Hearing-related symptoms and occupational noise exposure among women: An intervention study in preschool and obstetrics care

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ABSTRACT

Recent cross-sectional studies have showed that preschool teachers and obstetrics personnel risk developing hearing-related symptoms associated with noise exposure. An ongoing cohort follow-up and intervention study will provide causal interpretations and evaluation of preventive factors. This presentation will include an overview of the project with focus on the intervention study, assessing effects on self-reported noise exposure and hearing-related symptoms. The intervention was performed at one preschool and one obstetrics care unit with two control workplaces each. A participatory approach was used, involving personnel, managers and health and safety representatives. The process followed a common structure in identifying, selecting, implementing and evaluating the interventions, whereas the interventions were tailored to each workplace. Survey data was collected at baseline and two follow-ups, and analysed using generalised estimating equation (GEE). We did not find significant positive effects of the intervention. Factors such as limited resources for implementation and other work environment deteriorations probably explain some of the negative results. Meanwhile, qualitative data indicated positive experiences of the interventions. Thus, we suggest further studies with control of implementation and other changes in the workplace.

INTRODUCTION

There is an increasing awareness that not only workers within industrial settings but also personnel in human-service occupations, such as preschools and obstetrics care, are affected by occupational noise exposure. In preschool and obstetrics care the noise arise mainly from human interaction, essential or central to the work activities, such as intense speech communication, screaming, medical equipment or children playing. Due to the important information carried by these sounds and the fact that the children, the caretakers and the

personnel themselves emit the sounds, traditional noise attenuation measures, such as isolating or removing noise sources or using hearing protection devices, may prove difficult or may only be feasible in specific situations, but not effective overall. Due to loud noise and lacking prevention, personnel in human-service occupations may be at risk for hearing-related disorders.

A recent cohort study among preschool teachers has showed that the relative risk of hearing-related symptoms such as hyperacusis and sound-induced auditory fatigue was more than twice that of women in the general population working in other commonly occurring occupations [1]. Another study among obstetrics care personnel has showed an increased risk of tinnitus and sound-induced auditory fatigue in relation to a noise exposure index including years worked [2]. These results were derived from analysis of cross-sectional data. An ongoing follow-up of the cohort study and a new intervention study in preschool and obstetrics care will provide better possibilities for causal interpretations and evaluation of preventive factors.

Changes in work organisations implemented with a top-down approach from management or expertise level has the advantage of being viewed as legitimate by the management level, but may fall short in relevance, motivation and engagement among employees and may thus have little chance of success [3]. For example, one study found effects on clearness of objectives and motivation, but not on perceived health, employee turnover or sickness absence [4]. The researchers conclude that the implemented measures must have a good match to the problems that they are intended to address in order to be effective. As a response to such problems, and in contrast to top-down approaches, employee-driven change is often based on actual problems and realistic possibilities [3]. Process-oriented and dynamic change on the other hand is based on a democratic process where those who are involved and affected by the change have power and influence on equal terms. Process-oriented change can be viewed as a continuous loop of improvement, for example following the Noland approach with prescribed plan–do–study–act (PDSA) cycles [5], in which often small-scale changes are adapted to the specific and complex workplace context in an iterative way [6]. Translating theory of change into methods used in intervention studies, a conclusion could be that a participatory intervention method should increase the effectiveness and sustainability of the interventions by involving both employees and manager in an intervention process. Studies have argued that a participatory based intervention approach, where employees take an active part in identifying problems and finding solutions, can increase employees' involvement and commitment, and that focus is on interventions that are relevant to the specific needs of the workplace [7].

AIM

The presentation will give an overview of the research project, which includes an intervention study, but also a 4-year prospective longitudinal cohort study.

The main aim and focus of the presentation, and this paper, is on the intervention study, and mainly the quantitative results assessing if the intervention had an effect on self-reported noise exposure and self-reported hearing-related symptoms. Additional preliminary results from the cohort study will be presented, focusing on preventive effect of decreased self-reported noise exposure on self-reported hearing related symptoms in a large general population sample of women.

METHOD

Intervention

The intervention was performed in two different settings: one preschool and one obstetrics care unit. The participatory intervention approach included qualitative studies, reference ("steering") group meetings (the group consisted of personnel, managers and health and safety representatives), as well as workshops with personnel at each intervention workplace. The intervention process followed a common structured approach in order to identify, select, implement and evaluate the interventions, whereas the intervention measures were tailored to the specific needs of each workplace. First, the researchers performed qualitative studies, which fed into advice and guidance at the reference group seminars. Then, the scope and details of the interventions were decided on among the personnel and managers at each workplace in communication with the reference group and the researchers. Lastly, interventions were refined in the workshops and implemented by managers and personnel. Researchers planned and managed the scientific evaluation process, but managers and personnel were advised to continuously discuss the process at workplace meetings.

The interventions included changes in the physical environment (e.g. rebuilding rooms and adding sound absorbing materials), availability and use of hearing protection devices, as well as organisational and psychosocial changes (e.g. changes in organisational routines and working methods) and actions to increase awareness of the sound environment.

Data collection and analysis

Survey data was collected at three time points, at baseline (t0), and then two follow-ups at approximately 3 months (t1) and 9 months (t2) after baseline. All employed personnel received a paper survey at each time point, with reminders collected during the following 1 to 2 months. The survey responders and the study sample used in the analysis is described in the next section.

As dependent outcome variables, we had a repeated measure of noise exposure (noise so loud you have to raise your voice or have difficulty hearing normal conversation level) and hearing-related symptoms (hearing loss, tinnitus, difficulty perceiving speech, hyperacusis and sound-induced auditory fatigue). Details of the questions have been published elsewhere [8].

The repeated measures survey data was analysed using generalised estimating equation (GEE) with intervention group as explanatory independent variable. Each dependent variable was analysed separately in GEE models, controlling for baseline values of the outcome variable. The models were also adjusted for possible confounding effects (differences between the intervention and control groups due to the non-randomised intervention selection). For noise exposure as outcome, we adjusted for baseline noise annoyance, previous acoustic measures at the workplace and hearing protection, separately and together in a full model. For hearing-related outcomes, confounders were assessed both qualitatively (theoretical mechanistic approach) and also statistically (if they changed the estimates by >15% on two tested outcomes: sound-induced auditory fatigue and tinnitus), and included factors such as baseline self-reported noise exposure, noise annoyance, previous acoustic measures at the workplace, age, resources at work and support from managers. We performed the analyses in the full data set to increase power, but also stratified by setting, as the interventions and the working conditions were not identical in preschool and obstetrics care. The GEE analysis included only participants who responded at baseline and at least one of the follow-up time points, and hence excluded those who only responded at follow-up.

In addition, sound level measurements were performed during one week (five to seven days) at each time point using personal dosimetry and stationary measurements. Preliminary descriptive analysis and group comparisons will be presented, but is not included in this proceeding congress paper.

Study population

For each intervention setting, two control workplaces were recruited. In general, the obstetrics workplaces were larger than the preschools, and the control groups (two workplaces per setting) slightly larger than the intervention groups (one workplace per setting).

As seen in figure 1 the response rates were generally higher in all groups at t0 and t1 than at t2, and higher in preschool than in obstetrics care at t0 and t1, and comparable in the obstetrics groups at t0 and t1, and in preschool at t2. However, response rates were slightly lower in the control group in preschool at t0 and t1, and in the intervention group in obstetrics at t2. The lower response rate in obstetrics may partly be due to inclusion of hourly employees in the calculation. They were, according to managers, to a great extent retired personnel working only a few hours at random. They were hence initially not included in the study group, and they often declined to participate when inadvertently being send a survey. The difference in response rates in preschool may be related to a heightened interest in the intervention group at t0 and t1. Generally, the smaller number of personnel in preschool compared to obstetrics enabled a closer contact, and possibly higher motivation to respond. Generally, as seen in our study, a lower response rate is expected at follow-ups.

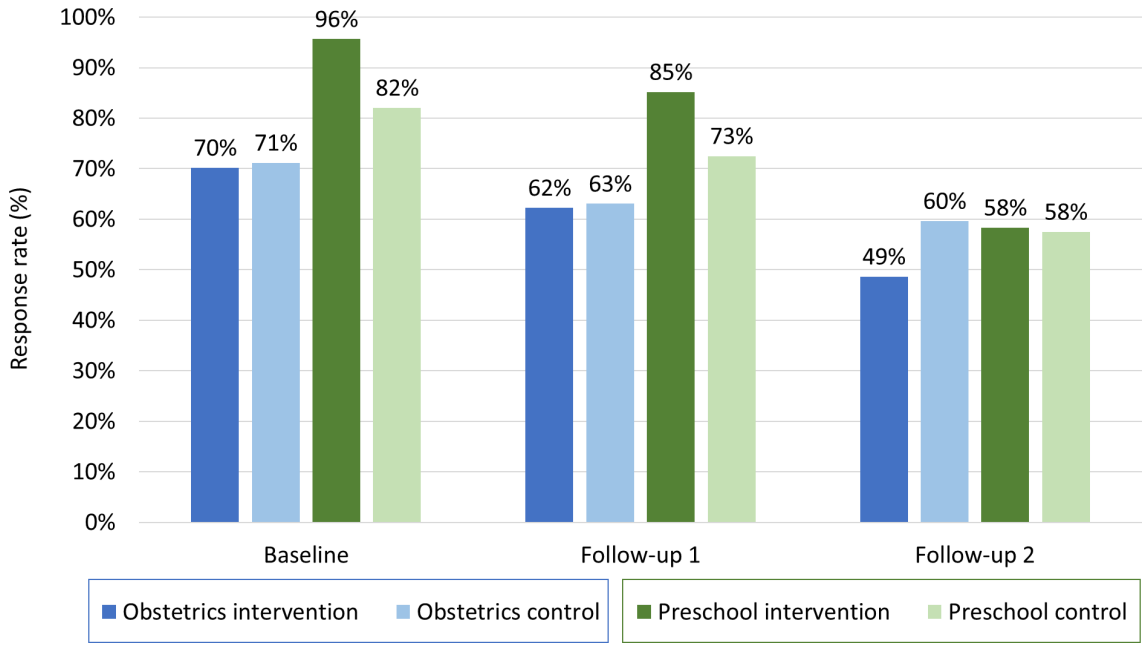

Figure 1: Response rates calculated as the number of responders divided by the total number of employed personnel, excluding known hourly employees, in percentages (%) for each time point and for each workplace setting separating the intervention and the control groups.

As described, participants that had not responded at baseline or only at baseline but neither of the follow-ups were excluded from the repeated measures analysis. Table 1 hence details the final number of subjects included in the analysis, and the corresponding proportion of the total number of responders. The number of subjects included in the analysis declined from baseline to follow-up 2, partly due to non-response and partly due to no longer being employed at the workplace. The obstetrics intervention group had a higher proportion of participants excluded due to incomplete data. This may be explained by a higher rate of personnel ending their employment, which was expressed in qualitative interviews.

Table 1: The number (n) of responders at each survey time point, and the number (n) and corresponding proportion (%) of subjects included in the GEE analysis for each time point and for each workplace setting separating the intervention and the control groups.

Time point	Setting	Intervention/ control	Total number of responders, n	Numbers and percentages of subjects included in analysis, n (%)
Baseline	Obstetrics	Intervention	73	50 (68)
		Control	79	66 (84)
	Preschool	Intervention	22	20 (91)
		Control	32	28 (88)
Follow-up 1	Obstetrics	Intervention	61	45 (74)
		Control	70	64 (91)
	Preschool	Intervention	23	20 (87)
		Control	29	25 (86)
Follow-up 2	Obstetrics	Intervention	54	40 (74)
		Control	68	56 (82)
	Preschool	Intervention	14	14 (100)
		Control	23	18 (78)

RESULTS AND DISCUSSION

Self- reported noise exposure

Even though some improvement in self-reported noise exposure was seen in the intervention groups, as shown in figure 2, generally, a larger proportion of the intervention groups than in the control groups reported an *increased* noise exposure, particularly at t2 compared to t0.

The higher proportion of increased noise exposure in the intervention groups than the control groups may explain the statistical analysis, which showed estimates with a positive direction (i.e. negative intervention effect). The analysis was only statistically significant in the obstetrics group and in the full sample analysis, but not in the preschool group. A somewhat larger proportion of the intervention group compared to the control group reported noise exposure and noise annoyance at baseline. The significant results were seen after adjusting for

baseline noise exposure. However, when adjusting for baseline noise annoyance, both separately and in a fully adjusted model, the results were no longer statistically significant. Albeit, still with a direction indicating a negative intervention effect. As the variables were not highly correlated, we argue that multi-collinearity is not the main explanation for these results.

Interestingly, in a detailed descriptive analysis, we found that noise annoyance at baseline was more common among those who reported *decreased* noise exposure at follow-up, compared to those who reported increased noise exposure. One might thus hypothesise that the intervention had a more positive effect on noise annoyance than on self-reported noise exposure, but further analysis is warranted as the same was seen also in the control group.

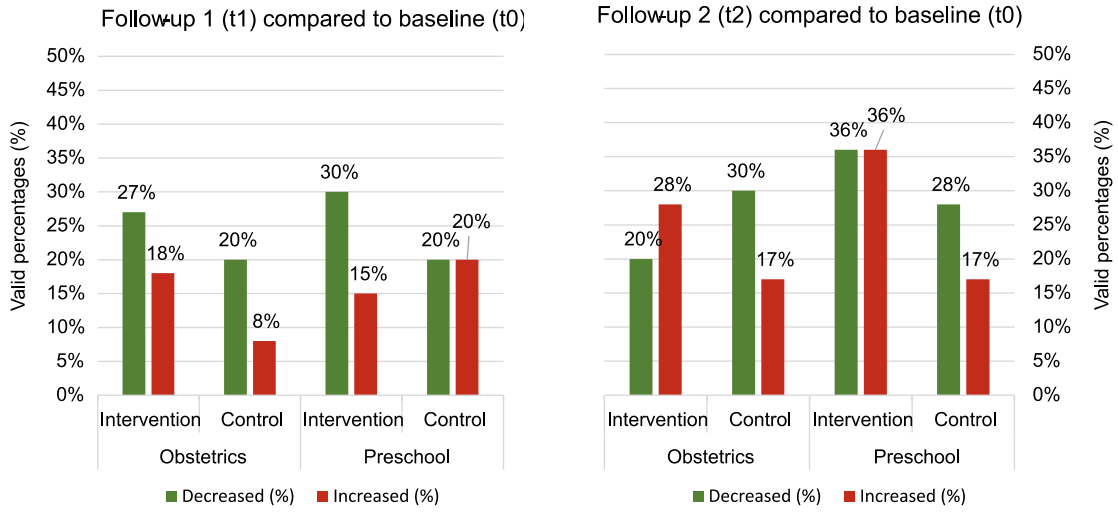

Figure 2: Descriptive data for change in self-reported noise exposure, categorised as decreased (less) noise exposure at follow-up, no change, or increased (more) noise exposure at each follow-up compared to baseline. Data is shown as valid percentages (%) among subjects included in the analysis for each workplace setting separating the intervention and the control groups. Change from baseline to follow-up 1 is shown to the left, and change from baseline to follow-up 2 is shown to the right. The category unchanged is not included in the figure.

Hearing-related outcomes

For the hearing-related outcomes, we could not show that the intervention had a statistically significant positive effect, with reduction of symptoms in the intervention group. The GEE models were either not statistically significant or significant but with a positive beta, which indicates that the intervention group was worse off than the controls.

The only significant results were found in the preschool setting for the outcomes hyperacusis and sound-induced auditory fatigue (p-values <0.001) and in the full sample analysis for hearing loss and sound-induced auditory fatigue (p-values <0.05), but no significant results were found in the obstetrics setting. As stated, the significant results showed positive estimates (intervention group is worse off than controls).

Among the non-significant models, we did find that the estimates were negative (intervention group better off than controls) for the outcome tinnitus in the preschool setting, and difficulty

perceiving speech and hyperacusis in the obstetrics setting, but none in the full sample analysis. As stated though, these models were not statistically significant. Only the outcome hyperacusis in the obstetrics group had a tendency toward a significant *p*-value (p=0.079), whereas the others were far from significant (p=0.805 and p=0.808). Moreover, in the preschool group, the models could not run for the outcome hearing loss and difficulty perceiving speech, probably due to few responses.

Descriptively, by comparing the follow-up responses to the baseline responses, we did find some improvement in the intervention group, but as with self-reported noise exposure, the proportion *deteriorating* (reporting more frequently occurring hearing-related symptoms) was often higher in the intervention groups than in the control groups.

Based on previous studies, we hypothesised a larger positive change after the intervention for the outcome sound-induced auditory fatigue compared to other symptoms. We did see a larger change in this outcome. However, as seen in figure 3, most of the change was negative, both in the intervention groups and the control groups. Still, in obstetrics care, a slightly larger proportion of the intervention group than the control group improved. The significant negative intervention effect found in the GEE model in the preschool group is supported by both a lower proportion of improvement at t1 and t2, as well as a higher proportion of deterioration at t2 compared to t0.

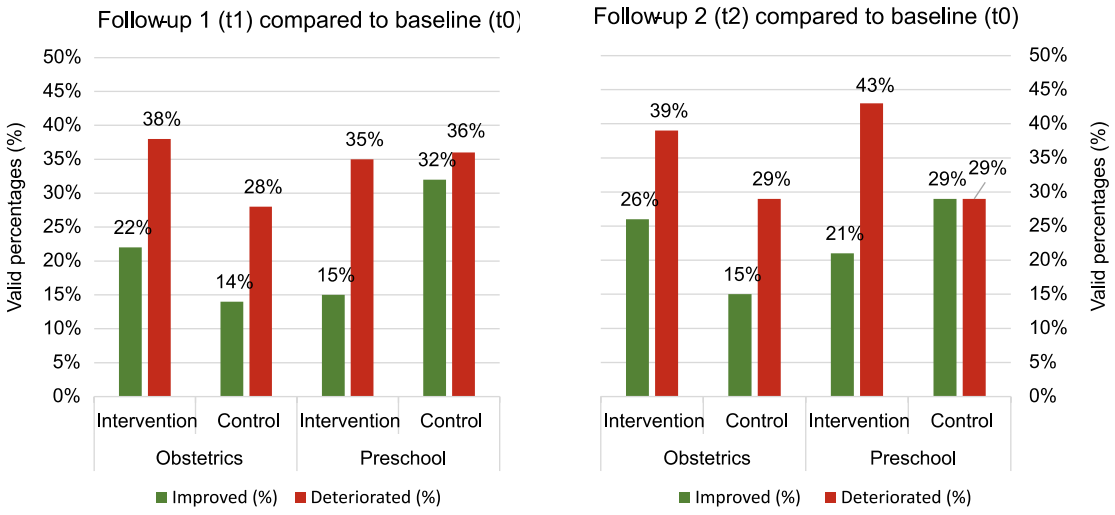

Figure 3: Descriptive data for change in self-reported sound-induced auditory fatigue, categorised as improved (less frequent) symptom at follow-up, no change, or deteriorated (more frequent) symptom at follow-up compared to baseline. Data is shown as valid percentages (%) among subjects included in the analysis for each workplace setting separating the intervention and the control groups. Change from baseline to follow-up 1 is shown to the left, and change from baseline to follow-up 2 is shown to the right. Category unchanged is not included in the figure.

As seen in figure 4, descriptive results for the symptom hyperacusis also showed a fair proportion of change. The significant positive estimate (negative intervention effect) seen in preschool is not supported by the descriptive data at t2, but at t1. Ideally, data from t2 should have had more weight in the analysis, since this is more likely the final and more sustained outcome after the intervention.

For hyperacusis in the obstetrics group, the tendency toward a significant positive intervention effect was supported by the descriptive data, as is also seen in figure 4. A larger proportion in the obstetrics intervention group compared to the control group *improved* in the outcome hyperacusis from baseline to t1 as well as from baseline to t2. However, the proportion that deteriorated was higher at t1 in the intervention group, which may explain the non-significant results. Although a fair number of subjects did report a change of outcome, they were most often less than 20 subjects, which likely decreased the statistical power.

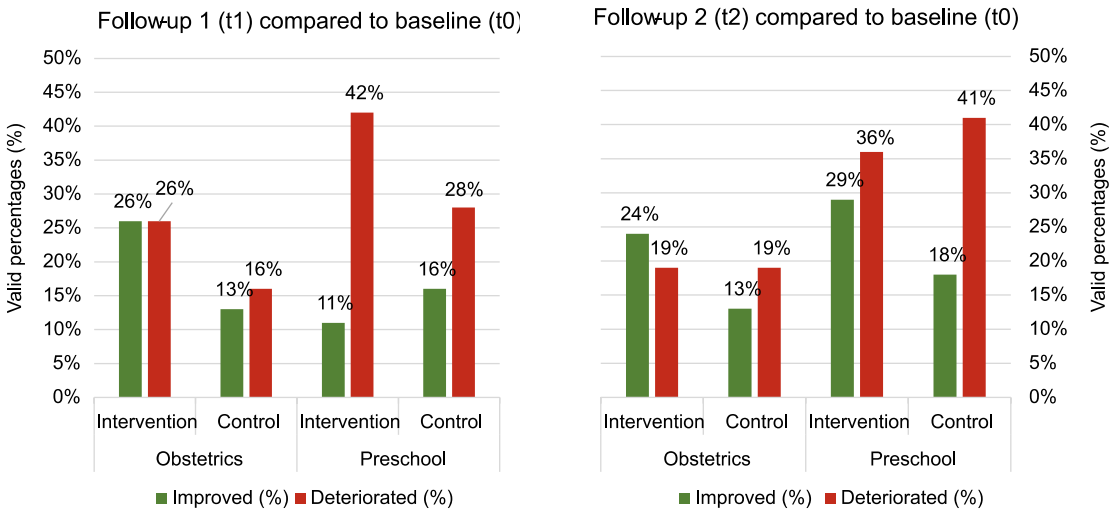

Figure 4: Descriptive data for change in self-reported hyperacusis, categorised as improved (less frequent) symptom at follow-up, no change, or deteriorated (more frequent) symptom at follow-up compared to baseline. Data is shown as valid percentages (%) among subjects included in the analysis for each workplace setting separating the intervention and the control groups. Change from baseline to follow-up 1 is shown to the left, and change from baseline to follow-up 2 is shown to the right. Category unchanged is not included in the figure.

The non-significant models showing a negative estimate (positive intervention effect) for tinnitus in the preschool group was supported by descriptive data, particularly at t2. However, the number of subjects who changed their report of tinnitus was rather low, often only one or two or at the most seven subjects. Hence, low statistical power is likely to have influenced this analysis and the estimated direction is not reliable. The number of subject who changed their responses from baseline to follow-up was low also for the outcome hearing loss as well as the outcome difficulty perceiving speech. One should note that these two outcomes were measured on a binary yes/no response scale, compared to the other outcomes which had five response alternatives in an ordinal frequency scale.

We had hypothesised that causing a change in hearing loss would be unlikely with such a short intervention. Usually hearing loss detectable in a survey would be more severe [9], and hence probably permanent. Similarly, we hypothesised that difficulty perceiving speech would be less possible to change as it may be related to hearing loss, but on the other hand also room acoustics. For tinnitus and hyperacusis, since the intervention was not directly aimed at hearing rehabilitation, we did not hypothesise a large reduction, but potentially a decreased symptom frequency. Based on previous intervention studies in preschool, we did hypothesise a significant reduction in sound-induced auditory fatigue [10, 11].

Intervention effect

We did not find statistically significant positive effects of the intervention. We hypothesise that 1) the awareness of being chosen as an intervention group, with the intervention activities raising awareness of problems with the sound environment and potential health effects, 2) not having met the high expectations of a positive intervention effect and much wanted change, and 3) possibly less than optimal implementation of interventions, may have influenced our results. The two latter have been discussed as possible explanations to negative intervention effects in other studies with a participatory approach [7]. In addition, studies have discussed a negative influence of employee disappointment due to poorly implemented interventions [12]. It is likely that these factors have a higher impact in participatory-based approaches, than top-down approaches, since employees have a higher degree of commitment and engagement with the intervention actions.

In support of these arguments, descriptive data indicated both that expectations with the interventions had not been fully met for the intervention group, and that resources to implement the interventions were lacking, including a perceived lack of support from the research group. Furthermore, there was not a unanimous response regarding our survey questions asking which interventions had been implemented, possibly reflecting less than optimal, if not poor, implementation.

In addition, qualitative data indicated that the intervention groups, particularly in obstetrics care, had a challenging psychosocial work environment with cutbacks, lay-offs and increased work load. Also, our intervention preschool had recently gone through a merge between two preschools, including moving to a new building. This preceded the intervention with about six months at baseline. According to qualitative data, the new building did not meet the personnel's expectations and they had still not fully "settled in" when the intervention was initiated. This too may have had a negative impact on the possibility of implementing the intervention and the perceived effect of the interventions aimed at improving the sound environment.

Furthermore, the rather limited sample size may also have had an effect, potentially causing type-II errors in the statistical analysis. Although descriptive data mostly supported the statistical results, many responders reported, in free-text, positive experiences with most of the interventions that were implemented. It is thus possible that the interventions were not in themselves negative, but had too little impact on the sound levels and sound environment to up weigh other negative changes in the work environment, which occurred simultaneously.

Our participatory-based approach did not lend us to fully plan for which interventions would be implemented. Some of the interventions, such as installing acoustic wall panels, selection of silent toys, silent rooms for recovery as well as hearing protection for personnel has been described in preschool [10, 11, 13]. However, for obstetrics care, we have found no published intervention studies aimed at improving the sound environment. Hence, it was difficult beforehand to perform power and sample size estimations for statistical analysis. Since the participatory-based approach is still rather uncommon, we have relied more heavily on qualitative evaluation of the interventions than what is perhaps usually the case in intervention studies. In those data, we clearly see that the work environment in both preschool and obstetrics is highly complex and that personnel strongly expressed problems with the psychosocial work environment. These factors have likely overshadowed some of the potential positive effect from the interventions aimed specifically at the sound environment, but also possibly affected the sense of importance needed for a successful intervention.

Future perspective

As the general response towards the specific intervention measures was positive, we suggest further studies into the effects of these interventions. Albeit difficult in practice, we suggest that the interventions should be further evaluated in larger samples where a more strict control of adequate implementation of the interventions is held, as well as possibility to control, or adjust for, other potential interfering and deteriorating work-related factors such as those relating to the psychosocial work environment. The importance of expectations should also be stressed. Although some researchers argue that it might be more realistic to "*aim for preventing deterioration rather than improving working conditions" [12],* we hope that improvement and a healthy work environment is attainable, and that it will continue to be the goal.

CONCLUSION

In summary, the intervention did not show any statistically significant positive effects, neither in self-reported noise exposure nor in hearing-related symptoms. The few statistically significant results found showed instead an opposite effects with the intervention group being worse off than the control group. However, there were factors possibly explaining the negative results and qualitative data indicated that personnel had positive experiences of the interventions. Thus, we suggest further studies into the effects of interventions tailored to the specific needs of a workplace, in a larger group with control of implementation and other changes in the workplace, keeping in mind potential influence of expectations.

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