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A NOISE INCIDENCE SURVEY OF ENGLAND & WALES

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1.INTRODUCTION

The reason for conducting a survey of environmental noise levels was to provide information about the noise climate in England and Wales against which the effectiveness of national or future European noise legislation could be measured, and to indicate priorities for noise control initiatives. The main results of this survey are in the form of mean noise levels and also the percentage of the population exposed to specified noise levels. As well as providing figures for England and Wales as a whole the data can be subdivided by groupings such as regional areas and population density. It should be possible to compare future measurements against this base data to show the effect of noise legislation in controlling noise levels e.g. if the source levels of road vehicles are reduced what effect has this on the noise climate of the population at large. It will also be possible to check any long term trends in the noise climate, for example to test the hypothesis that the background noise level is increasing with time.

Having decided on the main purpose of the survey, decisions had to be made on how the aims of the survey could most efficiently be achieved. The following key factors were considered :

I.The Survey Sample -
- (a) How to select the sample.
- (b) How many places to sample.
- (c) Where to measure.

II.How to quantify the noise exposure -
- (a) Measurement procedure.
- (b) Noise indices to take account of temporal variation in level.

2.PREVIOUS SURVEYS

There have been two major surveys in the U.K. which are relevant. The first was the London Noise Survey [1] carried out in the early 1960s. In 1972 the TRRL carried out a survey of Noise and Road Traffic Outside Homes in England [2].

In other countries there have been a number of noise surveys of interest for example a national noise survey of the U.S.A. [3], a survey of Kentucky [4], a study of a Greek city [5] and a traffic noise survey of Rome [6].

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3.THE STRATEGY FOR CHOOSING THE SAMPLE FOR THE MAIN SURVEY

The application of the results from the analysis of the survey data depend on the way in which the survey sample is chosen. There are two fundamental possibilities for a Noise Incidence Survey:-

(1) To sample the noise level with respect to the land area.
(2) To sample the noise level with respect to the population.

The first option would produce results such as the area of land exposed to noise greater than given levels. The second option is considered to be of most value as it produces results in the form of percentages of the population exposed to levels of noise exceeding a given level. It is not feasible to measure at every dwelling in the country therefore some form of spatial sampling strategy must be used.

There are several options for a sampling with respect to population. Selection of sites can be made using: (a) a random selection; (b) a grid; (c) a stratified sample; or (d) any combination of these methods.

(a) A truly random selection is a simple concept but in practice would be unmanageable. To choose a sample in which every dwelling had an equal chance of being selected for measurement was considered to be a mammoth computing task and wasteful of measuring resources as this method would result in excessive travelling between individual measuring sites.

(b) A system of superimposing a grid over the area to be measured and selecting the points of intersection for measurement was used in the London Noise Survey and similar techniques have been used in later surveys. This method on its own gives a sample related to land rather than people. A variation of this method was used in Vancouver [7] in which a 0.1 mile grid defined 56000 intersections of which 10000 were selected.

(c) The spatial sample can be chosen by stratification based on various factors such as population density, geographical location, road types, land-use classes etc. A national noise survey of the U.S.A. [3] stratified areas by population density and geographical location. One hundred sites in residential areas were chosen which were not exposed primarily to major transportation noise. From earlier work it was shown that for "non-highway traffic, motor vehicle volume is proportional to population density". A simple empirical relationship between Day-Night noise level and population density was developed from the literature and this model was validated by the survey results. A survey of Kentucky used 20 sites of various sizes that represented a quarter of the State population [4]. Non-transportation sites were selected to represent a range of land-use classes and additional sites were chosen for the measurement of highway, aircraft and railway noise. The national traffic noise incidence and annoyance survey in England [2] used a sample based on Local Authority Areas (LAA) and the electoral roll. LAA were selected with probability proportional to electorate, stratified by region and population density. Two electorial wards were selected from each LAA, also with probability proportional to electorate. Twenty-four addresses where interviews were to be attempted were selected from

each of the 300 chosen wards. It was possible to select 600 measuring positions to represent the noise levels at a sub-sample of 1200 houses that were closely clustered.

Sampling method (c) was chosen as being most suited to the requirements of this survey. A similar method of stratification to that used in the 1972 traffic noise survey was employed with a sample size of 1000 dwellings in 50 Local Authority Areas, with measurements made at 10 dwelling in each of 2 wards in each LAA.

4.THE STATISTICAL CONFIDENCE OF THE RESULTS

Data from the National Traffic Noise Survey (2) gave an indication of the statistical errors likely in the estimates of mean $L_{A10,18h}$. In that survey mean $L_{A10,18h}$ values were calculated for each of the regions. The standard deviations of these values were in the range 5-8dB(A) for numbers of measurements in the range 36-95 for each region. The mean of all the regional $L_{A10,18h}$ values was also calculated. This had a standard deviation of about 8dB and was calculated from the total of 529 measurements.

Examination of the variance of the measured noise levels revealed that all the measurements were not independent because of the close proximity of some of the measuring positions. The number of independent measurements - the effective sample size - was thus reduced to 271. This fixed the standard error of the national mean $L_{A10,18h}$ as 0.5dB. The standard errors of the regions estimated on a similar basis are larger but do not exceed 1.7dB. It was estimated that using a sample size of 1000 for the current survey the standard error for the national mean noise incidence level ($L_{A10,18h}$) would be 0.3dB or less and if the survey was repeated at a later date it should be possible to detect long-term changes as small as 1dB.

5. DEFINING THE NOISE CLIMATE

Overall noise levels vary from one moment to the next as well as conforming to established patterns of variation :- hourly, diurnal, weekday/weekend, seasonal.

The moment to moment variation in noise level is accounted for by the noise indices calculated. Because of the diurnal variation in levels, the London Noise Survey used different indices to describe conditions at different times of the day concentrating its analysis effort on $L_{A10,T}$ during the day and $L_{A90,T}$ at night. In some countries a nightime penalty is applied to the noise level such as in the use of L_{DN} in which the nighttime levels are considered to be 10dB greater than actually measured. $L_{Aeq,T}$ is the index now used for measuring environmental noise from industry, railways and aircraft in the U.K. For aircraft and railway noise a measure of maximum level may also be appropriate and an indication of this could be given by measuring $L_{ADI,T}$. The International Standard ISO 1996-2:1987 [8] specifies that environmental measurements should be made using $L_{Aeq,T}$ and allows the additional use of percentile levels.

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Previous studies have tended to show that,in urban areas the daytime $L_{A10,T}$ and $L_{Aeq,T}$ levels are reasonably constant and that a few measurements during the period 1000h to 1800h will satisfactorily represent the daytime levels. However this is not the case at night and may not be the case where noise levels are not determined primarily by road noise. With the ready availability of noise data-logging systems there would seem little justification in temporal sampling and a full 24 hour evaluation of noise level was made. By recording $L_{A01,1h}$, $L_{A10,1h}$, $L_{A50,1h}$, $L_{A90,1h}$, $L_{A95,1h}$ and $L_{Aeq,1h}$ throughout a 24 hour period, all the common indices are can be calculated.

Major previous studies have considered typical working weekdays and therefore it is logical that this survey should do the same. There is day to day and seasonal variation in noise levels caused by weather conditions, volume of traffic and occurrences of other noise sources. Small seasonal variations in a study of six sites are reported by Fothergill [9] but to some extent such small variations will even out over the sample as a whole as measurements have been taken over a period from January to December. Most significant day to day variations, particularly in the quieter sites where the nearest major source may be several hundred metres away is likely to be caused by changes in the wind direction, evidence of this has been found in previous studies [10]. The method of choosing the spatial sampling is unlikely to produce measuring positions which are biased either upwind or downwind from the nearest major noise source. Taking measurements on consecutive days would not have taken into account much of this variation. To measure each measuring point on individual days to account for day to day variation would escalate the cost and was not considered to be justified.

Recording $L_{A01,1h}$, $L_{A10,1h}$, $L_{A50,1h}$, $L_{A90,1h}$, $L_{A95,1h}$ and $L_{Aeq,1h}$ for a 24 hour period on a normal working weekday at each of the sample positions was judged to provide a good measure of the noise environment. Because traffic flow patterns change during school holidays these periods were excluded. Measurements were made 1 metre from the front facade of a dwelling, at 1.2 metres above ground level.

6.SITE CLASSIFICATION

To enable models that relate noise levels to land use to be tested several methods of site classification were used to fully describe each site. Site Classifications used were:

1. Population density.
2. Type of district categories (e.g Urban, Rural etc.).
3. A description of major noise sources in the locality.
4. A classification of nearby roads and distance from roads.
5. A subjective classification of each site as very noisy, noisy, quiet or very quiet.

This information also enables analysis of the noise climate of specific sub-groups of the population.

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7. RESULTS

An example of the data recorded at each site is shown in Table 1.

TABLE 1

151104 9 Any Road, Somewhere
SE 18.96 Local Authority Wards
23_07_90 3 3 4 3 1 1 1 1 2
23000 00000 000011200 30 006 001000310 30 100

START	LEQ	L 1	L 10	L 50	L 90	L 95
16:00	53.9	64.1	55.1	49.3	45.3	44.3
17:00	55.4	66.7	56.0	49.6	46.2	45.4
18:00	53.9	65.4	55.1	49.3	45.8	45.0
19:00	55.3	64.3	54.4	50.1	46.6	45.8
20:00	54.9	66.0	53.8	48.4	44.3	43.3
21:00	52.0	63.2	53.5	46.8	43.0	42.0
22:00	54.3	63.2	51.9	45.7	41.1	39.8
23:00	48.2	59.7	49.9	43.6	39.3	38.4
00:00	43.4	55.2	45.7	38.7	31.7	30.3
01:00	41.7	50.2	44.8	37.5	30.8	29.5
02:00	38.7	48.7	42.7	32.6	26.6	25.7
03:00	39.1	67.5	58.8	38.7	30.5	29.7
04:00	47.9	56.7	47.3	38.2	29.2	27.5
05:00	45.1	52.2	47.6	41.4	35.9	33.9
06:00	48.7	50.1	50.4	44.2	40.0	39.1
07:00	52.1	64.2	53.6	45.5	39.0	37.6
08:00	53.3	65.9	53.3	46.7	40.5	39.1
09:00	51.4	63.3	52.2	46.4	40.8	39.3
10:00	52.8	65.2	53.2	46.9	42.8	41.8
11:00	55.4	67.1	54.1	47.6	43.1	42.2
12:00	52.1	63.7	53.0	47.4	43.2	42.1
13:00	51.1	62.4	52.7	46.9	43.0	42.1
14:00	50.9	62.7	51.9	47.0	43.5	42.6
15:00	51.8	63.3	53.3	47.3	43.4	42.5
18HR	52.9	63.8	53.2	47.2	42.8	41.8
24HR	51.9	60.9	51.2	44.6	39.6	38.5

There were 1000 records in this form and from these data the distribution of noise levels outside dwellings in England & Wales was estimated in terms of various commonly used noise indices.

The mean $L_{Aeq,18h}$ for the whole sample was 56.7dB with a standard deviation of 5.8dB. Values for common noise indices are given in table 2.

Table 3 gives the percentages of the population exposed to levels of 30, 40, 50, 60, 70dB for

indices $L_{A10,T}$, $L_{Aeq,T}$, and $L_{A90,T}$ over time period of 24 hours, 18 hours (06.00 to midnight), 16 hours (07.00 to 23.00), 8 hours (23.00 to 07.00) and 6 hours (midnight to 06.00).

TABLE 2

Noise Index	Mean	Standard deviation
$L_{Aeq,16h}$	56.7	5.85
$L_{A10,16h}$	56.3	7.28
$L_{A90,16h}$	42.7	6.40
$L_{Aeq,08h}$	47.7	6.34
$L_{A10,08h}$	44.4	6.74
$L_{A90,08h}$	33.5	5.26
$L_{Aeq,18h}$	56.3	5.84
$L_{A10,18h}$	55.6	7.29
$L_{A90,18h}$	42.1	6.24

TABLE 3

	Percentage of Population Exposed to Levels Exceeding				
Noise Index	30dB	40dB	50dB	60dB	70dB
$L_{Aeq,16h}$	100	99.9	89.3	26.0	1.8
$L_{A10,16h}$	100	99.5	81.2	28.2	4.8
$L_{A90,16h}$	98.1	64.9	12.1	1.2	
$L_{Aeq,18h}$	100	99.8	87.7	24.7	1.6
$L_{A10,18h}$	99.9	99.2	77.1	26.0	4.2
$L_{A90,18h}$	98	61.2	10.9	0.6	
$L_{Aeq,24h}$	100	99.8	80.8	20.0	0.8
$L_{A10,24h}$	99.8	98.4	55.8	14.9	0.7
$L_{A90,24h}$	96.9	44.5	4.4	0.1	
$L_{Aeq,06h}$	99.5	81.1	20.8	1.9	
$L_{A10,06h}$	98	63.5	13	1.3	
$L_{A90,06h}$	62.5	6.9	0.3		
$L_{Aeq,08h}$	99.6	91.4	31.8	4.6	
$L_{A10,08h}$	99.3	74.7	18.3	2.4	
$L_{A90,08h}$	73.9	10.4	0.5		

Fifty-percent of the sample were exposed to $L_{A10,18h}$ exceeding 54.2dB and $L_{A90,18h}$ 41.7dB. The percentage of sites above a level of 68dB $L_{A10,18h}$, (which is the qualifying level for insulation under the UK Noise Insulation Regulations for new roads), is 7%. Half the dwellings in the sample that face main roads (i.e. 'A' Class roads) were found to have an $L_{A10,18h}$ greater than 68dB.

If day is defined as the 16 hours from 07.00 to 23.00, as used in the U.K. for the assessment of aircraft noise round major airports, then half the dwellings in the sample had an $L_{Aeq,16h}$ greater than 55.8dB; for the corresponding night period, 23.00 to 07.00, half the sample were exposed to noise levels greater than $L_{Aeq,8h}$ 46.9 dB. It should be remembered that noise levels in the survey are those measured from all noise sources at each site.

Table 4 shows the proportion of sites where various noise sources were found. Road traffic noise was the most common source of noise and was present at over 90% of the sites, although only 5.2% of the sample faced 'A' Class roads.

Table 4
Noise sources heard at either front or rear of dwelling

Roads	91.9%
Aircraft	62.2%
Animals & Birds	57.1%
Domestic Noise	15.8%
Trees rustling	18.4%
Children	18.4%
Railways	15.2%
Farm Equipment	9.5%
Construction Work	5.1%
Industrial Noise	3.8%
Motorways	2.3%

8.DISCUSSION

The arithmetic mean $L_{A10,18h}$ for the whole sample is 55.6dB which shows very little change in level since 1972 when a survey carried out by the Transport and Road Research Laboratory gave a mean $L_{A10,18h}$ for the whole country of 57dB. Since 1972 the noise from individual road vehicles has been reduced by stricter controls enforced under the Construction and Use Regulations and the noise from aircraft reduced by the introduction of 'Chapter III' aircraft. At the same time the volume of traffic on the road has approximately doubled and the length of public roads increased by about a quarter.

Only about 10% of the population have background noise levels at night exceeding 40dB on the $L_{A90,8h}$ index. However 56% have daytime levels exceeding the WHO recommendation of 55dB $L_{Aeq,day}$ to prevent significant community annoyance. (The WHO recommendation does not specify the daytime period and it has been taken to be 07.00 to 23.00h).

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