Exposure to high sound levels and risk of hearing related disorder among obstetrics personnel

S. Fredriksson[1], K. Persson Waye[1]

[1] Occupational and Environmental Medicine, Sahlgrenska Academy, University of Gothenburg, SE-41501, Gothenburg Sweden, sofie.fredriksson@amm.gu.se, kerstin.persson-waye@amm.gu.se

ABSTRACT

Exposure to high sound levels is a well-known cause of hearing disorder. However, this has not been adequately studied in non-industrial work environments. Therefore, a cross-sectional study was performed in an obstetrics ward including sound level measurements and a questionnaire survey among personnel (response rate 72%, n=115). Among 55 of those a nested case-control study was performed, with measurements of pure-tone audiometry, distortion product otoacoustic emissions (DPOAE) and hearing in noise test (HINT).

The sound level measurements showed that 46% of the measured shifts exceeded 80 dB LAeq and 27% of the shifts exceeded 115 dB LAFmax. More than half of the participants reported one or more hearing-related symptom and almost half of the group reported work-related stress and noise annoyance. Calculated cumulative occupational noise dose was significantly associated with increased odds of tinnitus and sound fatigue in logistic regression models. A small proportion of the participants had worse hearing compared to age-specific reference for audiometry at 6-8 kHz. Impaired hearing as measured by audiometry and DPOAE was furthermore significantly correlated to cumulative occupational noise dose.

The study shows that obstetrics personnel are exposed to high sound levels and have an increased risk of hearing disorder. This indicates a need for preventive action related to noise exposure in the obstetrics care.

INTRODUCTION

It is well-known that noise exposure can cause auditory injury such as hearing loss, tinnitus and sound sensitivity (Palmer et al. 2002, Kähäri et al. 2003, Henry et al. 2005). Sound induced auditory fatigue described as a need for quietness after a work-day has also been reported among personnel in communication intense work environments (Persson Waye et al. 2010). The European Agency for Safety and Health at Work has recognized that traditionally female-dominated work environments such as the health care sector are largely overlooked concerning noise research and risk assessments regarding noise exposure (European Agency for Safety and Health at Work 2012).

Based on a work-place inspection at an obstetrics ward in Sweden concerns were raised regarding high sound levels. The results, which were presented at a medical congress in Sweden in 2010 showed that both the lower action value 80 dB LAeq and the upper exposure limit 115 dB LAFmax were exceeded (Tenenbaum et al. 2010). One peer-reviewed study has published results from sound level measurements in a hospital in India where results showed that the highest equivalent

night time level in the hospital (71.9 dB LAeq) was measured in the obstetrics and gynecology ward, with slightly lower levels in the labor ward (Vinodhkumaradithyaa et al. 2008). In addition to potentially harmful exposure to high sound levels, midwifes in obstetrics care also report a high degree of work-related stress and burnout (Hildingsson et al. 2013). This may be important when considering noise exposure at the workplace, since the combination of these exposures may possibly interact in causing adverse health effects (Babisch 2002, Leather et al. 2003). There are also research showing a possible correlation between stress and hearing-related disorders (Muchnik et al. 1980, Horner 2003, Hasson et al. 2011, Hasson et al. 2013).

The aim of this study therefore was to evaluate potential risk of occupational noise-induced hearing-related symptoms among obstetrics personnel by measuring sound levels in the work-place and by analyzing the effect of and interaction between occupational noise exposure, noise annoyance and work-related stress on hearing-related symptoms among obstetrics personnel and to measure hearing among the personnel.

METHODS

Sound level measurements

Sound level measurements were carried out during 62 work-shifts in the labor ward of a general obstetrics ward at the Sahlgrenska University Hospital in Gothenburg, Sweden. Day shifts (n=19) were measured between 7 a.m. and 3:30 p.m. (8.5 h), evening shifts (n=12) between 1:45 p.m. and 9 p.m. (7.25 h) and night shifts (n=30) between 9 p.m. and 7 a.m. (10 h). The daytime and evening shifts were measured during separate weeks. All personnel (n=10) working during the measured shifts wore a personal dosimeter (Larson Davis 705+) set to measure A-weighted equivalent levels and maximum levels (fast) with a sampling interval of 30 seconds and with the microphone attached to the right shoulder. Personnel carrying a dosimeter documented work activities during the measured shift. The equivalent levels reported, refer to the full-shift length and will hence vary between 7.25 – 10 hours, hereinafter denoted as $LAeq_{(7\text{-}10h)}$. A few recordings were excluded due to faulty dosimeters, leaving 529 (85%) individual recordings to be included in the analysis.

Questionnaire survey among personnel

All personnel (n=160 women) employed at the general obstetrics ward were invited to participate in a questionnaire survey. A total of 115 (72%) participated by responding to the initial questionnaire. Two reminders were sent out to the participants and a third reminder was distributed at the work-place.

The questionnaire included items on hearing-related symptoms (hearing loss, tinnitus, sound sensitivity, sound induced auditory fatigue, general hearing status, speech perception) as well as items assessing noise exposure at work and in leisure time, work-related stress and noise annoyance and smoking. In the statistical analysis occupational noise exposure was assessed by calculation of a cumulative occupational noise exposure index derived from a set of items.

Nested case control with hearing tests

A sub-sample (n=55) of those who participated in the questionnaire study also participated in a follow-up nested case-control study which included hearing tests. Cases were defined as meeting one or more of the following criteria based on the questionnaire data with the same definitions as described in the previous section: having hearing loss, poor hearing, tinnitus and/or sound sensitivity. Controls were defined as those not meeting the above stated criteria as well as answering no to both of the questions regarding difficulty speech perception. Those who reported no hearing-related symptoms other than difficulty perceiving speech either in work or leisure time or had missing data on the criteria questions (n=26) were excluded from the case-control sample. Based on the selection criteria 34 participants of the initial study sample were defined as cases out of which 26 participated in the hearing tests and 55 were defined as controls out of which 29 participated.

The hearing tests included pure-tone air conduction audiometry using circum aural headphone Sennheiser HDA 200 tested at a fixed lowest measured level of 10 dB HL at the standard audiometric frequencies 0.25, 0.5, 1, 2, 3, 4, 6 and 8 kHz. Distortion otoacoustic emissions (DPOAE) was tested at 65 (L1) and 55 (L2) dB SPL by analysing the cubic distortion product (CDP= 2f1-f2) from 32 sets of primary input tones (f2/f2=1.23; f2 ranging from 707 Hz to 10,374 Hz). Finally, speech audiometry was assessed using the Swedish Hearing in Noise Test (HINT) (Hällgren et al. 2006). Otoscopy and middle ear status was assessed before hearing testing begun.

Statistical analyses

Hypothesis testing was performed using IBM SPSS statistics version 20. Differences in averages were analyzed using one-way analysis of variance or independent t-test, where applicable. Prevalence was calculated via frequency counts. Binary logistic regression with Wald test was used for analysis of associations between occupational noise exposure, work-related stress, noise annoyance and binary hearing-related outcomes. Based on a hypothesized order of importance of predictor variables, manual sequential logistic regression models were assessed and interactions between significant predictors were tested. Assessment of multi-collinearity between predictor variables included in the regression models was done using Pearson's correlation or Spearman's rank correlation, where applicable. Odds ratios with 95% confidence intervals were derived from the logistic regressions. Goodness of fit for the regression models was assessed using the Hosmer-Lemeshow test. The significance level was set at 5% ($p \leq 0.05$) for all hypothesis tests.

RESULTS

Sound level measurements

The average (arithmetic mean) equivalent level recorded in the labor ward was 70.3 dB $LAeq_{(7\text{-}10h)}$ and 106.3 dB LAFmax with a range of 56-87 dB $LAeq_{(7\text{-}10h)}$ and 83-122 dB LAFmax. The lower action level 80 dB LAeq was exceeded in 30 different dosimeter recordings during 28 different work shifts, which corresponds to 46% of all measured shifts or 6% of all dosimeter recordings. The upper exposure action level and exposure limit 85 dB LAeq was reached or exceeded in three recordings from

three different shifts, corresponding to 5% of all measured shifts or 0.6% of all recordings. The limit 115 dB LAFmax was reached or exceeded at 50 different occasions. However, 9 events could not be verified by the written logs and were therefore excluded. The remaining 41 events occurred in 17 different shifts corresponding to 28% of all measured shifts or 8% of all dosimeter recordings. There were no statistical differences in arithmetic mean equivalent or maximum levels when comparing recordings from different shifts (day, evening and night) nor recordings from dosimeters worn by midwifes compared to assistant nurses. The proportion of occupational groups were similar comparing personnel carrying dosimeters and the sample who later responded to the questionnaire.

Questionnaire survey

A total of 72% responded to the questionnaire. The average age of the 115 participants who answered the questionnaire was 45 years ranging from 22 - 65 (SD 11). On average they had worked in obstetrics care for 12 years ranging from 0.5 - 40 (SD 11). Of those who answered 68% were midwifes, 25% were assistant nurses and 7% had other qualifications such as nursing. As much as 42% were defined as having work-related stress. Almost half of the group (49%) experienced annoyance due to sound/noise at work and 58% reported being exposed to high sound levels during one fourth of their working time or more, but only a small proportion (9%) reported using hearing protections. The calculated occupational noise index based on the questionnaire data of the participants ranged from 4.5 to 64 points with an overall mean index of 19 (SD 12) A higher value of the index indicating a longer exposure time (in years) and a higher current reported noise level at work. The prevalence of each of the hearing-related symptoms in the total study sample are shown in table 1. No data was collected from the non-responders.

Table 1: Prevalence of self-reported hearing-related symptoms among obstetrics personnel.

Hearing-related symptom	Prevalence %	95% CI
Sound fatigue	32	23.4-40.6
Tinnitus	13	6.8-19.2
Sound sensitivity	13	6.8-19.2
Poor hearing	16	9.3-22.7
Hearing loss	9	3.7-14.3
Difficulty perceiving speech	32	23.4-40.6
Any of the symptom	55	45.9-64.1

Hearing tests

As audiometry was measured at a lowest level of 10 dB HL pure tone averages were not calculated. Instead comparisons were made against the age-specific 90th percentile Swedish reference data (Johansson and Arlinger 2002). The results showed that hearing thresholds in the study group were worse in 6-8 kHz compared to age-specific reference data. At 4 kHz only 5% of the ears had worse thresholds, whereas at 6 kHz 14% of the tested ears had worse hearing thresholds and at 8 kHz the prevalence was 15%. On average without age taken into account, 26% of right ears and 31% of left ears had thresholds worse than 25 dB HL at any test frequency

(0.25-8 kHz). Hearing thresholds (HTL) at 6000 Hz are plotted against age and compared to the 90th percentile reference in figure 1.

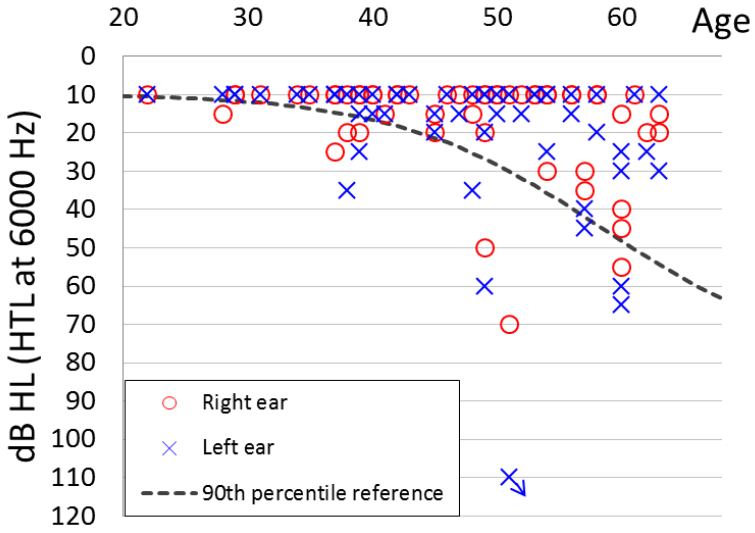

Figure 1. Hearing thresholds (HTL) in dB HL for the audiometric test frequency 6000 Hz plotted for each ear against age and compared to the 90th percentile reference data.

Out of 110 measurements 3 measurements from right ears and 7 left ears were excluded as tympanometry results were outside normal range defined as tympanic peak pressure -100 to +100 daPa and static admittance between 0,3 – 1,8 mmho. DPOAEs were defined as pass/fail using the cut-off value 3 dB SNR. Using this cut-off, the results showed that 4% of right ears and 8% of left ears failed DPOAE at frequencies averaged over 3-6 kHz and 10% of right ears and 25% of left ears failed DPOAE at frequencies averaged above 6 kHz up to 10 kHz. The average HINT results in dB SNR (Signal to Noise Ratio) was -4.4 dB SNR (SD 1.8) ranging from -9.9 - 2.4 dB SNR. Two participants' HINT results were excluded as they did not have Swedish as their first language.

Association between noise exposure index and hearing

Calculated cumulative occupational noise exposure as a single explanatory variable was significantly associated to tinnitus with p=0.049 and OR: 1.04 (95% CI 1.00 – 1.09) and sound fatigue with p=0.031 and OR 1.04 (95% CI 1.00 – 1.07). None of the other hearing-related symptoms were significantly associated to the occupational noise exposure index. This association is shown as an increasing prevalence with increasing noise exposure as seen in table 2.

Table 2: Occupational noise index grouped into four categories and prevalence of sound fatigue and tinnitus for each category of noise index.

	Grouping by noise index quartiles				**Total**
Number of participants (n)	28	29	29	29	115
Noise exposure index (range)	4.5 – 9.5	10 – 15	16 – 26	27 - 64	
Sound fatigue prevalence (%)	21	24	41	41	32
Tinnitus prevalence (%)	7	11	10	24	13

Work-related stress and noise annoyance were both significantly associated to sound fatigue in two separate models together with noise exposure (p=0.022, OR: 2.62, 95% CI 1.15 – 5.98 for stress and p<0.001, OR: 5.67, 95% CI 2.25 – 14.27 for noise annoyance). Tinnitus was not associated to stress nor noise annoyance. For sound fatigue, including all three significant explanatory variables (noise exposure, work-related stress and noise annoyance) resulted in marginal changes in point estimates for noise exposure and noise annoyance and both remained significantly associated to sound fatigue (p=0..25, OR:1.04 for noise exposure and p=0.001, OR: 5.25 for noise annoyance). It did however affect the estimates for work-related stress, which just missed statistical significance (p=0.053, OR: 2.39, 95% CI 0.99 – 5.76). No significant interaction was found between predictor variables. Neither smoking nor leisure time noise exposure had any significant effect on the analysis and they were not significantly associated to any of the hearing-related outcomes.

Both audiometry thresholds and DPOAE amplitude for the higher test frequencies were correlated to cumulative occupational noise index except DPOAE 6-10 kHz right ear. Higher noise exposure index was significantly correlated to higher (worse) pure tone and decreased DPOAE amplitude was significantly correlated to higher noise exposure index. After correction for multiple testing (Bonferroni) a few of the correlations were no longer significant (3 and 4 kHz right ear pure tone hearing thresholds and DPOAE amplitudes averaged over 6-10 kHz). HINT dB SNR was not correlated to noise index.

Table 3: Pearson correlation between noise exposure index and pure-tone audiometry thresholds (HTL), DPOAE average amplitudes and HINT dB SNR.

Variables tested against the noise index	**Pearson's r**	**p-value**	**Bonf. corr. p-value**
Pure tone audiometry thresholds			
HTL 3 kHz right ear	0.353	**0.008**	0.064
HTL 3 kHz left ear	0.406	**0.002**	**0.016**
HTL 4 kHz right ear	0.353	**0.008**	0.064
HTL 4 kHz left ear	0.483	**<0.001**	**<0.001**
HTL 6 kHz right ear	0.445	**0.001**	**0.008**
HTL 6 kHz left ear	0.446	**0.001**	**0.008**
HTL 8 kHz right ear	0.489	**<0.001**	**<0.001**
HTL 8 kHz left ear	0.491	**<0.001**	**<0.001**
Distortion product OAE average amplitudes			
DPOAE 3-6 kHz right ear	-0.520	**<0.001**	**<0.001**
DPOAE 3-6 kHz left ear	-0.467	**0.001**	**0.006**
DPOAE 6-10 kHz right ear	-0.246	0.079	-
DPOAE 6-10 kHz left ear	-0.370	**0.010**	0.060
DPOAE 3-10 kHz right ear	-0.477	**<0.001**	**0.001**
DPOAE 3-10 kHz left ear	-0.470	**0.001**	**0.006**
Hearing in Noise Test, binaural dB SNR	0.191	0.170	

CONCLUSIONS

This study presents unique data showing that sound levels in the obstetrics care are above the regulated limits for noise exposure at work. We could also show that obstetrics personnel report hearing-related symptoms and that a small proportion of the study participants had worse hearing compared to age-specific reference. In addition to this, we also found significant associations between calculated cumulative noise exposure and self-reported hearing-related symptoms (tinnitus and sound fatigue) as well as significant correlations between calculated cumulative noise exposure and measured hearing status via pure tone thresholds and distortion product otoacoustic emissions. These results indicate that risk assessment regarding the sound environment for personnel working in obstetrics care need to be addressed and that preventative action should be initiated.

To the best of our knowledge this is the first research study reporting obstetrics care sound environment as a possible risk for the personnel and we therefore encourage more studies in order to assess the strength of the results and the possible magnitude of the problem. Research is also needed that address the best form of intervention and prevention. Although immense evidence may be lacking for this specific work environment we strongly suggest that available preventative actions, such as use of hearing protective device are made available to the staff as soon as possible as auditory injuries such as tinnitus is often permanent and often very disturbing for those affected. Hearing protective devices is usually an easy and rather effective preventative action. However, in the case of obstetrics personnel an acceptable prevention method may be more complicated.

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