

# Is noise exposure in non-industrial work environments associated with increased sickness absence?

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Noise in non-industrial workplaces is an increasing problem. Annoyance and complaints over noise are frequently reported in these workplaces, whereas the risk of hearing damage is usually not the major concern. An important question arises for this type of noise of low to moderate intensity; that is, if it could be a cause of increased sickness absence, for example, via a mechanism starting with job dissatisfaction or via health problems caused by the noise exposure. This paper discusses this question starting from epidemiological studies on sickness absence, and supplemented with field and laboratory studies that address intermediate steps on the path to sickness absence, such as job dissatisfaction, symptoms, and physiological stress reactions. Only 3 epidemiological studies have investigated the effect of occupational noise on sickness absence. In the one study most pertinent to the question raised above, noise was associated with increased sickness absence in women holding jobs with complex work tasks. No firm conclusions can be made based on the studies that have illuminated possible intermediate steps to sickness absence. One reason is the wide variety of scopes and contexts addressed in these studies; the workplace exposures that have been investigated spans noise in schools, open-plan offices, hospitals and noise from ventilation systems, etc. Another reason is the presence of major weaknesses in many of the studies, such as confounding effects and problematic exposure assessments. It is concluded that based on the level of the current evidence an association between occupational noise exposure of low to moderate level and sickness absence is possible, but to settle the question more high quality studies are needed.

## INTRODUCTION

Occupational noise exposure has increased in Denmark in recent years according to self-reporting [1]. Data from the Danish Work Environment Cohort (DWECS) show that in 2005 approximately 1/3 of the working population was exposed to loud noise or to disturbing noise for at least ¼ of the working time. The proportion was highest among employees in jobs outside the industries and trades, for example, among educationists, primary school teachers, office workers, computer workers, hospital nurses etc. Noise problems in non-industrial professions have been observed and reported in other countries as well, for example, among pre-school teachers [2] and primary school teachers [3;4].

Since the 8-hr equivalent sound levels in general are low to moderate in

non-industrial jobs, the risk of hearing damage and other auditory effects is not the primary concern. On the other hand, even sounds at low levels can be a nuisance and a source of annoyance and irritation. If this was to be the only concern of noise of low to moderate sound levels, then it may be economical to use the resources on preventing other work environment exposures with a more serious and documented health risk. However, annoyance and irritation may lead to general dissatisfaction and consequently the use of sickness absence as a way of coping. Also, the psychological effects are not the only concern with regard to occupational noise exposure. Studies involving occupational groups with intense noise exposures demonstrate that there might be a link between occupational noise exposure and physiological stress reactions [5], elevated blood pressure [6]

and cardiovascular morbidity and mortality [6-8]. Such studies lead to the question if also noise exposure of low to moderate sound levels in is associated with adverse health effects, which in turn is expected to increase the risk of sickness absence, a consequence of great significance both for the individual, the workplace and for the society in general. The purpose of this article is therefore to present and discuss the evidence for a link between non-industrial workplace noise and sickness absence.

### WHERE TO LOOK FOR THE EVIDENCE

If there is a documented association between high level industrial noise exposure and adverse extra-auditory effects, why is it not possible to extrapolate risks from high sound levels (industrial levels) to lower levels (non-industrial levels)? The reason is that it is unlikely that the mechanism by which noise causes adverse health effects is the same for all sound levels. At high sound levels noise may feel physically unpleasant or even painful.

Having these unpleasant experiences, or just fearing to have them, may cause stress reactions. Noise of lower sound levels cannot work this way. Therefore it is important to focus on these studies where noise levels are typical for those in non-industrial workplaces.

The question of an association between occupational noise and sickness absence can be investigated either by studying directly noise exposure and sickness absence by studying associations between noise and intermediate steps along the pathway of increased absenteeism (Figure 1). An example of such an intermediate step is job satisfaction. Job satisfaction integrates many aspects of psychosocial work environment as well as individual psychological characteristics, and low job satisfaction is a risk factor of sickness absence in men [9]. Other relevant outcomes are psychological stress, fatigue and other symptoms, as well as physiological changes associated with stress reactions [10]. All these endpoints are plausible outcomes of noise exposure and are known or surmised predictors of sickness absence [11;12].

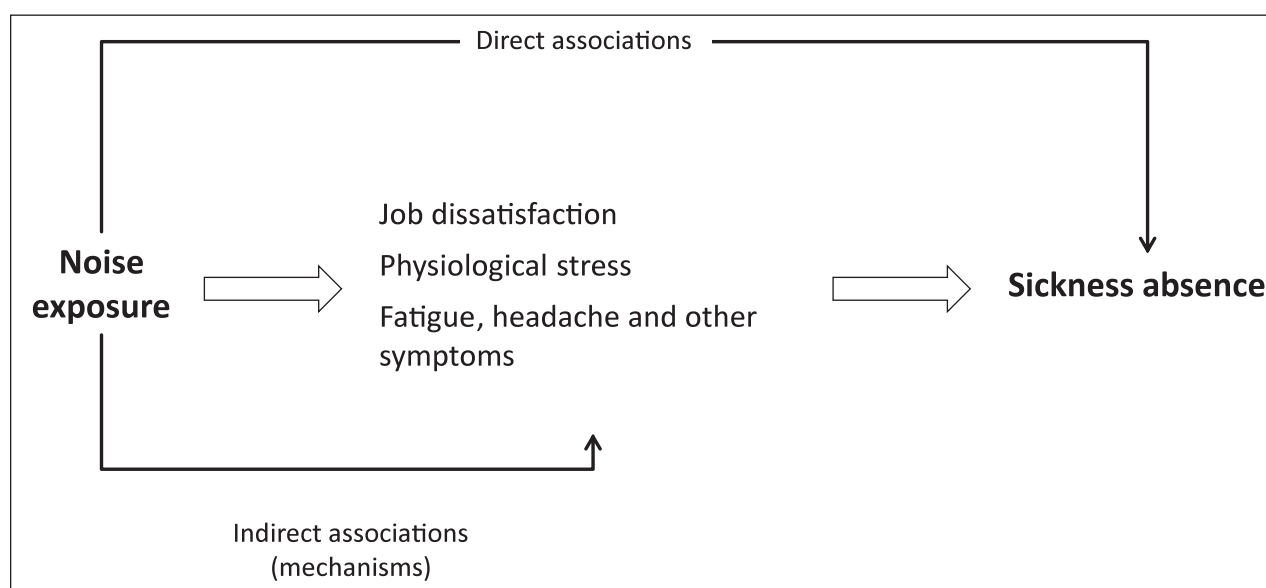


Figure 1. The association between noise exposure and sickness absence can be studied either directly or indirectly. The latter includes studies on the association between noise exposure and intermediate steps in the pathway to sickness absence.

Table 1. Studies on noise and sickness absence.

Study	Subjects and context <sup>a</sup>	Noise assessment	Sickness absence measure	Confounders adjusted for	Main findings
[13]	2,368 blue-collar workers (1,680 males and 688 females) from 21 manufacturing plants (the Cordis study)	Steady-state sound levels measured twice a day, twice a year at each work station. The levels defined as low (<75 dBA), moderate (75-84 dBA), and high (≥85 dBA)	Occurrence of ≥2 absences per year (from certificates)	Gender	Significant increase in the proportion of workers with high sickness absence with increasing noise levels (both men and women) .
[14]	802 white-collar workers (396 men and 484 women) ) from 21 industrial plants (the Cordis study)	Representative levels measured twice a year. Mean for all 271 workstations 63 dBA.	Sickness absence spells in a 2 year period (certified sickness absence)	Age, gender, tenure, industry, job classification, somatic complaints, use of hearing protection device	Sickness absence significantly associated with sound level for women holding complex job tasks
[15]	A random sample 5,186 employees in Denmark (2,657 men and 2,539 women) (the Danish Work Environment Cohort Study)	Self-reported ("Are you exposed to noise so loud that you have to raise your voice to talk to other people"). Responses divided into "¼ to most of the time", "¼ to ½ of the time", "rarely/very little", and "never".	Sickness absence spells ≥ 2 weeks from a national register (DREAM) .	Age, gender, length of education, cohabitation (living alone/living with a partner), number of children living at home, BMI, alcohol intake, smoking habits, physical workload	Sickness absence significantly associated with intermediate noise levels in men.

Notes. aType of workplace or noise studied.

## SICKNESS ABSENCE

Three studies have investigated the association between occupational noise exposure and sickness absence. The study by Melamed et al. [13] on blue-collar workers may be a little out of scope in this article that focus on noise in non-industrial workplaces. The results are nevertheless relevant because the authors find that in women sickness absence is increased in the group exposed to moderate noise levels, defined as between 75 and 85 dBA (there was too few women exposed ≥ 85 dBA to investigate the effect of high exposure in women). One of the limitations in this study is that the association might have been by confounders, such as the age and socio-economic status of the subjects. Also the fact that the study population was recruited from 21 different plants with possible different policies regarding employee absenteeism may have affected the results. The results in this study should therefore be regarded with some caution.

The study by Fried et al. [14] addressed noise and sickness absence in white-collar workers. Examples of the jobs held by the participants were computer programmers, mechanical engineers, laboratory technicians,

secretaries, accounting clerks and chemists. After adjusting for potential confounders including those mentioned above a significant three-way interaction between gender, job complexity and sound levels was found. That is, for female employees in jobs of high complexity (as rated by experts) measured sound levels had a significant influence on the sickness absence. In contrast, no association was observed between sound levels and sickness absence in female employees holding jobs of low complexity, and also not for men in jobs of either high or low job complexity. The interpretation suggested by these results is that noise imposes an extra mental workload, which is extra demanding in subjects engaged in complex task. But it is not obvious why this should be different for men and women, and therefore these results call for a closer examination of the effects of noise in persons involved in cognitively demanding tasks. This question will be addressed below when reviewing evidence for physiological reactions to noise as observed in laboratory studies.

Long-term sickness absence (≥ 14 days) were studied by Clausen et al. [15] and significant associations were found with moderate levels of self-reported noise exposure in men, but not to high

*Table 2. Field studies of the association between noise in non-industrial work environments and outcomes that increases the likelihood of sickness absence.*

Study	Subjects and context	Noise assessment	Main effect measures	Main findings
[16]	2391 office employees at 58 sites	Not measured	Environmental satisfaction, job satisfaction, performance rating	Environmental and job satisfaction, but not self- or supervised rated performance, were correlated with self-rated noise disturbance
[17]	N=439 (33% men) in 3 types of workplaces (industry, offices, laboratories)	60 dBA in average, most exposures in the range 50-65 dBA, all <85 dBA	Symptoms, symptom index	Non-significant (P=0.08) tendency to higher symptom index with higher sound levels
[18]	2856 office workers (1425 women, 1431 men)	59 dBA	Symptoms of the "sick building syndrome"	Sick building syndrome associated with self-reported noise levels, but not with measured sound levels
[19]	947 office workers (468 women, 479 men) in 5 buildings	40-61 dBA depending on the building	Symptoms of the "sick building syndrome"	Low-frequency noise associated with stuffy nose, itchy eyes, and dry skin
[20]	N=128 (44% men) in a government agency office	55 dB	Self-reported job satisfaction, health and well-being and organizational commitment	Lower job satisfaction, lower organizational commitment and more symptoms in group exposed to high job strain and high noise levels.
[21]	N=11 nurse in a pediatric intensive care unit	60.6 dBA (day: 61.2 dBA; night: 58.8 dBA)	Stress rating, salivary amylase activity, heart rate (HR), percent of time in tachycardia (HR>100 BPM), number of ectopic episodes	Heart rate, time in tachycardia, and stress and annoyance positively associated with sound level.
[22]	N=36 nurses at a coronary critical care unit	50-56 dBA	Perceived psychosocial work environment	Reduction in self-reported demands and pressure in the afternoon shift with reduction in reverberation time and improved speech intelligibility index. Reduction in self-reported strain in all shifts.
[23]	N=78 4 <sup>th</sup> grade school children (10 years of age)	59-87 dBA (equivalent daily sound levels with the class in the classroom)	Blood pressure, heart rate, salivary cortisol, disturbance rating, symptoms, emotional rating	Disturbance rating and symptoms (fatigue, headache) significantly correlated with sound levels. Cortisol difference (morning minus midday level) significantly correlated with sound levels

levels of self-reported noise exposure, after adjusting for a large number of potential confounders (Table 1). It is puzzling that risk of sickness absence was not increased at the highest exposure level, but a possible explanation is that the use of hearing protection is more prevalent in this group. Furthermore, it may be speculated that the lack of an association between noise exposure and sickness absence in women reflects that men and women are distributed unequally between blue- and white-collar jobs. The absence of an association between noise and sickness absence in women therefore suggests that occupational noise exposure in white-collar jobs is not associated with increased long-term sickness absence in women. One of the limitations of the study is the self-reported nature of the noise exposure. Persons that perceive their working environment as stressful have a higher risk of sickness absence

[11;12], and it is easy to believe that they also will perceive the work environment as noisier than their non-stressed colleagues.

The brief review of the three studies in Table 1 illustrates some of the problems in trying to directly address the association between noise exposure and sickness absence. Sickness absence is a non-specific outcome, and it is difficult and sometimes impossible to rule out confounding factors. It is quite reasonable to try to address the problem by looking for associations between noise and intermediate steps along the pathway to sickness absences (figure 1).

## FIELD STUDIES ON THE INTERMEDIATE STEPS TO SICKNESS ABSENCE JOB SATISFACTION

Sundstrom et al. [16] (see Table 1) found a significant negative association

between self-rated disturbance by noise and both (self-rated) job satisfaction and environmental satisfaction. However, correlating two self-reported measures run the risk of falling into the “triviality trap” [28], and this is likely to be the case with regard to disturbance and job satisfaction. In comparison, Leather et al. [20] found no association between objectively measured noise levels and job satisfaction. However, when including job strain in the analysis they found a significant moderating effect of noise exposure on the effect of strain on job satisfaction and organizational commitment. That is, in high strain subjects, increasing noise levels were associated with increased dissatisfaction, but not in low strain subjects. The cautious remarks regarding interaction effects also pertain to these results.

## SYMPTOMS

In the study by Kjellberg et al. [17], a symptom index was constructed consisting of responses to questions about fatigue, irritability, difficulty concentrating and tenseness. Measured sound levels described a near-significant fraction of the variance in the symptom index ( $p=0.08$ ). In the previously mentioned study by Leather et al. [20] an interaction was found between job strain and objectively measured noise with regard to various common symptoms (fever, headache, sore throat, muscle pains etc.). The frequency of reported symptoms was

significantly higher in the high strain, high noise group compared to the low strain, low noise group and the low strain, high noise group. Wålinder et al. [23] in a study of schoolchildren did find a clear correlation between daily equivalent sound levels in occupied classrooms and symptoms in schoolchildren (aged 10 years), for example, fatigue and headache. However, two measurements above 80 dBA are doubtful as they seem unrealistically high, in particular one measurement of an equivalent daily sound level of 87 dBA. The measurement is much higher than equivalent levels obtained in occupied classrooms in other studies [29-31]. The sound levels were recorded by stationary unsupervised monitors placed in the classrooms, and it cannot be ruled out that one or two high measurements are due to deliberate acts from some children.

The association between noise exposure and the sick building syndrome has also been investigated (see Table 2). The sick building syndrome denote the presence of various (at least 2) unspecific symptoms such as fatigue, drowsiness, headache, eye irritation, dry throat etc. Ooi et al. [18] found that self-reported noise exposure but not the measured sound level was associated with a significantly increased risk for sick building syndrome. That both exposure and outcome relies on self-reports increases the likelihood that the results are caused by confounding effects. In contrast to

*Table 3. Laboratory studies of the association between noise and physiological reactions.*

Study	Subjects and tasks	Noise exposure	Physiological effect measures	Main findings
[24]	40 women, simulated office work	Open-plan office noise at 55 dBA	Urinary cortisol, adrenaline and noradrenaline	Increased excretion of adrenalin in noise conditions.
[25]	19 women and 13 men, cognitive tests	Low-frequency ventilation noise at 40 dBA	Salivary cortisol	Increased excretion of cortisol in saliva in noise sensitive subjects in noise conditions.
[26]	28 women sensitive to low-frequency noise, cognitive tests	Low-frequency ventilation noise at 45 dBA	Salivary cortisol	No effect of noise on salivary cortisol.
[27]	10 women, cognitively demanding tests	Open-plan office noise at 65 dBA	Salivary cortisol, heart rate, heart rate variability	No significant effect of noise on physiological parameters.



the study just mentioned, Niven et al. [19] found significant associations between objectively measured low frequency noise and symptoms (stuffy nose, itchy eyes and dry skin), while high frequency noise was associated with reduced frequency of stuffy nose, that is, a protective factor. It is noteworthy that the symptoms (stuffy nose, itchy eyes and dry skin) are not those that normally are linked to noise, such as fatigue and headache. Rather, these symptoms are expected to be related to the air quality. The results are therefore under suspicion of having been confounded by the effects of mechanical ventilation, since mechanical ventilation systems are known to be a source of low frequency noise.

## STRESS

The effect of noise on work stress was investigated in a hospital coronary critical care unit by Blomkvist et al. [22]. Questionnaires were used to obtain information about the psychosocial working environment in two 20-day periods. In one of these periods the ceiling was covered with sound reflecting tiles, while in the other period it was covered with sound absorbing tiles. Sound absorbing tiles lead to an improved acoustic environment measured as reverberation time, speech intelligibility, and lower sound levels. All shifts experienced a reduction in self-reported arousal with sound absorbing ceiling compared to sound reflecting ceiling. However, as the authors rightly point out, it was not possible to conduct the study in a completely blinded fashion, and this should be taken into consideration when interpreting the results based only on only self-reports.

Morrison et al. (2003) found for 11 nurses in a hospital pediatric intensive care unit that measured average sound level was associated with both higher stress rating. However, for reasons

explained below, a confounding effect seems to be present which can have influenced this result.

## PHYSIOLOGICAL STRESS REACTIONS

Physiological measures have for unknown reasons rarely been employed in the field studies of noise effects. In the study mentioned above, Morrison et al. (2003) found that higher measured average sound level with higher mean heart rate (30 min intervals), longer time in tachycardia (>100 beats/min) after control for some confounders (seniority, shift, coffee intake). However, the rather strong association between sound level and heart rate (85 beats per min at 55 dBA to 110 beats per min at 65 dBA – equivalent to normal speech level at close distance) appears unphysiological, and it suggests the presence of a confounding effect, for example, hectic activity or a contribution to sound measurements from the nurses own voice.

In the study by Wålinder et al. (2007) physiological stress reactions were measured in schoolchildren during school. The change in cortisol (morning minus midday level) was significantly correlated with daily equivalent sound levels. From the results presented in the article it seems, however, that the association between cortisol and sound levels is likely to disappear if the extreme equivalent sound level of 87 dBA is omitted. A daily equivalent sound level of 87 dBA must be considered doubtful for the reasons explained earlier.

## LABORATORY STUDIES OF PHYSIOLOGICAL REACTIONS TO NOISE

The association between noise and activation of the physiological stress systems has also been investigated in laboratory studies. In the study by Evans and Johnson (2000) the test persons were working in a simulated

office environment with simulated office tasks in a background office noise or in quiet conditions. The subjects working in background noise excreted more adrenaline but not more cortisol in the urine compared to test persons working in the quiet conditions.

The exposure to low frequency ventilation noise was studied by Waye et al., (2002) and Bengtsson et al. (2004). In the experiment with cognitively demanding tasks (Waye et al., 2002), the subjects reporting to be noise sensitive had an altered pattern in cortisol excretion after the experiment. In the study where test subjects solved cognitively simple tasks, no effects on cortisol or stress levels were observed (Bengtsson et al., 2004).

Kristiansen et al. (2009) studied the effects of office background noise on cortisol excretion, and on heart rate and heart rate variability in subjects performing mentally demanding tasks on a computer. Subjects did the tasks with and without the background noise. Mentally demanding work elicited marked changes in heart rate and heart rate variability, while noise did not significantly affect any of the physiological indicators. These results seem to exclude the possibility of an acute physiological stress reaction to noise while engaged in cognitively demanding tasks. However, the relatively short duration (approximately 30 min) of the exposure does not exclude that physiological signs of cognitive exhaustion may develop after a longer period of noise exposure.

## CONCLUSIONS

At present, too few studies have been dedicated to the question of noise and sickness absence, particular noise at low to intermediate sound levels as in non-industrial workplaces, to give a clear answer. The study by Fried et al (2004) suggests that noise in combination with complex work tasks impose an extra

burden that can result in sickness absence. This interesting finding should be verified in other studies before a verdict can be made.

A somewhat higher number of studies have searched for effects that could be on the path to sickness absence. Results are inclusive with regard to job satisfaction, stress and unspecific symptoms. The wide variety of contexts and outcome measures contributes to the apparent lack of consistency. Another contribution comes from the presence of weaknesses in many of the studies, for example, confounding effects, problematic exposure assessments, the “triviality trap”, etc. Confounding is more easily controlled in laboratory studies, but once more the scarcity of studies makes it difficult to draw a firm conclusion. For every significant finding there is almost always another study made under similar conditions but with negative results.

Based on the level of the current evidence it must therefore be concluded that an association between occupational noise exposure of low to moderate level and sickness absence is possible, but to settle the question more high quality studies are needed.

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#### **NO (AMPLIFIED) TALKING ON THE BUS**

New York City Council has passed a bill that would ban open-air tour buses from using speakers to talk to tourists. Residents along tour bus routes have complained that the sound penetrates buildings. Twin America, the company that owns Coty Sights and Gray Line tour buses, feels the industry is being unfairly singled out. A company official estimates it will cost \$5 million to install a new quiet sound system that would force passengers to listen to their guide through headphones.

#### DEAFNESS IN DHAKA

According to a sample survey done at 21 spots in Dhaka (Bangladesh) by the Society for Assistance of Hearing Impaired Children (SAHIC) over a year, 76.9 per cent of the people covered had their hearing damaged by noise pollution.

#### FREE HEARING TESTS TO FACTORY WORKERS FOR COMPENSATION

Dozens of former factory workers who had their hearing damaged in the workplace could be in line for thousands of pounds of compensation. Employees whose health has suffered due to noisy machinery have been urged to attend a free clinic in Crewe. They are being hosted by Hartshill-based injury lawyers Attwood Solicitors. Last year, the law firm helped more than 100 ex-potters in Stoke-on-Trent pursue similar compensation claims. Lawyers say older and retired workers are suffering hearing loss after being subjected to high levels of noise during the 1970s and 1980s. And the results from a five-minute hearing test will determine whether a claim for compensation can be made. Successful cases have already been bought by Attwood against former Sandbach truck-maker Foden. Lawyer Ashley Attwood said the firm had been inundated with enquiries after holding similar sessions in the city last year. Claimants secured as much as £10,000. Mr Attwood said: "If the person was relatively young and had to wear a hearing aid for many years, we could be talking tens of thousands. "Many workers who experienced hearing loss while working in extremely noisy environments have simply had to put up with it. To claim, workers have to prove they were exposed to more than 80 decibels of noise at work. Compensation money comes from employers' insurers, which can be traced even if a firm has shut down. Former textile worker Marian Edmondson, of Nantwich, last year secured £1,500 in compensation after a case against VG Garments, in Crewe, which had ceased trading. Marian's exposure to noise led to reduced hearing and tinnitus. The 56-year-old said: "I thought I would just have to put up with it until I was told I had a right to compensation."