Department of Health

Noise and Insomnia: a study of community noise exposure, sleep disturbance, noise sensitivity and subjective reports of health

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EXECUTIVE SUMMARY

Annoyance caused by noise is a major source of complaint to local environmental health offices. Indeed, it is an undisputed fact that people are annoyed by a wide range of external noise events. It is also clear that non-auditory factors such as noise sensitivity and attitudes to noise are important in determining the level of annoyance. There is also considerable evidence of both objective and subjective sleep disturbance by noise. The effects of noise on mental health have been examined in a variety of ways. For example, there have been studies of noise and psychological symptoms both in the workplace and community. Noise annoyance is associated not only with noise exposure but with reporting of symptoms. While previous research suggests associations between noise exposure, noise sensitivity, noise-induced sleep disturbance and reports of health it is unclear how these factors relate to one another, and whether any associations might reflect characteristics of the person, such as negative affectivity (the tendency to perceive and report negative aspects of the environment and self).

The present project aimed to combine two different approaches to examine associations between community noise exposure, sleep disturbance, noise sensitivity and subjective reports of health. The first approach involved community surveys which allowed identification of cross-sectional and lagged associations. Following this, sub-groups defined in terms of noise exposure, noise sensitivity, sleep disturbance and health had their noise exposure at night objectively assessed and their sleep recorded using actimeters. The outcomes of these different approaches enabled us to test different models of associations between noise, noise annoyance and sensitivity and subjective reports of health.

An initial pilot study was conducted to determine the feasibility of the proposed surveys and to determine whether specific models could be examined in the main surveys. Results from this study (based on a sample of N=103) suggested that the questionnaire was in a suitable form. The results also suggested a model that could be tested in the main study. Reports of noise exposure and noise sensitivity were related to reports of noise-disturbed sleep. Noise exposure, noise sensitivity and noise-disturbed sleep were associated with reports of impaired health. The associations between noise, noise sensitivity and health largely reflected the personality trait of negative affectivity. Associations between noise-disturbed sleep and health were still significant when negative affectivity was covaried.

The main survey studied a random community sample selected from the electoral register. The sample (N=543) was found to be a representative one (based on comparisons with census data). Similarly, brief information obtained from over 400 non-responders showed a similar pattern to those who completed the full questionnaire. The cross-sectional results confirmed that effects of noise sensitivity and noise exposure largely reflected negative affectivity. However, there were still significant associations between noise-disturbed sleep and health even when negative affectivity was added to the analyses. These results were confirmed when exposure to a specific noise source (aircraft noise at night) was examined.

Three main problems were present in the first survey. First, noise exposure was generally low and, secondly, it was based entirely on the reports of the participants. These two problems were overcome by studying groups living close to major airports, some of whom were exposed to high levels of aircraft noise at night (living in night noise contour areas of > 57 dB) whereas others had low exposure. The research involved structured interviews at areas around specified airports and a postal survey of some of the airports where interviews were conducted and also other airports. High and low night time aircraft noise areas around each of the airports were identified and participants randomly selected (either from the electoral register or the postal address register). The data from the interviews (N=1,221) and postal questionnaire (N=648) confirmed the model suggested by the Bristol data. These results confirm that it is important to focus on the disturbed sleep as the perceived sleep disturbance was associated with perceived health problems (both physical and mental health). However, a third problem with these cross-sectional studies was that the direction of the causality could not be determined (i.e. Does noise-disturbed sleep cause health problems, or do health problems lead to greater susceptibility to noise-disturbed sleep?).

The next step in the research was to examine associations between longitudinal changes in noise exposure, noise sensitivity, noise disturbed sleep and health. This involved a 12 month re-test of the Bristol sample. 275 participants in the main survey completed a similar questionnaire 12 months later. This sub-sample were representative of the original one and did not differ significant from those who only completed the questionnaire at time 1 on any of the major variables of interest. Regression analyses were conducted on the data from the sub-sample who completed the questionnaire twice and the results revealed an identical pattern to the analyses carried out on the data from the whole time 1 sample. The results showed that ratings of noise exposure, noise sensitivity, interference with sleep and reported health were reliable over time (all correlations > 0.6). Perceived increases in noise exposure were correlated with increases in noise sensitivity and noise disturbed sleep (correlations in the range 0.2 to 0.3). However, changes in these variables were not generally associated with changes in reported health. One must now consider why noise disturbed sleep, which had shown such a strong association with health in the cross-sectional analyses, was no longer associated in the longitudinal analyses. One possibility is that the absence of an effect reflected the fact that many of the participants showed no change over time. Analyses were, therefore, conducted excluding those who showed no change in sleep disturbance. These still showed no effect of changes in noise disturbed sleep on changes in the health outcomes. There is, perhaps, a more straight forward explanation of why associations were found in the cross-sectional analyses but not the longitudinal. Noise disturbed sleep is often regarded as a symptom. Correlations between symptoms are usually high, hence the strong association between noise disturbed sleep and health outcomes in the cross-sectional analyses. However, they are also reliable over time and this explains why when the original effect is removed there is no longer an association at time 2.

The next part of the research moved from subjective reports to measuring noise exposure at night and recording sleep. One of the final questions in the main survey asked whether the person would be willing to have their noise exposure and sleep monitored in their own home. The aim was to identify couples who were willing to have this done because (a) one of the main influences on sleep is the person sleeping next to you, and (b) if couples are studied the measurement of noise exposure covers two participants rather than one.

Forty-five people who took part in the survey fulfilled the above criteria. Their partners also completed the questionnaire and this sample of 90 took part in the study. This cohort were representative of the main sample in terms of demographic characteristics and their responses to the questionnaire. Indeed, the cohort showed an identical pattern of associations to those found with the main sample. Five CEL 460 dosimeters were used to perform all monitoring and storing of noise data. The dosimeters were set up to store detailed profiles of LAeq,5s and Lmax,5s continuously for a preset period starting at 2300hrs and ending at 0800hrs over three consecutive nights, giving 12960 data points for each night at each location; 38,880 in total. The dosimeter microphones were mounted on microphone stands positioned at least 1m away from walls and 1.5m from windows at a height of between 1.2m to 1.5m above the floor. ‘Fast’ response was used for all measurements.

The dosimeters were set to cover the range of 25dB to 100dB(A) and have therefore recorded under-range or an over-range flags against the data points for any five second periods where noise levels were outside this range. Where an under-range occurred the data for Leq would not have been valid and therefore the data set to null; the values of Lmax would still have been valid and logged as normal. The missing data below 25dB(A) is not considered to be a disadvantage as it is low enough to be of little concern. Over-ranges can also be ignored as they were generally only caused by the subjects, either preparing to or awakening from sleep.

Data from the dosimeters were passed through various stages of conversion to import the numbers as time histories into dBTrait, a software package from 01dB. This software enables viewing of the data, coding using cursors and subsequent production of various noise indices about the time histories. Both LAeq and Lmax were imported as separate channels within this software.

Once converted, the first and last data points from every time history were checked against the original files to ensure the conversion process was successful. Markers were then manually added to the time histories to indicate the sleep start and end points for each of pair of subjects under consideration. Data for the period when both subjects were indicated as being asleep was then manually coded using the cursors. This was to identify various patterns found within the time history data; such as short high level rises in noise level or more general longer term rises.

Short events were defined as those lasting 60 seconds or less and exceeding 50dB(A) LAeq,5s at the maximum. Long events were defined as more general increases in background levels: no specific threshold was used but raised levels were those lasting more than 60 seconds. Once data coding was complete, various noise parameters could then be generated by the software for each short and long event along with hourly values of LAeq.

It should be noted that there are limitations to this method of data coding. Primarily it was not possible to identify the source of the rises in noise level identified as either long or short events. Some rises in noise level were identifiable; such as hourly clock chimes found in some of the data. However most sources do not have such easily predicted patterns. It follows therefore that it was also not possible to identify whether the noise source was inside or outside the room, although data before and just after sleep time, and just before and after wake times, were eliminated from the analysis to reduce the effect of noise from the subjects.

Noise and sleep measurements were taken over three nights including either a Friday or a Saturday night. The noise monitors were set to record between 11pm and 8am, the sleep watches were active for the whole three days and nights and the volunteers encouraged to wear the watches for as long as possible, the minimum being at least two hours before they went to bed. Volunteers were asked to press the marker button on the sleep watches when they first tried to go to sleep and when they awoke prior to getting up, not if they woke during the night. Sleep onset and awakening times were calculated by the sleep watch software after due reference to the markers in the sleep data (where present) and the volunteers sleep diary. For each of the three nights the noise monitors were active they recorded every 5 seconds the noise level both as average level (Leq) and a maximum level (Lmax) over the five second period. This continued over the 9 hour period.

From the objective sleepwatch data and the subjective sleep diary data sleep onset and wake times were deduced. The sleepwatches measure movement using an accelerometer and similar to the noise monitors records this reading over 5 second periods. The sleepwatch analysis software uses an algorithm based on level of movement in any 5-second period and the preceding and following periods to give a value of asleep or awake for that period. A global measure of number of hours sleep per night was derived, this was the difference between sleep onset and awakening, not taking into account any wakening during the night. Using this variable and the sleep/wake data from the actiwatch software, measures for actual sleep time, sleep efficiency and immobility as percentages and total activity and sleep fragmentation index as totals were derived.

In addition to the objective measures of sleep using the sleepwatch, each person was asked to fill in a sleep diary for each night of monitoring giving subjective measures of sleep quality. Visual analogue scales were used to measure how long they took to go to sleep, quality of sleep and how quickly they awoke. The sleep diary also asked how many times the person woke during the night, whether they were aware of any noise during the night and if so did it disturb their sleep. The procedures for measuring sleep and noise were effective with the main problem being the inability to distinguish self-generated noise from other sources. High correlations between the measures taken on different days suggest that we were studying stable effects.

Overall, sleep was good and, for the group as a whole, noise exposure was low. However, there was considerable individual variation in most measures. The results showed that there were no significant associations between the noise variables and the actiwatch variables. This probably reflects the low level of noise as associations are found with louder noise exposure. Three significant associations between noise exposure and sleep were obtained. The first showed that the number of noise events influenced the reported quality of sleep. Similarly, the number of noise events were correlated with the questionnaire scores of interference with sleep. Finally, higher noise levels were associated with being awake at the start and end of the night. It is unclear whether this represents an effect of noise on sleep latency and on awakening, or whether the higher noise levels reflect the higher self-generated noise when a person is awake.

None of the sleep parameters were associated with the mental health measures. However, those with higher GHQ scores were exposed to more noise during the night. Again, it is unclear whether the noise was from an external source or self-generated.

A final study addressed the issue of noise sensitivity. In this laboratory study noise annoyance to standard noise exposure was measured and volunteers also set noise exposures to a level where annoyance was beginning to occur. Blood pressure was monitored during quiet, loud white noise (80dB) and helicopter noise (varying intensity, Lmax = 80 dB). Questionnaire measures of noise sensitivity were not related to the annoyance but there was some evidence that mental health was related to changes in annoyance, with high GHQ scores being associated with initial sensitivity to noise but then reduced sensitivity following a noise exposure. Both white noise and helicopter noise led to increases in blood pressure. The effect of the white noise habituated quickly but the helicopter noise continued to elevate blood pressure. Noise sensitivity, noise annoyance, usual noise exposure and noise-disturbed sleep were not correlated with the blood pressure changes. In contrast, negative affectivity and psychopathology were associated with more rapid habituation to noise.

Overall, the results from the present studies may be summarized as follows. First, associations between reported noise exposure, noise sensitivity and health outcomes largely reflect negative affectivity. Secondly, while noise disturbed sleep is associated with impaired health this may reflect the fact that it is a symptom, and nothing correlates better with symptoms than other symptoms. Indeed, there is no evidence of a causal relationship between noise disturbed sleep and health. Objective measurement of noise exposure and sleep show little association between the two. Indeed, where associations do exist these may reflect self-generated noise while wake. Number of noise events during sleep appear to be related to subjective reports of impaired quality. Again, it is unclear whether this represents an effect of noise on sleep or whether individuals who have poor sleep are more likely to notice noise and attribute their poor sleep to this. These results were obtained in situations where noise exposure was generally low and sleep good. Louder exposures may clearly have a greater impact but it is unlikely that the majority of the population are exposed to this type of situation on a regular basis.

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