TRANSPORT RESEARCH LABORATORY

The development of accident-remedial intervention levels for rural roads

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Executive Summary

Traditionally, Local Highway Authorities (LHAs) have ranked accident problems by site, with the sites (often junctions) having the highest accident frequencies being given priority over others for accident-remedial treatment. In practice, only a few sites will be considered for treatment. These sites will have an accident frequency greater than x, say. 'x' is called an '*intervention level*' and will usually be greater than the average accident frequency per site.

Over time, intervention levels have decreased in absolute terms as accident frequencies have decreased through the success of remedial measures. LHAs are now finding that as the worst accident problem sites have been 'cured', it has become harder to prioritise in this fashion and accidents tend to be spread more evenly across whole areas.

The greatest potential for accident reduction is likely to be where the accident *rates* are greater than average (i.e. having taken the exposure into account). In addition to accidents per site (junction, bend etc), other useful ways to identify and prioritise accident problems might be to consider accidents per km or per vehicle-km. A further possibility is to consider the proportion of accidents of different types in an area compared to expected proportions.

There is a big difference between accident patterns on rural and urban roads (speed limits ≥50miles/h and ≤40miles/h, respectively). Accidents in rural areas are even less likely than those in urban areas to be concentrated at specific locations, but tend to be more scattered. Consequently, rural sites have rarely been identified as priorities for remedial treatment in the past. In addition, in rural areas, traffic and junction densities, and therefore the opportunities for traffic conflicts, are often lower than in urban areas.

It is important that a greater focus is now put on the rural road accident problem. Rural accidents tend to result in more severe casualties; in Great Britain, rural roads currently account for 43% of all accident costs. 59% of all fatalities take place on rural roads. Vulnerable road users are at risk too, with 24% of all pedestrian fatalities and 58% of all two-wheeler fatalities occurring on rural roads.

This report describes an investigation of readily available national accident and exposure data to derive suggested accident-remedial intervention levels for different situations on rural roads. The report provides, for each rural road class, suggested intervention levels - in terms of:

- accidents per km;
- accidents per vehicle-km;
- accidents per junction;
- accidents per bend;
- proportions of accident types.

1 Introduction

Traditionally, Local Highway Authorities (LHAs) have ranked accident problems by site, with the sites (often junctions) having the highest accident frequencies being given priority over others for accident-remedial treatment. This is the principal method by which LHAs allocate their road safety engineering budgets although, of course, the process will often involve considering other factors such as capacity, land development and policy issues and environmental matters. In practice, only a few sites will be considered for treatment. These sites will have an accident frequency greater than x, say. ‘x’ is called an ‘*intervention level*’ and will usually be greater than the average accident frequency per site.

Over time, intervention levels have decreased in absolute terms as accident frequencies have decreased through the success of remedial measures. LHAs are now finding that as the worst accident problem sites have been ‘cured’, it has become harder to prioritise in this fashion and accidents tend to be spread more evenly across whole areas. For this reason, mass action, route action or area action remedial treatments may be preferable to treatments at specific sites. Importantly, the use of low-cost measures may result in these other approaches being just as cost-effective as the traditional site-specific approach. It should be noted that the problems identified may also be tackled through enforcement, training and publicity and not necessarily engineering alone.

It is also likely to be useful to prioritise by taking exposure (as well as accident numbers) into account. It is well known that accident frequencies are highly correlated with traffic flows, road length and junction density. In other words, one would generally expect to find more accidents on a long road with high flows and a high number of junctions per km than on a short road with low flows and a low junction density. The greatest potential for accident reduction is likely to be where the accident *rates* are greater than average (i.e. having taken the exposure into account). In addition to accident frequency per site (junction, bend etc), other useful ways to identify and prioritise accident problems might be to consider accidents per km or per vehicle-km. A further possibility is to consider the proportion of accidents of different types in an area compared to expected proportions.

In order to prioritise roads/routes for treatment, the number of accidents per km or per vehicle-km would be ranked in size (as in the traditional site-specific approach). Accident type proportions would be ranked according to the relative size of the differences between the proportions of each accident type in the area of interest and in a Control area (representing ‘expected’ proportions). Unless the study area/road is distinctly unique, the proportions may be used to gauge whether a particular accident type occurs disproportionately more often in the study area and, if so, to trigger a more detailed accident investigation and remedial treatment (see section 5).

Of course, the ideal, and most practical prioritisation methods will probably, as now, involve considering a combination of the available remedial treatment types, intervention levels and other factors such as funding and political issues. The choice of which type of intervention level to use will almost certainly depend on the amount of detailed exposure data that are available.

There is a big difference between accident patterns on rural and urban roads (speed limits $\geq$50miles/h and $\leq$40miles/h, respectively). Accidents in rural areas are even less likely than those in urban areas to be concentrated at specific locations, but tend to be more scattered. Consequently, rural sites have rarely been identified as priorities for remedial treatment in the past. In addition, in rural areas, traffic and junction densities, and therefore the opportunities for traffic conflicts, are often lower than in urban areas.

It is important that a greater focus is now put on the rural road accident problem. Rural accidents tend to result in more severe casualties; in Great Britain, rural roads currently account for 43% of all accident costs. 59% of all fatalities take place on rural roads. Vulnerable road users are at risk too, with 24% of all pedestrian fatalities and 58% of all two-wheeler fatalities occurring on rural roads.

Whilst most local authority engineers will have a feel for the distribution of accident types (and the levels above which remedial treatment should be considered) in their area, it is likely that these intervention levels relate to *urban* roads and junctions. (Note that urban roads will include villages with 30miles/h or 40miles/h speed limits lying within rural areas.) For rural roads, it is considered appropriate to use different intervention levels, to facilitate the identification and prioritisation of rural road accident problems.

This report describes an investigation of readily available national accident and exposure data to derive suggested accident-remedial intervention levels for different situations on rural roads. The report provides, for each rural road class, suggested intervention levels - in terms of:

- accidents per km;
- accidents per vehicle-km;
- accidents per junction;
- accidents per bend;
- proportions of accident types.

Section 2 discusses the data used in the development of the intervention levels; Section 3 concerns the average accident rates derived; Section 4 explores the variability of accidents per vehicle-km; and Section 5 looks at national distributions of accident types. Sections 6 and 7 respectively summarise the techniques employed, discuss the results, draw conclusions and summarise the rural intervention levels suggested. References can be found in Section 8.

The work reported here has also contributed to the IHT Guidelines for Rural Safety Management (IHT, 1999).

Definitions

The following terms are used in the report:

Rural (or non-built-up) roads are those with a speed limit of 50miles/h or more.

Accidents are personal injury accidents which were reported to the police.

Junction accidents are those that occur at, or within 20m of, a junction.

Accident severity ratio is defined as the ratio of the number of fatal and serious accidents to all injury accidents.

Accident rates take exposure into account - e.g. number of accidents per km, or per vehicle-km.

2 Data sources and assumptions

2.1 National data

As a starting point, accident numbers, road lengths and vehicle flows were found for all rural roads in Great Britain (Department of Transport, 1994-97; Department of Transport, 1994-98). The data were generally averaged over 1994 and 1995 (exceptionally 1995 or 1996 data were used alone). The published accident data were supplemented where necessary through interrogation of the STATS19 database.

Assumptions

The following assumptions have been made where appropriate due to a lack of any detailed information:

- all 'B/C/Unclassified' roads are single-carriageways;
- all motorways are rural;
- all motorways are dual-carriageways;
- all Trunk/Principal roads (except motorways) are 'A' roads.

7% of all the rural accidents in Great Britain were not coded as occurring on dual- or single-carriageway roads but at roundabouts, on a circular highway, or on one-way streets. 91% of these accidents were on motorways or 'A' roads and these were combined with the appropriate dual-carriageway accident data, according to road class; those accidents occurring on 'B/C/Unclassified' roads were incorporated into the appropriate single-carriageway accident data.

2.2 Data from previous TRL studies

In order to explore the variability of accident rates, data relating to 236 rural single-carriageway roads were also studied. The sources of these data are given in the Appendix and, with the exception of the Cambridgeshire data, the data were those available from previous TRL studies. The data sets each spanned several years and some included accidents in 1994 and 1995; these accidents were, therefore, also part of the national dataset.

2.3 Junction density estimates

A literature search of published research reports and several personal enquiries provided little information relating to the numbers of junctions on rural roads in Great Britain. Junction numbers and densities were therefore *estimated* from a selected sample of roads using Landranger Ordnance Survey maps (scaled at 1:50,000). For each road class, the densities of junctions (number per km) in several sample areas across the country were averaged to arrive at a best-estimate, national figure. The main objective of using the sample data was to use the junction density estimates to estimate national accident frequencies per junction on all road classes. The estimated total number of junctions on rural roads in Great Britain was calculated using the total road lengths and the junction density estimates.

In all, approximately 1000km of single-carriageway roads and 2500km of dual-carriageway roads were studied across different areas of Great Britain. Although speed limit boundaries were not known precisely, rural sections of road were identified using the land use detail on the maps and plots of accidents by speed limit (as given on the STATS19 accident records). Built-up sections of road were not included. Junctions at the ends of road sections in the sample were included. 'A' and 'B' class roads are marked on Landranger maps in red and brown respectively. 'C' and 'Unclassified' roads are not marked as such but in estimating junction densities were assumed to be those marked in yellow.

For single-carriageway roads, every junction was counted, including small lanes but not bridleways and footpaths. Although the level of detail on the maps generally includes small lanes, minor private drives are generally excluded. However, unlike the practice for all other junctions, the presence of a private drive is only recorded in an accident if a vehicle was using the private drive at the time of the accident. Side roads joining from opposite sides of the carriageway were considered to be separate junctions unless they joined the main road at the same point (i.e. a crossroad junction). For dual-carriageway roads, junctions comprising several slip roads were counted as a single junction, even though the slip roads often met the main road some distance apart. Accesses to motorway service stations were not included.

Note that estimates are subject to variation between areas and should be *used with caution.*

2.4 Bend density estimates

One third of all rural single-carriageway accidents involve at least one vehicle 'going ahead on a bend' (Barker et al, 1998). However, there are no national data available which quantify bend frequencies. Indeed it is uncertain what exactly constitutes a 'bend'. As it was not practical to study bends nationally, a selected 1000km sample of single-carriageway roads was studied in more detail. The roads in this sample were those also used to estimate single-carriageway junction densities by road class (section 2.3).

The main objective of using the sample data was to use the bend density estimates to estimate national accident frequencies per bend on all road classes. To achieve this the average numbers of bends per km for each class of road in the sample areas were found from the 1:50,000 scale Landranger Ordnance Survey maps. This was an unavoidably subjective task, with one researcher making consistent judgements in defining a bend on the map. To judge how the bends defined in this way would relate to bends identified by a driver, a comparison was made between the numbers of bends identified from driving along 60km of rural ‘A’ class roads and from the same sections of road directly from the relevant Landranger map. There was good agreement between the two methods. (The identification of bends from maps was more difficult for dual-carriageways and so no estimates have been provided for these roads.)

Note that estimates are subject to variation between areas and should be *used with caution.*

Whether or not an accident is classified on the STATS19 accident form as having taken place on a bend is left to the discretion of the police officer completing the form. No definition of a bend is provided, so, for a few of the roads used to estimate bend densities, bend accidents for a two year period were plotted on maps. It was found that the bend accidents did lie on bends identified as described above, but, as one would expect, there were not accidents at all bends.

3 Accidents per km, per bend, per junction and per vehicle-km, by road class

3.1 All rural roads

Table 1 shows, nationally, the distribution across road class of accidents, vehicle flows, road lengths and junction and bend densities which were used to calculate the corresponding accident rates here. The accident severity ratios are also given. The table shows that the highest proportion of accidents on rural roads, and the greatest severities, occurred on single-carriageway ‘A’ roads. However, the majority of rural road length is ‘C’ class or ‘Unclassified’. The greatest proportions of traffic were on single-carriageway ‘A’ roads and motorways.

Tables 2 and 3 show best-estimate mean values for the numbers of accidents per km, vehicle-km, junction and bend on rural roads over the whole of Great Britain. (Note that for STATS19 completion, it is not specified which type of manoeuvre is preferred for use when an accident involves a vehicle turning at a junction on a bend. Therefore, it is likely that the true number of accidents that occur on bends is unknown; the estimated figures given should be *used with caution.)*

Table 2 Average numbers of accidents per km/junction/ bend on rural roads in Great Britain, by road class and carriageway type

Rural roads, Great Britain (based on an annual average of 60,815 accidents)		*Accidents per year*			
		Per 100 kms		*Per 100 junctions (estimated)*	*Per 100 bends (estimated)*
Carriageway type and road class		*All*	*Non-junction*	*Junction*	*Bend*
Single	A	75	43	14	15
	B	37	22	6	8
	C/Unclassified	8	6	1	3
	All	21	13	4	5
Dual	A	243	108	170	-
	Motorways	223	178	277	-
	All	235	136	182	-
All rural roads		30	18	5	-

See Sections 1, 2.1, 2.3 and 2.4 for definitions and assumptions

It is apparent from the tables that there is a strong correlation between accidents and traffic flow. For example, there are roughly ten times as many accidents per 100 kms on dual-carriageway roads as on single-carriageway roads (235 compared to 21 – Table 2). However, traffic flows are higher on dual-carriageways and thus dual-carriageways have only about half the accident rate of single-carriageways

Table 1 Percentage of road length, accidents, traffic, junction and bend densities on rural roads by road class and carriageway type (Great Britain)

Carriageway type and road class		*% of all accidents (94/95 average)*	*Accident severity ratio*	*% of all road length (km) (1994)*	*Traffic 10^8veh-kms (1995)*	*Estimated number of junctions per km*	*Estimated number of bends per km*
Single	A	36%	0.28	14%	735	2.3	1.2
	B	13%	0.28	11%	181	2.3	1.6
	C/Unclassified	20%	0.24	71%	267	2.2	1.4
	All	69%	0.27	96%	1183	2.2	1.4
Dual	A	19%	0.20	2%	490	0.79	-
	Motorways	12%	0.16	2%	709	0.16	-
	All	31%	0.18	4%	1199	0.29	-
All rural roads		100%	0.24	100%	2382	0.81	-
Total		(60,815)		(205,320)			

See Sections 1, 2.1, 2.3 and 2.4 for definitions and assumptions

Table 3 Average numbers of accidents per vehicle-km on rural roads in Great Britain, by road class and carriageway type

Rural roads, Great Britain (based on an annual average of 60,815 accidents)		*Accidents per 10^8 vehicle-kms*			
Carriageway type and road class		*Fatal*	*Serious*	*Non-junction*	*All*
Single	A	1.2	7	17	30
	B	1.3	11	27	44
	C/Unclassified	0.9	10	33	46
	All	1.2	8	22	35
Dual	A	0.6	4	11	24
	Motorways	0.2	1	8	10
	All	0.4	3	9	16
All rural roads		0.8	5	15	26

See Sections 1, 2.1, 2.3 and 2.4 for definitions and assumptions

(16 per 10^8 vehicle-km compared to 35 – Table 3). Therefore, whenever possible, it is important to consider traffic flows when looking at the implications of the number of accidents occurring.

The *estimated* average numbers of accidents at (rural single-carriageway) bends were similar but very slightly higher than those *estimated* for junctions. The numbers of accidents per junction were much higher for dual-carriageway roads than single-carriageway roads, reflecting the low junction densities and high traffic flows on dual-carriageway roads.

3.2 Sample of 236 rural single-carriageway roads

The main objective of studying the sample of 236 rural single-carriageway roads (for which data were already available) was to explore the variability of accident rates per vehicle-km (see section 4). However, Table 4 summarises all the data relating to this sample. The table shows a very wide range of values for each statistic, with the mean values not necessarily being the 50th percentile values. Tables 1 and 2 above showed that the national accident numbers and rates on single-carriageway ‘A’ roads were higher than on ‘B/C/Unclassified’ roads. However, when the traffic was considered (Table 3), the highest numbers of accidents per vehicle-km (about 45 per 10^8 vehicle-kms) were observed on the ‘B/C/Unclassified’ roads (compared to 30 per 10^8 vehicle-kms on the ‘A’ roads). The absolute values of the accident rates for the 236-road sample were greater than the national average values but the data followed the same pattern (53 accidents per 10^8 vehicle-kms on B/C/Unclassified roads compared to 32 per 10^8 vehicle-kms on the ‘A’ roads).

Table 4 Summary data for sample of 236 rural single-carriageway roads

Statistic	*Mean*	*Standard deviation*	*Total*
A roads (156 roads)			
Length (km)	3.59	3.53	560
Traffic flow (AADT)	11594	5646	1.8 x10^6
Accidents (per 10^8 veh-kms)	32.0	26.2	
Accidents (per yr)	4.02	4.93	627
Accidents (per km/yr)	1.24	1.14	
B/C/Unclassified roads (80 roads)			
Length (km)	1.84	0.93	147
Traffic flow (AADT)	4666	3120	0.4 x10^6
Accidents (per 10^8 veh-kms)	53.3	51.7	
Accidents (per yr)	1.49	1.77	120
Accidents (per km/yr)	0.77	0.74	

Table contents derived from data sets A, B, C and D, Appendix

4 Variability of accidents per vehicle-km between roads

4.1 Sample of 236 rural single-carriageway roads

Of course accidents per vehicle-km are likely to vary widely across Great Britain for many reasons. For example, it is possible that the relationship between accident rates and road length or levels of traffic flow may vary if these factors are correlated with contrasting road designs, land use, road class etc. The numbers of accidents per vehicle-km for the 236 rural single-carriageway roads for which data were already available from previous work were studied to investigate the between-road variability. The data sources (see Appendix) were not selected at random and may also have influenced the distribution of accident rates in the sample.

Figures 1 and 2 show binned distributions of accidents per vehicle-km for all 156 ‘A’ roads and all 80 ‘B/C/Unclassified’ roads, respectively. The sample shows a slightly left-skewed distribution of accidents per vehicle-km for all roads. Interestingly, although overall the numbers of accidents per vehicle-km for these roads exceed national mean values, only 36% of ‘A’ roads and 39% of ‘B/C/Unclassified’ roads from the sample of 236 roads have a value which exceeds the mean value.

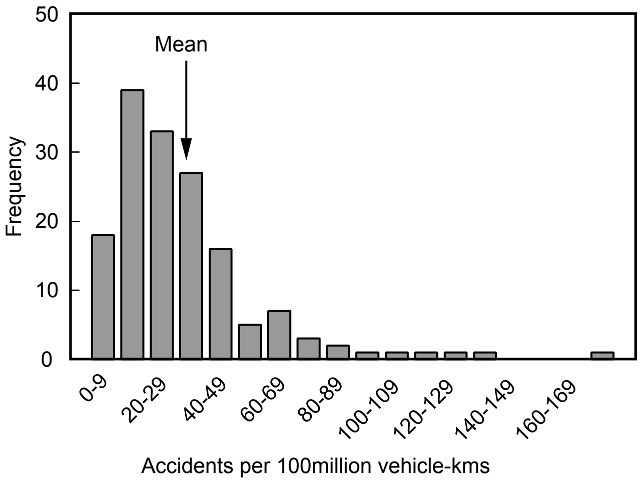

Figure 1 Frequency distribution of accidents per vehicle-km on 156 A roads

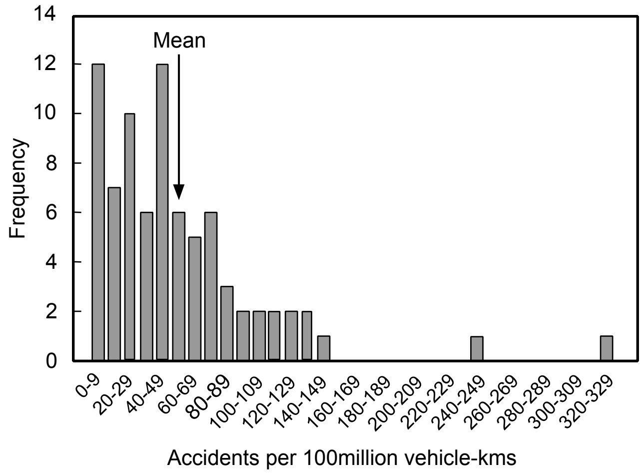

Figure 2 Frequency distribution of accidents per vehicle-km on 80 B/C/Unclassified roads

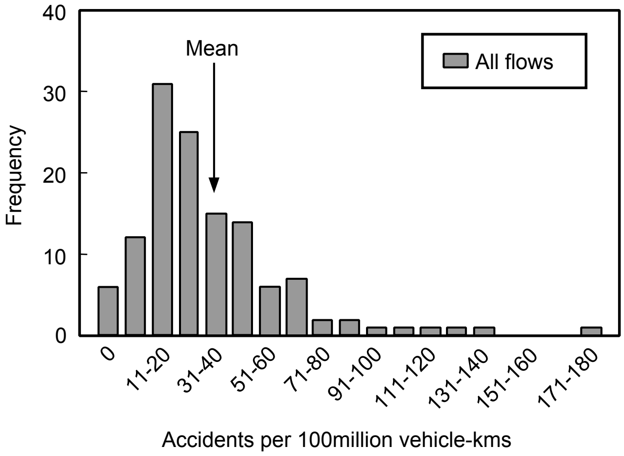

Figure 3 Frequency distribution of accidents per vehicle-km on 126 A roads ≤5km long

The variation in accidents per vehicle-km by road length is given in Table 5, for the ‘A’ roads. There appears to be no clear pattern with respect to road length but, once more, it was clear that there was a considerable range of values, indicated by the high standard deviation and differing maximum values. The group with the shortest road length (≤5km), which included the majority of the roads, had the highest variability.

Table 5 Accidents per vehicle-km from a sample of 156 rural single-carriageway ‘A’ roads

Road length (km)	*No. of roads*	*Accidents per 10^8 vehicle-kms*			*Mean traffic flow (AADT) (vehicles/day)*	*Mean length (km)*
		Mean	*Std. devn.*	*Maxi -mum*		
≤ 5	126	33	29	176	12045	2.2
5-10	20	25	10	48	8873	7.2
> 10	10	32	7	45	10908	14
All	156	32	26	176	11594	3.6

Table contents derived from data sets A, B, C and D, Appendix

Figure 3 shows the distribution of accidents per vehicle-km for the 126 ‘A’ roads in the sample that were up to 5kms long. These roads were further grouped according to their traffic flow levels. Figures 4-7 show the variation in accidents per vehicle-km for each of 4 levels of traffic flow. They show that the numbers of accidents per vehicle-km were similarly distributed for each level of flow. However, the mean values for the 4 levels of flow (<10,000, 10,000-14,999, 15,000-19,999 and ≥20,000 per day) were lower the higher the level of flow (39, 32, 27 and 24 accidents per10^8 vehicle-kms, respectively). This pattern is as one would expect (see section 4.2). (Note that the same pattern is observed for the whole 156 ‘A’ road sample. The fact that Table 5 does not show the same pattern is probably due to the small numbers of roads in the groups over 5km long).

Further examination of the data by data source revealed only one noticeable difference in accident rates between sources: the 75 modern Trunk ‘A’ roads in the sample

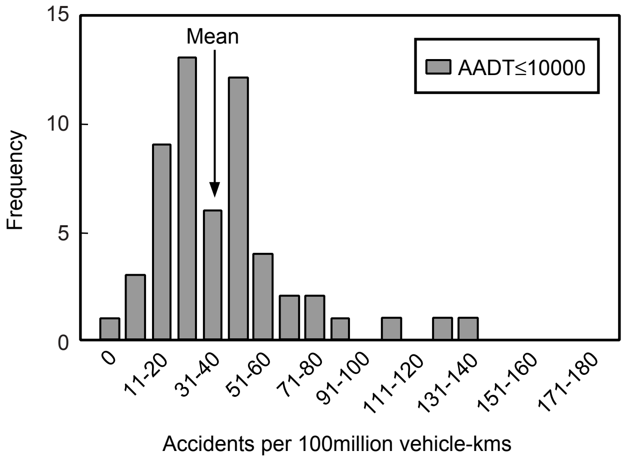

Figure 4 Frequency distribution of accidents per vehicle-km on 56 A roads ≤5km long with flows ≤10,000 vehicles per day

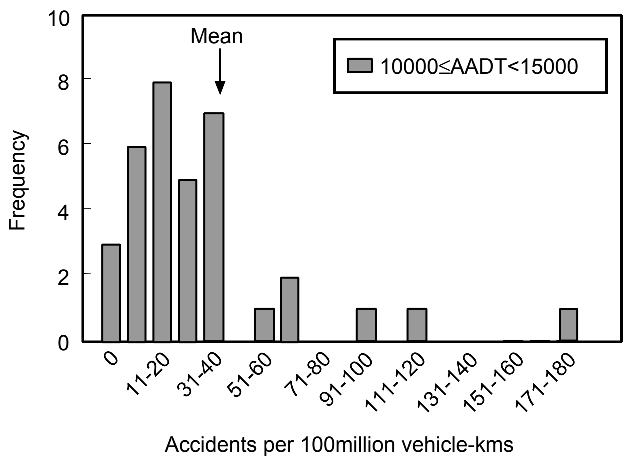

Figure 5 Frequency distribution of accidents per vehicle-km on 35 A roads ≤5km long with flows between 10,000 and 15,000 vehicles per day

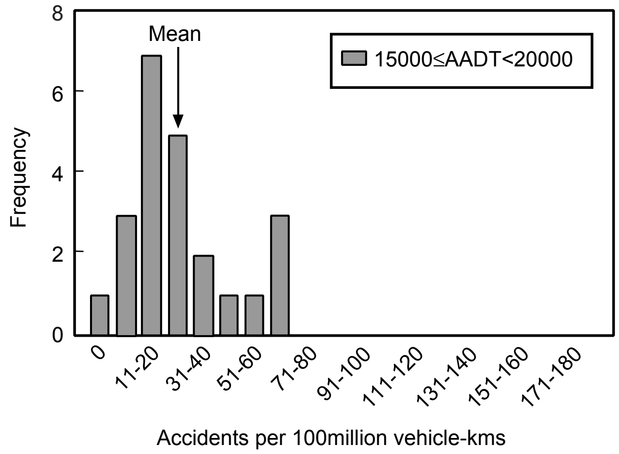

Figure 6 Frequency distribution of accidents per vehicle-km on 23 A roads ≤5km long with flows between 15,000 and 20,000 vehicles per day

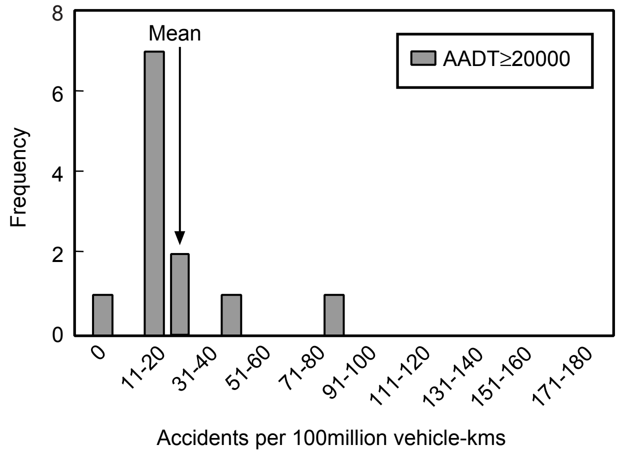

Figure 7 Frequency distribution of accidents per vehicle-km on 12 A roads ≤5km long with flows ≥20,000 vehicles per day

(data set C, Appendix) had, on average, lower numbers of accidents per vehicle-km than did the older designed (and non-trunk) 'A' roads in the sample. This is not surprising though as accidents per vehicle-km on modern, 2-lane, single-carriageway 'A' roads are known to be about 11% lower than those on older roads (Highways Agency, 1996).

4.2 Sample of 75 modern rural single-carriageway trunk roads

Accident frequencies are not purely dependent on the exposure variables road length and flow, but can also be related to other factors, such as junction density, road width, bendiness etc. However, although the precise relationship between accident frequencies and geometric factors on rural roads in general is not known, TRL has developed one model (see equation 1) to predict accident frequencies on rural single-carriageway, modern, trunk roads which takes the effect of junction density into account (Walmsley and Summersgill, 1998).

(1)

Where: A = number of accidents per year
Q = 2 - way average daily flow (thousands)
L = road length (km)
J_{maj} = number of major junctions
J_{min} = number of minor junctions

[Note: A major junction is where traffic on the major road has to give way to traffic on another road e.g. at a signalised cross road or a roundabout and a minor junction is where traffic on a minor road has to give way to traffic on the major road e.g. a T-junction or crossroad.]

The model gives an average result of 80 accidents per 100kms/yr for the modern rural single-carriageway trunk road data - i.e. about 7% higher than the estimated value of 75 for all rural, single-carriageway 'A' roads in Table 2. The numbers of accidents per vehicle-km are lower on the modern roads than on the older roads (see section 4.1). These results are broadly consistent with the results for the different road classes (i.e. in Tables 2 and 3, as road class changes from 'A' to 'B' to 'C/Unclassified', the number of accidents per km decreases while the number of accidents per vehicle-km increases).

Table 6 shows the model predictions for different levels of flow and different numbers of (major) junctions. (Constant road lengths of 5km with 0.4 minor junctions per km are assumed.) As the 2-way flow increases from 6000 to 24000 per day, the accident rate falls (see section 4.1 also); as the number of junctions (and so junction density) increases, the accident rate increases.

Table 6 Variation in accident rate with flow and number of junctions, using Equation 1 with L=5km and J_{min}/L=0.4/km

Accident rate (per 10^8veh-kms/yr)	*Flow per day (2-way)*		
	6000	*12000*	*24000*
0.1 major junctions/km	21	18	15
0.3 major junctions/km	24	20	17

Table contents derived from data set C, Appendix

5 Accident types occurring disproportionately often

Another method of identifying safety problems is to identify predominant accident types - rather than overall accident rates. An *accident type* may simply be one such as 'single-vehicle accidents', or it may be one that occurs at a particular type of site, under a particular set of attendant circumstances, such as 'accidents involving overtaking vehicles, at rural junctions'. An accident type is defined as *predominant* if it features *disproportionately* often with respect to its *expected* frequency, and not if it merely features more often than another accident type.

Consider, for example, the number of accidents that occur during the day and the number of accidents that occur at night. Many more accidents occur during the day than at night but this is partly due to exposure, as most travel takes place during the day. If differences in traffic levels are taken into account, it is found that the percentage of accidents at night is generally greater than one would expect. In other words, the propensity for accidents is greatest at night, or the probability of an accident occurring at night is disproportionately large.

However, explicit levels of exposure are often not known - i.e. the proportion of travelling that is at night, or the proportion of journeys by bicycle, or on foot, or the proportion of junctions that are roundabouts etc. One way of identifying disproportionate accident types is to compare the accident types in one 'Study' area with those in another 'Control' area. The 'Control' area should be one which it is believed has similar characteristics and would therefore be expected to have similar levels of exposure (both in terms of traffic patterns and elements of road layout). Of course, no Control is perfect and the accident types identified may still reflect different levels of exposure between the Study and Control areas. The Control data could equally well camouflage a particular problem. If the Control area chosen is much larger than the Study area, it is likely that localised variability within the Control data will be minimised and so comparisons will be fairly robust. National data may provide the best Control data for many purposes.

Distributions of numerous accidents types occurring nationally were found for rural, single-carriageway roads using STATS19 1994 and 1995 accident data (Barker et al, 1998). The full, detailed results can be found in that report but a number of important results are given here in Tables 7 and 8.

These accident type percentages can be compared with the percentages of the same accident types occurring in a Study area in order to identify accident types that warrant further attention.

In the example in Table 9 above, the national (Control) values can be considered as being average values, with accidents at mini-roundabouts, T-junctions and private drive junctions each over-represented in the Study area. These three accident types are therefore deemed worthy of further investigation. Suppose though that it is known that the Study area has an unusually high usage of mini-roundabouts on 'A' roads - this alone may account for the high incidence of accidents at mini-roundabouts in the Study area. It is also likely that the difference in the proportion of accidents at T-junctions in the Study and Control areas (i.e. 1% - of 54%) is too small to be statistically significant and may be due to chance. The difference in the proportion of accidents at private drives or entrances in the Study and Control areas (i.e. 2% - of 21%) is more likely to be statistically significant, depending on the numbers of accidents involved and the size of the Control data set. Let us further suppose that the incidence of private drives and T-junctions is believed to be no higher in the Study area than in the Control area. Given these scenarios, one might conclude that it may be more likely to be possible to apply an effective remedial treatment at private drives on 'A' roads in the Study area than at T-junctions, despite the fact that fewer accidents occur at private drives than at T-junctions.

Naturally, when prioritising between several over-represented accident types, a cost-benefit analysis will probably favour the over-represented accident types with most accidents, but the availability of an appropriate treatment will also be a factor.

6 Discussion and conclusions

This work has successfully brought together data from different sources to gain a better understanding of the numbers of accidents on rural roads and where they are

Table 7 Percentage of all accidents of various types on rural, single-carriageway roads in Great Britain (1994/95), by road class

		Road class			
Accident variable (STATS19)	*Percentage of all accidents*	*A* %	*B* %	*C/Unclassified* %	*All* %
Junction types	Not at a junction	57	62	73	63
	At or within 20m of a junction	43	38	27	37
	At a private drive junction	8	7	5	7
	At a T/Y junction	24	22	16	21
	At a crossroads	7	7	4	6
No. of vehicles involved	Only involved 1 vehicle	26	36	37	31
	Involved more than 2 vehicles	19	11	6	13
Pedestrians	Involved at least one pedestrian injury	3	3	4	4
Lighting	Occurred in daylight	72	70	71	71
	Occurred at night on an unlit road	19	24	24	21
Weather/road surface	Fine & dry	54	52	52	53
	Wet	37	38	36	37
	Ice/snow	4	5	6	5

Table 8 Percentage of all vehicles involved in all accidents of various types on rural, single-carriageway roads in Great Britain (1994/95), by road class

		Road class			
Accident variable (STATS19)	*Percentage of all accident-involved vehicles*	*A* %	*B* %	*C/Unclassified* %	*All* %
Vehicle types	Pedal cycle	2	3	4	2
	Two-wheeled motor vehicle	5	7	6	7
	Light goods vehicle	5	5	5	5
	Public service vehicle/heavy goods vehicle	7	5	5	6
Driver age and sex	Male drivers/riders (all ages)	72	71	70	71
	Male drivers/riders under 25 years old	16	20	23	18
	Male drivers/riders over 59 years old	8	7	6	7
	Female drivers/riders under 25 years old	6	7	7	7
	Female drivers/riders over 59 years old	2	2	2	2
Vehicle manoeuvre	Parked	2	2	2	2
	Waiting to go ahead	7	3	2	5
	Stopping	4	2	2	3
	Turning right	10	9	6	9
	Waiting to turn right	4	2	1	3
	Overtaking a moving vehicle on its offside	6	5	3	5
	Going ahead on a left hand bend	8	14	19	12
	Going ahead on a right hand bend	9	15	20	13
	Going ahead - other	46	42	41	44

Table 9 Example of comparison between a fictional Study area and a Control area

	Study area		*National[1,2]/ (Control area)*
Junction type - 'A' road junctions	*No. of accidents*	*%*	*%*
Not at or within 20m of junction	-	0%	0%
Roundabout	2	1%	2%
Mini-roundabout	3	2%	< 1%
T or staggered junction[3]	85	54%	53%
Y junction	5	3%	4%
Slip road	2	1%	1%
Crossroads	22	14%	15%
Multiple junction	2	1%	1%
Private drive or entrance[3]	33	21%	19%
Other junction	4	3%	4%
Total	157	100%	100%

[1] *The national values given are the intervention levels for each type. Although the data relate to 1994 and 1995, they are still suitable for use as they show little change between years.*

[2] *Check suitability of using national data for comparison purposes by looking at the national average traffic and junction density values given in Table 1. If values in the Study area are very different, choose a more appropriate Control area for which data are available.*

[3] *Statistical significance would be determined by the use of an appropriate statistical test.*

occurring. The results show that the method one chooses to measure accident occurrence is important in determining where the problems are. For example, although the greatest proportion of accidents in Great Britain occur on rural single-carriageway 'A' roads, the greatest number of accidents per km occur on dual-carriageway 'A' roads, and the greatest number of accidents per vehicle-km occur on 'C/Unclassified' roads.

If we make the assumption that there is an underlying accident rate (due perhaps to some basic failure rate of drivers which is broadly proportional to exposure - or opportunity for accidents), and that if accidents are occurring above this rate there must be some additional cause - such as inadequate or ambiguous road design, then these latter accidents are the most likely to be worth targeting. Therefore, it is preferable to take some account of exposure when prioritising treatment. The most important exposure variables will be road length and vehicle flow, but other exposure variables (such as pedestrian flows, or junction density) will often be important too, especially when considering specific accident types.

6.1 Techniques for identifying areas suitable for intervention

The following techniques have been proposed as alternatives to considering accident *numbers* alone:

- *Considering numbers of accidents per km - identify the roads/areas with the most accidents per km.* As rural accident frequencies are very low this approach is only really useful when considering a major route or a whole area. This is because accidents are discrete events and only one accident on one km of road will result in an accident frequency greater than the national average fractional value.
- *Considering numbers of accidents per junction or per bend - identify the junctions (or bends) with the most junction (or bend) accidents per junction (or per bend).* For the reasons explained in the previous paragraph, this approach will be most useful when considering a whole area. One accident at a particular junction or bend will result in an accident frequency far greater than the

national average fractional value. Naturally, it is possible that several sites will have the same accident rates and prioritisation will then have to be based on other factors.

- *Considering numbers of accidents per vehicle-km - identify the roads/areas with the most accidents per vehicle-km.* Using accidents per vehicle-km is a major improvement on using accidents per km but as the number of accidents per vehicle-km itself varies with flow (see section 4.2 for example) some care is needed when comparing accidents per vehicle-km for roads with very different flow levels.
- *Considering numbers of proportions of accident types - identify accident types occurring disproportionately often in the Study area, with respect to a Control area.* This is a particularly useful technique for comparing accident types (for which accident numbers may be very low) and where explicit exposure data are unavailable. The main difficulty may be identifying a suitable Control area which has comparable levels of exposure and for which accident data are available - a national Control may be most appropriate.

The preferred option will vary, depending on the situation and on the quantity and reliability of exposure data that are available. The use of a combination of options may also be appropriate as the accident analyses progress.

Once the accident problems have been identified by one or more techniques, and possible remedial measures have been considered, a cost-benefit analysis will provide the final information required to prioritise remedial treatments.

6.2 Conclusions

The results reported here indicate that the *estimated* average numbers of accidents at (rural single-carriageway) bends are similar but very slightly higher than those *estimated* for junctions. Intuitively one might expect higher accident rates at junctions than at bends as the crossing nature of traffic movements at junctions would seem to offer the most opportunity for conflict. It is possible that bends are more likely than junctions to be hidden hazards (i.e. unsigned or not visible on the approach). However, the true bend accident frequencies are likely to be lower than estimated, firstly because some bends may not be identifiable from maps, and secondly because it is likely that some junction accidents are on bends but that the vehicle manoeuvres are not classified as bend manoeuvres. Research is currently being undertaken by TRL for DETR Road Safety Division to try to develop a greater understanding of safety at bends.

A number of the analyses performed in this report have been carried out to confirm the robustness of the various results used in generating the intervention levels. The investigations using subsets of national data have shown that the overall figures for Great Britain in Tables 1-3 (developed with estimated data where necessary) appear to be fairly robust. Traffic flows and road length are the most important factors affecting accident frequency but it should be remembered that accident rates vary appreciably from one road to another because of the range of non-motor vehicle flows, junction densities, road features etc.

The explorations of the variance in accidents per vehicle-km reveal that one can expect a left-skewed distribution for a given sample of roads. Only about one third of roads in the 236-road sample had numbers of accidents per vehicle-km that exceeded the mean for the sample. If rural intervention levels were based upon 85th percentile values of the distribution of the number of accidents per vehicle-km, for example, it is likely that only a few accident problems would be identified, limiting the scope for treatments and requiring new intervention levels to be set within a short space of time. Therefore, it is recommended that rural intervention levels should be based upon *mean* national figures in the first instance. These are summarised in Table 10.

Table 10 Rural intervention levels, by road class

Rural roads (speed limit ≥50miles/h)		*Number of accidents per year*			
	All accidents	*All*	*Non-junction*	*At bends*	*At junctions*
Carriageway type and road class	*Per 10^8 veh-kms*	*Per 100 kms*	*Per 100 kms*	*Per 100 bends (estimated)*	*Per 100 jtns (estimated)*
Single					
A	30	75	43	15	14
B	44	37	22	8	6
C/Unclassified	46	8	6	3	1
All	35	21	13	5	4
Dual					
A	24	243	108	-	170
Motorways	10	223	178	-	277
All	16	235	136	-	182
All rural roads	26	30	18	-	5

See Sections 1, 2.1, 2.3 and 2.4 for definitions and assumptions

7 Summary of rural intervention levels

Table 10 summarises the intervention levels relating to all accidents, bend accidents and junction accidents, developed for use on rural roads, by road class.

The proportions of individual accident types, which constitute intervention levels, are given in full in Barker et al (1998). The most applicable values have been reproduced in Tables 7 and 8 of this report.

The effectiveness of rural safety accident-remedial work must be monitored and rural intervention levels reassessed at regular intervals, and adjusted, as appropriate.

8 References

Barker J, Farmer S and Nicholls D (1998). *Injury accidents on rural single-carriageway roads, 1994-95: An analysis of STATS19 data*. TRL Report TRL304. Transport Research Laboratory, Crowthorne.

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Appendix A: Details of sample of 236 rural single-carriageway roads

Data set (reference)	*County source*	*Number of:* A roads	B/C/Uncl. roads	*Accident data*	*Comments*
A	Surrey	28	41	1991-95	• Data relate to two areas of county. • Major intersections excluded. • Road sections are route sections.
B (Baruya, 1998)	Cheshire Dorset East Sussex Staffordshire West Midlands Kent Somerset London Wiltshire West Sussex Hampshire	47	39	1992-96	• Major intersections excluded.
C (Walmsley & Summersgill, 1998)	Bedfordshire Cambridgeshire Norfolk Leicestershire Northamptonshire Staffordshire Lancashire Kent Nottinghamshire Durham Northumberland Cheshire Cumbria Oxfordshire Cornwall Devon Dorset Gloucestershire Somerset Wiltshire Hereford/Worcester Shropshire Humberside North Yorks South Yorks West Yorks	75	0	3-5yrs (from 1979-90)	• English trunk roads only - all new (post 1968) schemes with available data. • Widest roads (10m) excluded.
D (Hughes & Amis, 1996)	Cambridge	6	0	1988-94	

Abstract

This report describes a study for DETR Road Safety Division to suggest a set of accident-remedial intervention levels for use on *rural* roads (i.e. those with speed limits ≥50miles/h) as these roads rarely qualify for consideration under traditional intervention levels.

Rural intervention levels have been developed which take exposure into account explicitly (using accident rates - accidents per km, or per vehicle-km, or per bend or junction), or which relate to expected proportions of different accident types - using national data.

When the accident occurrence in a particular area or on a given road exceeds the intervention level, it is suggested that that area/road should be considered for accident-remedial treatment.

Related publications

TRL336 *Accidents on modern rural single-carriageway trunk roads* by D A Walmsley, I Summersgill and C Binch. 1998 (price £50, code L)

TRL335 *Accidents on modern rural dual-carriageway trunk roads* by D A Walmsley, I Summersgill and C Binch. 1998 (price £50, code L)

TRL334 *The relationship between road layout and accidents on modern rural trunk roads* by D A Walmsley and I Summersgill. 1998 (price £35, code J)

TRL304 *Injury accidents on rural single-carriageway roads, 1994-95: an analysis of STATS19 data* by J Barker, S Farmer and D Nicholls. 1998 (price £25, code E)

TRL202 *Trials of rural road safety engineering measures* by J Barker. 1997 (price £35, code H)

RR65 *Accidents at rural T-junctions* by D Pickering, R D Hall and M Grimmer. 1986 (price £20, code C)

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