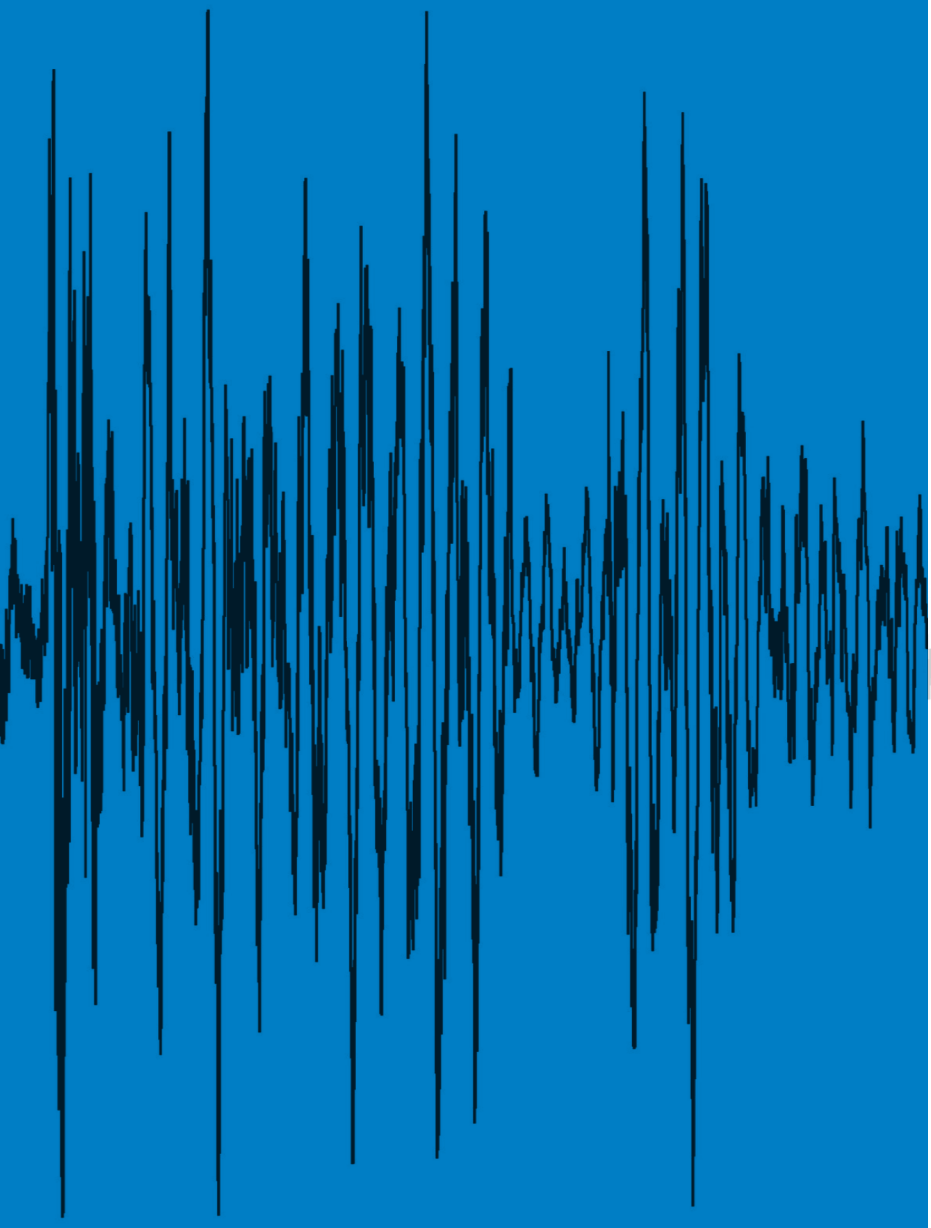
Indexed with MEDLINE, EMBASE & SCI

ISSN 1463-1741

Impact Factor® for 2010: 0.739



Noise & Health

A Bi-monthly Inter-disciplinary International Journal

www.noiseandhealth.org

July-August 2012 | Volume 14 | Issue 59

Wolters Kluwer Health | Medknow

Noise and stress effects on preschool personnel

Fredrik Sjödin, Anders Kjellberg, Anders Knutsson[1], Ulf Landström, Lennart Lindberg

Faculty of Building, Energy and Environmental Engineering, Laboratory of Environmental Psychology, University of Gävle, Gävle, [1]Department of Public Health, Sweden Mid University, Sundsvall, Sweden

Abstract

The aim of the study was to analyze the presence of stress-related health problems among preschool employees and the way in which these reactions are related to noise and other work parameters. The investigation included 101 employees at 17 preschools in Umeå County, located in northern Sweden. Individual noise recordings and recordings in dining rooms and play halls were made at two departments from each preschool. The adverse effects on the employees were analyzed by use of different validated questionnaires and by saliva cortisol samples. Stress and energy output were pronounced among the employees, and about 30% of the staff experienced strong burnout syndromes. Mental recovery after work was low, indicated by remaining high levels of stress after work. The burnout symptoms were associated with reduced sleep quality and morning sleepiness. Cortisol levels supported the conclusion about pronounced daily stress levels of the preschool employees.

Keywords: *Health, noise, preschool personnel, stress*

Introduction

The relation between noise exposure and hearing impairment has undergone extensive research since decades. The risk estimates for developing a noise-induced hearing loss (NIHL) are, therefore, well-established. However, other adverse noise effects like stress and fatigue are less well-understood. Many studies have shown that people who live close to airports have higher prevalence of sleep disturbances and other psychological problems.[1] Environmental noise from airport has also been linked to hypertension.[2] One possible mechanism that could explain why noise could lead to hypertension, sleep disturbance, and psychological problems is stress. Noise may affect stress in at least two ways: It may in itself be experienced as unpleasant, and it may make highly valued activities more difficult or even impossible to carry out, e.g. by being distracting or by making it harder to hear important sounds, most often speech. Stress leads to an activation of the hypothalamic-pituitary-axis, (HPA-axis), which results in an increased secretion of cortisol from the adrenal cortex. Acute stress is not dangerous for a healthy person, but chronic stress is associated with fatigue, insomnia, depression, burnout, hypertension, and myocardial infarction.[3-6]

Access this article online	
Quick Response Code:	Website: www.noiseandhealth.org
	DOI: 10.4103/1463-1741.99892

The present study concerns teachers in preschools. They have been found to complain of hearing problems, primarily tinnitus, but also hearing impairment.[7] Voice problems are another possible consequences of having to talk in environments with a high sound level.[8] A special distinction of the noise in this context is that the sound carries information, which professional responsibilities require the personnel to attend to. The sounds of falling chairs, playing, children crying, footsteps etc., thus cannot be ignored by the personnel. The noise in the preschool is also highly dominated by speech. Research has shown that irrelevant speech is more attention catching and put a larger cognitive load on the exposed personnel than meaningless noise.[9] To our knowledge, the health consequences of exposure to noise and mental demands in preschools have not been studied earlier.

One common model for assessment of work-related stress is the Effort-Reward Imbalance (ERI) model, proposed by Siegrist.[10] This model is based upon a hypothesis that demands and obligations on the employee may lead to a stress reaction, but that this reaction can be balanced by the rewards given by the employer and society. The combination of high demands and low reward may cause strain reactions. The ERI model has been associated with cardiovascular disease and psychosomatic symptoms.[11] Stansfeld showed in his review

that Effort-reward imbalance is associated with common mental disorders.[12] It has also been shown that effort/reward imbalance is rather widespread among teachers.[13]

One possible indicator of stress is self-rated stress. Wadman and Kjellberg[14] used a mood rating questionnaire, the Stress-Energy questionnaire, to assess the affective aspect of stress and its relation to health in a group of assembly workers. They found that the relation between psychosocial work characteristics and musculoskeletal complaints were fully mediated by stress, i.e. only when psychosocial conditions were reported to lead to stress did they give rise to neck-shoulder problems. Larsman *et al*.[15] obtained a similar result in a group of elderly female computer users. Kjellberg[16] found that also other possibly stress-related health problems were more common in the group with high stress. The other dimension measured by the questionnaire, Energy, reflects the energy and commitment experienced while working and has been found to be unrelated to the health indicators. The stress energy questionnaire has been used in several other Swedish studies regarding occupational stress with similar results e.g.[17-20]

Physiological measures constitute another type of stress indicator. Babisch[21] has suggested that increased level of cortisol could be a mediating factor between noise and cardiovascular disease, which was supported by a recent study based on data from six European countries. Their results indicated that morning cortisol was elevated in women exposed to environmental noise levels above 60 dBA. Other research has also found that the morning level of cortisol is associated with stress, but the results have not been consistent.[21,22] The most common and easiest way of measuring cortisol is to measure the cortisol concentration in saliva. Saliva cortisol usually increases during the first 30-60 minutes after awakening. This steep increase of cortisol values after awakening is known as the Cortisol Awakening Response (CAR).[23-25] The awakening response reflects an important part of the healthy cortisol circadian rhythm.[22,26]

A high CAR might be related to a high degree of work-related stress.[27] Another measure is Cortisol Decline over the Day (CDD). Low CDD reflects a flattening of the cortisol curve, which can indicate that the HPA-axis has been challenged by repeated stress. Chronic stress and depression could be associated with a flattening of the cortisol curve and high evening values.[28]

Another health aspect studied in the present investigation was burnout, which has been found to be rather widespread among teachers[29] and to be related to effort/reward imbalance.[13,30] Burnout is often a state deriving from long term stress, and Melamed showed that chronic burnout was related to physiological arousal.[31] Since the consequences of burnout are severe, the study of this syndrome is of great importance. Several studies have investigated occupational burnout often with focus on stress and the role of psychosocial work factors.

The probably most common symptom of stress among teachers is fatigue,[32] and studies have shown that high occupational noise may lead to fatigue.[33-35] In this study, fatigue was assessed by a multidimensional inventory.[3,36] Two other symptoms, that often are attributed to stress, headache[37] and neck/shoulder pain,[38] were also included.

Stress is also commonly known to be highly associated with impaired sleep and sleepiness. Akerstedt[4] showed in a review article that people suffering from disturbed sleep also show elevated levels of cortisol.[4] Sleep is an important health factor in stress – health models.[39] Benham showed that the stress – health model used in his study was strengthened by adding sleep quality to it. Ekstedt *et al*.[40] showed that patients suffering from occupational burnout also suffer from severe sleepiness and mental fatigue and that impaired sleep is an important factor in the development of burnout and fatigue.

Virtanen[41] suggest that it is possible that depression may be the result of work-related long term stress in a similar way as it might be the result of stressful life events. Research regarding depression and its link to working conditions is, however, inconclusive. Hammen[42] pointed out in her review that further multivariate research is needed to find the different pathways to depression. In this study, we, therefore, included depression as a possible health effect.

The main aim of the present study was to analyze the relation between noise exposure and stress (self-reported and cortisol) among preschool teachers. Another aim was to analyze the association between noise and stress on the one hand, and fatigue, insomnia, depression, and burnout on the other.

Methods

All data collection was conducted from Monday to Friday during one full week at each participating preschool.

Participants

Participating preschools were invited to the study through the local school authorities in cooperation with the research group. An invitation was sent to the principle of each preschool (n = 64). Seventeen preschools volunteered to participate in the study. In meeting with the principle and representatives from each preschool, two departments at each preschool were selected. Departments that had planned changes regarding personnel or physical changes of the department were excluded. Departments with many temporary employees were also excluded.

At each of the selected departments, three subjects were given the opportunity to participate in the study. To be included in the study, participants had to meet the following inclusion criteria: They should work at least 30 hours per week, not being short term employed, work as a child care worker

or preschool teacher with no planned changes of leaving the department. A total of 87 females with a mean age of 41.5 years (SD 10.0 years) and 14 males with a mean age of 38.7 years (SD 10.5 years) were invited to participate in the study. Thus, in total, 101 subjects were included in the study with a mean age of 41.0 years (min 25 years, max 63 years, range 38 years).

Data collection

Presence of children

The participants in the study monitored the daily presence of the children. Data regarding age, gender, and number of children were collected for each study day. The records were collected by the research group at the end of the study week.

Noise exposure

The noise exposure was measured using personal and stationary recordings. The personal recordings were based on dosimeters worn during the whole working day, Monday to Friday. The stationary recordings were carried out during the working days, Monday to Friday, in dining rooms and playing halls. The noise exposures are described in LA_{eq}, dB(A) max. By using LA_{eq}, (equivalent continuous A-weighted sound pressure level), the exposures are given in terms of overall values during the individual work hours of the personnel, thus giving an average noise level where high noise events in the fluctuating noise pattern have a high influence. The use of dB(A) max was aimed to illustrate the highest recorded values during the work hours. Changes in the noise levels were based on analyses of one second periods of the sound and was defined as the number of seconds with a sound level exceeding 85 dB(A). This deviation from the LA_{eq} can be interpreted as a large deviation in the sound level. A more detailed description of the recordings and analyses of noise exposures are given in Sjodin *et al*.[7]

Subjective ratings were used for evaluation of different noise sources at the preschool. Questions were asked regarding different possible sources and their disturbance from i.e. the children's voices, noise from the children's activities, other sounds from the children, porcelain, cutlery, drying cabinets etc. The noise level was also rated using the question "Are you exposed to high sound levels at work?" The occurrence of sudden changes in the sound environment was rated using a seven-graded scale.

Questionnaires

Demographic data regarding aspects of the working environment, personal health, medication, leisure activities were answered by the participants in the different questionnaires.

In addition, during Wednesday, the subjects filled in two questionnaires designed to measure stress/energy and subjective fatigue at four time points (at wake-up time, one hour after wake-up, 11:00 am, and 09:00 pm). This was done after leaving a saliva sample (see below). To measure the subjective stress and its relation to the psychosocial work conditions, the Stress-Energy adjective check list was used.[43] This questionnaire contains twelve items measuring two factors, *Stress and Energy*. Each item is rated on a scale ranging from (0 = not at all, 1 = hardly any, 2 = to a little degree, 3 = to some degree, 4 = to a high degree, 5 = to a very high degree). The mean score 2.4 for the stress questions is considered to be the neutral midpoint on the stress scale. Similarly, the mean score 2.7 for the energy questions is considered to be the neutral midpoint on the energy scale. The two scales are combined and form four categories, Worn-out (high stress + low energy), Committed under pressure (high stress + high energy), Bored (low stress + low energy), and Committed with no pressure (low stress + high energy).

Subjective fatigue was measured using the Swedish Occupational Fatigue Inventory (SOFI),[3,36] a questionnaire, developed to measure five dimensions of fatigue. These five dimensions are lack of energy, physical exertion, physical discomfort, lack of motivation, and sleepiness. The physical exertion factor was judged to be of limited relevance in the studied group and was, therefore, excluded. Each factor is measured with five items rated from 0 = not at all, 1 = hardly any, 2 = to a little degree, 3 = to some degree, 4 = to a high degree, 5 = to a very high degree.

Burnout was measured using the *Shirom-Melamed Burnout Questionnaire* (SMBQ).[31,44] The SMBQ contains four subscales with a total of 22 items. Each item is rated on a seven point scale from 1 (almost never) to 7 (almost always) with no verbal explanation in between the lowest and highest score. The subscales are: Emotional and physical exhaustion, tension, listlessness, and cognitive weariness. Four states of burnout are calculated, and subjects with a score less or equal to 2.75 are characterized as healthy, 2.76 to 3.75 equals to low burnout, 3.76 to 4.46 equals to high burnout, and subjects with a score of 4.47 and higher are characterized as pathologically burnt out.[44-46]

Stress-inducing work characteristics were assessed with the *Effort/Reward Imbalance model* (ERI).[10] The ERI model measures the energy and commitment that is put into work by the employees and to what extent this is rewarded in terms of material assets, feedback, and appreciation and has been shown to predict stress-related health problems. A value higher than 1.0 indicates a severe imbalance between effort and reward, meaning that the employees do not feel enough rewarded for the work they put in.

The Karolinska Sleepiness Scale (KSS) was used to assess sleepiness.[47] The KSS is a 9-point scale with verbal anchors every second number score: 1 = very alert, 3 = alert, 5 = neither alert nor sleepy, 7 = sleepy, but with no difficulty

staying awake, and 9 = very sleepy, fighting against sleep, requiring great effort to stay awake. The evaluations were made at home Monday to Friday. The Karolinska Sleep Diary (KSD) is used to assess different aspects of sleep, including quality of sleep. It was filled in after awakening on all days of the week, except Monday when the diary was filled in the evening. It included 10 questions with five response options.

Based on the Karolinska Sleep Diary, a disturbed sleep index was constructed by calculating the mean score for the questions about stress before going to sleep, difficulties falling asleep, sleep quality, disturbed or restless sleep, premature awakening, time awake during the night, enough sleep, deep or light sleep, easy getting out of bed in the morning, fully rested. A lower score thus indicating poor sleep quality and recovery. Reliability of the index was analyzed using Cronbach's Alpha = 0.80.

Depression was assessed using the Major Depression Inventory (MDI).[48,49] This is a commonly used self-reported questionnaire that can be scored by the total sum of the items to the WHO ICD-10[50] algorithms for depressive symptomatology and the severity scales. The MDI items are rated on a scale ranging from (1 = all the time, 2 = most of the time, 3 = about half the time, 4 = less than half of the time, 5 = small amount of the time, 6 = at no time), using the last two weeks as a time frame. Calculating the MDI score, which ranges from 0 to 50, can be used to divide the individual score into different depression groups.[49]

Saliva cortisol

In the middle of the study week (Wednesday), cortisol was collected four times using saliva sampling kits (Salivette®, Nümbrecht Germany). Time of leaving the samples were immediately after wake up, one hour after wake up, at 11:00 am, and at 09:00 pm. The participants received oral and written information about how the saliva should be sampled. They were also instructed to avoid tooth brushing and any food intake 30 minutes before leaving the sample. The two morning samples and the evening sample taken at home were brought to the preschool and stored in a refrigerator at the preschool until the end of the study week. The samples were collected by the research group at the end of the work week and then stored in a freezer (-20 Celsius) until analyzed at Stockholm University Stress Clinic. Orion Diagnostica Spectria® Cortisol RIA[51] procedure was used to analyze the saliva samples.

Cortisol Awakening Response (CAR) and Cortisol Decline over the Day (CDD) were calculated. CAR was the difference in cortisol concentration from the waking sample to the second sample. CDD was the difference between the maximum morning concentration (i.e. the highest of the two morning samples) and the evening sample.

Statistical methods

All analyzes were made using SPSS version 17.0. All correlations with normal distributed data were analyzed by using Pearson's correlation coefficient or linear regression analysis. Data not normal distributed were analyzed using Spearman's correlation coefficient. Comparisons of means were analyzed using one way ANOVA analyzes and T-tests.

Ethics

The study has been approved by the regional ethical review board. Each participant was thoroughly briefed about the purpose of the study and how the study was designed. All personnel were informed that presented data would be anonymous and that data only would be presented group-wise. All participating personnel gave their written consent to participate, and they were informed that their participating was strictly voluntarily and that they, at any time, could choose to leave the study.

Results

Gender differences

Descriptive data separated by genders is shown in Table 1. As can be seen from the table, some differences can be observed between women and men. To decide whether men and women should be kept apart in the analyzes, gender differences regarding exposure and effect variables were tested using independent samples t-test. Significant differences ($P < 0.05$) were seen for variables regarding sleep. Women felt more tired at wake up, 3.4 (women) vs. 3.8 (men) on a five point scale in the KSD questionnaire. Women also tended to wake up somewhat earlier than planned in the morning, 4.2 (women) vs. 4.7 (men). All these items are included in the KSD index. Women also reported longer time in bed, 7 h 42 min (women) vs. 7 h 13 min (men).

Women also showed higher cortisol values one hour after wake up, as well as a larger Cortisol Awakening Response (CAR).

Due to the small gender differences, men and women were not separated in the following analyzes, except for cortisol data.

Noise exposure

The mean individual noise exposure during a working day was about 71 LA_{eq}, whereas the mean values of the stationary recordings were considerably lower (about 63 LA_{eq}). The mean number of noise events above 85 dB(A) per hour were 66. Figure 1 shows mean individual and stationary recordings from the 17 preschools. Noise level differences between the preschools were rather small, but a one way ANOVA showed that they were significant

both for the individual (F(16/74) = 3.31, $P < 0.001$) and stationary (F(16/44) = 6.71, $P < 0.001$) measurements. The number of sound events above 85 dB(A), however, did not differ significantly between preschools (F(16/69) = 1.69, $P = 0.07$). The varying number of degrees of freedom is the result of some cases of technical measurement failures.

Figure 2 shows the average number of sound events exceeding 85 dB(A) at different times of the day. As expected, the number of sound events above 85 dB(A) were found to be related to the activities of the departments, especially the vocal and playing activities, which were the dominating noise sources reported by the personnel. The mean number of high sounds increased in conjunction with late morning meal (09:00 am to 10:00 am) and afternoon meal (02:00 pm to 03:00 pm). Lower number of sound events above 85 dB(A) were observed during the children's rest periods (12:00 am to 1:00 pm).

The children's voices were rated at a mean value of 3.3 (SD 0.6), and sound from the children's activities were rated at a mean value of 3.0 (SD 0.6). The noise level was rated at a mean value of 2.9 (SD 0.6). Sudden changes in the sound environment was rated to a mean value of 5.2 (SD 1.2), corresponding to "several times per day" to "sometime per hour."

Experiences of stress and energy

The individual ratings and distribution of stress energy ratings in the four stress-energy categories during four times of the day are shown in Figure 3 and Table 2.

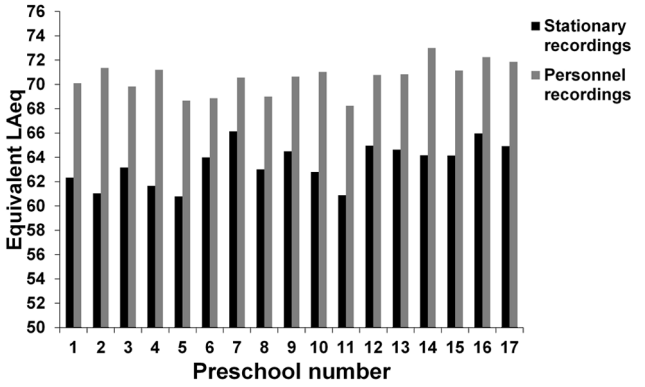


Figure 1: Noise exposure levels (LA_{eq}) of the 17 investigated preschools (black staples stationary recordings, grey staples personnel recordings)

Table 1: Mean values of objective noise recordings, subjective rated sound environment, different mediators, and health effect variables separated by gender

	Women			Men		
	N	Mean	SD	N	Mean	SD
Objective noise recording						
Mean LA_{eq} dosimeter recording	78	70.63	1.95	13	70.20	1.76
Mean sound level above 85 dB(A)	73	65.90	28.63	13	68.01	25.84
Mean LA_{eq} stationary recording	87	63.42	2.23	14	63.80	2.30
Mean number of children	87	13.63	2.65	14	13.35	3.85
Subjective rated sound environment						
Rated sound level	81	2.89	0.61	12	3.08	0.67
Rated fluctuation	80	5.26	1.16	13	4.62	1.12
Rated disturbance of children's voices	81	3.28	0.58	13	3.23	0.73
Rated disturbance of noise from children's activities	80	3.04	0.58	13	3.08	0.64
Mediators						
Noise annoyance	80	55.59	15.40	13	50.15	21.56
Rated stress at work	76	2.42	1.00	11	1.95	0.75
ERI	80	0.63	0.26	13	0.59	0.36
CAR	80	6.51	10.01	11	-4.73	8.01
CDD	80	20.60	7.15	11	16.43	8.16
Health effects						
Burnout	80	3.24	0.84	13	2.84	0.98
Depression	80	9.14	7.77	13	7.77	6.87
SOFI lack of energy	76	1.79	0.93	11	1.59	0.73
SOFI physical discomfort	76	1.78	0.81	11	1.32	0.43
SOFI lack of motivation	76	1.26	0.36	11	1.36	0.34
SOFI sleepiness	76	1.22	0.35	11	1.34	0.45
KSS before sleep	80	6.78	1.11	13	6.70	1.00
KSS after sleep	81	6.04	1.28	13	5.50	1.97
KSD index	81	3.76	0.39	13	3.88	0.40

(Rated sound level = "Are you exposed to high sound levels at work," 1= not at all, 2 = somewhat, 3 = to a high degree, 4 = to a very high degree;" Rated fluctuation = How often do the sound level suddenly increase from i.e. children screaming, chairs falling over etc." 1 = never or almost never, 2 = Sometimes a week, 3 = A few times a week, 4 = Sometimes per day, 5 = Several times per day, 6 = Sometimes per hour, 7 = several times per hour; Rated disturbance of children's voices and rated disturbance of noise from children's activities = "1 = not present, 2 = present but not annoying, 3 = present and somewhat annoying, 4 = present and very annoying.")

There is a gradual increase in both energy and stress during the three first rating periods. The pronounced energy and stress evaluation of the period 11:00 pm are of special interest. In the evening, the stress ratings fell to the morning levels. At no time point, any person fell into the worn out group (high stress low energy) and during the working day, none fell into the low energy group. The percent of participants falling into the high stress group at the four measurement points was 4%, 20%, 45%, and 12%, respectively.

Stress and energy ratings were positively correlated at wake up (.41, $P < .001$) and in the evening (.45, $P < .001$) but were uncorrelated one hour after wake up and at mid-day at work.

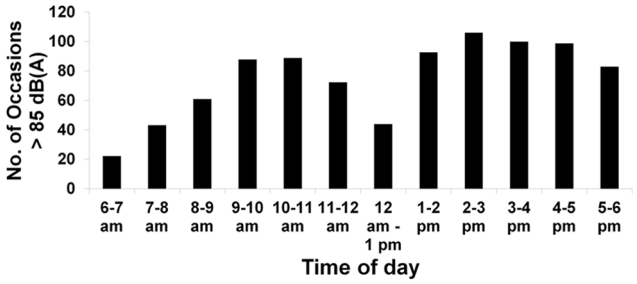


Figure 2: Average number of one second periods with noise levels above 85 dBA in individual recordings during different periods of the day at the preschools investigated

Effort-reward imbalance

The results of the analyzes of effort and reward are given in Table 3. A value above 1 indicates a high effort in relation to its reward. A value close to 0 indicates high rewards with low effort. As seen from Table 3, the average effort-reward balance showed an imbalance indicating that the effort was rather low relative to the reward; only four participants had an ERI score that were higher than 1.0.

Salivary cortisol

Changes in cortisol levels over day are described in Table 4. As seen from the table, the highest values obtained are one hour after wake-up for women and at wake-up for men. Significant differences between men and women are observed for the one hour after wake-up value and CAR. Due to individual faults, when using the sampling kits, these results were based on a reduced number of subjects.

Table 2: Stress and energy ratings during the working day of the employees

	N	Mean	Minimum	Maximum	SD
Stress at wake up	91	1.38	0.00	4.17	0.71
Stress 1 h after wake up	89	1.93	0.50	3.67	0.69
Stress at mid day	87	2.36	0.50	4.50	0.98
Stress at 9 pm	87	1.50	0.33	3.33	0.69
Energy at wake up	91	1.86	0.17	3.83	0.86
Energy 1 h after wake up	91	3.39	1.67	4.50	0.62
Energy at mid day	91	3.59	1.00	4.80	0.52
Energy at 9 pm	87	2.71	0.17	4.50	0.90

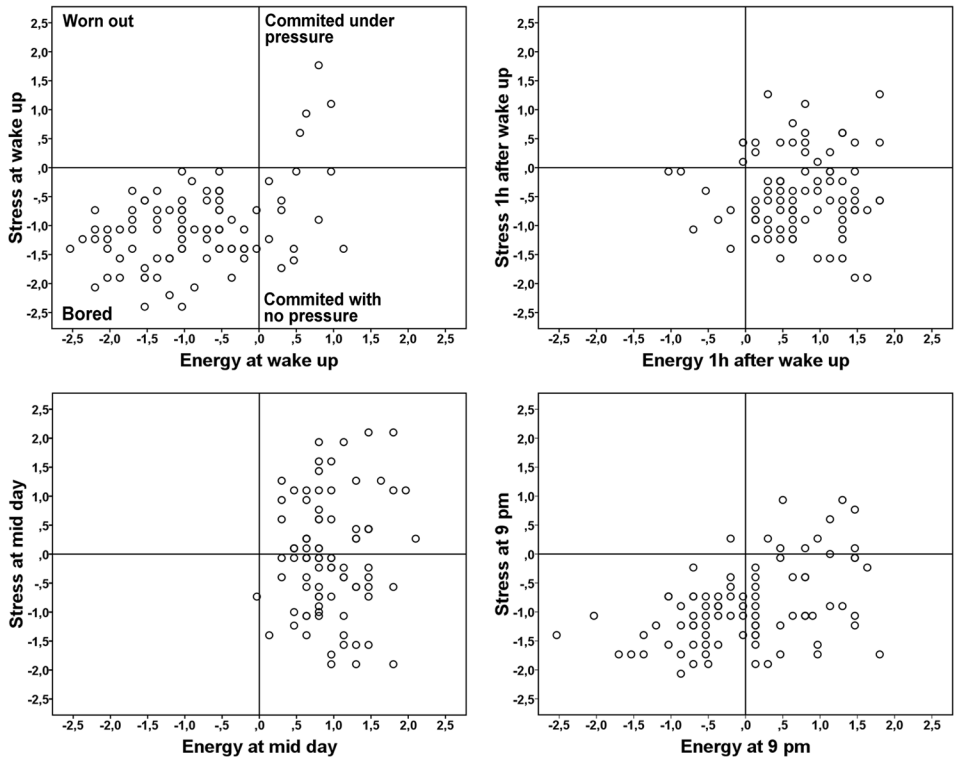


Figure 3: Stress and energy deviations from neutral midpoint of the employees during the four times of ratings during the day (upper left = worn out, upper right = committed under pressure, lower left = bored, lower right = committed with no pressure)

Fatigue (the SOFI Questionnaire)

As seen in Table 5, the preschool personnel rated their occupational fatigue at midday regarding *lack of energy, physical discomfort, lack of motivation, and sleepiness* at work lower than comprehensive teachers in Sweden rating the same factors after the end of the work day,[3] using independent two-sample *t*-test with unequal sample sizes and unequal variance (t = -12.77, df = 154, $P < 0.05$).

Sleep and sleepiness

Sleepiness was evaluated by use of the Karolinska sleep scale (KSS) and the Karolinska sleep diary (KSD). The personnel rated their sleepiness before sleep in average 6.76 (SD 1.15), corresponding close to "sleepy, but with no difficulty staying awake." The personnel rated their sleepiness at wake up in average 6.00 (SD 1.42), between "neither alert nor sleepy" and "sleepy, but with no difficulty staying awake."

Depression

The mean value of depression among the employees using the MDI depression rating scale was 8.95 (SD 7.63). When categorizing the individual scores according to Olsen *et al*.[49] into four groups, regarding depression severity in this study, it was found that 87.1% showed no depression, 5.4% of the employees showed a mild depression, and 7.5% employees showed a moderate depression. No employees were characterized as having a severe depression.

Burn out

According to the criteria of Melamed,[31,44-46] the ratings indicated a pathologically burnt out state for 10 percent of the participant and 14 percent were classified as highly burnt out. This meaning that around one fourth of the employees are suffering from burn out syndromes according to the Shirom-Melamed Burnout questionnaire.

Table 3: Mean values of effort, reward, and imbalance index

	N	Minimum	Maximum	Mean	SD
Effort	93	1.00	3.67	1.91	0.57
Reward	93	1.64	4	3.25	0.50
ERI	93	0.25	1.94	0.62	0.27

Analyzes of associations between noise and effect variables

The analyzes of associations are based on the theoretical connections described in Figure 4.

Noise and its association to health

The associations between noise and different effects are based on objective measurements of the sound environment and subjective ratings.

Objective measurements consists of LA_{eq} with personal and stationary recordings, number of sound events above 85 dB(A), and mean number of children during the week. Subjective measurements include ratings of noise annoyance, experiences of sound level and sound fluctuation, children's voices, and noise from the children's activities.

Noise and its relation to burnout

Analyzes of variance using one way ANOVA showed that there were no significant differences between the four burn-out categories and whether they were influenced by any of the objective noise exposure measures; LA_{eq} personal recordings, LA_{eq} stationary recordings, number of sound events above 85dB(A), and mean number of children during the week, ($P = 0.30 – 0.78$).

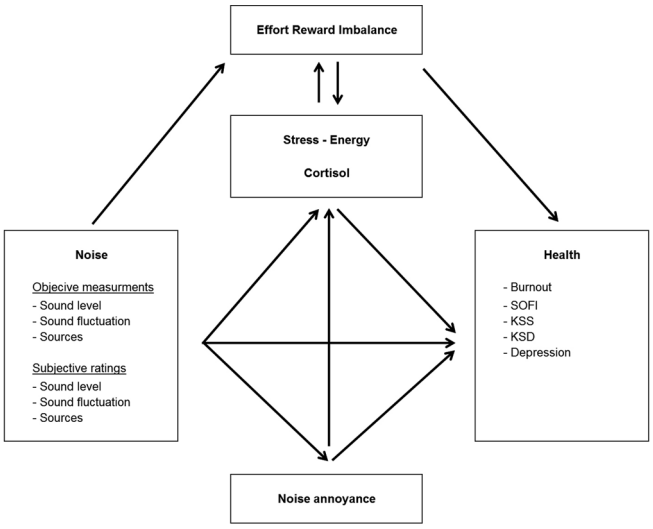


Figure 4: Theoretical model of associations between noise, stress, annoyance, and health effects

Table 4: Cortisol levels of women and men at different time points of the day, cortisol awakening response, and cortisol decline over the day

	Women Mean cortisol			Men Mean cortisol			Difference Mean cortisol
	N	nmol/L	SD	N	nmol/L	SD	nmol/L
At wake up	81	14.24	7.02	11	16.54	9.68	−2.29
One hour after wake up	80	20.75	7.85	11	11.81	3.64	8.94*
Mid day	81	3.73	2.77	11	3.78	3.77	−0.05
9 pm.	81	1.38	1.91	11	1.66	2.12	−0.28
CAR	80	6.51	10.01	11	-4.73	8.01	11.24*
CDD	80	20.6	7.15	11	16.43	8.16	4.18

*Difference significant at the 0.05 level

Table 5: Number of respondents (*n*) Means (m), standard deviations (sd) for preschool personnel ratings using the SOFI-questionnaire compared to comprehensive school teachers in Åhsberg[3]

	Lack of energy	Physical discomfort	Lack of motivation	Sleepiness
At mid day				
n	87	87	87	87
m	0.76*	0.72*	0.27*	0.24*
sd	0.91	0.79	0.36	0.37
At 9 pm				
n	87	87	87	87
m	1.52*	1.31	0.91	1.05
sd	1.15	1.16	0.85	0.98
Teachers[3]				
n	94	94	94	94
m	3.01	1.42	1.19	1.16
sd	1.39	1.18	1.21	1.14

* = $P < 0.05$ compared with ratings by comprehensive teachers in Åhsberg[3]

When testing for group differences regarding rated noise level at work and burnout, significant differences were found (F(88/91) = 4.53, $P < 0.05$) showing that employees who rated the noise as higher also were more burned out.

No significant group differences were seen regarding associations between different burnout groups and the children's voices and sound from the children's activities.

Noise and its relation to fatigue

Non-parametric correlation analyzes using Spearman's correlation for the four scales (physical discomfort, lack of motivation, lack of energy, and sleepiness) of the SOFI questionnaire were made. No significant correlations were found between any of the objective sound characteristics and the different scales of SOFI.

Neither were there any significant group differences when one way ANOVA analyzes regarding subjective noise characteristics and the different scales of the SOFI questionnaire.

Noise and its relation to sleep and sleepiness

A weak but significant correlations between the KSD Index and time with sound level above 85 dB(A) was seen using Spearman's correlation (r = 0.216, $P < 0.05$). This showing that, with increasing time with sound levels above 85 dB(A), the rated sleep quality also improved. No significant correlations were seen between KSD and mean LA_{eq} using personnel and stationary recordings nor mean number of children during the week. Furthermore, no correlations were seen for any of the objective sound measurements and KSS scale before and after sleep.

Analyzes using one way ANOVA showed significant group differences regarding KSS sleep feelings before going to bed and rated sound level at work. Employees reporting higher noise levels at work reported being more tired before going to sleep (F(89/91) = 3.40, $P < 0.05$). Similar group differences were also seen for rated KSS sleep feelings before going to bed and disturbance of noise from the children's activities (F(89/91) = 3.36, $P < 0.05$). The employees being the most disturbed by noise from the children's activities also reported being more tired before going to sleep.

No other group differences were seen between subjective noise characteristics and sleep and sleepiness.

Noise and its relation to depression

Analyzes of variance using one way ANOVA showed that there were no significant differences between the four depression categories in any of the objective noise exposure measures ($P = 0.32$ - 0.86).

The association between subjective sound variables and depression was analyzed using one way ANOVA. Significant groups differences were seen for rated sound fluctuation and depression. Higher depression was associated to higher subjectively rated sound fluctuation (F(88/91) = 3.23, $P < 0.05$).

Noise and its association to acute stress

Noise and its association to stress-energy

Participants were dichotomized into a low and high stress group using the stress energy questionnaire using the index value of 2.4 as cut off, which is considered to be the neutral midpoint of the stress scale (High stress group = stress index values higher than 2.4, Low stress group = stress index values below 2.4). Independent samples T-test show no significant difference regarding LA_{eq} recorded with personal or stationary recordings or mean number of children during the week. However, when testing for time with sound level above 85 dB(A) during the week, the high stress group had a significant higher exposure than the low stress group (72.5 and 59.8, respectively, t = -2.0, df = 76, $P < 0.05$).

There was no significant difference in subjectively rated exposure between the two stress groups.

Noise and its relation to stress cortisol

The correlation between the objective sound measurements and the cortisol values obtained during the four different time points of the day were analyzed using Pearson's correlation. No significant correlations were found for the cortisol values obtained at wake-up, one hour after wake-up, and at 9 pm.

However, the cortisol values obtained during work, at mid day, showed a positive significant correlation to mean number children present at the department during the week. The more the children, the higher value of cortisol (r = 0.212, $P < 0.05$).

The association between CAR and objective sound measurements from the day before the cortisol test day was analyzed using Pearson's correlation. There was no significant association between sound level or time with sound level above 85 dB(A) and CAR the day after exposure.

No associations were seen for CDD and any of the tested objective sound measurements.

No group differences were seen for subjectively rated sound environment and CAR or CDD using one way ANOVA.

Noise and its association to Effort Reward Imbalance

Spearman's correlation was used to analyze the association between Effort Reward Imbalance (ERI) and the different objective sound measurements. Analyzes showed a positive correlation between ERI and stationary LAeq ($r = 0.205$, $P < 0.05$); ERI and time with sound level above 85 dB(A) ($r = 0.273$, $P < 0.05$). This showing that employees with higher noise exposure and more time with sound levels above 85 dB(A) also reported a higher ERI score.

Regarding associations between subjective sound environment ratings and ERI, one way ANOVA analyzes were used. Significant group differences were seen regarding rated sound level at the department and ERI ($F(89/91) = 4.91$, $P < 0.05$). The group who rated the sound level the highest also reported the highest ERI.

Significant group differences were also seen for rated disturbance from the children's voices and ERI. Employees with higher ERI also rated a higher disturbance from the children's voices ($F(90/92) = 4.93$, $P < 0.05$). Similar was seen regarding ERI and disturbance of noise from the children's activities ($F(89/91) = 8.39$, $P < 0.01$).

No significant group difference was seen between the rated sound fluctuation and ERI.

Noise and its association to noise annoyance

No significant correlation was found between rated noise annoyance and the objective noise measurements as can be seen from Table 6. However, the correlation between noise annoyance and subjective noise variables using Spearman's correlation showed significant association for all tested associations. This showing an association between noise annoyance and a poor subjectively rated sound environment.

Analyzes of associations between noise annoyance, stress and health

Noise annoyance and its association to subjective rated stress at work

Noise annoyance and stress were analyzed using linear regression, see Figure 5. As seen from the figure, high noise annoyance was associated with higher stress levels during work ($r^2 = 0.047$, $P < 0.05$).

Noise annoyance and its association to cortisol

Noise annoyance and its association to cortisol was analyzed using Pearson's correlation. The morning cortisol value at wake-up correlated positively with noise annoyance during work ($r = 0.284$, $P < 0.05$). No significant correlations were found for the other time of the day (1 h hour after wake up, mid day, and 9 pm). This indicates that high rated noise annoyance is associated with higher morning cortisol values.

CAR and CDD values did not correlate to noise annoyance. However, the correlation between CAR and noise annoyance rating was close to significant showing that a lower CAR is associated to higher noise annoyance ($r = -0.192$, $P = 0.07$).

Noise annoyance and its association to health

As seen in Table 7, rated noise annoyance at work and different health effects correlated significantly for several health disorders (KSS before sleep, depression, and burnout). All significant correlations show similar effects, that is higher noise annoyance is correlated to higher rated health disorder.

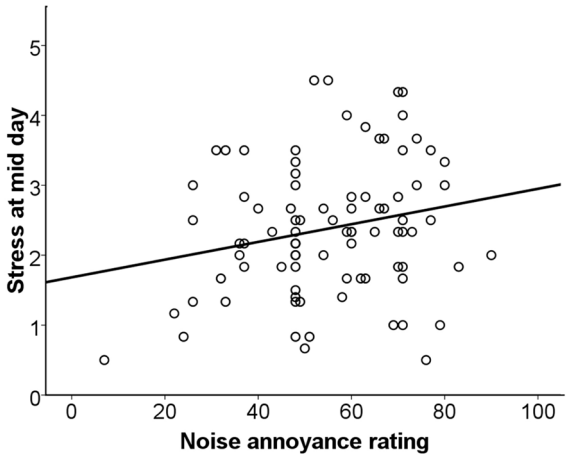


Figure 5: Linear regression between noise annoyance and rated stress during work

Table 6: Correlations regarding objective sound exposure and rated noise annoyance

		LA_{eq} personal recording	LA_{eq} stationary recording	Number of sound events above 85 dB(A)	Number of children
Noise annoyance	Pearson correlation	.086	.047	.064	.115
	P-value	.423	.655	.560	.272
	N	89	93	84	93

Stress and its association to health

Subjectively rated stress at work and its association to health

As seen in Table 8, rated stress at work and different health effects differ between the low stress group and the high stress group. The high and low stress group is dichotomized in accordance to previous analyzes. As can be seen in Table 8, significant differences are seen for SOFI lack of energy, SOFI physical discomfort, SOFI lack of motivation, SOFI Sleepiness, KSD, depression, and burnout. The higher stress group was generally associated to higher rated health disorders.

Cortisol and its association to health

No significant associations were found between cortisol and health variables.

Stress and its association to ERI

Rated stress and its association to ERI were tested in linear regression analyzes. As seen from Figure 6, increased ERI is associated with increased stress. The association was significant with ($r^2 = 0.054$, $P < 0.05$).

No significant correlations were found between ERI and any of the cortisol values, CAR, and CDD.

ERI and its association to health

The association between ERI and health variables was tested using Spearman's correlation. As can be seen in Table 9, significant correlations were found between ERI and SOFI, KSD, KSS before sleep, depression, and burnout. All health effects showed the same relation to ERI. Increased ERI was associated with higher rated health impairments.

Discussion

The effects of noise exposure and other work-related parameters could be described in terms of acute as well as long term stress-related ill health.

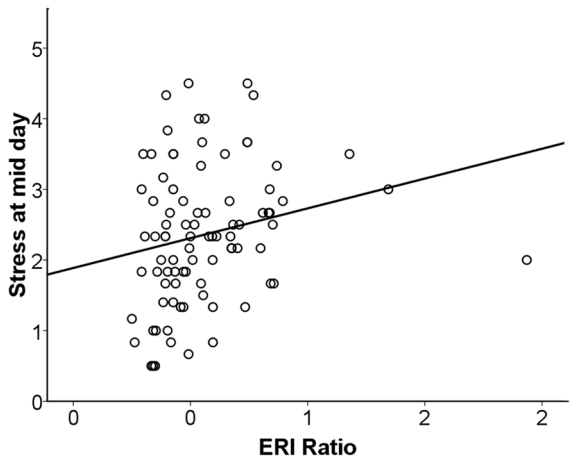


Figure 6: Scatterplot showing rated ERI and rated stress at mid day

Subjective acute responses (experiences of sudden changes in the sound environments, disturbances from the children's voices, disturbances from noise related to the children's playing activities, and noise annoyance) were associated with burnout, depression, and effort-reward imbalance. The corresponding correlations with objective noise characteristics were in no case significant. This was also true for the long term health effects.

Table 7: Pearson's correlation between health variables and rated noise annoyance

	N	R	*P*-value
SOFI lack of energy	86	0.20	0.06
SOFI physical discomfort	86	0.04	0.73
SOFI lack of motivation	86	0.06	0.57
SOFI sleepiness	86	0.12	0.26
KSD	93	−0.10	0.33
KSS before sleep	92	0.25	0.02*
KSS after sleep	93	0.04	0.67
Depression	92	0.26	0.01*
Burnout	92	0.33	0.00**

*Significant at 0.05 level, **Significant at 0.01 level

Table 8: Mean values and standard deviation of different health variables dichotomized into high and low stress groups

		N	Mean	SD	t-test *P*-value
SOFI lack of energy	Low stress	48	1.38	0.59	-4.96
	High stress	39	2.24	1.02	$P < .01$
SOFI physical discomfort	Low stress	48	1.48	0.58	−3.28
	High stress	39	2.01	0.92	$P < .01$
SOFI lack of motivation	Low stress	48	0.94	0.28	−2.57
	High stress	39	1.14	0.42	$P < .01$
SOFI sleepiness	Low stress	48	1.22	0.35	−0.56
	High stress	39	1.27	0.39	ns
KSD	Low stress	48	3.85	0.39	1.72
	High stress	39	3.71	0.38	ns
KSS before sleep	Low stress	48	6.66	1.03	−0.75
	High stress	38	6.84	1.15	ns
KSS after sleep	Low stress	48	5.92	1.50	0.29
	High stress	39	6.01	1.23	ns
Depression	Low stress	48	6.88	6.37	3.15
	High stress	39	11.92	8.56	$P < .01$
Burnout	Low stress	48	3.02	0.90	1.99
	High stress	39	3.39	0.83	$P = .05$

Table 9: Correlations between ERI and tested health variables

	N	R	*P*-value
SOFI lack of energy	87	0.32	0.02**
SOFI physical discomfort	87	0.27	0.01**
SOFI lack of motivation	87	0.14	0.20
SOFI sleepiness	87	0.17	0.12
KSD	93	−0.21	0.04*
KSS before sleep	92	0.33	0.00**
KSS after sleep	93	0.06	0.58
Depression	93	0.40	0.00**
Burnout	93	0.47	0.00**

*Significant at 0.05 level, **Significant at 0.01 level

The subjective experiences of the noise thus seem to be stronger and more relevant indicator of health than the personal and the stationary recordings. The lack of association between health and the objective sound measurements may partly be explained by the rather low variance of the objective measurements. The lack of significant correlations between noise measures and annoyance ratings may be interpreted in this way.

More likely is that the health effects primarily are explained by other factors than the noise and that these effects overshadow possible noise effects.

Daily effort and fatigue also increases the risk for long term health effects. The noise experiences and long term-related stress are described by use of the Melamed questionnaire, showing a strong association between burnout and subjective experiences of the sound environment. The mostly burned out employees are more disturbed and thus suffering more in the noisy environment. These correlations do not, of course, mean that noise contributed to the development of burn out symptoms. It is at least as likely that increased sensitivity to noise is a consequence of the burn out state.

The study thus confirms a number of correlations between experiences of noise and short term as well as long term stress-related ill health. Besides the direct correlation to noise, short term as well as long term ill health was seen for a number of other indicators.

A fundamental finding of the study was the character of stress-energy balance of the employees. The balance between stress and energy confirms the picture of employees with high commitment and positive effort during work. At the same time, the number of employees with high stress levels during work was rather high.

The stress-energy measurement also shows an interesting pattern of how stress and energy positively correlate in the morning and negatively in the evening. This pattern is quite expected with increasing activity in the morning and a decrease in activity in the evening. However, when at work, employees show an extremely unusual high energy out-put, and nearly half of the employees also report high stress levels. This is rather unusual compared with most other studies using the stress-energy model. A study of call-centers personnel,[16] e.g., found that high stress levels were associated with a lower degree of commitment. The finding in the present study confirms a high commitment of the employees to the children. This high commitment is also supported by the Effort Reward Imbalance model.

The ERI model indicates that the work is highly rewarding. ERI did also correlate with Shirom-Melameds burnout questionnaire, this indicating that high burnout might be related to low job satisfaction. The high motivation at work may also explain the relative low prevalence of depression among the employees. In this study, we have shown that it is possible that work-related stress and burn out is associated with subjective rated depression using the MDI questionnaire. The lack of employees with a major depression may be explained by the healthy worker effect, meaning that individuals with a severe depression are most likely unable to work and thus not included in the study.

Furthermore, the high motivation at work also support the ratings in the SOFI inventory, showing low scores regarding lack of energy, physical discomfort, lack of motivation, and sleepiness at work. However, in the evening after work when compared to comprehensive teachers in another study in Sweden,[3] only lack of energy was significantly lower for the preschool personnel. The comparison between the preschool teachers and the comprehensive teachers, however, should be made with care. Beside differences in work duties, differences also existed in the perspective of methods being used. Fatigue ratings in the study of Åhsberg[3] were carried directly after finishing a working day with many lessons.

The effects on disturbed sleep in the present study were more pronounced among women, a gender difference, which also has been confirmed in other studies.[52] Gender differences were also seen in the cortisol responses, women responding with higher cortisol levels one hour after wake-up time. Previous findings, reporting higher daily stress and burn out levels among women than men,[53] however, were not that clearly confirmed in the present study.

Impaired night sleep causes tiredness during the following day, with consequences meeting the work. The correlation between tiredness and stress-related ill health has been verified in several previous studies.[4] Beside the work situation, the fatigue sensation often creates a problem in home environments.

The mental effects of noise in the perspective of learning and memory have previously been investigated in several studies, showing negative effects on learning and memory.[54,55] In the preschool environments, the work is combined with a number of stressors, making performance more difficult to execute, with a higher cognitive load as a result.

In this study, about 25% of the employees fell into the groups highly burned out or pathologically burned according to Melameds criteria.[31,44-46] The finding should be considered in the perspective of the national and international definitions given to burnout. The definitions are under debate and vary, especially in an international perspective. In a recent Swedish study by Nordin *et al*.,[53] using the SMBQ, the prevalence among Swedish women was found to be 15.9%. Using the same criteria of burnout as Nordin *et al*.,[53] we obtained a prevalence of burnout among the preschool personnel of 20.4% The results in the other health indicators cast a doubt

on this rather dramatic finding. Participants who were labeled highly or pathologically burnt out appeared rather or very healthy in many of the other measures.

Several subjective noise variables were associated to annoyance and burn out and effort reward imbalance. As a consequence, this indicates a risk for stress levels and fatigue when working in larger children groups. The employees who suffer from burn out show a lower capability of coping with stress and workload, but also a higher sensibility to the complex sound environment. This gives an insight of the impact of the sound environment on health. The long term and situational effects of the noise are probably combined to and in many cases overruled by a number of other work and beside work-related factors. The stress-energy output also speaks for a working situation and employment, with a high degree of commitment and motivation. The interaction between commitment, motivation, work load, and stress is far from clearly described. The participating factors and interactions involved in building up the stress-energy situation and failure to recovery probably can be described only by use of a multidisciplinary approach, including physical as well as behavioral- and organizational work-related aspects.

The results of the study should be considered in the perspective of the relatively large study group, including participants who were highly committed. A benefit of the study is also the way, in which the subjective experiences of noise could be analyzed and compared to objective noise variables.

The conclusions drawn regarding the associations between stress, health effects, and subjective experiences are mainly based on subjective ratings. This should be taken into account when interpreting the data. However, the questionnaires used in this study have been validated and are used in several other studies, which in turn support and strengthen our conclusions.

Address for correspondence:
Mr. Fredrik Sjödin,
Faculty of Engineering and Sustainable Development Building, Energy and Environmental Engineering, Laboratory of Environmental Psychology, University of Gävle, SE - 801 76, Gävle, Sweden.
E-mail: fredrik.sjodin@hig.se

References

1. Passchier-Vermeer W, Passchier WF. Noise exposure and public health. Environ Health Perspect 2000;108:123-31.
2. van Kempen EE, Kruize H, Boshuizen HC, Ameling CB, Staatsen BA, de Hollander AE. The association between noise exposure and blood pressure and ischemic heart disease: A meta-analysis. Environ Health Perspect 2002;110:307-17.
3. Åhsberg E. Dimensions of fatigue in different working populations. Scand J Psychol 2000;41:231-41.
4. Akerstedt T. Psychosocial stress and impaired sleep. Scand J Work Environ Health 2006;32:493-501.
5. Melamed S, Shirom A, Toker S, Berliner S, Shapira I. Burnout and risk of cardiovascular disease: Evidence, possible causal paths, and promising research directions. Psychol Bull 2006;132:327-53.
6. Stansfeld SA, Haines MM, Burr M, Berry B, Lercher P. A review of environmental noise and mental health. Noise Health 2000;2:1-8.
7. Sjodin F, Kjellberg A, Knutsson, A, Landstrom, U, Lindberg, L. Noise exposure and auditory effects on preschool personnel. Noise Health 2012;14:72-82.
8. Sodersten M, Granqvist S, Hammarberg B, Szabo A. Vocal behavior and vocal loading factors for preschool teachers at work studied with binaural DAT recordings. J Voice 2002;16:356-71.
9. Venetjoki N, Kaarlela-Tuomaala A, Keskinen E, Hongisto V. The effect of speech and speech intelligibility on task performance. Ergonomics 2006;49:1068-91.
10. Siegrist J. Adverse health effects of high-effort/low-reward conditions. J Occup Health Psychol 1996;1:27-41.
11. van Vegchel N, de Jonge J, Bosma H, Schaufeli W. Reviewing the effort–reward imbalance model: Drawing up the balance of 45 empirical studies. Soc Sci Med 2005;60:1117-31.
12. Stansfeld S, Candy B. Psychosocial work environment and mental health--a meta-analytic review. Scand J Work Environ Health 2006;32:443-62.
13. Bauer J, Unterbrink T, Hack A, Pfeifer R, Buhl-Grießhaber V, Müller U, *et al*. Working conditions, adverse events and mental health problems in a sample of 949 German teachers. Int Arch Occup Environ Health 2007;80:442-9.
14. Wadman C, Kjellberg A. The role of the affective stress response as a mediator for the effect of psychosocial risk factors on musculoskeletal complaints--Part 2: Hospital workers. Int J Ind Ergon 2007;37:395-403.
15. Larsman P, Sandsjö L, Klipstein A, Vollenbroek-Hutten M, Christensen H. Perceived work demands, felt stress, and musculoskeletal neck/shoulder symptoms among elderly female computer users. The NEW study. Eur J Appl Physiol 2006;96:127-35.
16. Kjellberg A, Toomingas A, Norman K, Hagman M, Herlin RM, Tornqvist EW. Stress, energy and psychosocial conditions in different types of call centres. Work 2010;36:9-25.
17. Kjellberg A, Wadman C. The role of the affecitve Stress Response as a mediator of the effect of psychosocial risk factors on musculoskeletal complationts - Part 1: Assembly workers. Int J Ind Ergon 2006;2007:367- 74.
18. Eklöf M, Ingelgård A, Hagberg M. Is participative ergonomics associated with better working environment and health? A study among Swedish white-collar VDU users. Int J Ind Ergon 2004;34:355-66.
19. Norlander T, Johansson Å, Bood S. The affective personality: Its relation to quality of sleep, well-being and stress. Soc Behav Pers 2005;33:709- 22.
20. Persson R, Garde AH, Hansen ÅM, Ørbæk P, Ohlsson K. The influence of production systems on self-reported arousal, sleepiness, physical exertion and fatigue—consequences of increasing mechanization. Stress Health 2003;19:163-71.
21. Babisch W. Stress hormones in the research on cardiovascular effects of noise. Noise Health 2003;5:1-11.
22. Ising H, Kruppa B. Health effects caused by noise: Evidence in the literature from the past 25 years. Noise Health 2004;6:5-13.
23. Clow A, Thorn L, Evans P, Hucklebridge F. The Awakening Cortisol Response: Methodological Issues and Significance. Stress 2004;7:29- 37.
24. Lundberg U. Coping with stress: Neuroendocrine reactions and implications for health. Noise Health 1999;1:67-74.
25. Nader N, Chrousos GP, Kino T. Interactions of the circadian CLOCK system and the HPA axis. Trends Endocrinol Metab 2010;21:277-86.
26. Clow A, Hucklebridge F, Thorn L. The cortisol awakening response in context. Int Rev Neurobiol 2010;93:153-75.
27. Schlotz W, Hellhammer J, Schulz P, Stone AA. Perceived work overload and chronic worrying predict weekend-weekday differences in the cortisol awakening response. Psychosom Med 2004;66:207-14.
28. Rosmond R, Dallman MF, Bjorntorp P. Stress-related cortisol secretion in men: Relationships with abdominal obesity and endocrine, metabolic and hemodynamic abnormalities. J Clin Endocrinol Metab 1998;83:1853-9.
29. Hakanen JJ, Bakker AB, Schaufeli WB. Burnout and work engagement among teachers. J Sch Psychol 2006;43:495-13.
30. Bakker AB, Killmer CH, Siegrist J, Schaufeli WB. Effort-reward

imbalance and burnout among nurses. J Adv Nurs 2000;31:884-91.
31. Melamed S, Ugarten U, Shirom A, Kahana L, Lerman Y, Froom P. Chronic burnout, somatic arousal and elevated salivary cortisol levels. J Psychosom Res 1999;46:591-8.
32. Borg MG. Occupational stress in British educational settings: A review. Educ Psychol 1990;10:103-27.
33. Kryter KD, Poza F. Effects of noise on some autonomic system activities. J Acoust Soc Am 1980;67:2036-44.
34. Goyal S, Gupta V, Walia L. Effect of noise stress on autonomic function tests. Noise Health 2010;12:182-6.
35. Kjellberg A, Muhr P, Skoldstrom B. Fatigue after work in noise - an epidemiological survey study and three quasi-experimental field studies. Noise Health 1998;1:47-55.
36. Åhsberg E, Gamberale F, Kjellberg A. Perceived quality of fatigue during different occupational tasks Development of a questionnaire. Int J Ind Ergon 1997;1997:121-35.
37. Jensen R, Olesen J. Tension-type headache: An update on mechanisms and treatment. Curr Opin Neurol 2000;13:285-9.
38. Linton SJ. A review of psychological risk factors in back and neck pain. Spine (Phila Pa 1976) 2000;25:1148-56.
39. Benham G. Sleep: An important factor in stress-health models. Stress Health 2010;26:204-14.
40. Ekstedt M, Soderstrom M, Akerstedt T, Nilsson J, Sondergaard HP, Aleksander P. Disturbed sleep and fatigue in occupational burnout. Scand J Work Environ Health 2006;32:121-31.
41. Virtanen M. Stress at work--a risk factor for depression? Scand J Work Environ Health 2010;36:433-4.
42. Hammen C. Stress and depression. Annu Rev Clin Psychol 2005;1:293- 319.
43. Kjellberg A, Wadman C. Subjective stress and its relation to psychosocial work conditions and health complaints. A test of the Stress-Energy model (English summary). Arbete Och Hälsa 2002;12:31.
44. Melamed S, Kushnir T, Shirom A. Burnout and risk factors for cardiovascular diseases. Behav Med 1992;18:53-60.
45. Grossi G, Perski A, Evengard B, Blomkvist V, Orth-Gomer K. Physiological correlates of burnout among women. J Psychosom Res 2003;55:309-16.
46. Shirom A, Westman M, Shamai O, Carel RS. Effects of work overload and burnout on cholesterol and triglycerides levels: The moderating effects of emotional reactivity among male and female employees. J Occup Health Psychol 1997;2:275-88.
47. Akerstedt T, Gillberg M. Subjective and objective sleepiness in the active individual. Int J Neurosci 1990;52:29-37.
48. Bech P, Rasmussen NA, Olsen LR, Noerholm V, Abildgaard W. The sensitivity and specificity of the Major Depression Inventory, using the Present State Examination as the index of diagnostic validity. J Affect Disord 2001;66:159-64.
49. Olsen LR, Jensen DV, Noerholm V, Martiny K, Bech P. The internal and external validity of the Major Depression Inventory in measuring severity of depressive states. Psychol Med 2003;33:351-6.
50. WHO. ICD-10 classification of mental and behavioral disorders. Diagnostic criteria for research. Geneva: World Health Organization; 1993.
51. Orion D. Spectria Cortisol RIA coated tube radioimmunoassay. Cat NO 06119 2010. Available from: http://www.oriondiagnostica.com/files/odextra/Clinical%20Chemistry%20brochures/303_07GB_Spectria_Steroid_Assays_Family_Brochure.pdf. [Last accessed on 2012 Jan 24].
52. Fahlen G, Knutsson A, Peter R, Akerstedt T, Nordin M, Alfredsson L, *et al*. Effort-reward imbalance, sleep disturbances and fatigue. Int Arch Occup Environ Health 2006;79:371-8.
53. Norlund S, Reuterwall C, Hoog J, Lindahl B, Janlert U, Birgander LS. Burnout, working conditions and gender--results from the northern Sweden MONICA Study. BMC Public Health 2010;10:326.
54. Hygge S, Evans GW, Bullinger M. A prospective study of some effects of aircraft noise on cognitive performance in schoolchildren. Psychol Sci 2002;13:469-74.
55. Kjellberg A, Ljung R, Hallman D. Recall of words heard in noise. Appl Cogn Psychol 2008;22:1088-98.

How to cite this article: Sjödin F, Kjellberg A, Knutsson A, Landström U, Lindberg L. Noise and stress effects on preschool personnel. Noise Health 2012;14:166-78.
Source of Support: AFA insurance, **Conflict of Interest:** None declared.