



CLIENT PROJECT REPORT CPR1131

Analysis of STATS19 data to examine the relationship between the rate of vehicle accidents involving pedestrians and type approval noise levels

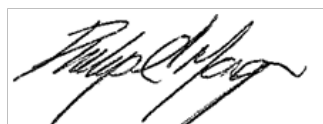
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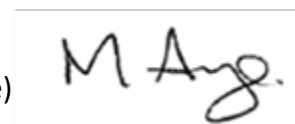
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1 Introduction and background

In response to issues such as carbon reduction and as part of a drive towards cleaner fuels the Department for Transport (DfT) is actively pursuing the use of electric and hybrid electric (E/HE) vehicles. However, at low speeds, such vehicles can be quieter than their internal combustion engine (ICE) counterparts and concerns have been raised over the increased potential for accidents between E/HE vehicles and vision impaired pedestrians who rely on audible environmental cues to assist with their mobility and orientation.

The Department commissioned research to investigate UK accident statistics to determine whether the perceived accident risk is real and whether E/HE cars are more difficult to audibly detect than their conventional counterparts (Morgan, Morris, Muirhead, Walter, Martin, in press)¹. The research indicated that pedestrian vehicle involvement density (defined as the number of vehicles involved in accidents with pedestrians divided by the number of registered vehicles) is no higher for E/HE cars than the average for ICE cars and that some modern ICE cars are as quiet as their E/HE counterparts, even at low speeds.

The UNECE are developing recommendations for artificial sound to be added to electric and/or hybrid electric vehicles to make their presence known to vulnerable pedestrians. UNECE Regulation 51 sets the test method, and the limit values, for drive-by noise emissions from vehicles. Noise levels when the vehicle is stationary must also be measured and noted, but there is no regulatory limit set at type approval².

Developments of Regulation 51 are discussed in UNECE GRB (vehicle regulations, working party on noise), and GRB established a task group to determine the extent to which vehicles should be fitted with added sound to alert vulnerable pedestrians of their approach. The possibility exists that fitting such warning devices to ICE vehicles may be desirable if they are 'too quiet'.

This then raises the question 'how quiet is too quiet?' with respect to determining which other cars might need to be fitted with added sound. This quantification would be required in order to calculate the potential cost to industry should such a recommendation develop into legislation.

The aim of this work is to investigate whether there is a correlation between type approval (TA) noise certification levels and vehicle involvement density across the vehicle subset comprising *cars and vans less than 3.5 tonnes*, regardless of propulsion type. The term 'vehicles' will refer to this subset throughout the remainder of the report.

If such a correlation were to exist then a comparison with the vehicle involvement density for E/HE vehicles may give an indication of the conventionally powered vehicles which might

¹ Morgan, P. A., Morris, L., Muirhead M., Walter L. and Martin, J. (in press). *Assessing the perceived safety risk from quiet electric and hybrid vehicles to vision-impaired pedestrians* (PPR525). Crowthorne: Transport Research Laboratory.

² VOSA enforce a 99 dB(A) limit on cars imported from outside the EU as part of the Individual Vehicle Approval (IVA) process. The appropriate manual for passenger cars can be downloaded from https://online.businesslink.gov.uk/Transport_files/124_IVA_M1_Inspection_Manual_Version_0311.pdf

be considered as a candidate for added sound. This would give an indication of how many vehicles might be affected should UNECE recommendations on added sound extend to conventionally powered vehicles.

2 Data linking methodology

To examine vehicle involvement density in terms of TA noise levels, the following three data sets needed to be matched:

- A table of all registered vehicles on the road in Great Britain in the years 2005-2008³, organised by make and model with information on the number registered, engine size and propulsion type (provided by DfT)
- A table of TA noise levels for vehicles entering production in 2007⁴, available from www.kba.de; the KBA database was used because it contained more information than the equivalent UK data held in the “New Car Fuel Consumption and Emission Figures” booklets that the Vehicle Certification Agency (VCA) publishes annually
- A table of all vehicles involved in accidents involving pedestrian casualties over the period 2005-2008 (extracted from the STATS19⁵ database), organised by make and model with information on the speed limit of the road on which the accident occurred, the engine size and propulsion type of the vehicle, whether or not the pedestrian was disabled in some way⁶ and the type of manoeuvre the vehicle was performing at the time of the accident

In general, ‘vehicle involvement density’ is defined as the number of vehicles involved in an accident divided by the total number of registered vehicles. For this study, the vehicles are categorised by TA noise level and the calculations are made on a year-by-year basis for the period 2005-2008, e.g. the number of vehicles with a TA noise level of 72 dB(A) involved in accidents in the year 2005 divided by the number of ICE vehicles with a 2007 TA noise level of 72 dB(A) registered in that year.

Additionally, in the current study the accidents of interest are only those where the vehicle collided with a pedestrian; this will be defined as ‘pedestrian vehicle involvement density’.

It is noted for accidents involving multiple vehicles, only those vehicles in direct collision with the pedestrian are considered, not the total number of vehicles. Care must therefore be exercised if numbers or findings from this study are compared with results from other studies.

³ These years were selected to match the period examined as part of the previous study (Morgan et al., in press).

⁴ A check was made against cars entering production for the first time in 2008 and the derived data set was updated accordingly.

⁵ STATS19 is a database in which police throughout Great Britain record details of road accidents that involve personal injury. The basic details of the people, vehicles and roads involved in these accidents are recorded, and since 2005 the factors which contributed to accident causation have been included.

⁶ This is a contributory factor recorded in the STATS19 database if “[the] pedestrian [is] either suddenly overcome by illness (e.g. blackout) or generally affected by illness (e.g. cold or ‘flu), or ... [is] suffering from a permanent disability (including poor eyesight), which contributed to the accident. [It] also includes pedestrians suffering from poor mental health (e.g. depression).”

The first two data sets were cross-referenced to derive a table, for each of the years 2005-2008, linking the number of registered vehicles to TA noise levels for each model of car that could be matched. The second two data sets were also cross-referenced to derive a table, for each of the years 2005-2008, assigning TA noise levels to vehicles involved in accidents with pedestrians.

There are a few important caveats to note with regard to this process. Firstly not all cars involved in accidents with pedestrians over this period can be assigned appropriate data with respect to both noise and registration numbers for the following reasons:

- No fully electric vehicles are included in the matched databases since there are no electric vehicles in the 2007 noise database. There are some hybrid vehicles in the noise database but it would be misleading to highlight these since they would likely have been running in petrol/diesel mode during the type approval pass-by noise test.
- Terminology and engine classification are not always consistent across the data sets. This may result in certain types of car not always being linked, e.g. electric vehicles are not well classified in the registered vehicle data and therefore are difficult to link. To simplify the matching process and avoid anomalies in the registration data, models with less than 10 registered vehicles nationwide were not considered.
- Since the TA noise database represents the year 2007, registered models of car that had gone out of production before this time could not be picked up and matched to noise data. This resulted in approximately two thirds of the registered vehicles being matched to noise data and about three quarters of the cars in the accident database being assigned noise levels. Nevertheless the resulting data set captured over 20 million registered vehicles and more than 12,000 accidents for each of the years 2005-2008.

Secondly there are some inherent sources of uncertainty with respect to assigning an appropriate noise level to a vehicle:

- The most important point to make is that the type approval noise test, which involves full throttle acceleration, is not representative of the operation of vehicles on the road or at the time of an accident. From tests conducted as part of the previous study to assess the perceived safety risk from E/HE vehicles (Morgan, *et. al.*, in press) it is noted that noise levels at 20 km/h can be of the order of 20 dB quieter than those reported at type approval. Nevertheless the type approval data is the only comprehensive noise data set that exists and has been used to provide an indicative indication of the potential noise of the vehicle.
- The noise data provides more specific information on vehicle model type than the registration data and therefore an appropriate TA noise level for one model type must be derived from values corresponding to numerous variations of this model. An example of how this was done is given in Appendix A.
- Cars were matched by make, model, engine size and propulsion type. The age of the car was not considered. For example a ten year old 1.6 litre, petrol Ford Focus was matched to the TA noise level for 1.6 litre, petrol Ford Focus cars going through the type-approval test in 2007. However TA noise levels in recent years, for which data are available, show that the error this introduces, particularly relative to the issue of

matching model types mentioned in the above bullet, is minimal. An example of this, for the 1.6 litre, petrol Ford Focus, is illustrated in Appendix B.

- No correction factor was applied to the TA noise levels to account for wear and tear of the engine and exhaust system that may have occurred over the lifetime of the vehicle. Whilst it has been shown that exhaust systems in particular can degrade such that exhaust noise increases over time⁷ there is no sufficiently robust correction that could be readily applied to pass-by noise levels.

As a result of these limitations in the data the analysis focussed only on relative vehicle involvement density for cars and vans with different TA noise levels. Absolute vehicle involvement density cannot necessarily be reliably obtained from this process and therefore care must be taken when comparing results to the vehicle involvement densities derived as part of the previous investigation into accident statistics.

⁷ Muirhead, M., Morgan, P. A. and Morris, L. (2010) *Proposals for in-service exhaust noise testing* (PPR506). Crowthorne: Transport Research Laboratory.

3 Data analysis methodology

With these two matched datasets, the relationship between pedestrian vehicle involvement density and vehicle TA noise levels⁸ has been investigated.

Table 3.1 shows the total number of vehicles involved in accidents with pedestrians and the total number of registered vehicles from 2005-2008 from the two matched databases described above.

Pedestrian vehicle involvement densities have been calculated for the following cases:

- Accidents on all roads, regardless of speed limit
- Accidents on roads with a 30 mph speed limit
- Accidents on all roads, regardless of speed limit, where the pedestrian had a temporary or permanent disability which may have contributed to the accident.

These results are presented in Chapter 4.

Table 3.1: Number of vehicles in pedestrian accidents and number of registered vehicles by pass-by noise level⁹.

Pass-by noise dB(A)	Number of vehicles in pedestrian accidents	Number of registered vehicles (millions)
<71	5,109	8.8
71	13,475	21.7
72	15,989	23.7
73	9,275	14.9
74	5,887	9.9
75	644	1.3
>75	471	1.4

⁸ Both pass-by and stationary noise levels were examined, however, no correlation was found with respect to stationary noise levels and given that these stationary levels have already been shown not to correlate with pass-by noise (Muirhead et al, 2010) we focus solely on the results for pass-by noise.

⁹ Note that these are the number of registered vehicles and accidents with pedestrians for which a corresponding TA noise level for the vehicle could be assigned. Therefore the data will not necessarily match the absolute figures from the previous study (Morgan et al., in press).

4 Results

4.1 Accidents on all roads, regardless of speed limit

The coloured lines in Figure 4.1 show the pedestrian vehicle involvement density for vehicles in seven categories of TA noise level, for each of the years 2005-2008. The two extreme noise level categories are combinations of groups with small numbers of accidents, in order to make the analysis robust.

In addition, pedestrian vehicle involvement densities have been plotted for popular vehicle models in each of the years 2005-2008 to give an idea of the spread in pedestrian vehicle involvement density across both the four year period and different vehicle types. The greater the number of registered vehicles of a particular type the larger (and darker) the circle in Figure 4.1.

For the purpose of Figure 4.1 a popular vehicle model was defined as one which represents either more than 1% of the registered cars and vans for that year or one of the top five registered vehicles having the associated TA noise level.

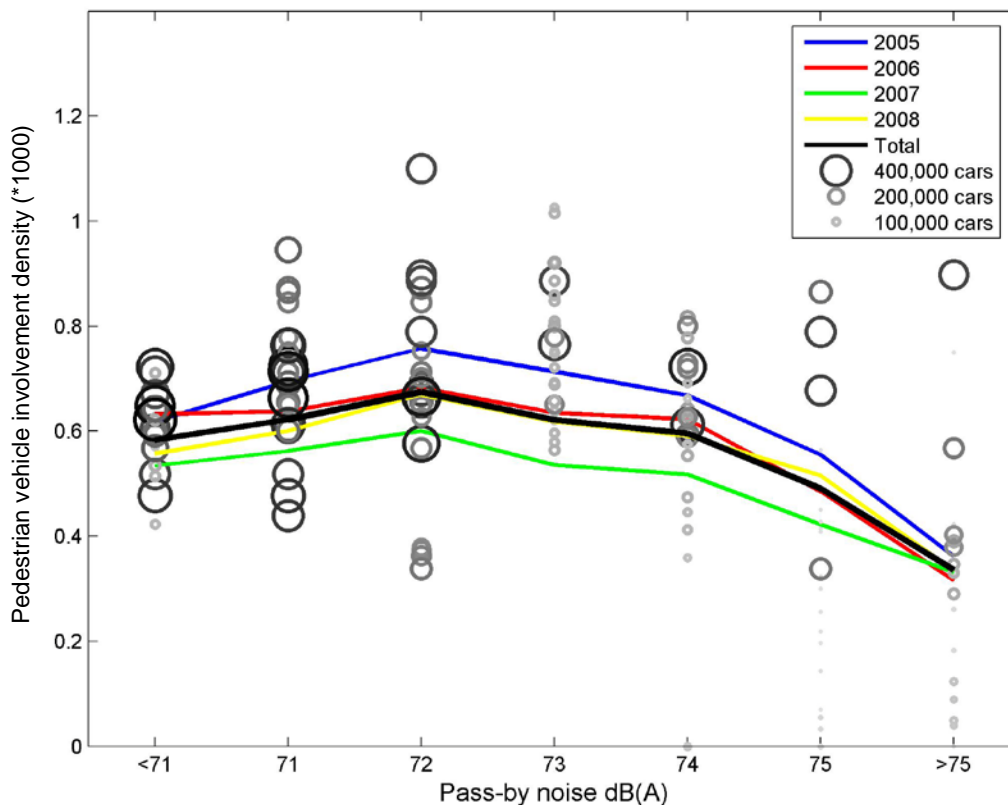


Figure 4.1: Pedestrian vehicle involvement density by pass-by noise level from 2005-2008

The associated pedestrian vehicle involvement density for E/HE vehicles only, derived over the period 2005-2008 as part of the previous study (Morgan *et. al.*, in press), is 0.49 which is just below all the average pedestrian vehicle involvement densities shown in Figure 4.1 for vehicles with TA noise levels up to 74 dB(A).

There is little correlation between TA noise level and pedestrian vehicle involvement density for vehicle with TA noise levels below 75 dB(A). The TA noise limit for most vehicles is set at 74 dB(A) and is only greater than this for certain specific types of vehicle including off-road vehicles. Therefore the lower pedestrian vehicle involvement densities for vehicles with TA noise levels over 74 dB(A) could be the result of a larger proportion of these vehicles driving off-road or in rural areas with fewer pedestrians.

This analysis only takes into account accident numbers and registered vehicles; it does not attempt to disaggregate other factors, which may lead to different pedestrian vehicle involvement densities, such as mileage and road type use (motorways or urban minor roads).

4.2 Accidents on roads with a 30 mph speed limit

Table 4.1 presents the data for accidents occurring on 30mph (or lower) roads. This subset of accidents represents those that occur at low speed in mostly urban areas, where there are likely to be more pedestrians.

Table 4.1 shows that, except for vehicles with high TA noise levels, the proportion of vehicles involved in accidents with pedestrians on lower speed roads remains fairly constant at about 91%. Therefore the pattern in pedestrian vehicle involvement densities with respect to TA noise on 30mph (or lower) roads is similar to that for the corresponding pedestrian vehicle involvement densities for all roads.

Table 4.1: Vehicles involved in pedestrian accidents where the speed limit is less than or equal to 30mph

Pass-by noise dB(A)	Number of vehicles in pedestrian accidents at ≤30mph	Percentage of vehicles in accidents at ≤30mph	Pedestrian vehicle involvement density *1000
<71	4,698	92.0%	0.54
71	12,330	91.5%	0.57
72	14,662	91.7%	0.62
73	8,424	90.8%	0.56
74	5,342	90.7%	0.54
75	586	91.0%	0.45
>75	393	83.4%	0.28

4.3 Accidents where the pedestrian had a disability which may have contributed to the accident.

Table 4.2 shows the proportion of vehicles involved in pedestrian accidents where the pedestrian had a temporary or permanent disability contributing to the cause of the accident. This includes partial and full blindness and therefore includes those people who may be most at risk of being involved in an accident with a quiet vehicle.

Table 4.2: Vehicles involved in pedestrian accidents where the pedestrian was disabled, either temporarily or permanently, and this was deemed to be a contributory factor in the accident

Pass-by noise dB(A)	Number of vehicles in pedestrian accidents with pedestrian disability	Percentage of vehicles in accidents with pedestrian disability	Pedestrian vehicle involvement density *100000
<71	101	2.0%	1.15
71	283	2.1%	1.31
72	275	1.7%	1.16
73	176	1.9%	1.18
74	134	2.3%	1.36
75	11	1.7%	-*
>75	12	2.5%	-*

* number of vehicles is too small to calculate a robust accident density

Table 4.2 shows that there does not seem to be a relationship between the proportion of accidents involving a pedestrian where a contributory factor to the accident was that the pedestrian was disabled in some way and different pass-by noise categories. There is no discernable pattern in accident densities.

5 Conclusions

There appears to be little correlation between pedestrian vehicle involvement density and TA noise level for the majority of vehicles. The spread of pedestrian vehicle involvement densities between different vehicle models for each TA noise level is relatively large. Where some form of correlation does appear to exist (e.g. for TA noise levels greater than 74 dB(A)) this is likely to be as a result of factors other than noise, such as the mileage and road type use of off-road vehicles.

No conclusions about the effect of vehicle noise on pedestrian vehicle involvement density can be drawn. Additionally there was no evidence of a pattern in pedestrian vehicle involvement densities when only considering those accidents occurring on 30mph (or slower) roads or where the pedestrian was disabled.

A more sophisticated analysis is theoretically possible – a cluster analysis, generalised linear model or linear regression model on the pattern observed in Figure 4.1 could be defined, however, given the limitations in the data and the difficulty in assessing causal links, it is suggested that this is unnecessary at this point.

If sufficient information could be added to the accident data (including, for example, vehicle size) to remove all other trend effects it would be possible to assess whether a causal link exists between TA noise and pedestrian vehicle involvement density. Accident rate models or graphical modelling could be used. Some information on mileage would be needed in order to include information about different types of vehicles travelling more miles, on different types of roads.

The analysis in the previous study (Morgan et al., in press) did not show an increased pedestrian vehicle involvement density for E/HE vehicles with respect to their ICE counterparts which raises the question as to whether added sound is necessarily required. The analysis described above would provide greater confidence as to whether the relative TA noise level of the vehicle is a contributory factor in pedestrian vehicle involvement densities. This would then provide evidence from which a more robust assessment could be made as to the need for added sound.

If added sound is required for E/HE vehicles at low speeds because of their quiet nature then it can be argued that added sound would also be required for ICE vehicles that are just as quiet. Currently, a new test methodology may have to be considered based on a low speed pass-by conducted close to the speed above which added sound would not be required. The results of such a test, which would include hybrid electric vehicles in their electric state and be a more realistic measure of noise with respect to 'every-day' driving, could potentially show a correlation with pedestrian vehicle involvement density.

One way in which to analyse such data would be to look at the noise levels recorded from such a test and examine the proportion of E/HE vehicles at each level. The point at which the proportion of E/HE vehicles drops to an appropriately low percentage could then be used to define a value below which added sound may be considered; however noise levels for the current fleet would be required in order to achieve this.

With information on the number of vehicles requiring added sound the associated cost to industry could be estimated. Additionally the impact on environmental noise of added sound measures could also be considered.

If added sound were considered necessary, the data from a low speed test could potentially be used to help define the amount of added sound required. For example, added sound may need to bring the maximum vehicle noise during the test up to the defined limit that has been set for type approval. However, this ignores people's perception of vehicle noise and its characteristics and work needs to be done in this area to fully understand the issues and form definitive conclusions about added sound.

Appendix A

As part of the matching process described in Chapter 2 an appropriate type approval noise level had to be assigned to vehicles in the registration database. This appendix describes some of the assumptions that had to be made as part of this process, using Audi A3 cars on the road in 2007 as an example.

The registration data provide the number of registered Audi A3 cars as shown in Table A.1. The model type is not broken down any further so information on the fuel type and engine size is also included for matching with the noise database.

Table A.1: Extract from the registration database 2007

Vehicle make and model	Fuel type	Engine size (cc)	Number of registered vehicles
AUDI A3	PETROL	1751-1800	25804

Retrieving data on all petrol, 1.8 litre Audi A3 cars from the KBA database yields 10 entries, shown in Table A.2. Without any knowledge of the breakdown of registered Audi A3 cars between the different models in Table A.2 an indicative type approval noise value is taken as the median value in this range.

Another entry in the registration database refers to petrol, 1.8 litre Audi Quattros without any information on whether the cars are in the A3, A4 or A6 family etc. In the absence of this detail an indicative type approval value is taken as the median of all values for different petrol, 1.8 litre Audi Quattros. As a result the noise values for the A3 Quattros are used to help determine type approval levels for two separate entries in the registration database.

In a more general context this matching process had to be automated and as such models in the registration database were assigned to all models in the noise database for which the model name matched either of the model names in the first two columns of the noise database and the engine size and fuel type matched. This approach was also used in matching the accident data to the noise data.

Table A.2: KBA database 2007

Vehicle make and model	TSN ¹⁰	Engine capacity	Stationary noise	Pass-by noise	Transmission type ¹¹	Fuel type
A3	APG	1781	82	72	5M	Petrol
A3	APG	1781	85	71	4A	Petrol
A3	AUM	1781	78	71	5M	Petrol
A3	AUM	1781	79	70	4A	Petrol
A3	AUM	1781	78	70	5A	Petrol
A3	AUQ	1781	79	72	5M	Petrol
A3	AUQ	1781	77	71	5A	Petrol
A3	QUATTRO	ARX	1781	79	5M	Petrol
A3	QUATTRO	ARX	1781	79	5M	Petrol
A3	QUATTRO	ARY	1781	78	6M	Petrol

¹⁰ From the kba database: *“The so-called type code number (TSN)... is allocated in the KBA for filling in the registration certificate... in accordance with EC-Directive 1999/37/EC... It is not based solely on the characteristic data for the vehicle, which influence fuel consumption and emission type approval values; therefore differing fuel consumption and emission type approval values are frequently stated for the same TSN and vice versa... The TSN is to be found in the field 2.2 of the registration certificate where it appears in the first three digits of the nine digit code number”*

¹¹ First digit=Number of gears, M=Manual, A=Automatic

Appendix B

Vehicles were assigned indicative type approval noise levels based on 2007/2008 noise data as described in Chapter 2 and Appendix A irrespective of their year of manufacture since available KBA data were not available for all prior years. VCA data, however, do go back to the year 2000 and this was used to investigate possible errors in assigning 2007 noise levels to older vehicles. A number of makes and models were looked at and a summary of the data for petrol, 1.6 litre Ford Focus cars¹² is provided in Table B.1.

The table shows the range of type approval noise levels, for this model, listed in the KBA and VCA databases for each year together with a median value. As can be seen type approval noise values have changed very little over this period and the difference between the KBA and VCA data for 2007 is greater than the differences reported in the VCA databases going back to 2000.

Therefore when compared to the issues encountered in matching model types, described in Appendix A, the errors resulting from using 2007 noise data are considered small.

Table B.1: Type-approval noise levels, 2000-2007, for 1.6 litre petrol Ford Focus cars

Database	Range of noise levels dB(A)	Median noise level dB(A)
VCA 2008	70-71	71
KBA 2007	69-73	70
VCA 2007	71	71
VCA 2006	69-73	70
VCA 2005	69-73	70
VCA 2004	69-70	70
VCA 2003	69-70	70
VCA 2002	69-70	70
VCA 2001	69-70	70

¹² Chosen as an example since (a) they represent a common model for which many were registered and (b) the data are representative of the results found when examining how type approval noise levels have changed since 2000