Analysis of Portsmouth 20mph Road Casualty Data with Allowance for Random Variation

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Summary

The City of Portsmouth (UK) introduced 20mph speed limits on most of its residential roads in a scheme completed in 2008. In 2010, the Department for Transport published an analysis comparing Portsmouth road casualty data before and after the introduction of the new limits. The analysis gave raw figures but carried out little statistical analysis in drawing conclusions about which changes can be explained as year-to-year random variation, and which changes indicate a real change in the underlying risk to road users.

This report presents calculations based on the published raw data with allowance for random variation. The first conclusion is that the change in total casualties from 183 (before) to 142.4 per year (after) is statistically significant (P = 0.0005), with non-overlapping 95% confidence intervals. The decrease is a fall of 22%.

Secondly, the change in the killed and seriously injured (KSI) rate from 18.7 to 19.9 per year is not statistically significant (P > 0.5), with 95% confidence intervals that almost completely overlap.

In conclusion:

(1) On the total casualty rate
There is strong evidence that the underlying total casualty risk fell after the introduction of the 20mph speed limits.

(2) On the KSI rate
The change in KSI casualty rate is well within year-to-year random variation, with large uncertainties around the estimates of risk, due to the small numbers. Further data is needed before conclusions can be drawn concerning whether the KSI risk is affected by the introduction of 20mph speed limits.

Introduction

In the city of Portsmouth (UK), 20mph speed limits were introduced on most residential roads in a scheme completed in 2008. The Department for Transport published a report in 2010 summarising the changes and including data on road casualties during the 3 years before and the 2 years after the changes were introduced [1].

The raw data was that total road casualties fell from 183 per year before the change to 142.4 per year after the change, and killed and seriously injured (KSI) casualties increased from 18.7 per year before the change to 19.9 per year after the change. The DfT report gave little guidance on how these apparently conflicting changes might be interpreted, and different organisations have interpreted the figures in different ways. The *Daily Telegraph* concentrated on the change in KSI casualties, with the headline "20mph limit has not made roads safer" [2], and the *Daily Mail* similarly had a headline "Why death rates INCREASED in 20mph zones... " [3]. Road safety campaigners have highlighted the fall in total casualties [4].

It is regrettable that the DfT report gave little guidance on interpretation of the data because statistical techniques are available that can assist in understanding to what extent the changes seen reflect real changes in the underlying risk and to what extent they can be explained as part of year-to-year random variation. This report aims to give the guidance that is missing from the DfT report, so that campaigners and decision-makers can engage in an evidence-based debate.

Methods

The analysis in this report is based on Table A.3 of the DfT report, which is reproduced here as Appendix 1.

Consideration of random variation

Most people are familiar with the principles of random variation in random events. For example, if a particular kind of event happens randomly 10 times over 10 years, it is unlikely that it will occur exactly once each year; the rate will be once per year on average, but some years will contain no events, and some two, and maybe even more. With larger numbers of events, the proportional random variation is less, so if say 100 events occur randomly over 10 years, the average will be 10 per year, but typical values will be between 5 and 16 per year.

When events are purely random, the expected amount of random variation can be calculated via the Poisson formula [5]. For road casualties, there are some non-random factors affecting when the casualties occur (for example, there may be more than one casualty in a collision), but these effects are small, and the Poisson formula can be used as a guide to how much random variation there may be within observed figures.

By calculating the expected amount of random variation in the observed rate of road casualties, we can form an opinion on whether any observed change in the annual casualty rate could be part of year-to-year random variation, or is likely to indicate a real change in the underlying risk to road users. Statisticians do this by the calculation

of 95% confidence intervals (95% CIs) [5] which is a range around the observed rate. On average, 95% of these 95% CIs contain the true value. This report presents calculations of 95% CIs around the observed road casualty figures in Portsmouth.

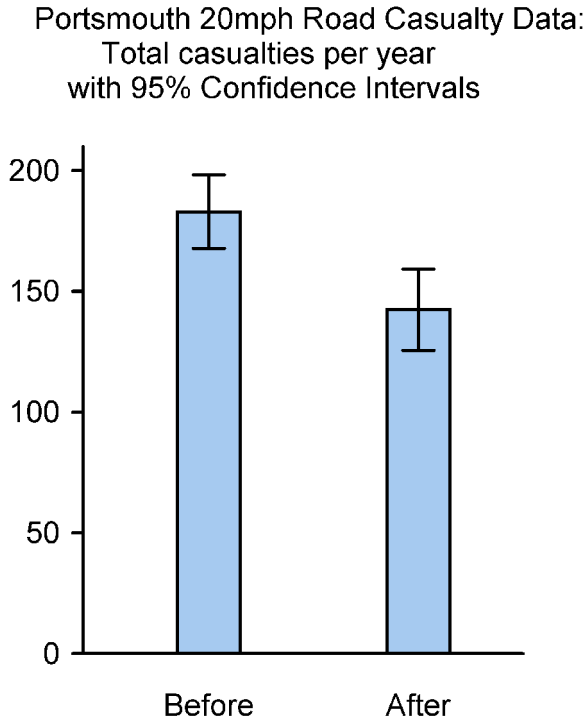
As well as calculations of 95% CIs, this report contains statistical tests of the change in casualty rates, giving a *P* value in each case [5]. The *P* value (ranging from 0 to 1) gives the chance of the observed changes (or more extreme changes) occurring when there is no change in the underlying risk. Hence low *P* values indicate that the changes seen are unlikely to be due to random variation, and so are likely to indicate a real change in the underlying risk. High *P* values indicate that the changes seen could well be part of natural random variation.

Results

The calculations are set out in Appendix 2.

Total casualty rate

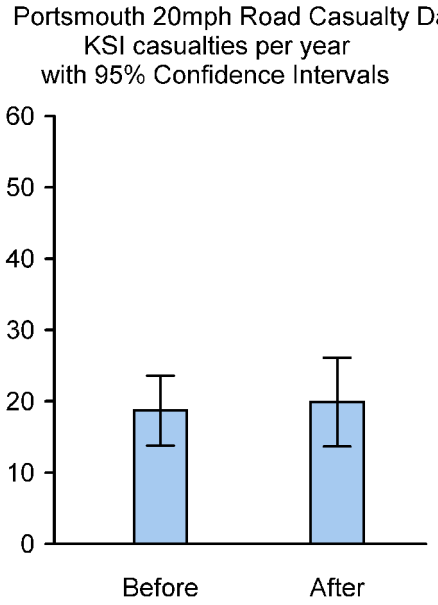
The chart compares the total casualty rate per year in the 3 years before and the 2 years after the introduction of 20mph speed limits. The rate changed from 183.0 to 142.4. The 95% CI for the 'before' rate was 168 to 198, and for the 'after' rate was 126 to 159. These confidence intervals do not overlap and a statistical test of the change



gives a highly significant *P* value of 0.0005 (see Appendix 3). We can therefore conclude that the change in observed rate is very unlikely to be due to chance year-to-year variation, and that there is strong evidence that the introduction of the 20mph limits is associated with a fall in the total risk of road casualties. The fall in casualties was 40.6 per year (95% CI 18 to 63), which is a fall of 22% (95% CI 10% to 35%).

KSI casualty rate

The second chart compares the KSI casualty rate in the 3 years before with the 2 years after the introduction of 20mph speed limits. The rate changed from 18.7 to 19.9. The 95% CI for the 'before' rate was 13.8 to 23.6, and for the 'after' rate was 13.7 to 26.1. These confidence intervals overlap almost completely and a statistical test of the



change is not statistically significant, $P > 0.5$. We can therefore conclude that the change from 18.7 to 19.9 is well within chance year-to-year variation, and therefore that there is no good evidence either way as to the effect of the introduction of 20mph speed limits on KSI casualties, and that more data is needed before an opinion on this can be formed.

Discussion and Conclusions

In summary, the total road casualties fell from from 183 to 142.4 per year in the 2 years after the introduction of the 20mph limits compared to the 3 years before, and this indicates a real reduction in risk to road users. There is too little data to draw conclusions from the KSI casualty figures, since the change from 18.7 to 19.9 is well within year-to-year random variation.

The effects of random variation can also be studied in the the variation across the 6 Portsmouth sectors in the data reproduced in Appendix 1, and restructured in Appendix 2. The total casualty rate fell consistently in all sectors, by between 11% and 44%, suggesting a relatively small random component in the observed figures. In contrast, the KSI rate fell in three sectors and rose in three sectors, with changes varying from -40% to +71%. This fits with the conclusions of the formal statistical analysis that the smaller numbers of KSI casualties means that random variation is proportionately much greater and dominates the observed KSI figures.

The lack of statistical analysis in the DfT report is disappointing since the calculation is straightforward, and can avoid misinterpretations by non-specialists. However, the lack of 95% confidence intervals in the DfT report is not unusual in the field of road casualty statistics, although a recent exception is the report from the North West Public Health Observatory [6]. Lack of consideration of random variation can lead to misinterpretations in several ways. For example, apparent falls in rates (which in reality are within random variation) can give false reassurance that road safety measures are working; and apparent rises in rates (in reality due to random variation) can give unjustified concerns that measures are not working. So a recommendation that arises from this report is that 95% confidence intervals should become more widely used in analysis of road casualty statistics.

References

1. Department for Transport (2010) *Interim Evaluation of the Implementation of 20 mph Speed Limits in Portsmouth: Final Report - September 2010* (http://www.dft.gov.uk/pgr/roadsafety/speedmanagement/20mphPortsmouth/pdf/20mphzoneresearch.pdf).

2. http://www.telegraph.co.uk/news/uknews/road-and-rail-transport/8038821/20mph-limit-has-not-made-roads-safer.html

3. http://www.dailymail.co.uk/news/article-1317430/20mph-zone-increases-death-rates-switching-cameras-reduces-accidents.html

4. http://www.20splentyforus.org.uk/press_releases.htm

5. Altman (1991) *Practical Statistics for Medical Research* Chapman and Hall, London.

6. Deacon L, Perkins C & Bellis M (2011) *Road Traffic Collisions and Casualties in the North West of England* (http://www.nwph.net/nwpho/Publications/Forms/rta.html).

Appendix 1. Portsmouth data (reproduction of Table A.3 of the DfT Report). Change in casualty numbers in Portsmouth sectors by road user type and injury severity.

Sector	Casualty Class	Before (Average of 3 year data)			After (Average of 2 year data)			% change	
		KSI	Slight	Total	KSI	Slight	Total	KSI	Total
Central East	Pedestrian	1.7	8.7	10.3	1.0	8.0	9.0	-40%	-13%
	Passenger	0.3	2.7	3.0	0.0	3.0	3.0	-100%	0%
	Driver/Rider	4.0	21.3	25.3	3.5	18.5	22.0	-13%	-13%
	Total	6.0	32.7	38.7	4.5	29.5	34.0	-25%	-12%
Central West	Pedestrian	1.0	6.0	7.0	1.5	4.5	6.0	50%	-14%
	Passenger	0.3	3.3	3.7	0.0	4.0	4.0	-100%	9%
	Driver/Rider	1.7	15.7	17.3	2.5	12.0	14.5	50%	-16%
	Total	3.0	25.0	28.0	4.0	20.5	25.0	33%	-11%
North East	Pedestrian	0.0	4.7	4.7	1.0	2.0	3.0	N/A	-36%
	Passenger	0.0	4.3	4.3	0.0	2.5	2.5	N/A	-42%
	Driver/Rider	2.7	18.7	21.3	2.5	9.0	11.5	-6%	-46%
	Total	2.7	27.7	30.3	3.5	13.5	17.0	31%	-44%
North West	Pedestrian	0.3	3.7	4.0	0.0	3.0	3.0	-100%	-25%
	Passenger	0.3	1.7	2.0	0.0	1.5	1.5	-100%	-25%
	Driver/Rider	1.0	10.7	11.7	1.0	6.5	7.5	0%	-36%
	Total	1.7	16.0	17.7	1.0	11.0	12.0	-40%	-32%
South East	Pedestrian	1.3	7.7	9.0	3.5	4.5	8.0	163%	-11%
	Passenger	0.0	8.7	8.7	0.0	2.5	2.5	N/A	-71%
	Driver/Rider	1.0	18.3	19.3	0.5	17.0	17.5	-50%	-9%
	Total	2.3	34.7	37.0	4.0	24.0	28.0	71%	-24%
South West	Pedestrian	2.0	8.3	10.3	1.7	7.4	9.1	-14%	-12%
	Passenger	0.0	4.7	4.7	0.0	4.6	4.6	N/A	-2%
	Driver/Rider	1.0	15.3	16.3	1.1	12.0	13.1	14%	-20%
	Total	3.0	28.3	31.3	2.9	24.0	26.9	-5%	-14%
All Sectors	Pedestrian	6.3	39.0	45.3	8.7	29.4	38.1	38%	-16%
	Passenger	1.0	25.3	26.3	0.0	18.1	18.1	-100%	-31%
	Driver/Rider	11.3	100.0	111.3	11.1	75.0	86.1	-2%	-23%
	Total	18.7	164.3	183.0	19.9	122.5	142.4	6%	-22%

Some values do not sum to the total due to rounding

Appendix 2: Calculation of confidence intervals of rates per year

	Sector	Before (3 years of data)								After (2 year of data)								Change in rate per year
		Years	Rate per year	Number observed	Variance of number observed	Rate per year				Years	Rate per year	Number observed	Variance of number observed	Rate per year				
						Variance	Standard error	Lower end of 95% CI	Upper end of 95% CI					Variance	Standard error	Lower end of 95% CI	Upper end of 95% CI	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	
Total Casualties	Central East	3	38.7	116	116	12.89	3.59	31.7	45.7	2	34	68	68	17.00	4.12	25.9	42.1	-12%
	Central West	3	28	84	84	9.33	3.06	22.0	34.0	2	25	50	50	12.50	3.54	18.1	31.9	-11%
	North East	3	30.3	91	91	10.11	3.18	24.1	36.5	2	17	34	34	8.50	2.92	11.3	22.7	-44%
	North West	3	17.7	53	53	5.89	2.43	12.9	22.5	2	12	24	24	6.00	2.45	7.2	16.8	-32%
	South East	3	37	111	111	12.33	3.51	30.1	43.9	2	28	56	56	14.00	3.74	20.7	35.3	-24%
	South West	3	31.3	94	94	10.44	3.23	25.0	37.6	1.75	26.9	47	47	15.35	3.92	19.2	34.6	-14%
	All Sectors	3	183	549	549	61.00	7.81	167.7	198.3		142.4			73.35	8.56	125.6	159.2	-22%
KSI Casualties	Central East	3	6	18	18	2	1.41	3.23	8.77	2	4.5	9	9	2.25	1.50	1.56	7.44	-25%
	Central West	3	3	9	9	1	1	1.04	4.96	2	4	8	8	2.00	1.41	1.23	6.77	33%
	North East	3	2.7	8	8	0.89	0.94	0.85	4.55	2	3.5	7	7	1.75	1.32	0.91	6.09	31%
	North West	3	1.7	5	5	0.56	0.75	0.24	3.16	2	1	2	2	0.50	0.71	0	2.39	-40%
	South East	3	2.3	7	7	0.78	0.88	0.57	4.03	2	4	8	8	2.00	1.41	1.23	6.77	71%
	South West	3	3	9	9	1	1	1.04	4.96	1.75	2.9	5	5	1.63	1.28	0.40	5.40	-5%
	All Sectors	3	18.7	56		6.22	2.49	13.81	23.59		19.9			10.13	3.18	13.66	26.14	6%

Notes

Cols 2 and 10: Taken from the DfT report: 'Before' data was collected for 3 yrs; 'After' data was collected for 2 yrs except for the South West sector where it was 1 yr 9 months.
Cols 3 and 11: The rate per year is taken from the DfT report, which is reproduced in Appendix 1.
Cols 4 and 12: The number of casualties observed is calculated from multiplying the rate per year and the number of years.
Cols 5 and 13: The variance of the total for a Poisson variable is equal to the total number.
Cols 6 and 14: The variance of the rate per year for each sector is calculated from the variances of the total divided by the square of the number of years. The variance of the rate per year for all sectors is calculated as the sum of the variances of the six sectors.
Cols 7 and 15: The standard error is the square root of the variance.
Cols 8 and 16: The lower limit of the 95% confidence interval is calculated from the rate less 1.96 times the standard error.
Cols 9 and 17: The upper limit of the 95% confidence interval is calculated from the rate plus 1.96 times the standard error.

Appendix 3: Comparison of 'before' and 'after' rates

	Rate before	Variance of rate before	Rate after	Variance of rate after	Change in rate	Variance of change	Standard error of change	Lower end of 95% CI of change	Upper end of 95% CI of change	z-value for change	P value for change
Total casualties	183	61.0	142.4	73.3	-40.6	134.3	11.6	-63.3	-17.9	3.50	0.0005
KSI casualties	18.7	6.22	19.9	10.13	1.2	16.4	4.0	-6.7	9.13	0.30	> 0.5

All *P* values are two-sided