DYNAMIC RANGE OF AMBIENT NOISE AND SLEEP

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Introduction Presented are the results of monitoring regarding the question whether the disturbance of sleep depends on equivalent continuous sound pressure level or on single noisy events in an otherwise relatively quiet environment. The monitoring of the effects of noise on health that was repeated three times already (and is still ongoing) is based on a 9-year monitoring of noise levels in outdoor environment in residence areas and three (1995, 1998, 2002) health questionnaire surveys, each time in approximately 10,000 respondents in a total of 21 towns in the Czech Republic. Results of the previous surveys were presented at the congress "Noise Effects `98" held in Sydney.

Methods The basis of the system is parallel monitoring of environmental noise alongside with the health of people exposed to the noise under monitoring. The study was conducted through the monitoring of noise and indicators of health at selected noisy as well as quiet localities, with similar populations and numbers of inhabitants that were adequate from the point of view of statistical significance, i.e. 300 to 1,000. The averages of twenty-five 24-h LAeq in 42 individual localities form a continuous series of values. The average noise levels in the survey from the last period (1998-2002) expressed as LAeq ranged from 39 to 69 dB in daytime, from 30 to 54 dB at night, when expressed in LA90. Average values of the differences between the 1%-level (LA1) and the 90%-level (LA90) at night in individual localities ranged from 2.5 dB to 23.6 dB. There were no significant differences among individual localities in terms of window orientation of dwelling rooms facing noisy streets, and there was only a slight increase of the number of windows facing noisy streets in noisy localities. There is, however, a significant increase in the percentage of respondents in noisy localities who open their windows less, or not at all, which applies not only in daytime, but also during the night. At the same time, the occurrence of selected indicators of health with regard to the so-called "civilisation" diseases, the influence on sleep and neurotic syndromes was monitored using a questionnaire (based on CINDI) assessing selected health indicators and demographic, sociological, and lifestyle data. In this way, answers including data on the selected indicators of health were obtained from subjects aged 30 - 90 years. The number of answers obtained in the last health survey was 12,182 in 2002. In all the follow-up periods, a relationship between the noise at the site of residence and the prevalence of "civilisation" diseases was demonstrated by means of a regression curve (fitted) in a field of resulting points. Morbidity, expressed as the percentage of diseases prevalent in the population in each locality, was 81% to 103 % in the last period under study. The significance of the relationship between noisiness during the night expressed in LAeq and reported morbidity had better probability than 90 % (p<0.1).
The effect of nosiness on sleep was evaluated using questions asking both about falling asleep and about the duration and quality of sleep as well as the use of hypnotics. The frequency of occurrence of having difficulty falling asleep and of bad sleep was assessed using the following categories: no (exceptionally), rarely (about twice a month), occasionally (1-2 times a week), and more frequently (more than twice a week). The duration of sleep was assessed using three categories: less than 6 h on a daily basis, 6-8 h, and more than 8 h. The use of hypnotics was assessed using the following categories: regularly daily, rarely, and never. Using the answers from the respondents and noisiness at individual localities, a field of resulting points was

obtained that was subsequently fitted with a regression curve expressing the relationship between the answers and noisiness.

Results: Increasing levels of noisiness (LAeq) are associated with decreasing numbers of respondents who state having no difficulties falling asleep, which can be followed from the answers to the question: "Do you have any difficulty falling asleep (or exceptionally); the decline is statistically significant ($p< 0.005$) according to the regression curve by 10%, from 53 to 43%. Difficulties when falling asleep rarely occurred in 18–22% ($p< 0.05$), occasionally in 17–18%($p<0.05$), and more frequently in 10%–15%($p<0.025$). The percentage of respondents who do not have any sleep disturbances is derived from answers to the question: "Do you have bad sleep (or exceptionally)". Increasing noisiness in LAeq is accompanied by decreasing percentages of respondents who do not have bad sleep, and this relationship is again statistically significant ($p<0.005$); a decrease by 11%, from 44 to 33%. No statistical significance, however, was apparent for all more detailed questions, and the difference in values was 4-5%. When noisiness was expressed as LA-90, the percentage of respondents answering that they do not have bad sleep decreases statistically significantly with the noisiness according to the regression curve ($p<0.005$), by 11%, from 43 to 32%. Similarly, the number of respondents who had no difficulty falling asleep declined significantly with increasing noisiness expressed as L-90, by 9%, from 52 to 43%($p<0.005$). The results for more detailed questions are numerically similar to those for LAeq, but there is no statistical significance. When the noisiness in the localities was expressed as the difference between the average value of noisy events, e.g. LA-1, and the average value of permanent background noise, e.g. LA-90, increasing values of the difference were significantly associated with decreasing numbers of respondents who had no difficulty falling asleep by 9%, from 54 to 45%;($p<0.005$). The number of those who responded that they had no sleep disturbances declined by 10%, from 45% to 35%. The results for more detailed questions show a statistically significant increase in the percentage of those who had frequent problems falling asleep, by 4%($p<0.05$), from 10 to 14%, and an increase by 3%($p>0.05$) in the percentage of subjects with frequently disturbed sleep, i.e. from 14 to 17%. The effect of noise on average duration of sleep was weak and not significant. The effect of noise on use of hypnotics was manifested by significant increase of irregular use in case of LAeq (21%-28%, $p<0.025$) and L-90 ($p<0.05$). A decline of the percentage of subjects who were not using hypnotics was statistically significant for LAeq (72%-62%, $p< 0.025$) and LA-90 ($p< 0.05$). For the difference LA-1 – LA-90, the decline was weak and not significant.

Discussion: It is obvious from the results given above that the declines in the number of subjects who had no difficulties falling asleep or bad sleep were similar and statistically significant for all three descriptors of noisiness used. The association with disturbances of falling asleep was found the strongest in LAeq in all categories of more detailed questions, and in the question about occasionally disturbed sleep. A slightly significant association was found for the difference LA-1 – LA-90 to the question asking about occasional disturbance of sleep, with an increase of occurrence by 3%. The use of hypnotics is clearly most dependent on LAeq. It is therefore not necessary to prefer the use of dynamic range of noise, if the noise events are not following closely after each other, so probably to a lesser extent disturbing the process of falling asleep than strong variable permanent noise. For evaluation of the disturbance of sleep the dynamic range of ambient noise is approximately equally significant as LAeq. It can be concluded that LAeq is a sufficiently suitable descriptor of ambient noise for the purposes of monitoring of its effects on sleep, and it is not necessary to employ other descriptors in all cases – their use should be reserved for extreme cases.

Keywords: dynamic range of noise, sleep, LAeq, L-90, L-1–L-90, health study