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RURAL RESIDENTS' RESPONSE TO REDUCTIONS IN TRAFFIC NOISE CAUSED BY RESURFACING A SECTION OF MOTORWAY WITH POROUS ASPHALT

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ABSTRACT
A section of jointed concrete motorway in rural England was resurfaced with porous asphalt. Noise measurements and interviews with local residents took place just before the resurfacing work started, and again one and four years later. The resurfacing produced reductions in community noise exposure of about 4.5 to 6 dB(A) $L_{A10,18h}$ at villages about 0.5 km from the motorway. Noise levels had increased somewhat after three years, but were lower than they had been before the resurfacing. Smaller changes were observed at a village about 1.5 km from the motorway. The resurfacing was associated with reductions in noise dissatisfaction ratings.

1 - INTRODUCTION

A section of M40 about 3 km long was resurfaced with porous asphalt (PA) during 1994 as part of the routine maintenance of the motorway. The existing surface of jointed, brushed concrete had been repaired several times, and was in poor condition. Previous studies of PA and noise in the UK have shown that vehicle noise levels close to the road were 3 to 5 dB(A) lower than those measured near impervious surfaces [1]. The resurfacing of the M40 motorway provided an opportunity to measure the effectiveness of PA in reducing traffic noise at longer distances from the motorway, and to assess the perceptions the noise changes by residents in villages 0.5 to 1.5 km from the motorway − villages in which motorway traffic was the dominant noise source.

2 - METHOD

Surveys took place in 1994 (just before the resurfacing), 1995 and 1998. A village about 4 km along the motorway, beyond the effect of the resurfacing, was used as a control site. Unfortunately, this location was subsequently affected by the adjacent motorway being reconstructed with a stone mastic asphalt surface in 1997, and so could not be used as a control for the 1998 survey. The surveys were all done at exactly the same time of year (June) to minimise between-survey differences in vegetation and weather. During each survey, noise was monitored continuously at base-stations in each village. Shorter-duration measurements at satellite positions scattered throughout the villages enabled exposure to be estimated for each survey house. Indices included $L_{A10,18h}$ for the day preceding the interview at that house, and the average $L_{A10,18h}$ for the seven days preceding the interview, and for the month-long survey period. Wind and weather data were obtained from a weather station about eight miles from the study area; traffic flows were measured by existing buried-loop counters.

$L_{A10,18h}$ values at the base stations were adjusted for between-survey differences in wind velocity using analysis of covariance; covariates were the means of the 18 one-hourly components of wind velocity perpendicular and parallel to the motorway at its closest point to the base station. A correction for traffic flow was not needed because it varied little from survey to survey. The questionnaire asked about noise nuisance (dissatisfaction, bother and interference with various activities) indoors, in the garden and out and about in the area.

3 - RESULTS

3.1 - Effects of the resurfacing on noise exposure in the survey villages

Changes in $L_{A10,18h}$ at the survey villages are shown in Table 1. The wind normalisation procedure resulted in some substantial adjustments to the estimated effects of the resurfacing: the raw reductions in $L_{A10,18h}$ between 1994 and 1995 were 3.9, 2.7, 9.6 and 1.4 dB(A) at Aston Rowant, Lewknor, Postcombe and Tetsworth respectively.

Base station (& approx. distance of village from motorway, km)	Mean base-station $L_{A10,18h}$ dB(A) in 1994 survey month	Decrease [increase] in mean $L_{A10,18h}$ and 95% confidence interval (dB(A))		
		1994 to 1995	1994 to 1998	1995 to 1998
Aston Rowant (1.5)	52.0	1.9 ± 0.8	1.6 ± 0.7	[0.3 ± 0.8]
Lewknor (0.5)	60.1	4.7 ± 1.0	2.5 ± 0.9	[2.1 ± 1.1]
Postcombe (0.5)	67.4	6.1 ± 1.0	3.5 ± 0.9	[2.6 ± 1.0]
Tetsworth (control) (0.3)	70.8	[0.6 ± 1.1]	-	-

Table 1: Changes in $L_{A10,18h}$ adjusted for between-survey differences in wind velocity.

3.2 - Noise nuisance in each survey period

Assessments of dissatisfaction on a seven point rating scale ranging from 0 to 6, with 0 labelled 'definitely satisfactory' and 6 labelled 'definitely unsatisfactory' are reported here.
Table 2 shows ratings of dissatisfaction with noise from the motorway "overall, taking indoors and outside together."

Mean dissatisfaction rating	Aston Rowant				Lewknor				Postcombe				Tetsworth (control)		
	94	95	98	Stat sig*	94	95	98	Stat sig*	94	95	98	Stat sig*	94	95	Stat sig*
Last 24 hrs	2.6	2.1	1.5	2	3.2	1.8	1.9	1,2	4.7	2.5	2.8	1,2	3.7	3.6	
Last 7 days	2.8	2.3	1.6	2	3.5	1.9	2.3	1,2	4.7	2.6	3.1	1,2	3.8	3.5	
Last few months	3.2	2.4	1.6	1,2,3	3.6	2.0	2.5	1,2	4.7	2.9	3.0	1,2	3.6	4.1	
Sample size	36				57				40				49		

Table 2: Nuisance from motorway noise – "Overall, taking indoors and outside together".

* statistical significance: 1 = 94/95 means are significantly different at the 0.05 level (one-tailed test), 2 = 94/98 means are significantly different at the 0.05 level (one-tailed test), 3 = 95/98 means are significantly different at the 0.05 level (two-tailed test).
There was a substantial and statistically significant reduction in noise dissatisfaction in 1995 following the resurfacing at Lewknor and Postcombe and this was maintained in 1998. At Aston Rowant the reductions between 1994 and 1995 were mostly non significant, but there were further reductions in ratings in 1998. There were no statistically significant differences in ratings between 1994 and 1995 at the control site, Tetsworth.

3.3 - Effect of the resurfacing on noise nuisance

Responses to the noise dissatisfaction questions summarised in Table 2 will have been open to influence by wind-induced differences in noise exposure between the survey periods. Analysing the relation between

exposure and dissatisfaction provides a way of adjusting for such influences, and estimating the effect of the resurfacing itself on noise nuisance.
Figure 1 shows the relation between dissatisfaction with M40 noise indoors and out over the seven days prior to the interview, and the mean $L_{A10,18hr}$ noise exposure (not adjusted for wind) at the interview address during the same period. Addresses were grouped into five noise bands based on exposure during the 1994 survey. The five noise bands are − in $L_{A10,\ 18h}$ dB −: 45 to <50; 50 to <55; 55 to <60; 60 to <65; 65 to <70. The regressions were weighted according to the number of addresses in each group. The 1994 'before-change' regression line lies above the others, indicating that the effect of the change in exposure is greater than that predicted by the steady-state relations between noise and nuisance. This pattern is familiar from previous research on the effects of traffic noise changes on community response (e.g. [2]).

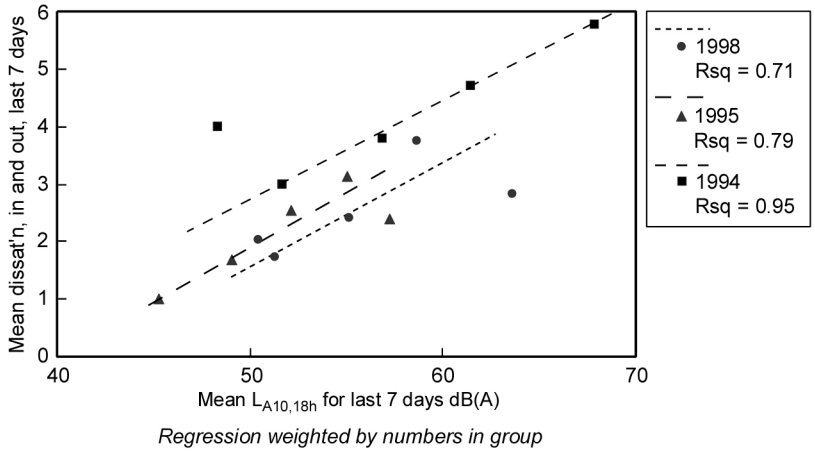

Figure 1: Dissatisfaction vs. noise exposure.

An analysis of covariance was used predict the effect on dissatisfaction ratings of a given change in exposure. Table 3 shows the results of using this to predict the change in dissatisfaction associated with the wind-normalised changes in noise from Table 1. It indicates that resurfacing was associated with substantial reductions in mean dissatisfaction ratings in 1995, with benefits persisting in 1998.

Site	1994 to 1995 decrease in dissatisfaction rating	1994 to 1998 decrease in dissatisfaction rating
Aston Rowant	1.1	1.4
Lewknor	1.6	1.5
Postcombe	1.8	1.7

Table 3: Estimated shifts in dissatisfaction ratings ("overall, taking indoors and outside together") associated with the wind-adjusted noise changes at the survey sites.

4 - CONCLUSIONS

1. The study provides good evidence that resurfacing with porous asphalt reduced noise exposure by about 4.5 to 6 dB(A) $L_{A10,18h}$ at survey villages about 0.5 km from the motorway and that benefits were still apparent four years afterwards. Smaller changes were observed at a village about 1.5 km from the motorway. The resurfacing was associated with significant reductions in noise dissatisfaction ratings.

2. The fact that respondents at the control site showed no significant changes in dissatisfaction ratings between 1994 and 1995 gives reassurance that extraneous factors such as national publicity about traffic noise, and certain types of re-interviewing effect, were not responsible for the observed reduction in dissatisfaction ratings. Responses may nevertheless have been influenced to some extent by uncontrolled factors tending to increase or decrease the apparent benefit of the resurfacing.

3. The change in dissatisfaction ratings following resurfacing was greater than would be predicted from 'steady state' relations between noise exposure and dissatisfaction. This 'excess' effect of a *change* in noise has been observed in previous studies.

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