AN INTERVENTION STUDY OF THE RELATIONSHIPS BETWEEN INDOOR AIR-RELATED HEALTH PROBLEMS, PRODUCTIVITY AND CLEANLINESS IN AN OFFICE SETTING.

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ABSTRACT
An intervention study was conducted in an office building to examine the effect of improved cleaning quality on perceived indoor air quality, health and productivity. Effects of a controlled increase in cleaning quality were studied by questionnaires, registration of sickness absence, psychological tests, measurements of air quality, and visual and instrumental measurements of cleaning quality as described in the internordic standard INSTA 800. The intervention (blind) included introduction of a quality based cleaning programme including all interior surfaces on 2 floors. The intervention led to reduced dust load on furniture and fixtures. INSTA 800 proved to be a good tool to assess cleaning quality. No correlations were found between the two methods used for measuring cleaning quality. Instrumental measurements should be chosen if low dust loads on surfaces are desired. The results indicated that improved cleaning quality may reduce SBS symptoms, improve productivity and reduce short time sickness absence.

INDEX TERMS
Intervention study, Offices, Cleaning quality, SBS symptoms, Productivity

INTRODUCTION
Cleaning consumes 20-30 % of the facility management budget of Norwegian office buildings, and is often the most costly part of this budget (Norwegian Building Research Institute). Cost reductions are continuously searched for, and can usually be accomplished by introduction of more effective cleaning methods (Schneider, Nilsen and Dahl, 1994) (Nilsen, Dahl, Jørgensen et al., 2002) in combination with reduced cleaning frequencies. On the other hand reductions in cleaning may result in lower cleaning quality and increased dust load. Insufficient cleaning can cause increased occurrence of SBS-symptoms (Skov et al., 1987), and studies have revealed improved air quality and reduced SBS-symptoms after carrying out intensive cleaning actions (Skyberg, Skulberg, Kruse et al., 1999). New tools (Schneider, Løbner, Nilsen et al., 1994) (Nilsen, Dahl, Schjønning et al., 2000) have made it possible to study the relations between indoor air quality and the quality level obtained by the cleaning program in the building. This intervention study was carried out in order to measure the effects of a controlled increase in cleaning quality on indoor air quality, SBS-symptoms, productivity and sick leave in an office building. The hypothesis was: Improved cleaning quality will reduce the occurrence of SBS-symptoms and improve the productivity.

METHODS

The study was carried out in a non-problem, non-complaint office building. The intervention was blind and included introduction of a quality based cleaning program on 2 floors with a total of 70 offices. The new cleaning program included all interior surfaces of the offices; floors, furniture and fixtures, walls and ceiling. In the intervention group the quality of cleaning was increased in a controlled way. In addition modern cleaning methods were introduced in order to save time and reduce the use of water and cleaning chemicals. The control group consisted of two floors in the same building with a total of 50 offices, where the old frequency based cleaning program with no quality requirements was retained. The old cleaning system included floors, furniture and fixtures below 180 cm. Both groups of offices were cleaned twice a week.

Quality of cleaning was followed closely during the study by (i) visual inspection, and (ii) measurements of dust on surfaces by using a laser extinction meter and gelatinous foils (Schneider, Petersen, Kildesø et al., 1996), as described in the internordic standard NS INSTA 800 (Norwegian Standards Association, 2000). Dust measurements were performed immediately before cleaning (at the highest level), and visual inspections of cleaning quality were performed just after cleaning.

Effects of the controlled increase in cleaning quality were studied by questionnaires ("now"-situation, filled in weekly (2-3 times) in each measurement period, administered by e-mail), registration of sickness absence (January-March 2000 and 2001), psychological tests (anxiety, awareness and power of concentration), and measurements of airborne particles (particle counter, larger than aerodynamic diameter 0,3 μm). Number of occupants were 50 in each of the 2 study groups. Response rates for the questionnaires were 82% before and 83% after intervention (approx. equal in the 2 groups). Psycological tests were performed on 55 occupants before and 43 occupants after intervention (approx. equally distributed among the 2 groups). Sicness absence (whole days) were recorded by the administration of the companies in the building. Measurements were carried out in the spring (March/April) of 2000 ("before") and the spring of 2001 ("after"). In addition thermal factors (temperature, relative humidity) and other air quality parameters (TVOC, CO, CO_2) were followed up during the intervention period.

Statistical analysis was performed using a statistical program (SAS, version 6) for calculation of mean, variance, standard deviation, testing of hypothesis (Mann-Whitney U-test), and correlation analysis (Pearson). Level of significance was 0,05.

RESULTS

The new cleaning program resulted in a statistically significant increase in visual cleaning quality (occurrence of litter, dust and stains) on all four surface categories (furniture and fixtures, walls, floors and ceilings) in the offices comprising the intervention group. A smaller and statistically significant increase in quality (unintended) was also measured in the control group. A statistically significant difference between the two groups was only found on "furniture and fixtures", see figure 1.

Dust deposits were reduced (statistically significant) on all surfaces in the intervention offices, and on all surfaces except "difficult accessible furniture and fixtures" in the control group (unintended reduction). Dust deposits increased (0,0587, borderline, not statistically significant) on "difficult accessible furniture and fixtures" in the control group. Differences in dust level between the two groups were found for "difficult accessible furniture and fixtures"

(statistically significant) and "easy accessible furniture and fixtures" (0,0598, borderline, not statistically significant). Figure 2 shows the results for dust on "difficult accessible furniture and fixtures".

Measurements of airborne particles showed no difference in total concentration of particles (aerodynamic diameter> 0,3 μm) between control and intervention offices, but a tendency (not statistically significant, large variations) to difference was found for non-respirable (aerodynamic diameter> 3 μm) particles, see figure 3.

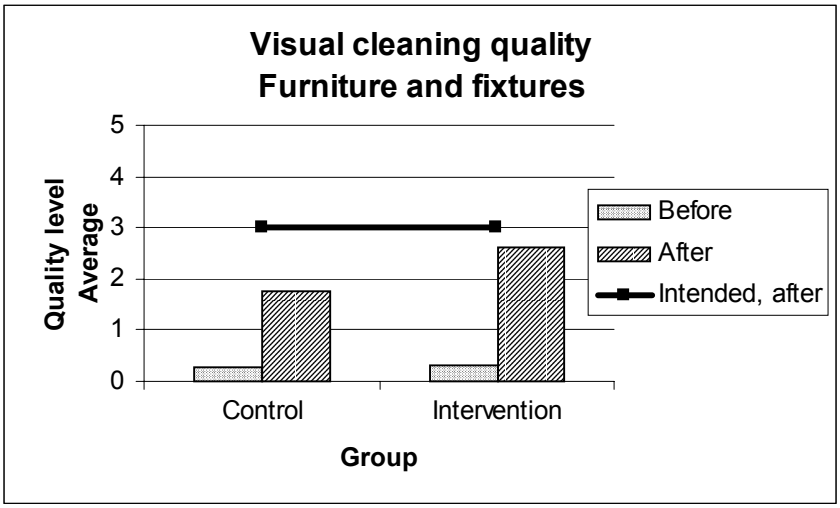

Figure 1. Visual cleaning quality; occurrence of litter, dust and stains on furniture and fixtures before and after intervention. Intended level (agreed visual cleaning quality, min.) after intervention is showed by bold line.

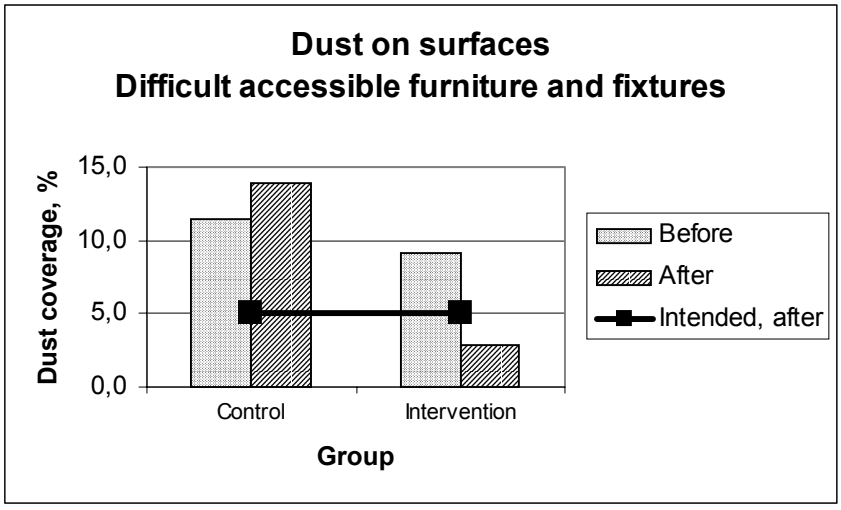

Figure 2. Dust on furniture and difficult accessible fixtures before and after intervention. Intended level (agreed dust level, max.) after intervention is showed by bold line.

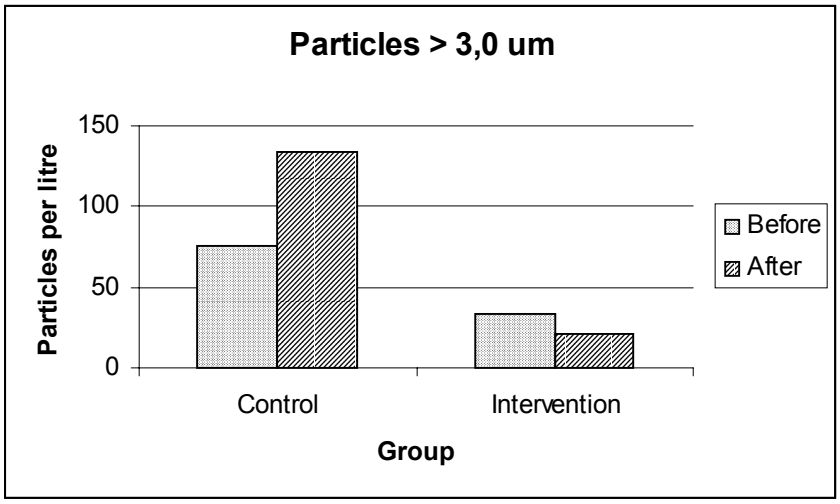

Figure 3. Average concentration of airborne particles with aerodynamic diameter larger than 3,0 μm (non-respirable) before and after intervention.

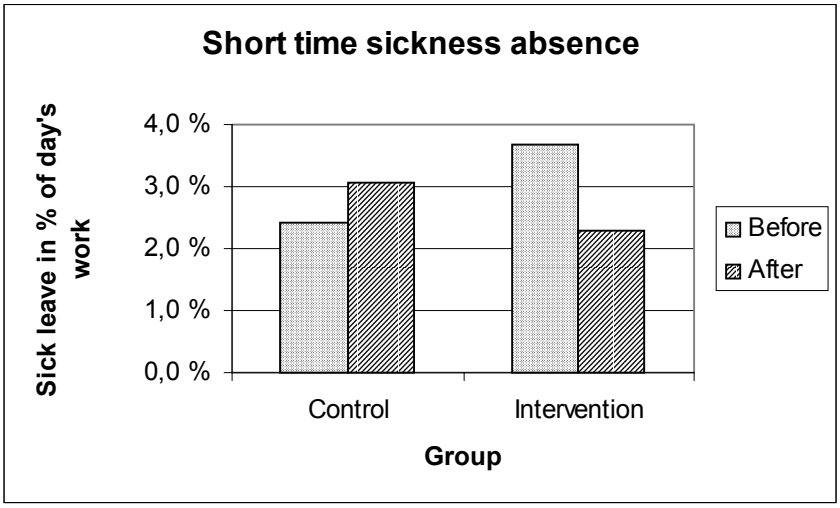

Figure 4. Short time sickness absence (up to 16 days) in percent of day's work in control and intervention offices before and after intervention.

The questionnaires revealed tendencies (not statistically significant) to reduced occurrence of "tiredness", "irritated eyes" and "dry air", and increased self-estimated "power of concentration" and "productivity" in the intervention offices when compared to the control group. No increase in power of concentration could be proved by the psychological tests. Sickness absence was reduced by 12,5 % in intervention offices, and increased by 3,9 % in control offices. The changes were mainly caused by changes in short time sick leave (less than 16 days), see figure 4. The cleaning cost was reduced by 17,4 % in the intervention offices.

DISCUSSION

The intervention led to increased cleaning quality and reduced dust load on furniture and fixtures, but a smaller and unintended rise in cleaning quality was also measured in the control group. A transition period of 6 months was necessary to fully introduce the new cleaning program.

INSTA 800 proved to be a good tool to assess cleaning quality. No correlations (Pearson correlation coefficient) were found between the two methods used for measuring cleaning quality. In order to ensure low dust levels on surfaces and high cleaning quality regarding dustiness, dust should be measured with instruments.

No statistically significant improvements in indoor air quality were found, but some tendencies to reduced occurrence of both mucousal and diffuse general symptoms, and a reduction in the coarser fraction of airborne particles could be seen. Similar effects have been found in other studies (Roys, Raw and Whitehead, 1993) (Franke, Cole, Leese et al., 1997) (Skyberg, Skulberg, Kruse et al., 1999). The lack of statistical significance may be caused by:

1. Non-problem building, low occurrence of indoor air-related symptoms in both control and intervention offices before intervention
2. Unintended and statistically significant improvement of cleaning quality in the control offices
3. Construction work in parts of the intervention offices during the study

In order to avoid "rub-off" effects on cleaning quality it is recommended to perform future studies of this kind with separate buildings for control offices and intervention offices.
The reduction in short time sickness absence was large and amounted to more than 50 day's work in the intervention offices. The change may be caused by random variations, but it is large and the result supports the conclusion that the indoor environment has been improved.
The reduction in short time sickness absence amounts to a reduction in production costs for the first quarter of 2001 of more than € 10 000 in the intervention offices. For comparison the total cleaning cost of the intervention offices was € 30 600 for 2001 (new cleaning program). The new cleaning program included new surfaces like walls and inventory above 180 cm, and ceiling. Despite this the cleaning cost was reduced considerably. The cost reduction was mainly due to introduction of more effective cleaning methods.

CONCLUSIONS

The intervention gave the following positive effects in the non-complaint offices:

- Improved visual cleaning quality on furniture and fixtures (after cleaning)
- Reduced maximum levels (before cleaning) of dust deposits on furniture and fixtures
- Slight improvements in SBS-symptoms (tendencies)
- Large reduction in short time sickness absence giving a considerable reduction in production costs
- Large reduction of cleaning costs despite expansion of the cleaning extent to new surfaces (high inventory, walls, ceilings)

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