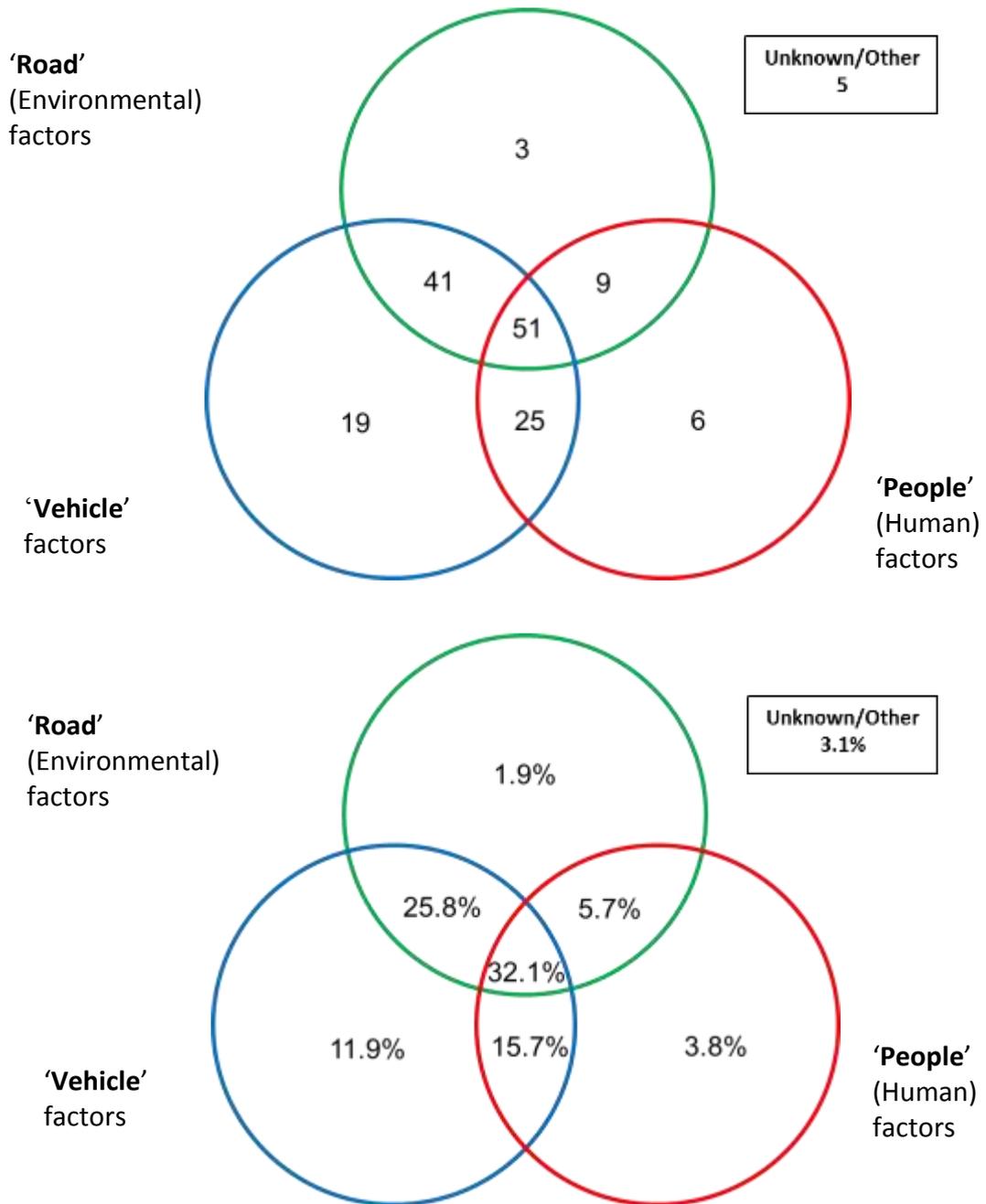


Figure 23: Collisions by countermeasures category (n=159)

Figure 23 suggests that, in approximately one third of the cases (n=51) where countermeasures from all three areas/groups were applied, an intervention in either the people, vehicle or road elements has the possibility of altering the risks sufficiently to prevent the fatality from occurring. This assumes that any one appropriate countermeasure could prevent the fatality.

3.5.1 Countermeasure confidence

The following three graphs present the frequency of the individual countermeasures that were applied to all cases. The countermeasures were ranked based on the investigator's confidence that they would have been able to:

- Avoid the collision entirely.
- Significantly reduce the severity of the collision (i.e. reduce the fatality to at least serious injury).

These aspects were assessed independently of each other and the effectiveness score calculated according to Table 6, below. This ranking resulted in a score of between 2 and 8, with lower rankings meaning that the investigator was more confident that the countermeasure would be appropriate. Avoidance and severity reduction were assessed together because both of these outcomes met the aims of the countermeasure: to prevent the fatality occurring.

Table 6: Countermeasure confidence and scoring

Counter-measure	Investigator confidence the countermeasure would <u>avoid</u> the collision	Investigator confidence the countermeasure would <u>reduce the severity</u> of the collision	Confidence score
1	High = 1	High = 1	2
2	Low = 2	Low = 2	4
3	None = 3	None = 3	6
4	High = 1	None = 3	4
5

The more confident the investigator was that the countermeasure would have been effective in either of these criteria is represented by a darker frequency bar in the following graphs. The following graphs are ranked by the countermeasures with greatest frequency that had a confidence score between 2 and 4. The same analysis is performed in Appendix C where only countermeasure frequency was considered.

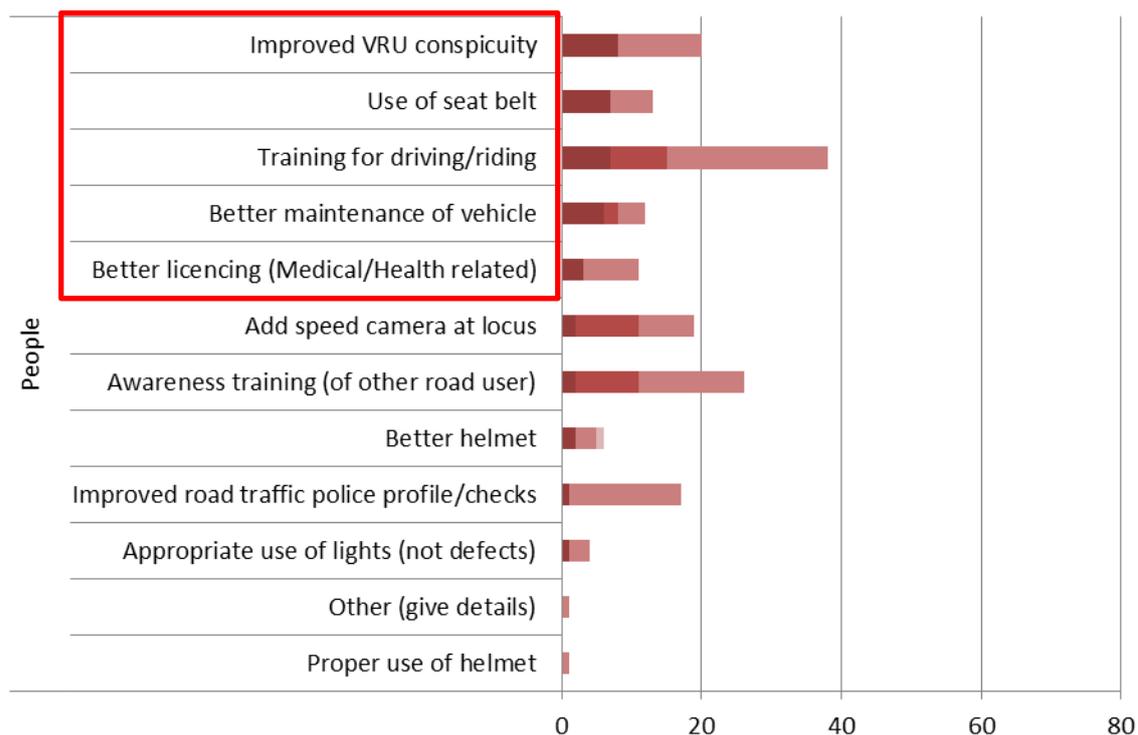


Figure 24: Frequency and confidence of specific people countermeasures, five most common countermeasures highlighted in red

Figure 24 shows the countermeasures that the investigator had most confidence would avoid or reduce the fatality. The priority ‘people’ countermeasures can be identified as:

- Improved Vulnerable Road User (VRU) conspicuity
- Use of seat belts
- Training for driving/riding (where this includes improved driver hazard perception and responding appropriately to changes in risk)
- Better maintenance of vehicle
- Better licencing (Medical/Health related)

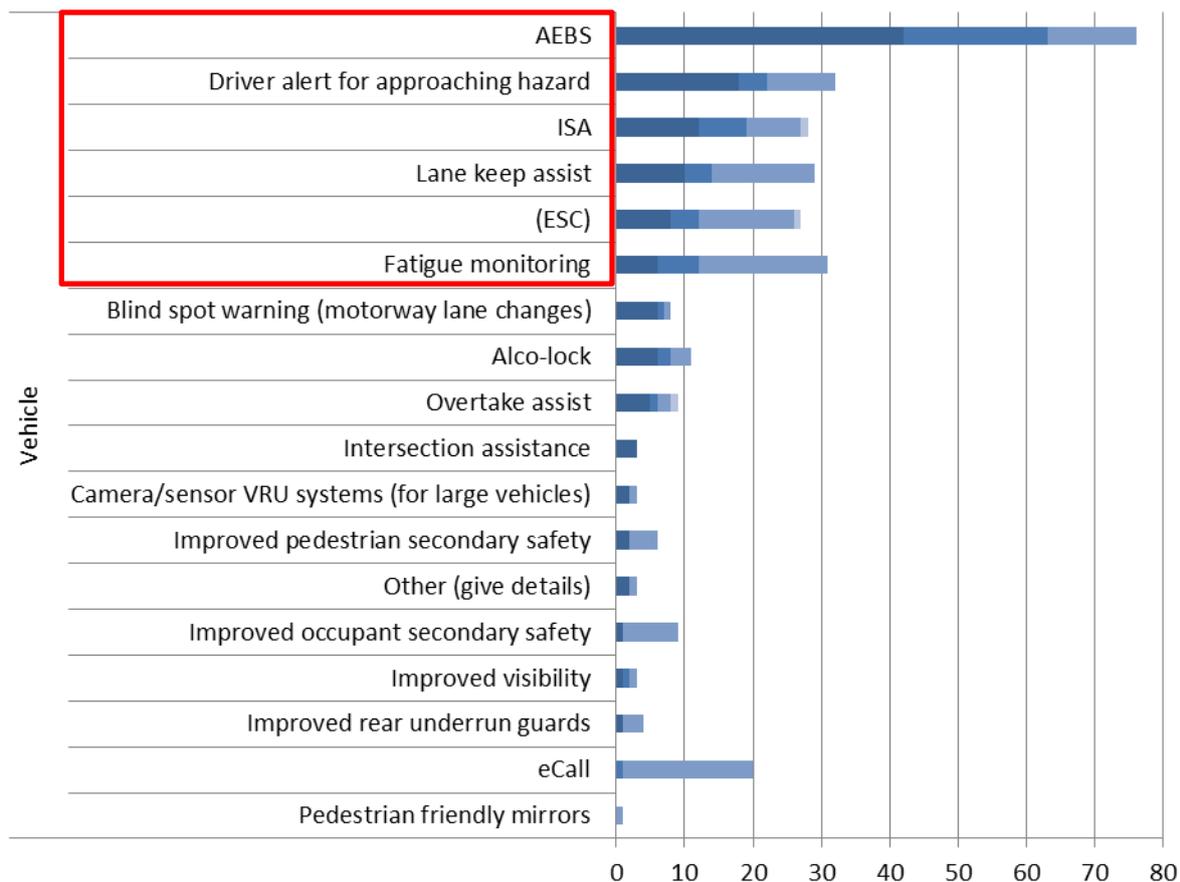


Figure 25: Frequency and confidence of specific vehicle countermeasures, five most common countermeasures highlighted in red

Figure 25 shows the countermeasures that the investigator had most confidence would avoid or reduce the fatality. The priority ‘vehicle’ countermeasures can be identified as:

- Automatic Emergency Braking System (AEBS) – this category includes a range of AEBS including urban and inter-urban AEBS and pedestrian AEBS
- Driver alert for approaching hazard
- Intelligent Speed Assist
- Lane Keep Assist
- (Electronic Stability Control (ESC))
- Fatigue monitoring

Electronic stability control (ESC) is mandated to be fitted to all new cars and small commercial vehicles in the EU since 2014 (new types from 2011). As a result, this countermeasure has already been implemented to its fullest extent and because of high rates of fitment prior to regulation is currently estimated to be fitted to 95% of the fleet. Therefore, this countermeasure has been excluded from the remainder of the analysis and the countermeasure, fatigue monitoring is presented.

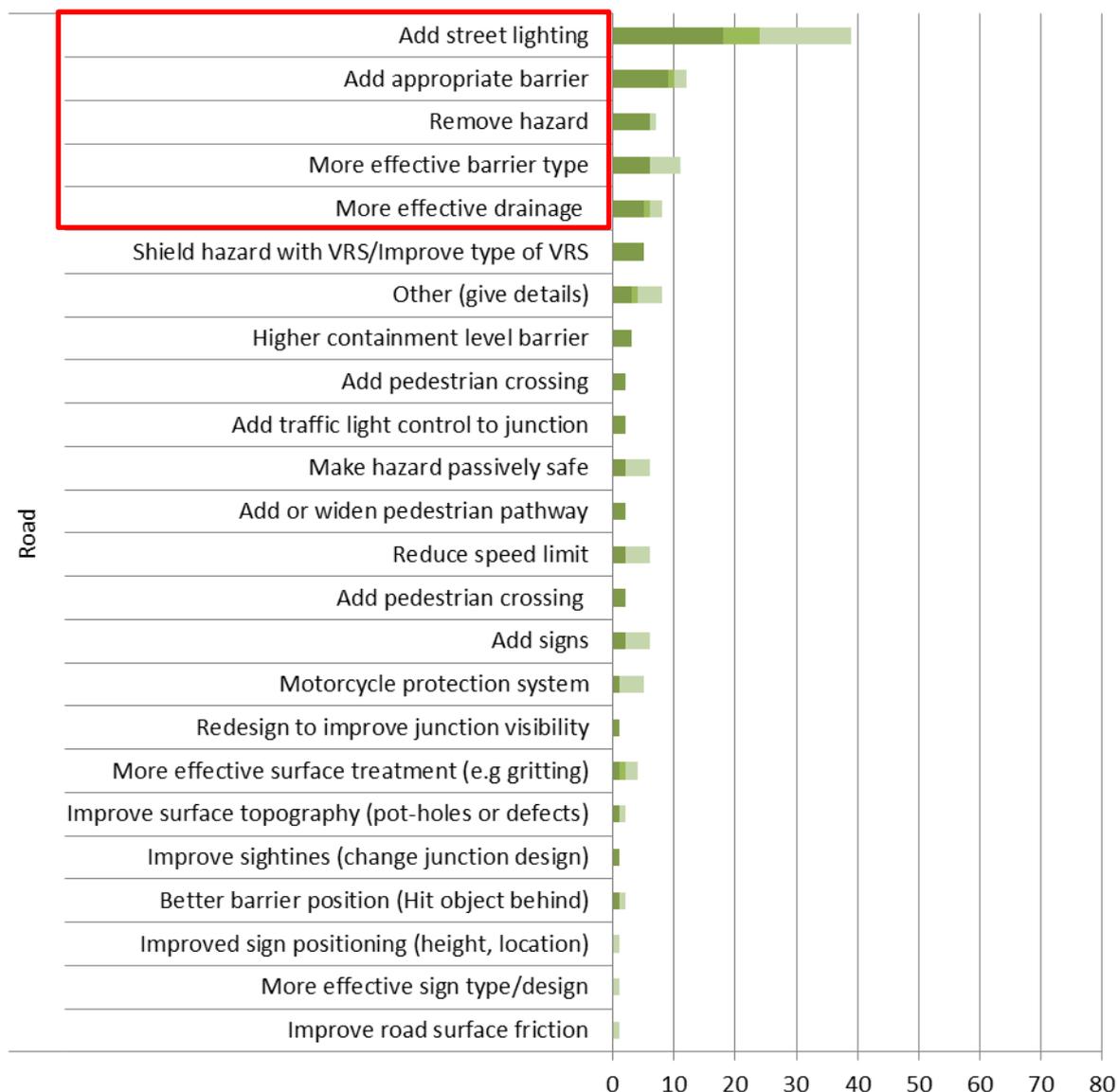


Figure 26: Frequency and confidence of specific road countermeasures, six most common countermeasures highlighted in red

Figure 25 shows the countermeasures that the investigator had most confidence would avoid or reduce the fatality. The priority ‘road’ countermeasures can be identified as:

- Add street lighting
- Add appropriate barrier
- Remove hazard
- More effective barrier
- More effective drainage
- Shield hazard

3.5.2 Countermeasure target populations: how many fatalities could be prevented?

Interventions using countermeasures that influence all three elements of the safe systems approach ('People', 'Vehicles', 'Road') are important for the prevention of fatalities on the SRN.

Now that the most effective countermeasures influencing the three elements of the safe systems approach have been identified it is important to understand firstly how many fatalities each individual countermeasure could have prevented and to understand to whom these countermeasures should be applied.

Table 7 shows the number of fatalities that could have potentially been prevented by each of the top countermeasures from Figure 24, Figure 25 and Figure 26.

It should be noted here that each countermeasure has been assessed separately and because multiple countermeasures can address the same fatality, the sum of the fatalities in Table 7 is greater than the total number of fatalities in the HEFDB. For example, Figure 23 shows that in 51 of the collisions, countermeasures from either category of 'people', 'vehicle', 'road' could influence the fatality.

Table 7: Potential fatalities prevented by countermeasures

Countermeasure		Fatalities potentially saved		
		High confidence	Low confidence	Total
People	Improved VRU conspicuity	8	12	20
	Use of seat belt	6	6	12
	Training for driving/riding in particular circumstances	8	28	36
	Better maintenance of vehicle consumables/features	8	6	14
	Better licencing (Medical/Health related)	3	8	11
Vehicle	AEBS	43	32	75
	Driver alert for approaching hazard	23	14	37
	ISA	13	17	30
	Lane keep assist	13	20	33
	Fatigue monitoring	9	27	36
Road	Add street lighting	13	24	37
	Add appropriate barrier	9	3	12
	Remove hazard	8	1	9

Countermeasure	Fatalities potentially saved		
	High confidence	Low confidence	Total
More effective barrier type	6	7	13
More effective drainage	5	3	8
Shield hazard with VRS/Improve type of VRS	5	0	5

Table 7 shows that:

- Vehicle countermeasures are estimated to prevent the most fatalities (100 high confidence and 102 low confidence)
- The target population for vehicle countermeasures is approximately twice that of the people and road groups
- AEBS is estimated to be able to prevent the greatest number of fatalities. This includes all types of AEBS
- For the road countermeasures, adding street lighting could influence up to 37 fatalities per annum (based on 2014 data)
- Some fatality groups (e.g. pedestrians) could have been prevented by multiple countermeasures. Care should be taken not to double count the potential number of fatalities prevented.

3.5.3 Countermeasure target populations: who should the countermeasures apply to?

Each countermeasure is assigned to an individual road user to whom it will influence. This may not always be the person that has been killed, but another road user who could have influenced the outcome or occurrence of the collision. For example, the countermeasure 'use of a seat belt' will directly influence the person to whom it is attributed. In contrast, 'AEBS' can be attributed to the driver of a vehicle that impacted and killed another road user and so the fatality is not the person who should be targeted with that countermeasure.

Table 8 and Table 9 present demographic and other information for the individuals to whom the countermeasures apply to and not the fatalities they could have presented. This information is presented to aid decisions on the group(s) that the countermeasures should be targeted at. This is important information to any subsequent campaigns or initiatives to ensure that the information or action on countermeasures is focussed effectively on the appropriate people or groups.

Table 10 provides information on the specific carriageways to which the countermeasures apply, rather than the road users since all of the people involved in the collision are influenced by these 'road' countermeasures.

An extensive breakdown and pivot tables of each countermeasure is provided in Appendix D.

Table 8: Five most applicable 'People' countermeasures and the road user demographic to which they apply

	Improved VRU conspicuity	Use of seat belt	Training for driving/riding	Better maintenance of vehicle	Better licencing	Total individuals
Gender						
Female	3	4	5	4	2	18
Male	17	9	32	8	9	75
Not known	0	0	1	0	0	1
Total	20	13	38	12	11	94
Age						
0-16	0	1	0	0	0	1
17-24	4	1	11	1	0	17
25-34	3	0	8	5	0	16
35-44	4	5	4	2	1	16
45-54	0	1	6	1	2	10
55-64	4	0	3	1	1	9
65-74	0	0	0	0	0	0
75+	4	0	0	1	5	10
Unknown	1	5	6	1	2	15
Total	20	13	38	12	11	94
Vehicle type						
Car	0	7	23	6	9	45
HGV	0	5	2	1	2	10
LGV	0	1	0	0	0	1
Motorcycle	2	0	8	3	0	13
Pedal Cycle	2	0	0	0	0	2
Pedestrian	14	0	0	0	0	14
Alighted	2	0	5	2	0	9
Total	20	13	38	12	11	94

	Improved VRU conspicuity	Use of seat belt	Training for driving/riding	Better maintenance of vehicle	Better licencing	Total individuals
Collision type						
Overtake/ Lane change	1	1	10	3	2	17
Head on	0	1	7	2	3	13
Lost control	0	7	15	4	0	26
Collision with obstruction	0	2	2	2	1	7
Rear end	2	1	4	0	2	9
Turning/ Merging	1	1	0	0	3	5
Pedestrian/ Pedal cycle	16	0	0	1	0	17
Total	20	13	38	12	11	94
Vehicle ownership						
Hired or leased	0	0	1	0	1	2
Loaned or borrowed	0	1	4	0	0	5
Owned by company	1	5	3	1	1	28
Owned by driver or rider	3	6	23	10	6	11
Unknown	16	1	7	1	3	48
Total	20	13	38	12	11	94
Journey purpose						
Commuting to/from work	2	0	5	2	0	9
Journey as part of work	1	6	4	1	2	14
Taking school pupil to/from school	0	1	0	0	0	1
Other/Not known	16	6	29	9	9	69
Not known	1	0	0	0	0	1
Total	20	13	38	12	11	94

Table 9: Five most applicable 'Vehicle' countermeasures and the demographic/characteristics to which they apply

	Automated Emergency Braking (AEB)	Driver alert for approaching hazard	Intelligent Speed Adaptation (ISA)	Lane keep assist	Fatigue monitoring	Total countermeasures
Gender						
Female	13	4	3	4	4	28
Male	60	26	24	25	27	162
Not known	3	2	1	0	0	6
Total	76	32	28	29	31	196
Age						
17-24	16	7	8	10	11	52
25-34	14	5	3	6	4	32
35-44	17	7	4	4	4	36
45-54	5	2	7	0	2	16
55-64	4	1	0	3	1	9
65-74	5	2	2	2	2	13
75+	1	1	0	0	1	3
Unknown	14	7	4	4	6	35
Total	76	32	28	29	31	196
Vehicle type						
Car	40	14	16	20	21	111
Motorcycle	3	1	6	0	0	10
HGV	19	10	3	4	4	40
LGV	9	5	1	5	6	26
Taxi/Private Hire	2	0	0	0	0	2
Other	1	0	0	0	0	1
Alighted	2	2	2	0	0	6
Total	76	32	28	29	31	196

	Automated Emergency Braking (AEB)	Driver alert for approaching hazard	Intelligent Speed Adaptation (ISA)SA	Lane keep assist	Fatigue monitoring	Total countermeasures
Collision type						
Overtake/ Lane change	11	0	4	3	3	21
Head on	8	3	4	9	4	28
Lost control	0	4	14	10	10	38
Collision with obstruction	9	11	2	5	3	30
Rear end	23	13	2	1	10	49
Turning/ Merging	5	0	1	0	0	6
Pedestrian/ Pedal cycle	19	1	1	1	1	23
Misc	1	0	0	0	0	1
Total	76	32	28	29	31	196
Vehicle ownership						
Hired or leased	3	2	1	2	2	10
Loaned or borrowed	1	1	1	2	3	8
Owned by company	29	11	5	8	6	59
Owned by driver or rider	34	14	16	14	16	94
Unknown (decamp)	1	0	0	0	1	2
Unknown	8	4	5	3	3	23
Total	76	32	28	29	31	196
Journey purpose						
Commuting to/from work	1	1	1	1	2	6
Journey as part of work	29	12	5	8	9	63
Other/Not known	46	19	22	20	20	127
Total	76	32	28	29	31	196

Table 10: Six most applicable 'Road' countermeasures and the characteristics to which they apply

	Add street lighting	Add appropriate barrier	Remove hazard	More effective barrier type	More effective drainage	Shield hazard with VRS ¹⁰	Total carriageways
Carriageway class							
Motorway							
Dual carriageway	15	6	0	6	5	1	33
A class							
Dual carriageway	18	6	4	5	2	4	39
Single carriageway	5	0	2	0	1	0	8
Slip road	1	0	1	0	0	0	2
Total	39	12	7	11	8	5	82
Collision type							
Overtake/ Lane change	4	1	1	2	1	1	10
Head on	1	0	1	1	1	0	4
Lost control	2	10	5	8	4	4	33
Collision with obstruction	2	0	0	0	2	0	4
Rear end	2	1	0	0	0	0	3
Turning/ Merging	3	0	0	0	0	0	3
Pedestrian/ Pedal cycle	24	0	0	0	0	0	24
Misc	1	0	0	0	0	0	1
Total	39	12	7	11	8	5	82
Was the vehicle restrained by VRS							
Yes	10	2	2	4	2	1	21
No	1	2	2	6	2	0	13
Not applicable	28	8	3	1	4	4	48
Total	39	12	7	11	8	5	82

¹⁰ Vehicle Restraint System

	Add street lighting	Add appropriate barrier	Remove hazard	More effective barrier type	More effective drainage	Shield hazard with VRS ¹¹	Total carriageways
Hazard reached off carriageway							
Yes	1	2	2	7	2	1	15
No	13	3	3	3	3	1	26
Not applicable	25	7	2	1	3	3	41
Total	39	12	7	11	8	5	82
Offside vehicle restraint system type							
None	14	1	3	0	2	1	21
Concrete	1	0	0	1	1	1	4
Open box beam	7	3	1	2	2	1	16
Tensioned corrugated beam	15	6	3	7	2	2	35
Wire rope	2	2	0	1	1	0	6
Total	39	12	7	11	8	5	82
Nearside vehicle restraint system type							
None	27	11	5	3	3	4	53
Open box beam	5	0	1	3	4	1	14
Tensioned corrugated beam	3	1	1	4	1	0	10
Other	4	0	0	1	0	0	5
Total	39	12	7	11	8	5	82

¹¹ Vehicle Restraint System

3.6 ADAS fitment and fleet penetration: estimated effect on future fatalities

The fitment of Advanced Driver Assistance Systems (ADAS) has the potential to prevent a proportion of SRN fatalities and these technologies will penetrate into the fleet, contributing to future casualty targets. In order to estimate the fatality benefits that might be realised by the progression of ADAS into the fleet, the potential propagation of these technologies into the car fleet was considered for three different scenarios representing the lower, medium, and upper estimate for fleet penetration.

The first scenario assumes that the adoption of technologies continues along the current trend and that with no fundamental changes in consumer information testing or legislation that promote a different response from the automotive industry or the rapid adoption of the technology.

In the second scenario, Euro NCAP testing will proceed in future years according to the current roadmap (Euro NCAP, 2015) and future amendments and action as technology develops further. This will promote the increase of target technologies on new cars as car manufacturers are motivated to offer systems. Furthermore, it is anticipated that legislation will follow, as Euro NCAP testing and reward drives the fitment rate upward by implementing a minimum performance requirement for all cars when the cost benefit of the measure has been shown to warrant mandatory fitment.

The third scenario involves the introduction of legislation mandating the fitment of ADAS for new vehicles. In this case it is expected mandatory requirements for all new registrations would be introduced approximately 5-7 years after regulation is in place. This coupled with the fact that the development and agreement of the technical requirements to enable regulatory action is likely to take at least one year, means that regulation will not directly affect fleet fitment in the 2020 time horizon.

Historical fitment rates for technologies such as ESC show that it can take up to the order of a decade for newly introduced technologies to appear on the majority of newly registered cars. If technologies are promoted and/or tested through NCAP, this increases the proportion of vehicles for which the system is offered, but of course this may not translate into fitment to the vehicle. Regulation of systems means that the system is equipped to all new registrations, and usually ramps up rapidly in advance of the regulatory implementation date. However, the time taken for a system to penetrate to 100% fleet fitment, even with fitment to a large proportion of or all new registrations, takes a number of years.

To evaluate the effect of ADAS technologies on the Highways England 2020 casualty targets, estimates for the current and future fleet fitment of systems was made (see Table 11). This was made based on information on current model fitment strategies and TRL's judgement on the likely future fleet fitment based on planned (or likely) EuroNCAP action and the estimated timeline for mandatory regulatory requirements after 2020. Here we have assumed EuroNCAP take action on the majority of systems except mandatory ISA after 2020, with subsequent regulatory action following on afterwards. Should this not be the case, the fleet penetration estimates will be towards the lower end of the fleet fitment estimate. It can be seen from Table 11 that the 2020 time horizon is so close that no action (either

consumer testing or regulation) has enough time to be implemented such that it will deliver any improvements on the baseline estimate.

Table 11: Estimated proportion of fleet with each ADAS fitted in 2020 and 2030 (based on TRL predictions)

ADAS	2014 estimate	2020 estimate (all action)	Baseline (no action)	EuroNCAP (post 2020)	Regulation (post 2020)
	2014	2020	2030	2030	2030
ESC	95%	100%	100%	100%	100%
Lane departure warning	<1%	<2%	<5%	<60%	<80%
Lane keeping	<0.5%	<1%	<5%	<60%	<80%
AEBS (city - low speed shunts ONLY)	<1%	<2%	<5%	<60%	<80%
AEBS	<0.5%	<1%	<5%	<60%	<80%
AEBS (Pedestrian/cyclist)	<0.5%	<1%	<5%	<60%	<80%
ISA	0%	0%	<1%	<60%	<80%
Blind spot warning (motorway lane changes)	<0.5%	<1%	<5%	<60%	<80%
Overtake assist	0%	<0.5%	<3%	<50%	<80%
Fatigue monitoring	<0.5%	<1%	<5%	<60%	<80%
Alco-lock	0%	0%	<5%	<60%	<80%
Driver alert for approaching permanent hazard (sharp bend, steep decline)	0%	<0.5%	<3%	<50%	<80%
Driver alert for approaching temporary hazard (road works, broken down vehicle, queuing traffic)	0%	<0.5%	<3%	<50%	<80%
Intersection assistance	0%	<0.5%	<3%	<60%	<80%
Camera/sensor VRU systems (for large vehicles)	<0.5%	<1%	<5%	<60%	<80%

For some systems, particularly costly systems, actual fleet fitment rates may be lower than predicted above since a large proportion of systems are offered as optional extras and therefore the fleet penetration depends on the uptake of the system by the consumer (unless dictated by regulation), something for which limited data exist.

Based on the estimated number of fatalities that the introduction of a particular countermeasure could avoid or reduce for the 2014 sample of 159 collisions (176 fatalities),

predictions were made of the numbers of fatalities that might be prevented by 2020 and 2030 for three scenarios: baseline, EuroNCAP encouragement, and Regulation. These estimates make a number of assumptions about the rate at which systems will be equipped to vehicles as well as the exposure and collision involvement of equipped vehicles, and should therefore be used as an indication of how future fatalities might be affected by the top five ADAS countermeasures when compared against the estimated “no action” baseline for that year (see Table 12).

Table 12: Estimated number of annual fatalities prevented by top 5 ADAS systems in 2020 and 2030 compared with estimated ‘no action’ 2020/2030 penetration levels into the vehicle parc

ADAS	High confidence ADAS could avoid/reduce fatality			All confidences ADAS could avoid/reduce fatality		
	2020 (all actions)	2030 (NCAP testing)	2030 (Regulation)	2020 (all actions)	2030 (NCAP testing)	2030 (Regulation)
AEBS (all types)	0	25	34	1	44	59
Driver alert for hazard	0	12	18	0	19	30
Fatigue monitor	0	5	7	0	21	29
ISA	0	8	10	0	18	24
Lane keep assist	0	8	10	0	20	26

Table 12 shows that only negligible contributions to the 2020 target can be expected from ADAS because of the low penetration rate of the systems (or in the case of ESC because it is already mandated and equipped to most vehicles). For the 2030 time horizon, a greater number of fatalities could be prevented; up to 34-59 per annum for all types of AEBS systems should these be regulated in coming years.

For the 2030 time horizon the estimates are more speculative but show that, assuming EuroNCAP or regulatory action occur at, or soon after 2020, a greater percentage of collisions with these countermeasures could be addressed, potentially up to 34% of fatalities prevented (59/176) with regulation on all AEBS for example, and up to 24% of fatalities prevented for ISA (see Table 13, below).

Table 13: Estimated percentage of annual fatalities prevented by top 5 ADAS systems in 2014 sample for 2020 and 2030 compared with estimated 'no action' 2020/2030 penetration levels into the vehicle parc

ADAS	High confidence ADAS could avoid/reduce fatality			All confidences ADAS could avoid/reduce fatality		
	2020 (all action)	2030 (NCAP testing)	2030 (Regulation)	2020 (all action)	2030 (NCAP testing)	2030 (Regulation)
AEBS (all types)	0%	14%	19%	1%	25%	34%
Driver alert for hazard	0%	7%	10%	0%	11%	17%
Fatigue monitor	0%	3%	4%	0%	12%	16%
ISA	0%	5%	6%	0%	10%	14%
Lane keep assist	0%	5%	6%	0%	11%	15%

Practical recommendation:

Highways England should take a 'lead role' on the fitment of ADAS to new vehicles used for business purposes. Measures to encourage fleet managers and the general public to value the benefits provided by ADAS and specify fitment of systems should be encouraged.

4 Discussion

4.1 Methodology and approach

This work has focussed on causation and countermeasures of fatal collisions that occurred on the Strategic Road Network (SRN). Understanding the causation factors in the collision is one aspect; in this project we have assessed a range of causation factors within each group of people, vehicle, and road. The next step was to determine the most appropriate way to avoid or mitigate the collision outcome. It should be noted – as can be seen by the graphics in section Figure 23 – that the countermeasure for the collision can be in a different category (i.e. ‘people’, ‘vehicle’, ‘road’) to the causation factor. For example, an collision caused by excessive speed (people) can be addressed in many ways: speed calming measures (roads), or Intelligent Speed Assist (ISA) (vehicle) as well as better training (people).

Our analysis investigated the countermeasures in terms of frequency of being assigned to a fatality (irrespective of the investigator’s confidence) and in terms of applicability, based on a ranking method that incorporated the level of confidence assigned to the countermeasure. This is important because certain countermeasures may be less frequently appropriate, but when they are, they may be very applicable. We placed the focus on those measures that were judged to ‘definitely’ or ‘probably’ affect the fatality. This represented a crude measure of effectiveness (the ability of the measure to avoid or mitigate the collision) based on the confidence levels and a set of assumptions about the performance of each countermeasure.

4.2 Main results

4.2.1 Causation

Human (‘people’) causation factors were identified in all (but 1) of the collisions and were the sole causation category for more than 42% of the cases. Based on the 159 fatal collisions reviewed, the causation factors associated with collisions always involved a ‘people’ component.

- 42.8% of collisions had causation factors relating solely to ‘people’.
- 31.4% of collisions had had factors relating to ‘people’ and ‘road’.
- 12.1% of collisions had factors relating to ‘people’ and ‘vehicle’.
- 12.6% of collisions had factors relating to all three categories.

The five most frequently recorded ‘people’ causation factors were:

- Careless or thoughtless.
- Risk-taking behaviour.
- Lack of attention.
- Excessive speed.

- Reckless.

These behaviours were often combined with lack of vehicle maintenance, in particular tyres. A particularly common collision type involved pedestrians or pedal cyclists and people who had alighted from their vehicles and entered the carriageway. Poor or no street lighting was the main 'road' causation factor, with this being associated with vulnerable road user collisions.

4.2.2 Countermeasures

The countermeasures that were assigned to the collision encompassed all aspects of the safe systems model. The majority of collisions had countermeasures in multiple 'people', 'vehicle', 'roads' categories, indicating a range of possible approaches to avoid or reduce the resulting fatalities.

- 32.1% of collisions had countermeasures in all three categories.
- 25.8% of collisions had countermeasures in 'road' and 'vehicle' groups.
- 15.7% of collisions had countermeasures in 'vehicle' and 'people'.
- 5.7% of collisions had countermeasures in 'road' and 'people'.
- 11.9% of collisions had countermeasures solely in the 'vehicle' category, reflecting the fitment of advanced vehicle systems.
- Smaller percentages of collisions had countermeasures solely in the 'road' or 'people' category: 1.9% and 3.8% respectively.

4.2.2.1 'People' Countermeasures

Table 8 provides the demographic information of the people to whom the countermeasures should be applied to avoid or reduce the fatality.

- 80% of the 'people' countermeasures were attributed to males (75 of 94) which is the same proportion of males as the overall fatality sample.
- 29% of the people with the countermeasure 'training for better driving/riding', were young drivers, aged 17-24 (11 of 38). Important collision types for 'training' countermeasures were overtake/lane change, head-on, and loss of control.
- 42% of the 'Better maintenance' countermeasures were attributed to the 25-34 age group (5 of 12).
- 'Use of seat belt' should be targeted at 35-44 age group, with this group accounting for 38% of the people to whom this countermeasure was assigned (5 of 13).
- Car users had 48% of all countermeasures applied to them, reflecting their greater exposure on the road (45 of 94).
- Improving VRU conspicuity should be considered a priority; all 14 pedestrians with assigned countermeasures may have been avoided with better conspicuity.
- In most cases the journey purpose was unknown (70). However, when the journey purpose was known (24), 58% were carrying out the journey as part of work (14 of 24).

Improved VRU conspicuity

'Improved VRU conspicuity' was the most effective countermeasure in this category and applied only to vulnerable road users (VRUs) in the carriageway. All of the people this was applied to were fatalities who were killed by being struck by other road users, including two vehicle occupants who alighted from their vehicles and entered the carriageway. The target population for this countermeasure were primarily males from a range of age groups, but should apply to any person that enters the carriageway or any vulnerable road user in general. By increasing the visibility of the VRU, the countermeasure acts to enable other road users to perceive the hazard earlier and take action to completely avoid the collision.

Use of a seat belt

The mechanisms by which the use of a seat belt can reduce the severity of an occupant's injuries are well known. 12 of the 13 occupants this countermeasure applied to were fatalities, and one was a serious injury. Although the number of people to whom this countermeasure was applied is comparatively low, the effectiveness at reducing the severity of the injuries was high. This is demonstrated by the collisions that involved other belted occupants in the same vehicle who survived; only the fatalities were unbelted. One of the three child (under 16 years) fatalities in the HEFDB sample could have been prevented by the use of a seat belt. This countermeasure applied to a much higher proportion of females than other countermeasures and was focused on primarily passenger car and HGV occupants. A larger proportion of the target population are in the 35 to 44 age bracket; however, many of the population had unknown age. The majority of the people this countermeasure applied to owned the vehicle or were driving a company owned vehicle as part of their work.

Training for driving/riding in particular circumstances

This countermeasure is a broad intervention that does not relate to improving driver skill but encompasses:

- Training to improve hazard perception skill.
- Training or education to reduce risky driving manoeuvres.
- Training or education to reduce risky pre-driving behaviour (e.g. drink or drug use).
- Training or education to reduce other risky behaviours while driving (e.g. seat belt wearing).

This applied to primarily younger age groups of mainly car drivers and motorcycle riders. This countermeasure was also applied to some of the alighted occupants, where training and education in perceiving the hazards of entering a live carriageway could have prevented the collision from occurring. Most of the training pertains to collisions that involve driver/rider error (e.g. overtaking manoeuvres, head on collisions and loss of control).

Better maintenance of vehicle

Avoiding collisions by ensuring a vehicle is roadworthy was an intervention that was mainly applied to drivers in 25 to 34 year category and primarily to drivers/riders who owned the vehicle. The target vehicles included passenger cars, HGVs, and motorcycles. This

countermeasure was also applied to two alighted occupants who entered the carriageway because their vehicles broke down; better maintenance may have prevented them being exposed to the dangerous situation.

Better licencing (medical or health related)

This countermeasure specifically addresses road users who suffered medical episodes or health related issues that resulted in the collision. If the medical conditions were known to the DVLA, the likelihood of the driver being issued a licence to drive would have been low. This intervention applied primarily to the 75+ year age bracket, but also included drivers from 35 to 64 years of cars and HGVs.

It is known that some medical issues may not be reported to the DVLA because the driver is fearful that their licence may be revoked. Furthermore, other health conditions which may be difficult to detect in accident research may, unknowingly to the driver, affect fitness to drive. Where possible, policies should be developed and encouraged that support 'fitness to drive' and promote early diagnosis and treatment of health issues that could increase the risk of a fatal collision. This would be most effectively implemented by companies ensuring that employees driving for work underwent regular health checks and were 'fit to drive'.

4.2.2.2 'Vehicle' Countermeasures

The most frequently coded countermeasure group was 'vehicle' countermeasures, highlighting the significant potential of ADAS to influence fatal collisions.

Table 9 shows the demographic information for the 'Vehicle' countermeasures. The five most effective countermeasures are primarily attributed to 17 to 44 year old male drivers of cars, HGVs and LGVs. The two most frequent collision types they address are loss of control and rear-end collisions, for vehicles that are primarily owned by the driver or by the company they are driving for as a part of their work.

Automatic Emergency Braking System (AEBS)

This countermeasure includes all AEBS systems (e.g. pedestrian, 'urban' and 'inter-urban' systems). TRL considered the performance criteria of these systems based on generic performance characteristics of current systems, including functionality within a speed range and environmental conditions. For example, it was assumed that for pedestrian systems, the function was limited to daylight.

In terms of the people that should be targeted for this countermeasure, the main group was drivers aged 17 – 44, with drivers aged 35 – 44 being the modal age group. For this countermeasure, cars, HGVs and LGVs predominated, with this reflecting the exposure on the road. It was estimated that AEBS would apply to 19 HGVs (25% of vehicles with AEBS as a countermeasure). For these vehicles, AEBS is already regulated and so no further action is required to implement this countermeasure for vehicle crashes, although pedestrian AEB is not mandated.

Rear-end, pedestrian and overtake/lane change collisions will be most affected by this technology. For the vehicles that the AEBS should be targeted at, there was a near equal split of owned or owned by company and a large proportion were being driven as part of

work. This suggests that encouraging businesses and fleets to equip AEBS would be effective at driving fitment.

Driver alert for upcoming hazard

This countermeasure applied to a range of drivers and riders in terms of their age demographic; males again dominated the target group. The data indicates however those driver alert systems would be most effective in collisions with obstructions and rear-end collisions. Similar to AEBS, almost all of the vehicles AEBS applies to are the owned by the driver/rider or by their company with an approximately even split. Just fewer than half the vehicles were being driven as a part of work. This measure is considered likely to address the same target population of fatalities as AEBS.

Intelligent Speed Assistance (ISA)

This measure should be targeted at young male drivers of cars, but also some motorcycles, HGVs and LGVs. Most of the vehicles in the collision sample were involved in loss of control where excessive speed was a known causation factor. The vehicles in question were typically owned by the driver or rider.

Lane keep assist

The data from 2014 showed that this should be targeted at mainly young male drivers of cars, and to a lesser extent HGVs and LGVs. The collision types associated with these vehicles involved drivers having loss of control, head-on and collisions with obstructions.

Electronic stability control (ESC)

This measure is already mandated on vehicles (from 2014) and was equipped voluntarily to a large proportion of new registrations for about a decade before being mandated. Therefore, although this has been identified as a countermeasure for some vehicles which were not equipped (approximately 95% of the fleet is estimated to be equipped in the collision year 2014) no action is appropriate as these collisions will be addressed as ESC reaches 100% fleet penetration, which is expected by or prior to 2020.

4.2.2.3 'Road' Countermeasures

For 'road' countermeasures designed at addressing barrier impacts, a staged assessment was made. This considered: removing the hazard, adding a barrier, adding a more effective barrier and shielding the hazard. Therefore, these countermeasures address the same issue but with different approaches to address the problem.

Add street lighting

This was judged the countermeasure in which the investigator had the greatest confidence would avoid or reduce the fatality. This applied mainly to pedestrian and pedal cycle collisions. This indicates that had the VRUs been more visible, the collision could have been potentially avoided. These collisions could also be addressed or avoidance made more likely by making the VRUs more conspicuous.

Add appropriate barrier

This countermeasure was evenly split between motorways and A class carriageways; all motorways and all but one A-road had a central barrier. This countermeasure is primarily aimed at loss of control collisions and preventing the vehicles from leaving the carriageway. The majority of vehicles for which this countermeasure was appropriate were not restrained (67%) as there was no barrier present to retain them; this is coded as 'not applicable'. The addition of barriers or vehicle restraint systems (VRSs) to the nearside of the carriageway is what was deemed to have potentially prevented the fatalities in these cases.

Remove hazard

The countermeasure 'remove hazard' applied exclusively to A-roads. This related to roadside objects located inside the clear zone of the carriageway that could be moved or removed (e.g. trees, road signs and lampposts). This is a more desirable countermeasure from a safety point of view and was prioritised more highly than adding VRSs to protect the vehicles from the hazards.

More effective barrier

This applied to both Motorways and A-roads and specifically addressed collision loci where a VRS was present, but did not perform as intended, resulting in the vehicle either not being restrained or reaching the hazards behind the barrier. The majority of these cases had barriers on both sides of the carriageway; however, the number of vehicles that were not restrained and the number that reached hazards behind the barrier were relatively high. It should be noted that the cost or implications of implementing a more effective barrier were not considered at the time of coding. The only focus was to apply a countermeasure that could independently have prevented the fatalities from occurring.

More effective drainage

This countermeasure applied to motorways and A-roads, with a slight tendency towards motorways although the sample was very small. This countermeasure specifically addresses loss of control collisions where standing water on the carriageway was believed to have induced the loss of control that lead to the fatality. In these cases, changing the driver's behaviour to drive according to the conditions of the road and ensure the vehicle's tyres are roadworthy is also likely to have been a valid countermeasure. However, removing the standing water from the road surface would have significantly reduced the likelihood of the collision occurring in these cases.

Shield hazard with VRS/Improve VRS type

This applied mainly to A-roads, although the sample was small. This countermeasure also addresses vehicles losing control and leaving the carriageway and impacting a hazardous roadside object or furniture. Specifically this countermeasure would add a VRS at the locus to prevent the vehicle from reaching the hazard. As mentioned earlier, this countermeasure addresses the same fatality population as removing the hazard, where removal of the hazard might not be feasible.

4.3 Priorities for Highways England

The results of the ranking of potential countermeasures according to the safe systems approach gives prioritisation for measures that could prevent the fatality (avoidance or mitigation) in each of the 'people', 'vehicle', 'roads' groups. In this study, we have provided an overview of all countermeasures and also focus on the 'road' countermeasures, for which Highways England could have a direct influence on implementation. Of these, the priority measures were:

- Add street lighting;
- Add appropriate barrier;
- Remove hazard;
- More effective barrier type;
- More effective drainage; and
- Shield hazard with vehicle restraint system (VRS).

However, potential solutions in other categories could also be beneficial. Envisaging the Reason's risk model (1990), fatalities that had more than one potential countermeasure could be addressed by any one countermeasure. In terms of the numbers of applicable countermeasures, those in the 'vehicle group' outnumbered those in 'road' and 'people' indicating that ways to positively influence driver behaviour via the fitment of ADAS is more frequently applicable. Also, addressing behavioural deficiencies via training (or controlling failures with licencing improvements) could also address fatalities that could also be influenced by 'road' countermeasures.

4.4 Limitations

There are also some general caveats that should be considered when interpreting the results of this study. The main one of these is that the results are based on a sample of 159 fatal collisions; although it has been assumed that these are representative of all fatal collisions on the SRN, this has not been tested. It is possible that collisions in 2014 might be different to the longer term trend and a larger sample spanning a greater number of years would provide a more robust sample. Indeed, ongoing annual analysis would be the ideal way to increase the sample and also monitor any changes in the collision causation and countermeasures over time.

In this study, the coding of the collision data was based on a subset of information contained within the police fatal file and although investigators re-examined information in the file, and in some cases gleaned additional information from photographs, the information was limited to that available in the file. While the extent and quality of information in the files was found to be good and generally consistent, any bias in the recording of source data has not been assessed. Some aspects of collision information are also genuinely more difficult to record and this may have influenced how often certain data or evidence was collected. For example, information on vehicle defects may be easily established for tyres, but may be more difficult, or less likely to be detected, for other mechanical defects. If this is the case for certain aspects of the case, these will not have been considered fully when the causation and countermeasures were assessed. Therefore,

the results reflect the existing data rather than necessarily the full picture. The extent of missing data has been assumed to be small, but again this has not been investigated. To collect information about every aspect would require a dedicated data collection study collecting data at the scene in parallel with police data. This would be resource intensive, but would deliver benefit over and above that available from police file data.

We assessed countermeasures by applying a feature that wasn't present in the collision and theoretically assessing the outcome based on assumed performance characteristics. However, this predictive approach is fundamentally subject to a level of uncertainty since how the countermeasure would apply and function in each specific circumstance is limited by the detail of the data available from the fatal file and assumptions on how well the countermeasure would work in the specific circumstances. However, we attempted to minimise the effects of this by using experienced collision investigators and also by developing consistent guidance rules for the function and performance of each countermeasure. This approach aimed to standardise the approach to the predictive assessment, but even with this in place, it is possible that the effectiveness of the countermeasure may have been overestimated in some circumstances. In addition, each case was reviewed by another member of the team prior to being released into the database for analysis.

We assumed that any one of the countermeasures judged to be effective could have avoided or reduced the fatality as per the model of risk proposed by Reason (1990). However, in practice it may be that the countermeasure would not have been as effective as predicted, or that more than one intervention would have been required to prevent the fatality. Therefore, the predictions made by the method employed may overestimate the fatality savings to an unknown degree.

In this assessment process, we have not considered cost or implementation feasibility of potential measures. This is because these aspects can change over time, but primarily because it is necessary to determine the most objective picture of which countermeasures might influence the outcome. Only once this step has been completed can the cost effectiveness of the measure be identified. If potential measures are excluded at the onset on the grounds of cost, measures that might eventually be cost effective for implementation would not be available for consideration. Thus, these results should be interpreted with this in mind; that the implementation cost-benefit for the measures has *not* been included in the prioritisation. Therefore, more work is required to determine the most cost effective and feasible implementation strategy should any subsequent action be taken.

4.5 Highways England targets and the extent to which ADAS fitment is expected to contribute

The results of the countermeasure analysis have identified the most important countermeasures for each category using a safe systems approach. These have estimated, based on the effectiveness of the countermeasure, a prioritisation for the most appropriate countermeasures. This information has been combined with a vehicle ADAS roadmap to make an estimate of the population of fatalities that could be affected. This showed that in the time horizon of the Highways England target to reduce KSIs by 40% by 2020, the estimated increase in fleet fitment of systems is very small and will therefore have a negligible effect on the 2020 target. In the longer term, action from consumer testing or

regulation has the potential to contribute more significantly to post 2020 targets, but this depends on the timing of any actions as the future is inherently uncertain.

It should also be noted that the estimates made here are subject to a range of assumptions on the speed that systems penetrate into the fleet, and the extent to which the results of the sample collisions in 2014 can be applied more generally to future collisions. In addition, each countermeasure was assessed individually so a proportion of the predicted casualties can be addressed by more than one ADAS countermeasure. Therefore, some of the casualties prevented by one system will reduce the potential of other systems and the estimates should be viewed with this in mind.

5 Conclusions

This work has successfully reviewed and coded 159 police fatal cases from fatal collisions that occurred on the Strategic Road Network (SRN) in 2014. The study successfully identified the causation factors and predictive countermeasures for these collisions, such that the findings could be used to prioritise solutions to prevent or mitigate the injuries of future collisions with similar characteristics. The main conclusions can be summarised as:

- Police fatal files typically contain data that allow collision causation and countermeasures to be identified from existing information and photographs. The most important information in the police report was the Collision Unit Investigation (CUI) report and scene and vehicle photographs.
- TRL coded information from the file (both directly and from additional data derived from the information in the file) and coded the information into a database. The strengths of this approach is that the information can be easily analysed and can respond to a range of very different research questions, therefore making it a powerful resource with which to investigate fatal collisions in terms of their characteristics, causation factors and countermeasures. The data can be examined at a high level to show trends or used for case-by-case analysis.
- 43 of the 159 fatal collisions (27% of all fatal collisions) involved a single road user. For these collisions, loss of control was the dominant causation factor. For multi-road user fatal collisions, 32 (20%) involved a pedestrian or pedal cycle. Rear end (24; 15%) and head-on (21; 13%) were the next largest collision groups, with passenger cars dominating the sample overall.
- Based on the 159 fatal collisions reviewed, the known causation factors always involved a 'people' component. However, the countermeasures assigned to the collision encompassed all aspects of the safe systems model. The majority of collisions had countermeasures in all three categories ('people', 'vehicle', 'road') indicating a range of possible approaches to avoid or reduce the resulting fatalities despite the human-centric causation.
- The 'people' countermeasures that were rated most highly in terms of confidence that they would avoid or reduce the fatality were:
 - Improved VRU conspicuity;
 - Use of seat belt;
 - Training;
 - Better maintenance; and
 - Better licencing.
- 'Vehicle' countermeasures were twice as frequently assigned compared with other safe system categories, indicating that more fatalities could be influenced with these countermeasures. The target group for these was typically young males. Those measures rated most highly in terms of confidence that they would avoid or reduce the fatality and should be considered future priorities were:
 - AEBS;
 - Driver alert for approaching hazard;
 - ISA;

- Lane keep assist; and
 - Fatigue monitoring.
- The introduction of ADAS has the potential to avoid or prevent future casualties. Currently, ADAS systems tend to be optional equipment and offered on a proportion of new registrations, the effect realised by 2020 (the Highways England target date) is estimated to be negligible and is wholly dependent on optional uptake rate. Action should be taken to encourage uptake of key technologies on cars. Larger benefits are achievable by ADAS by the 2030 time horizon (e.g. up to 19%-34% of annual fatalities for AEBS with combined functionality).
- The 'road' countermeasures that were rated most highly in terms of confidence that they would avoid or reduce the fatality were:
 - Add street lighting;
 - Add appropriate barrier;
 - Remove hazard;
 - More effective barrier type;
 - More effective drainage; and
 - Shield hazard.

These results should be treated as initial indicators for ways in which to reduce fatalities on the SRN and seen as the first step in understanding what the evidence says about how to prevent or reduce fatalities. Before implementation of the conclusions of this report it would be important to consider three main aspects:

Sample size and its representativeness to all fatal collisions on the SRN

- A larger sample via further data collection is recommended to increase the confidence that the data is representative before any investment decisions are made. Ongoing collection, as well as improving the robustness of the data, would enable trends over time to be investigated. In the longer term, this would also allow evaluation and monitoring of implemented countermeasures, something that is essential to ensure that investments are effective at delivering the predicted reductions.

Cost and feasibility of countermeasure implementation

- Some solutions identified in this report will have vastly differing costs. This in itself may make certain approaches much more preferable and others unfeasible. The most appropriate way to determine the best implementation strategy would be to consider the cost-benefit of each countermeasure, so that the predicted fatality saving and the implementation cost are taken into account. While this level of analysis was out of scope of this study, further work could focus on determining cost benefit and the recommended countermeasure implementation strategy.

Whether the countermeasure can be directly influenced by Highways England and if so, whether this is the most effective way to address the fatality.

- From the Highways England perspective, countermeasures related to the 'road' domain may be under their direct control, whereas potential countermeasures in other aspects ('people', 'vehicle') may not. So, firstly, specific measures that are under direct Highways England influence may provide the fastest way to reduce road

injury and deaths on the Strategic Road Network. At present, the most promising countermeasures under Highways England's influence are:

- Add street lighting;
 - Add appropriate barrier;
 - Remove hazard;
 - More effective barrier type;
 - More effective drainage; and
 - Shield hazard.
- For fatalities that can be influenced by countermeasures in other categories, other solutions may be more effective, but will potential require a multi-stakeholder approach.

6 Recommendations

In order to reduce fatalities on the SRN, it is recommended that Highways England consider the following for the next steps in terms of the further research and high level steps required:

1. Implement an on-going assessment of fatal collisions on the SRN to investigate and assess causation factors and countermeasures and add to the dataset for 2014 analysed here. This will allow a stronger evidence base to determine countermeasures, enable the monitoring of collision causation trends over time, and – in the longer term – evaluate the effectiveness of implemented countermeasures. A dedicated Independent UK Road Accident Investigation Branch could capture and code enhanced information, generating an even more powerful dataset to form the empirical foundation for future road safety research for SRN and all other roads in the UK.
2. Prior to implementing any countermeasures on the SRN, carry out a cost benefit study to develop an appropriate implementation strategy for those measures which can be directly implemented by Highways England.
3. Develop a strategy to influence the implementation of countermeasures not under Highways England's direct control, such that these contribute to future casualty reduction targets and the Highways England vision that *"no one should be harmed when travelling or working on our network."*

6.1 Detailed recommendations

The following highlight initial actions which follow from recommendations 2 and 3 and propose steps that can be implemented in the short or medium term to directly affect the risk of fatalities on the SRN:

4. Highways England should promote safer vehicle purchasing decisions in terms of both primary (e.g. ADAS) and secondary (e.g. crashworthiness) safety to accelerate the penetration of safer vehicles into the UK vehicle parc (see Section 3.6 p.51). This has the potential to deliver safety benefits; the earlier this can be encouraged, the more future benefits can be realised. Ideally, this should include consumer and corporate level action. For example, Highways England could:
 - a. Promote a Euro NCAP 5-star only company vehicle policy and specify a minimum ADAS fitment specification. There is an opportunity for Highways England to implement this policy itself and lead this campaign from the front.
 - b. Promote the uptake of the most effective forms of ADAS as demonstrated by the shortlist generated in this report. This should include the promotion and education of the consumer to justify the additional cost of these technologies by quantifying their added safety benefit.
 - c. Produce information to fleet managers recommending a vehicle specification for procurement. This would also deliver benefits to employers in terms of ensuring the safety of their employees.
5. Pedestrians and occupants who have alighted are road user types at significant risk of being killed on the SRN (see Section 3.2, p.24). The types of roads on the

SRN mean these road users should have low exposure; however, clearly they are over represented in the findings of this report. Fatal collisions involving these people can be easily avoided by reducing their exposure on the carriageway and ensuring that they know what they should do in the event they do enter the carriageway.

- a. It is recommended that Highways England provide an intervention campaign to minimise the exposure and risk of pedestrians and alighted occupants being struck. Further research may be required to provide evidence on what these people should do in the event that they do find themselves on the carriageway and where they should find refuge to maximise their safety. Previous campaigns addressing this issue include “Get out and stay out”; these could be revisited and built upon.
6. Rear end collisions are a potentially easily avoidable collision type, yet common in the dataset (see Section 3.3 p.27). Highways England could positively affect the occurrence of these collisions by influencing driver behaviour and providing clear advice and education on appropriate following distances for the prevailing road conditions. Further research may be required to understand the best approach and which specific groups and behaviours could be addressed or targeted.
7. ‘People’ causation factors are the most frequently attributed factors in this study, present in all but one collision (see Figure 16, p.31). It is recommended that Highways England engage in interventions to address the most common factors and behaviours identified by improving voluntary compliance to road safety regulations and traffic law (see Figure 19, p.34).
8. Consideration should be given to information and education to improve vehicle maintenance regimes, especially those relating to tyres (See Figure 20, p.35).
9. Countermeasures relating to ‘people’ (see Figure 24, p.40) that are practical to implement might include education and information to improve:
 - a. Awareness/information campaigns to VRUs about their own conspicuity and simple measures they could take to improve this.
 - b. Seat belt wearing and the understanding and importance of this measure for vehicle occupants.
 - c. Training with respect to hazard perception and risk awareness for drivers/riders.
 - d. The culture of reporting conditions that affect ability to drive so that appropriate treatment can be sought to reduce collision risk. An awareness campaign in conjunction with DVLA could promote reporting and treatment of medical issues. Highways England, and businesses more generally, should be encouraged to promote a fit-to-drive approach and health screen employees who drive for work to promote treatment of conditions that increase risk of fatal collision (e.g. sleep apnoea).
10. In terms of ‘road’ causation factors (see Figure 26, p.42), this research suggests that:

- a. Adding street lighting was the most effective countermeasure; however, the majority of these collisions involved people in the road. The most effective way to mitigate these types of collision should be considered as other solutions may also be effective.
- b. Providing a better barrier solution, whether that is adding/removing/improving a barrier or removing the hazard entirely could be considered; more work is required to understand if there are appropriate general solutions or case-by-case approach is more meaningful.
- c. In some fatal collisions the causation involved items on the carriageway (see Figure 21, p.36). This emphasises the importance of swift and safe removal of debris and other items from the carriageway.
- d. Some collisions included examples of poorly secured loads (see Figure 21, p.36), highlighting the importance of ensuring loads are secured correctly. Guidance and education on best practice should be provided.

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Greater Manchester Police	Hertfordshire Constabulary
Northumbria Police	Essex Police
Durham Constabulary	Thames Valley Police
North Yorkshire Police	Hampshire Constabulary
West Yorkshire Police	Surrey Police
Humberside Police	Kent Police
Cleveland Police	Sussex Police
West Midlands Police	Devon and Cornwall Constabulary
Staffordshire Police	Avon and Somerset Constabulary
West Mercia Constabulary	Gloucestershire Constabulary
Warwickshire Police	Wiltshire Constabulary
Derbyshire Constabulary	Dorset Police
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Reason, J. (1990). The Contribution of Latent Human Failures to the Breakdown of Complex Systems. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 327 (1241): 475–484. doi:10.1098/rstb.1990.0090.

Appendix A Collision type matrix

	TYPE	1	2	3	4	5	6	7	8
A	Overtaking And Lane Change	Pulling Out Or Changing Lane To Right	Head On	Cutting In Or Changing Lane To Left	Lost Control (Overtaking Vehicle)	Side Road	Lost Control (Overtaken Vehicle)	Weaving In Heavy Traffic	OTHER
B	Head On	On Straight	Cutting Corner	Swinging Wide	Both Or Unknown	Lost Control On Straight	Lost Control On Curve		OTHER
C	Lost Control Or Off Road (Straight Roads)	Out Of Control On Roadway	Off Roadway To Left	Off Roadway To Right					OTHER
D	Cornering	Lost Control Turning Right	Lost Control Turning Left	Missed Intersection Or End Of Road					OTHER
E	Collision With Obstruction	Parked Vehicle	Accident Or Broken Down	Non Vehicular Obstruction (No Animals)	Workman Vehicle	Opening Door			OTHER
F	Rear End	Slow Vehicles	Cross Traffic	Pedestrian	Queue	Signals	Other		OTHER
G	Turning Vs Same Direction	Rear Of Left Turning Vehicle	Left Side Side Swipe	Stopped Or Turning From Left Side	Near Centre Line	Overtaking Vehicle	Two Turning		OTHER
H	Crossing (No Turns)	Right Angle (70° to 110°)							OTHER
J	Crossing (Vehicle Turning)	Right Turn Right Side		Two Turning					OTHER
K	Merging	Left Turn In	Right Turn In	Two Turning					OTHER
L	Right Turn Against Traffic	Stopped Waiting To Turn	Making Turn						OTHER
M	Maneuvering	Parking Or Leaving	U-Turn	U-Turn	Driveway Manoeuvre	Parking Opposite	Angle Parking	Reversing Along Road	OTHER
N	Pedestrian Crossing Road	Left Side	Right Side	Left Turn Left Side	Right Turn Right Side	Left Turn Right Side	Right Turn Left Side	Manoeuvring Vehicle	OTHER
P	Pedestrians Other	Walking With Traffic	Walking Facing Traffic	Walking On Footpath	Child Playing	Attending To Vehicle	Entering Or Leaving Vehicle		OTHER
Q	Misc	Fell While Boarding Or Alighting	Fell From Moving Vehicle	Train	Parked Vehicle Ran Away	Equestrian	Fell Inside Vehicle	Trailer Or Load	OTHER

Figure 27: Collision type matrix by which collisions are coded

Appendix B Case with unknown accident causation factor

Case summary

This case is a single vehicle collision with one occupant; a small hatchback car that was travelling along a straight section of a dual carriageway (trunk road) at night in dark conditions. No street lighting was present along this section of carriageway. It was raining and scattered patches of standing water had formed on the road surface.

For unknown reasons the vehicle left the carriageway on the near side, passing over a narrow grass verge and across a concrete drainage gully. The vehicle continued through roadside trees before coming to rest in a flooded field beyond the tree line. At some point during its journey from the road to its final rest position, the vehicle had rolled over, although it was found on all 4 wheels.

The incident was not witnessed but a passing motorist noticed the head lights of the collision vehicle in the field and contacted the emergency services, who discovered the vehicle. The deceased driver was found inside the vehicle, after suffering traumatic head and throat injuries. The driver was also found to be unbelted.

Causation factors

Due to no one witnessing the collision coupled with the fact there was no physical evidence left on the road surface and limited information given by the police report, it is not possible to define the exact causation factor(s) as to why the vehicle left the road.

The most obvious factors could be attributed to the weather conditions; wet road surface, dark conditions. However, it was a straight section of road; and therefore it is unlikely environmental factors were the cause of the vehicle leaving the road.

The vehicle itself was found to have no mechanical defects.

This leaves human error as the most likely factor. The driver was familiar with the vehicle and not young age or inexperienced and no obvious distractions were found within the vehicle. Fatigue is therefore the more obvious factor given the lack of evidence of any harsh driver input (steering or braking) prior to the vehicle leaving the road. Countermeasures

Several counter measures would have possibly/probably avoided the vehicle leaving the road as well as definitely reducing the injury severity:

- Taking fatigue as the most likely factor, having a fatigue monitoring safety feature fitted would have alerted the driver, possibly avoiding the collision.
- Lane departure warning/keeping would have assisted the vehicle in not leaving the road.
- Adding a suitable barrier along this section of carriageway on the near side would have definitely assisted in keeping the vehicle on the road.

Appendix C Countermeasure frequency

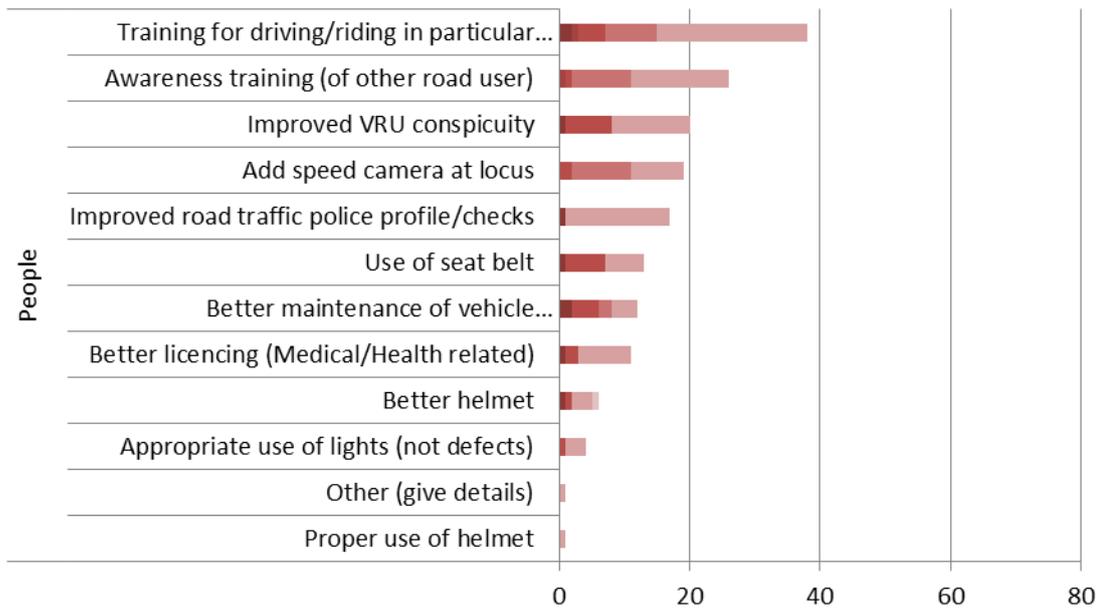


Figure 28: Frequency and confidence of specific people countermeasures, five most common countermeasures highlighted in red

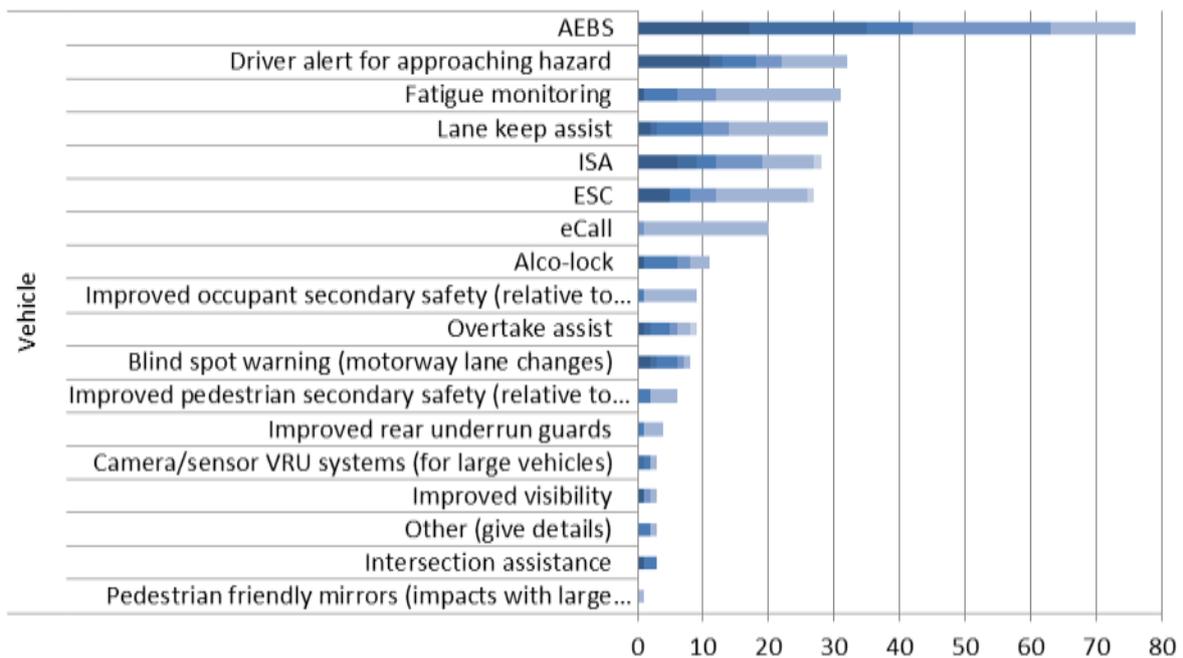


Figure 29: Frequency and confidence of specific vehicle countermeasures, five most common countermeasures highlighted in red

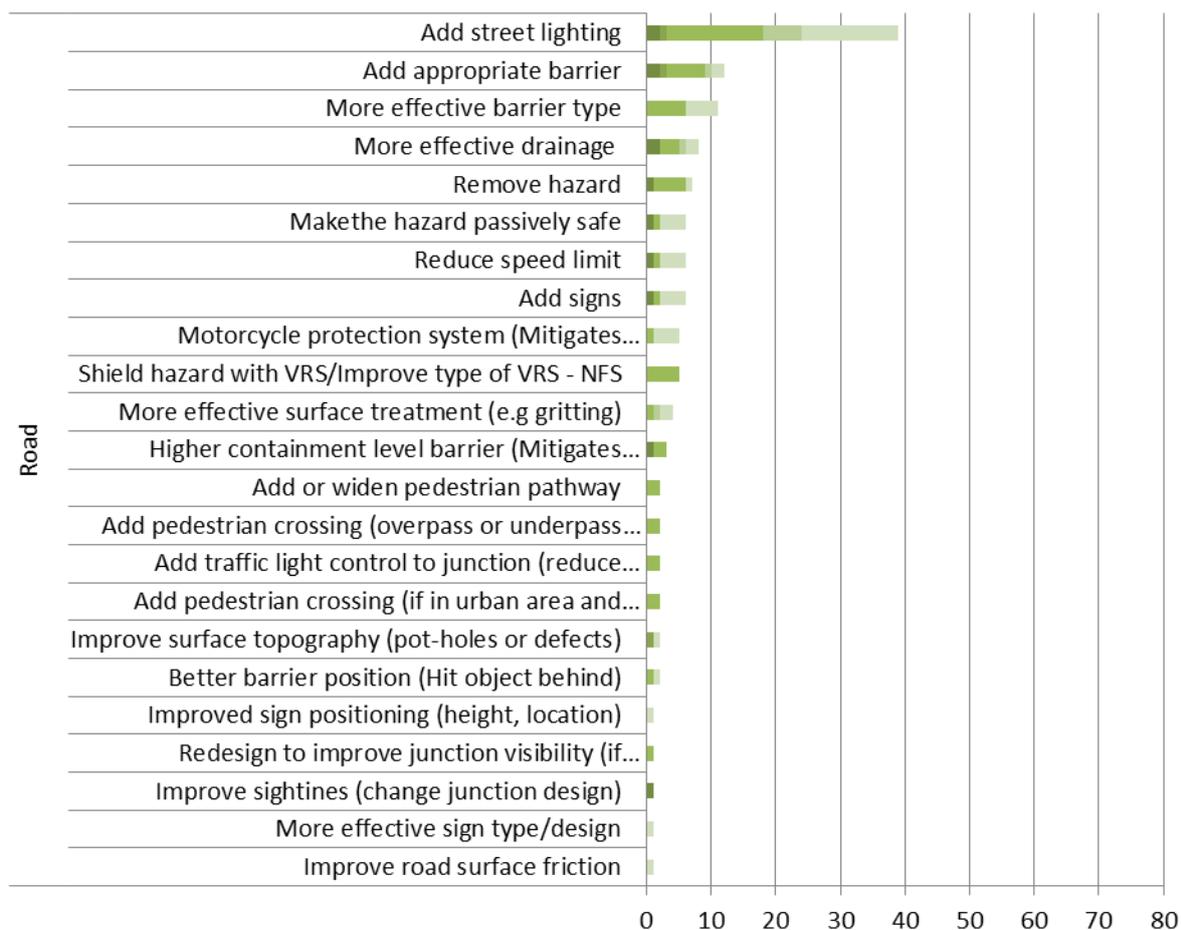


Figure 30: Frequency and confidence of specific road countermeasures, five most common countermeasures highlighted in red

The following tables provide demographic information for the people to whom the five most frequent countermeasures were applied.

Table 14: Five most frequent 'People' countermeasures and the demographic to which they apply

	Training for driving/riding in particular circumstances	Awareness training	Improved VRU conspicuity	Add speed camera at locus	Improved road traffic police profile/checks	Total
Gender						
Female	5	3	3	2	1	14
Male	32	22	17	15	16	102
Not known	1	1	0	2	0	4
Total	38	26	20	19	17	120
Age						
0-16	8	0	3	5	1	17
17-24	11	4	4	5	7	31
25-34	4	3	4	1	4	16
35-44	6	8	0	3	2	19
45-54	3	3	4	0	0	10
55-64	0	1	0	0	0	1
75+	0	1	4	0	0	5
Unknown	6	6	1	5	3	21
Total	38	26	20	19	17	120
Vehicle type						
Car	23	6	0	11	13	53
HGV	2	9	0	0	0	11
LGV	0	2	0	1	1	4
Motorcycle	8	4	2	3	0	17
Pedal Cycle	0	0	2	0	0	2
Pedestrian	0	2	14	0	2	18
Alighted	5	3	2	4	1	15
Total	38	26	20	19	17	120
Collision type						
Overtake/Lane change	10	6	1	0	0	17
Head on	7	0	0	3	5	15
Lost control	15	1	0	11	6	33

	Training for driving/riding in particular circumstances	Awareness training	Improved VRU conspicuity	Add speed camera at locus	Improved road traffic police profile/checks	Total
Collision with obstruction	2	4	0	1	0	7
Rear end	4	8	2	3	3	20
Turning/Merging	0	3	1	1	0	5
Pedestrian/Pedal cycle	0	4	16	0	3	23
Total	38	26	20	19	17	120

Table 15: Five most frequent 'Vehicle' countermeasures and the demographic to which they apply

	AEBS	Lane keep assist	ISA	Driver alert for approaching hazard	Fatigue monitoring	Total
Gender						
Female	13	8	6	4	4	35
Male	61	43	32	26	27	189
Not known	3	0	1	2	0	6
Total	77	51	39	32	31	230
Age						
0-16	5	0	9	2	2	18
17-24	16	18	11	7	11	63
25-34	14	11	4	5	4	38
35-44	17	6	6	7	4	40
45-54	5	3	3	2	2	15
55-64	4	6	0	1	1	12
75+	1	0	0	1	1	3
Unknown	15	7	6	7	6	41
Total	77	51	39	32	31	230
Vehicle type						
Car	40	35	21	14	21	131
Motorcycle	4	0	9	1	0	14
HGV	19	6	3	10	4	42
LGV	9	10	2	5	6	32
Taxi/Private Hire	2	0	0	0	0	2
Other	1	0	0	0	0	1
Alighted	2	0	4	2	0	8
Total	77	51	39	32	31	230
Collision type						
Overtake/Lane change	11	5	7	0	3	26
Head on	8	16	4	3	4	35
Lost control	0	20	19	4	10	53

	AEBS	Lane keep assist	ISA	Driver alert for approaching hazard	Fatigue monitoring	Total
Collision with obstruction	9	7	3	11	3	33
Rear end	23	2	3	13	10	51
Turning/Merging	5	0	2	0	0	7
Pedestrian/Pedal cycle	19	1	1	1	1	23
Misc	2	0	0	0	0	2
Total	77	51	39	32	31	230

Table 16: Five most frequent 'Road' countermeasures and the demographic to which they apply

	Add street lighting	Add appropriate barrier	More effective barrier type	More effective drainage	Remove hazard from roadside	Total
Gender						
Female	4	1	1	0	2	8
Male	36	11	10	8	5	70
Not known	1	0	0	0	0	1
Total	41	12	11	8	7	79
Age						
0-16	3	1	3	1	2	10
17-24	8	5	2	3	1	19
25-34	7	2	1	0	0	10
35-44	4	2	1	0	0	7
45-54	6	1	0	1	1	9
55-64	3	0	1	0	2	6
Unknown	10	1	3	3	1	18
Total	41	12	11	8	7	79
Vehicle type						
Car	19	11	9	7	5	51
Motorcycle	3	0	0	0	2	5
HGV	8	1	1	0	0	10
LGV	2	0	0	0	0	2
Taxi/Private Hire	2	0	0	0	0	2
Pedestrian	5	0	0	0	0	5
Alighted	2	0	1	1	0	4
Total	41	12	11	8	7	79
Collision type						
Overtake/Lane change	4	1	2	1	1	9
Head on	1	0	1	1	1	4
Lost control	2	10	8	4	5	29
Collision with obstruction	2	0	0	2	0	4

	Add street lighting	Add appropriate barrier	More effective barrier type	More effective drainage	Remove hazard from roadside	Total
Rear end	2	1	0	0	0	3
Turning/Merging	3	0	0	0	0	3
Pedestrian/Pedal cycle	25	0	0	0	0	25
Misc	2	0	0	0	0	2
Total	41	12	11	8	7	79

Appendix D Detailed countermeasure breakdown

This section presents multiple pivot tables and graphs relating to the countermeasure target population.

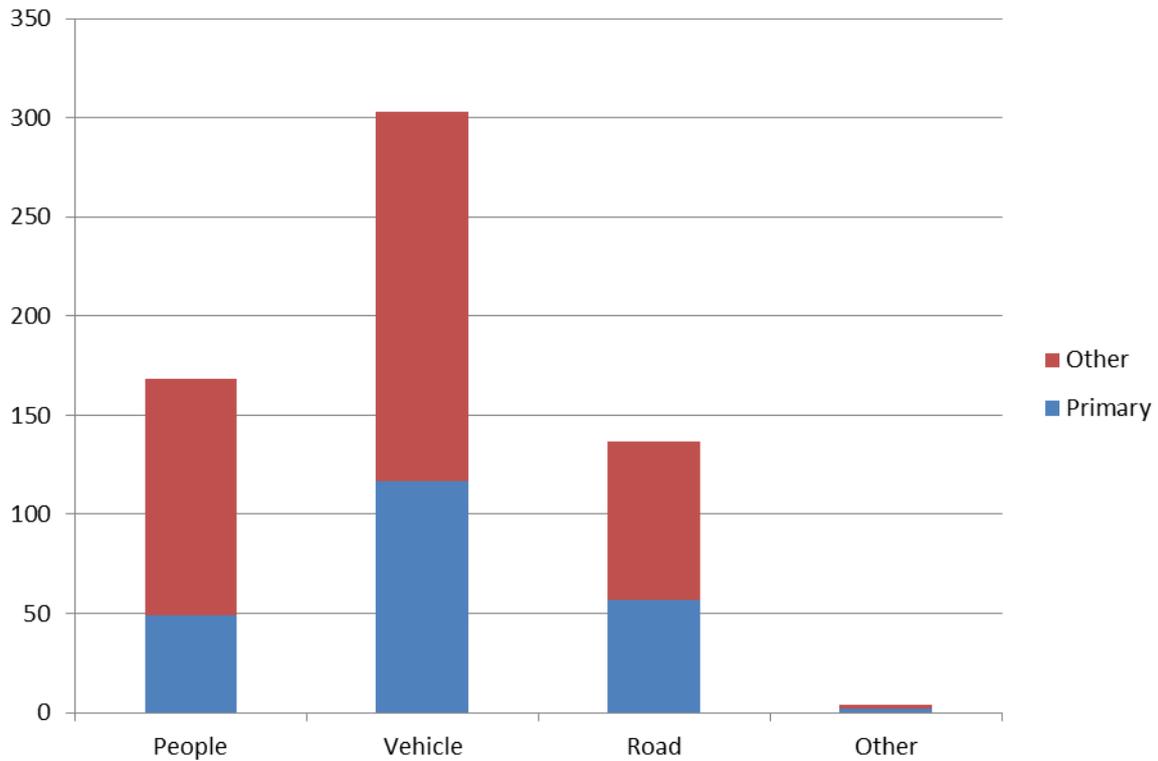


Figure 31: Frequency of countermeasures in each category with those that were determined to be the primary countermeasure for that collision

D.1 Countermeasures by collisions types

Table 17: Countermeasures assigned to overtake and lane change collisions

Overtake/Lane change	
People	
Training for driving/riding in particular circumstances (weather, road type)	10
Awareness training (of other road user)	6
Better maintenance of vehicle consumables/features (brakes, tyres, lights etc.)	3
Better licencing (Medical/Health related)	2
Better helmet	2
Use of seat belt	1
Improved VRU conspicuity	1
Vehicle	
AEBS	11
Blind spot warning (motorway lane changes)	6
Overtake assist	4
ISA	4
eCall	4
Lane keep assist	3
ESC	3
Fatigue monitoring	3
Camera/sensor VRU systems (for large vehicles)	2
Improved visibility	2
Alco-lock	1
Road	
Add street lighting	4
More effective barrier type	2
Motorcycle protection system (Mitigates motorcycle impacts)	1
Shield hazard with VRS/Improve type of VRS	1
Add appropriate barrier	1
More effective drainage	1

Overtake/Lane change	
Add signs	1
Other (give details)	1
Reduce speed limit	1
Remove hazard	1
Improve road surface friction	1
Grand Total	83

Table 18: Countermeasures assigned to head on collisions

Head on	
People	
Training for driving/riding in particular circumstances (weather, road type)	7
Improved road traffic police profile/checks	5
Add speed camera at locus	3
Better licencing (Medical/Health related)	3
Better helmet	2
Better maintenance of vehicle consumables/features (brakes, tyres, lights etc.)	2
Use of seat belt	1
Vehicle	
Lane keep assist	9
AEBS	8
ESC	7
ISA	4
Fatigue monitoring	4
Driver alert for approaching hazard	3
Improved occupant secondary safety (relative to current typical level)	3
Alco-lock	2
Other (give details)	2
Overtake assist	1
eCall	1
Road	
Reduce speed limit	2
Other (give details)	2
More effective surface treatment (e.g. gritting)	1
More effective drainage	1
Add street lighting	1
Higher containment level barrier (Mitigates crossover)	1
Remove hazard	1
More effective barrier type	1
Other	
Other (add comments)	1
Grand Total	78

Table 19: Countermeasures assigned to loss of control or cornering collisions

Lost control or cornering	
People	
Training for driving/riding in particular circumstances (weather, road type)	15
Add speed camera at locus	11
Use of seat belt	7
Improved road traffic police profile/checks	6
Better maintenance of vehicle consumables/features (brakes, tyres, lights etc.)	4
Better helmet	1
Awareness training (of other road user)	1
Appropriate use of lights (not defects)	1
Other (give details)	1
Proper use of helmet	1
Vehicle	
ESC	16
ISA	14
Lane keep assist	10
Fatigue monitoring	10
Alco-lock	8
eCall	7
Driver alert for approaching hazard	4
Improved occupant secondary safety (relative to current typical level)	2
Road	
Add appropriate barrier	10
More effective barrier type	8
Remove hazard	5
Shield hazard with VRS/Improve type of VRS	4
Motorcycle protection system (Mitigates motorcycle impacts)	4
Make the hazard passively safe	4
More effective drainage	4

Lost control or cornering	
More effective surface treatment (e.g. gritting)	3
Improve surface topography (pot-holes or defects)	2
Add street lighting	2
Reduce speed limit	2
Better barrier position (Hit object behind)	2
Other (give details)	1
Add signs	1
Higher containment level barrier (Mitigates crossover)	1
Other	
Other (add comments)	1
Grand Total	173

Table 20: Countermeasures assigned to collisions with obstructions

Collision with obstruction	
People	
Awareness training (of other road user)	4
Training for driving/riding in particular circumstances (weather, road type)	2
Better maintenance of vehicle consumables/features (brakes, tyres, lights etc.)	2
Use of seat belt	2
Appropriate use of lights (not defects)	1
Add speed camera at locus	1
Better licencing (Medical/Health related)	1
Vehicle	
Driver alert for approaching hazard	11
AEBS	9
Lane keep assist	5
Fatigue monitoring	3
eCall	2
Overtake assist	2
ISA	2
Blind spot warning (motorway lane changes)	2
Improved pedestrian secondary safety (relative to current typical level)	1
Improved rear underrun guards	1
Road	
Add signs	2
More effective drainage	2
Add street lighting	2
Make the hazard passively safe	1
Improved sign positioning (height, location)	1
Grand Total	59

Table 21: Countermeasures assigned to rear end collisions

Rear end	
People	
Awareness training (of other road user)	8
Training for driving/riding in particular circumstances (weather, road type)	4
Improved road traffic police profile/checks	3
Add speed camera at locus	3
Improved VRU conspicuity	2
Better licencing (Medical/Health related)	2
Use of seat belt	1
Better helmet	1
Vehicle	
AEBS	23
Driver alert for approaching hazard	13
Fatigue monitoring	10
eCall	4
Improved rear underrun guards	3
ISA	2
Improved occupant secondary safety (relative to current typical level)	2
Lane keep assist	1
Overtake assist	1
ESC	1
Road	
Other (give details)	2
Add street lighting	2
Redesign to improve junction visibility (if permanent obscuration)	1
Add signs	1
Reduce speed limit	1
Add appropriate barrier	1
More effective sign type/design	1
Grand Total	93

Table 22: Countermeasures assigned to turning or merging collisions

Turning/Merging	
People	
Better licencing (Medical/Health related)	3
Awareness training (of other road user)	3
Use of seat belt	1
Improved VRU conspicuity	1
Add speed camera at locus	1
Appropriate use of lights (not defects)	1
Vehicle	
AEBS	5
Intersection assistance	3
Improved occupant secondary safety (relative to current typical level)	2
ISA	1
Overtake assist	1
Road	
Add street lighting	3
Add traffic light control to junction (reduce conflicts)	2
Higher containment level barrier (Mitigates crossover)	1
Other	
Other (add comments)	1
Grand Total	29

Table 23: Countermeasures assigned to pedestrian or pedal cycle collisions

Pedestrian/Pedal Cycle	
People	
Improved VRU conspicuity	16
Awareness training (of other road user)	4
Improved road traffic police profile/checks	3
Appropriate use of lights (not defects)	1
Better maintenance of vehicle consumables/features (brakes, tyres, lights etc.)	1
Vehicle	
AEBS	19
Improved pedestrian secondary safety (relative to current typical level)	5
eCall	2
Camera/sensor VRU systems (for large vehicles)	1
Driver alert for approaching hazard	1
Lane keep assist	1
Fatigue monitoring	1
ISA	1
Improved visibility	1
Other (give details)	1
Pedestrian friendly mirrors (impacts with large vehicles)	1
Road	
Add street lighting	24
Add or widen pedestrian pathway	2
Add pedestrian crossing (if in urban area and appropriate)	2
Add pedestrian crossing (overpass or underpass when crossing is not appropriate e.g. on fast roads)	2
Improve sightlines (change junction design)	1
Other (give details)	1
Add signs	1
Other	
Other (add comments)	1
Grand Total	93

Table 24: Countermeasures assigned to miscellaneous collisions

Misc	
Vehicle	
AEBS	1
Road	
Add street lighting	1
Make the hazard passively safe	1
Grand Total	3

D.2 Countermeasures applied to road users

Table 25: Countermeasures assigned to cars

Car	
People	
Training for driving/riding in particular circumstances (weather, road type)	25
Improved road traffic police profile/checks	13
Add speed camera at locus	12
Better licencing (Medical/Health related)	9
Awareness training (of other road user)	8
Use of seat belt	7
Better maintenance of vehicle consumables/features (brakes, tyres, lights etc.)	7
Appropriate use of lights (not defects)	2
Other (give details)	1
Vehicle	
AEBS	42
ESC	21
Fatigue monitoring	21
Lane keep assist	20
eCall	16
Driver alert for approaching hazard	16
ISA	16
Alco-lock	10
Improved occupant secondary safety (relative to current typical level)	8
Overtake assist	6
Blind spot warning (motorway lane changes)	6
Improved pedestrian secondary safety (relative to current typical level)	5
Other (give details)	2
Intersection assistance	2
Pedestrian friendly mirrors (impacts with large vehicles)	1
Road	

Car	
Add street lighting	20
Add appropriate barrier	11
More effective barrier type	9
More effective drainage	8
Remove hazard	5
Make the hazard passively safe	5
Shield hazard with VRS/Improve type of VRS	4
More effective surface treatment (e.g. gritting)	3
Add signs	3
Other (give details)	3
Reduce speed limit	2
Add traffic light control to junction (reduce conflicts)	2
Higher containment level barrier (Mitigates crossover)	2
Improve surface topography (pot-holes or defects)	1
Better barrier position (Hit object behind)	1
Improved sign positioning (height, location)	1
Improve road surface friction	1
Improve sightlines (change junction design)	1
Other	
Other (add comments)	3
Grand Total	361

Table 26: Countermeasures assigned to HGVs

HGV	
People	
Awareness training (of other road user)	9
Use of seat belt	5
Training for driving/riding in particular circumstances (weather, road type)	2
Appropriate use of lights (not defects)	2
Better licencing (Medical/Health related)	2
Better maintenance of vehicle consumables/features (brakes, tyres, lights etc.)	1
Vehicle	
AEBS	19
Driver alert for approaching hazard	10
Lane keep assist	4
Fatigue monitoring	4
Improved rear underrun guards	4
Camera/sensor VRU systems (for large vehicles)	3
ISA	3
Improved visibility	2
ESC	1
Blind spot warning (motorway lane changes)	1
Intersection assistance	1
Improved pedestrian secondary safety (relative to current typical level)	1
eCall	1
Road	
Add street lighting	7
Reduce speed limit	1
Add signs	1
More effective barrier type	1
More effective sign type/design	1
More effective surface treatment (e.g gritting)	1
Other (give details)	1

HGV	
Better barrier position (Hit object behind)	1
Add appropriate barrier	1
Higher containment level barrier (Mitigates crossover)	1
Other	
Other (add comments)	1
Grand Total	92

Table 27: Countermeasures assigned to LGVs

LGV	
People	
Awareness training (of other road user)	2
Add speed camera at locus	1
Use of seat belt	1
Improved road traffic police profile/checks	1
Vehicle	
AEBS	9
Fatigue monitoring	6
Driver alert for approaching hazard	5
Lane keep assist	5
ISA	1
Other (give details)	1
eCall	1
Overtake assist	1
Road	
Add street lighting	2
Reduce speed limit	1
Add signs	1
Grand Total	38

Table 28: Countermeasures assigned to motorcycles

Motorcycle	
People	
Training for driving/riding in particular circumstances (weather, road type)	10
Add speed camera at locus	6
Awareness training (of other road user)	5
Better helmet	4
Better maintenance of vehicle consumables/features (brakes, tyres, lights etc.)	3
Improved VRU conspicuity	2
Proper use of helmet	1
Vehicle	
ISA	8
ESC	4
AEBS	3
Overtake assist	2
eCall	2
Driver alert for approaching hazard	1
Blind spot warning (motorway lane changes)	1
Improved visibility	1
Alco-lock	1
Improved occupant secondary safety (relative to current typical level)	1
Road	
Motorcycle protection system (Mitigates motorcycle impacts)	4
Remove hazard	2
Reduce speed limit	2
Add street lighting	2
Redesign to improve junction visibility (if permanent obscuration)	1
Other (give details)	1
Add signs	1
Make the hazard passively safe	1
Improve surface topography (pot-holes or defects)	1
Grand Total	70

Table 29: Countermeasures assigned to pedal cycles

Pedal Cycle	
People	
Improved VRU conspicuity	2
Better helmet	1
Road	
Other (give details)	1
Add street lighting	1
Grand Total	5

Table 30: Countermeasures assigned to pedestrians

Pedestrian	
People	
Improved VRU conspicuity	16
Improved road traffic police profile/checks	3
Awareness training (of other road user)	2
Road	
Add street lighting	5
Add or widen pedestrian pathway	2
Add pedestrian crossing (if in urban area and appropriate)	2
Add pedestrian crossing (overpass or underpass when pedestrian crossing is not appropriate e.g. on fast roads)	2
Other (give details)	1
Grand Total	33

Table 31: Countermeasures assigned to taxis or private hire vehicles

Taxi/Private Hire	
Vehicle	
AEBS	2
Road	
Add street lighting	2
Grand Total	4

Table 32: Countermeasures assigned to other vehicles

Other	
People	
Better helmet	1
Training for driving/riding in particular circumstances (weather, road type)	1
Better maintenance of vehicle consumables/features (brakes, tyres, lights etc.)	1
Vehicle	
AEBS	1
ESC	1
Road	
Shield hazard with VRS/Improve type of VRS	1
Motorcycle protection system (Mitigates motorcycle impacts)	1
More effective barrier type	1
Grand Total	8

D.3 Countermeasures to specific causation factors

D.3.1 People countermeasures

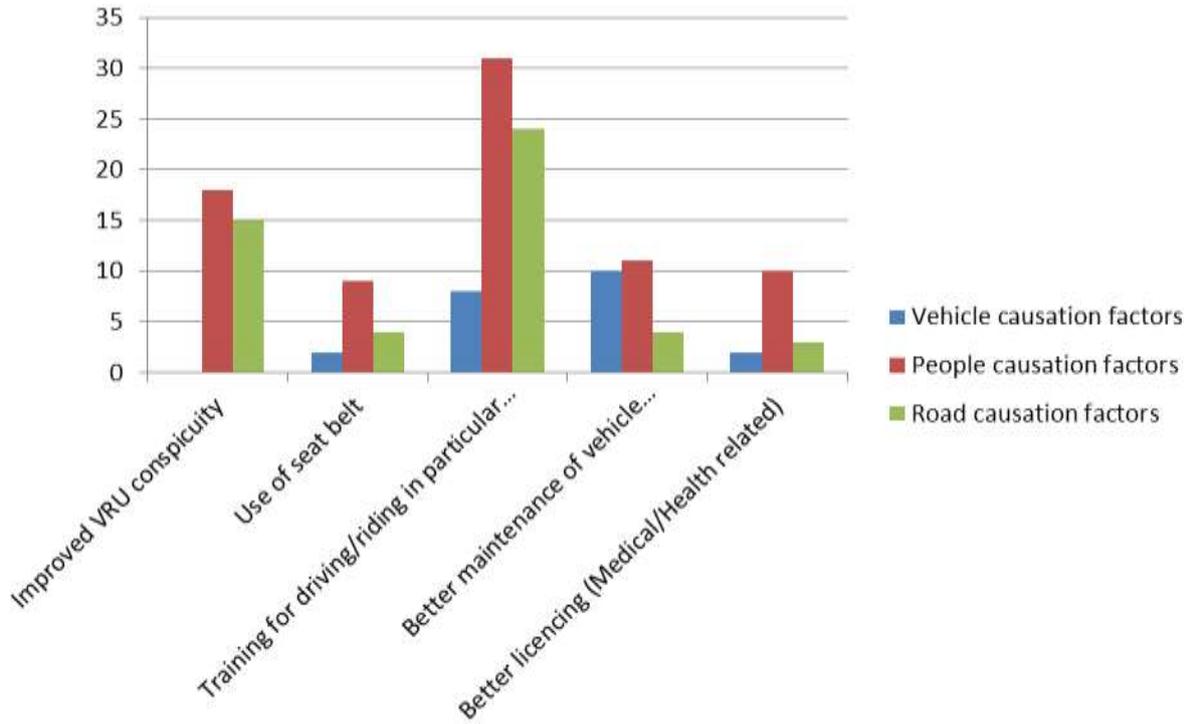


Table 33: Most confident people countermeasures with the human causation factors present in that case

	Improved VRU conspicuity	Use of seat belt	Training for driving/ riding	Better maintenance of vehicle	Better licencing (Medical/Health related)	Grand Total
Animal out of control	0	0	1	0	0	1
Bend or winding road at site	0	3	9	2	2	16
Earlier collision	0	1	6	2	1	10
Glare from headlights	1	0	0	0	0	1
Glare from sun	1	0	0	0	0	1
High winds at site	0	0	0	0	0	0
Inadequate signing at site	0	0	0	0	0	0
Narrow road at site	0	0	0	0	0	0
Obscuration due to weather	1	0	1	0	0	2
Other local-factor	1	0	2	0	0	3
Poor or street lighting at site	11	1	7	1	0	20
Poor surface at site	0	0	2	0	0	2
Road works at site	0	0	0	0	0	0
Slippery road at site	0	0	8	2	1	11
Steep hill at site	0	0	3	0	1	4
Surroundings obscured by bend or winding road	0	0	1	0	1	2
Surroundings obscured by buildings fences vegetation	1	0	1	0	1	3
Surroundings obscured by moving vehicle	1	1	5	0	0	7
Surroundings obscured by stationary or parked car	0	0	0	0	0	0

Table 34: Most confident people countermeasures with the vehicle causation factors present in that case

	Improved VRU conspicuity	Use of seat belt	Training for driving/riding	Better maintenance of vehicle	Better licencing (Medical/Health related)	Grand Total
Defective brake system	0	0	3	2	0	5
Defective electrical system	0	0	0	0	0	0
Defective fuel system	0	0	0	1	0	1
Defective lighting	0	0	0	1	1	2
Defective Steering	0	0	0	0	0	0
Defective suspension	0	0	1	2	0	3
Defective trailer attachment	0	0	0	0	0	0
Defective tyres	0	0	6	6	1	13
Defective wheels	0	0	0	0	0	0
Other defects	0	2	1	3	1	7

Table 35: Most confident people countermeasures with the road causation factors present in that case

	Improved VRU conspicuity	Use of seat belt	Training for driving/riding	Better maintenance of vehicle	Better licencing (Medical/Health related)	Grand Total
Aggressive driving	0	0	0	0	0	0
Alcohol	7	0	2	1	1	11
Bad overtake	0	0	4	1	0	5
Carelessness thoughtless	6	1	9	3	5	24
Cross from behind parked car	0	0	0	0	0	0
Disability	0	0	0	0	0	0
Distraction through listening to music	0	0	1	0	0	1
Distraction through physical object on or in vehicle	0	1	3	0	0	4
Distraction through physical object outside of vehicle	0	0	1	0	0	1
Distraction through stress or emotional state of mind	1	0	0	0	0	1
Drugs	1	1	1	1	2	6
Error of judgement	5	1	4	0	1	11
Excess hours	0	0	0	0	0	0
Excessive speed	0	3	11	1	0	15
Failed to look	1	0	0	0	0	1
Failure to judge others persons path or speed	1	0	1	0	1	3
Failure to see pedestrian in blind spot	0	0	0	0	0	0
Fatigue	0	0	1	0	1	2
Following too close	0	0	0	0	0	0
Ignored lights at crossing	0	0	0	0	0	0
Ignored sign	0	1	1	0	0	2
Illness	1	1	0	0	1	3
Inconspicuous	12	0	0	1	1	14

	Improved VRU conspicuity	Use of seat belt	Training for driving/riding	Better maintenance of vehicle	Better licencing (Medical/Health related)	Grand Total
Inexperience	0	0	6	2	0	8
Insufficient lighting	4	0	0	1	0	5
Lack of attention	3	1	1	0	3	8
Looked but did not see	0	0	1	0	0	1
Nervous or uncertain	0	0	0	0	0	0
Other bad manoeuvre	0	1	2	1	3	7
Other personal factor	0	1	1	0	1	3
Panic behaviour	0	1	1	2	1	5
Playing	0	0	0	0	0	0
Reckless	4	0	5	1	1	11
Risk taking behaviour	8	1	9	1	2	21
Unauthorised passengers	0	0	0	0	0	0
Unauthorised passengers2	0	0	0	0	0	0
Walking in carriageway	11	0	0	0	0	11

D.3.2 Vehicle countermeasures

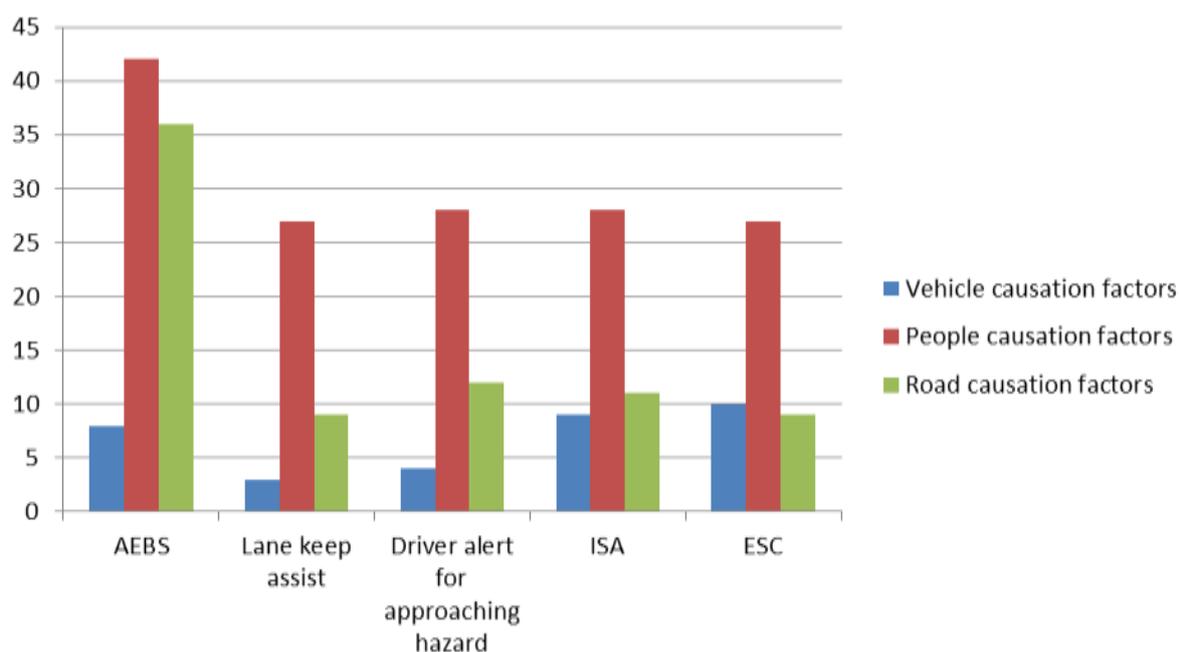


Table 36: Most confident vehicle countermeasures with the human causation factors present in that case

	AEBS	Driver alert for approaching hazard	ISA	Lane keep assist	Fatigue monitoring	Grand Total
Animal out of control	1	0	0	0	0	1
Bend or winding road at site	1	0	5	8	4	18
Earlier collision	11	4	1	0	2	18
Glare from headlights	1	0	0	0	0	1
Glare from sun	3	1	1	0	0	5
High winds at site	0	0	0	0	0	0
Inadequate signing at site	2	1	0	0	0	3
Narrow road at site	0	0	0	0	0	0
Obscuration due to weather	0	2	1	0	0	3
Other local-factor	2	4	1	0	2	9
Poor or street lighting at site	20	3	2	1	2	28
Poor surface at site	0	2	2	0	0	4
Road works at site	0	0	0	1	0	1
Slippery road at site	0	2	5	0	1	8
Steep hill at site	3	0	0	1	0	4
Surroundings obscured by bend or winding road	0	0	0	1	0	1
Surroundings obscured by buildings fences vegetation	2	0	0	1	0	3
Surroundings obscured by moving vehicle	6	0	1	0	0	7
Surroundings obscured by stationary or parked car	0	0	0	0	0	0

Table 37: Most confident vehicle countermeasures with the vehicle causation factors present in that case

	AEBS	Driver alert for approaching hazard	ISA	Lane keep assist	Fatigue monitoring	Grand Total
Defective brake system	2	2	3	0	1	8
Defective electrical system	0	0	0	0	0	0
Defective fuel system	0	0	1	0	0	1
Defective lighting	0	0	0	0	1	1
Defective Steering	1	0	0	0	0	1
Defective suspension	1	0	2	0	0	3
Defective trailer attachment	0	0	0	0	0	0
Defective tyres	5	1	5	2	4	17
Defective wheels	2	1	0	1	0	4
Other defects	0	0	1	1	1	3

Table 38: Most confident vehicle countermeasures with the road causation factors present in that case

	AEBS	Driver alert for approaching hazard	ISA	Lane keep assist	Fatigue monitoring	Grand Total
Aggressive driving	0	0	1	0	0	1
Alcohol	1	0	3	4	1	9
Bad overtake	1	1	3	0	0	5
Carelessness thoughtless	5	2	9	5	4	25
Cross from behind parked car	0	0	0	0	0	0
Disability	0	0	0	0	0	0
Distraction through listening to music	0	0	1	0	0	1
Distraction through physical object on or in vehicle	2	2	4	3	2	13
Distraction through physical object	1	1	1	0	0	3

	AEBS	Driver alert for approaching hazard	ISA	Lane keep assist	Fatigue monitoring	Grand Total
outside of vehicle						
Distraction through stress or emotional state of mind	0	0	0	0	0	0
Drugs	3	3	2	3	4	15
Error of judgement	3	2	5	0	1	11
Excess hours	0	0	0	0	0	0
Excessive speed	8	5	21	6	4	44
Failed to look	4	2	0	3	3	12
Failure to judge others persons path or speed	10	5	4	1	1	21
Failure to see pedestrian in blind spot	0	0	0	0	0	0
Fatigue	2	2	0	0	3	7
Following too close	0	0	1	0	0	1
Ignored lights at crossing	1	1	0	0	0	2
Ignored sign	2	1	1	0	0	4
Illness	1	0	0	3	1	5
Inconspicuous	0	0	0	0	1	1
Inexperience	1	0	2	0	1	4
Insufficient lighting	1	0	0	0	0	1
Lack of attention	9	5	4	5	8	31
Looked but did not see	1	0	0	0	0	1
Nervous or uncertain	0	0	0	0	0	0
Other bad manoeuvre	2	1	1	5	2	11
Other personal factor	0	0	1	2	1	4
Panic behaviour	1	1	0	0	0	2
Playing	0	0	0	0	0	0
Reckless	2	0	6	3	0	11
Risk taking behaviour	4	2	9	3	3	21

	AEBS	Driver alert for approaching hazard	ISA	Lane keep assist	Fatigue monitoring	Grand Total
Unauthorised passengers	0	0	0	0	0	0
Unauthorised passengers2	0	0	0	0	0	0
Walking in carriageway	0	0	0	0	0	0

D.3.3 Road countermeasures

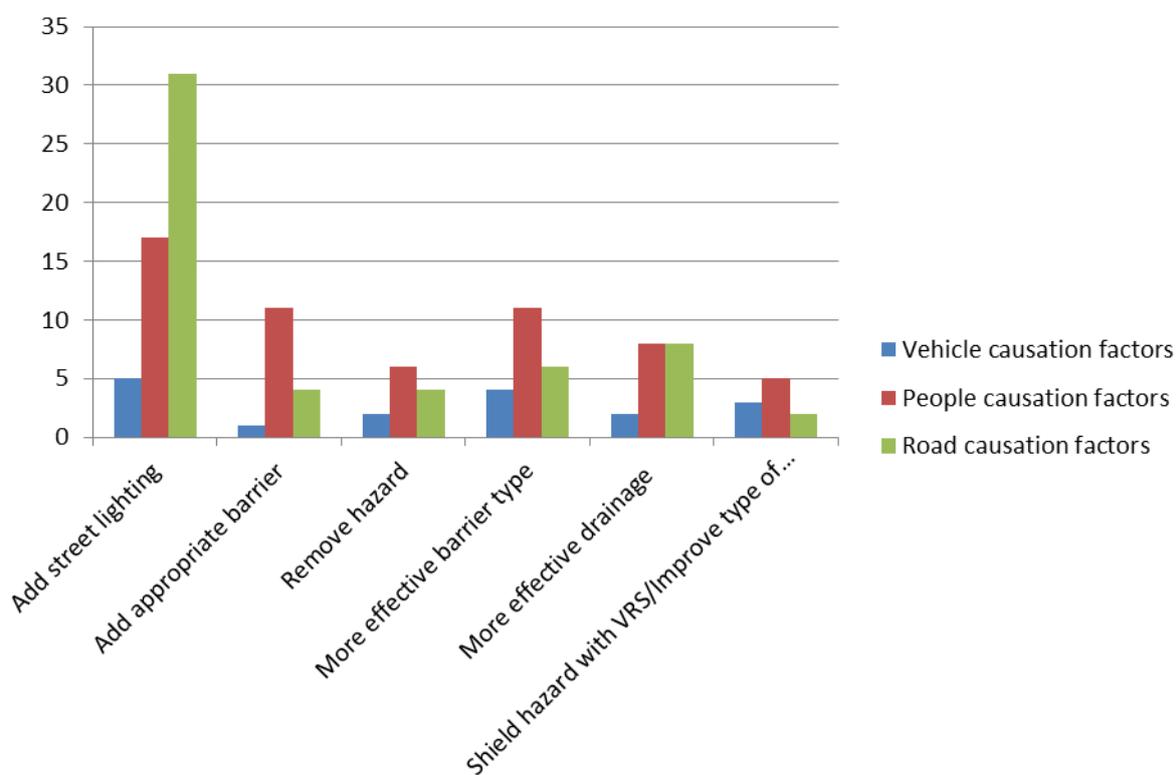


Table 39: Most confident road countermeasures with the human causation factors present in that case

	Add street lighting	Add appropriate barrier	Remove hazard	More effective barrier type	More effective drainage	Shield hazard with VRS/Improve type of VRS	Grand Total
Animal out of control	2	0	0	1	0	0	3
Bend or winding road at site	0	1	3	0	1	1	6
Earlier collision	6	1	0	0	0	0	7
Glare from headlights	1	0	0	0	0	0	1
Glare from sun	0	0	0	0	0	0	0
High winds at site	0	0	0	0	0	0	0
Inadequate signing at site	0	0	0	0	0	0	0
Narrow road at site	0	0	0	0	0	0	0
Obscuration due to weather	2	1	0	0	3	0	6
Other local-factor	1	1	1	1	4	1	9
Poor or street lighting at site	28	1	1	2	1	0	33
Poor surface at site	0	1	0	0	3	0	4
Road works at site	0	0	0	0	0	0	0
Slippery road at site	0	2	1	2	7	2	14
Steep hill at site	0	0	0	0	0	0	0
Surroundings obscured by bend or winding road	0	0	0	0	0	0	0
Surroundings obscured by buildings fences vegetation	0	0	0	0	0	0	0
Surroundings obscured by moving vehicle	5	0	0	0	0	0	5
Surroundings obscured by stationary or parked car	0	0	0	0	0	0	0

Table 40: Most confident vehicle countermeasures with the vehicle causation factors present in that case

	Add street lighting	Add appropriate barrier	Remove hazard	More effective barrier type	More effective drainage	Shield hazard with VRS	Grand Total
Defective brake system	1	0	0	1	0	1	3
Defective electrical system	0	0	0	0	0	0	0
Defective fuel system	0	0	0	0	0	0	0
Defective lighting	0	0	0	0	0	0	0
Defective Steering	1	0	0	0	0	0	1
Defective suspension	1	0	1	0	0	1	3
Defective trailer attachment	0	0	0	0	0	0	0
Defective tyres	4	1	1	3	2	3	14
Defective wheels	0	0	0	0	0	0	0
Other defects	0	0	0	0	1	0	1

Table 41: Most confident road countermeasures with the road causation factors present in that case

	Add street lighting	Add appropriate barrier	Remove hazard	More effective barrier type	More effective drainage	Shield hazard with VRS	Grand Total
Aggressive driving	0	0	1	0	0	0	1
Alcohol	3	3	1	1	1	1	10
Bad overtake	0	0	1	1	0	0	2
Carelessness thoughtless	5	2	1	4	2	2	16
Cross from behind parked car	0	0	0	0	0	0	0
Disability	0	0	0	0	0	0	0
Distraction through listening to music	0	0	0	1	0	0	1
Distraction through physical object on or in vehicle	1	0	0	3	0	0	4
Distraction through physical object outside of vehicle	1	0	1	1	0	0	3

	Add street lighting	Add appropriate barrier	Remove hazard	More effective barrier type	More effective drainage	Shield hazard with VRS	Grand Total
Distraction through stress or emotional state of mind	1	0	0	0	0	0	1
Drugs	1	3	1	1	1	0	7
Error of judgement	3	0	0	2	0	1	6
Excess hours	0	0	0	0	0	0	0
Excessive speed	1	4	2	3	3	2	15
Failed to look	3	0	0	0	0	0	3
Failure to judge others persons path or speed	2	0	0	0	0	0	2
Failure to see pedestrian in blind spot	0	0	0	0	0	0	0
Fatigue	0	1	0	0	0	1	2
Following too close	0	0	1	0	0	0	1
Ignored lights at crossing	0	0	0	0	0	0	0
Ignored sign	1	0	0	1	0	0	2
Illness	0	1	0	0	0	0	1
Inconspicuous	6	0	0	0	0	0	6
Inexperience	1	0	0	2	0	3	6
Insufficient lighting	5	0	0	0	0	0	5
Lack of attention	2	1	2	2	0	1	8
Looked but did not see	1	0	0	0	0	0	1
Nervous or uncertain	0	0	0	0	0	0	0
Other bad manoeuvre	0	0	1	2	0	1	4
Other personal factor	0	0	0	1	0	0	1
Panic behaviour	1	0	0	2	1	0	4
Playing	0	0	0	0	0	0	0
Reckless	3	1	1	2	1	0	8
Risk taking behaviour	5	3	2	5	1	2	18
Unauthorised passengers	0	0	0	0	0	0	0

	Add street lighting	Add appropriate barrier	Remove hazard	More effective barrier type	More effective drainage	Shield hazard with VRS	Grand Total
Unauthorised passengers2	0	0	0	0	0	0	0
Walking in carriageway	5	0	0	0	0	0	5

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