INDOOR AIR QUALITY AND CLIMATE IN KINDERGARTENS - RELATION TO HEALTH EFFECTS

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Two investigations of the indoor climate were performed with different setup in six kindergartens in the winterseason. One year elapsed between the investigations. Symptoms and health effects were registered among children and staff. There were significant differences between the kindergarten having lowest CO_2 values and the two with the highest values regarding the amount of days with airway symptoms among children and staff. For operative investigation and evaluation of indoor climate in kindergartens, use of direct reading instruments is recommended.

INTRODUCTION

Investigations on the indoor climate in 50 norwegian kindergartens demonstrated unacceptable conditions (1). This prompted the health authority of the township of Lillehammer to contact the Labour Inspection for advice. An investigation of the conditions in the six kindergartens was initiated and performed in 1987-89.

MATERIAL & METHODS

All six full-time kindergartens, owned and run by the township, were investigated. These represented all "ordinary" kindergartens from which there had not been any complaints of "inferior indoor climate". Three kindergartens had natural ventilation, one of them had a particularly large indoor air space. Three had different types of ventilation systems, one had exhaust fan and two had balanced ventilation, one of which had "displacement ventilation".

All kindergartens were inspected and evaluated by occupational hygienist and occupational physician. The predominant complaints and symptoms related to indoor climate were registered. Staff from the kindergartens and the local food and water control authorities assisted in performing the measurements.

The first investigation of indoor climate was performed during six days in the forenoon at a

timing when the indoor milieu had been loaded for several hours by children and staff. Outdoor temperature, indoor air temperature 0,1 m and 1,1 m above the floor, globe temperature, air velocity and relative humidity were registered. CO_2-level was measured in three parallels with Dräger pumps and tubes.

Care was taken to obtain an unbiased and separate registration of sick absence and health effects. Sick absence, other absence, health condition and symptoms among all children and staff were registered every day in a three-month period by the personel of the kindergartens and with the understanding of and cooperation from the parents.

In the evaluation of the material children with chronic illness were excluded. All registered days, present in the kindergartens and sick absence from known cause, represents the total registered number of days for each. Sick absence was estimated as the proportion of days absent with registered disease divided by the total number of registrated days for each individual. Number of days with symptoms were registered while in kindergarten and at home on sick absence and divided by the total number of registered days.

We wanted to evaluate the methods employed and results obtained in the first investigation of the indoor climate and to scan for improvements in measuring methods with more usable results at less costs. The indoor climate investigation was therefore repeated one year later with the use of new instruments and resources from local health services.

RESULTS

General cleaning standard was acceptable. In one of the kinder-gartens without ventilation, visible moisture was demonstrated in the building construction in the cellar where the children had an actvity-room. Lighting-conditions were generally poor with too weak lighting in the older buildings. Strong lighting with marked contrast blending was demonstrated as a possible additional cause for eye-problems and headache in the newest kindergarten.

Only one of the six kindergartens with balanced mechanical ventilation, had sufficient air shift according to the CO_2-norm of 1200 ppm (2) in the test period (Fig 1, L). The kindergarten with large air volume (K), without mechanical ventilation had results varying slightly around the norm. The newest kindergarten, with the most advanced displacement ventilation system (R), had an average of close to 1800 ppm CO_2. This was found to be caused by faulty use of the ventilation system.

The kindergarten with exhaust fan (S) did not meet the demands, even with correct use (the fan in full use and all vents open). The building had been used for many years with the vents closed and ventilation turned off. The staff noticed marked improvement of the indoor climate when the ventilation system was turned on. Conditions, therefore, may previously have been appreciably worse than the results of our measures might indicate.

Two kindergartens without mechanical ventilation clearly exceeded the norms for CO_2. There was co-variation between CO_2 and relative humidity (RH %) in the total material (Fig.2). The kindergarten with the highest CO_2, also had the highest RH %, most frequent complaints about "dry air", even though it was the only one which used humidifiers.

The CO_2-load in kindergartens without mechanical ventilation seems to be reduced at low outdoor temperatures, while for kindergartens with balanced ventilation the opposite is the case: redused fresh air provision at low temperatures.

In the study of health effects, analyses were performed on a material consisting of 225 persons from five kindergartens, 55 adults (staff, all women), 87 girls and 83 boys after the exclusions. There were no significant differences in sick absences between the kindergartens. Boys had more symptoms and more sick absences than girls. The girls, on the other hand, more frequently stayed home when they had symptoms. The frequency of symptoms registered among the staff was on the same level as for the children, but resulted in appreciably rarer absences.

Differences in prevalence of symptoms were found between the kindergartens, - some of the differences being statistically sgnificant (Fig 3). The results correlated with the findings done in the indoor investigation. The kindergartens with the most inferior indoor climate (H,O) had the highest frequency of airway-symptoms, -while the kindergarten with the best results on the indoor investigation (L) had the lowest.

The indoor climate reinvestigation one year later has confirmed and elaborated on the results derived from the first. The results were appreciably more precise with the continuos monitoring of PMV (ISO 7730) and CO_2 and represents a better foundation for suggestions of future improvements. Only the newest kindergarten having the advanced displacement ventilation system showed any differences from the previous investigation. The technical installations are now correctly used and the kindergarten has the lowest CO_2-values. Lack of maintenance of the climate installations had developed in one of the kindergartens. Although the PMV-values in some cases were acceptable early in the day, measurements as a rule showed temperatures increasing unacceptably through the day.

DISCUSSION

Our results are in accordance with the results from other investigations (1,3). Only a small fraction of the kindergartens seem to fullfill the regulations from the health authorities.

Even though use of new and more advanced instruments may seem to be too expensive, especially for local building- and health-authorities, - such use gives a good foundation for the choice of measures that may be impressively more expensive. In the light of saved labour during the investigation that has now been obtained compared to the first investigation, - we find the increased costs of the instruments well justified.

Our investigations suggests that appreciable improvement may be obtained for all kindergartens by better control of the temperature, having lower temperature especially towards the end of the day. Improved ventilation and elimination of moisture-problems is an obvious necessity. In one kindergarten with balanced ventilation, cleaning, use and maintenance of the climate installations had to be appreciably improved.

It should be ascertained that the staff is well informed, - to full understanding - on ventilation

and climatic conditions so that buildings and installations are both used and maintained at an optimal level.

Lillehammer is a rather homogenous city and there is hardly reason to believe that there are any significant differences in social level, housing, outdoor pollution etc. in the homes of children and staff from2 the investigated kindergartens.

Significant differences between the kindergartens regarding airway symptoms correlated very well with the indoor-air parameters. The same results might have been found by chance due to differences in epidemic or infectious diseases in the area and in the different kindergartens. The results, however, are in accordance with results from other findings demonstrating correlation between indoor air quality and symptoms (3,4). Correlation between the highest CO_2, RH%, most frequent complaints about "dry air", and a high frequency of symptoms is consistent with other findings connecting sensations of "dry air" to irritative symptoms of the eye as a result of indoor air pollution (5).

As will be understood the present investigation has limitations, - hence no certain conclusions concerning co-variance between indoor climate factors and health effects should be drawn. Still the results may indicate that the quality of the indoor environment in the kindergartens has an impact on the prevalence of airway symptoms among the inhabitants. For the children this may influence their risk of developing long-lasting hyperreactivity in their airway mucous membranes.

CONCLUSIONS

Deficient understanding, planning and construction of - and the wrong use of - climate installations seems to be important reasons for bad indoor climate.

Complaints on "dry air" were most frequent in the kindergarten with the lowest ventilation rate and highest air humidity. This confirms that deficient air quality may lead to a sensation of "dry air", even though the humidity may not be low.

High values for CO_2 and RH% may both indicate too low ventilation rate during the wintertime. Kindergartens without mechanical ventilation obtain a better air shift when the outdoor temperature decreases. This may be caused by increased leakage of fresh air into the building through the building-construction due to thermic forces.

These investigations demonstrate a great demand for further improvements of the indoor climate in kindergartens. It is important to detect, elaborate and implement improved methods for prevention of airway-diseases due to bad indoor environments not only in kindergartens but also in schools and other comparable buildings. Extensive innovation and rehabilitation will be needed in many instances.

ACKNOWLEDGMENT

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from Simrad Optronics.

REFERENCES

1. Andersen T, Kvendbø J F (1987) Inneklima i barnehager. Undersøkelse av 50 barnehager i fem fylker (Indoor Climate in Kindergartens. Investigation of 50 kindergartens in five norwegian counties): Troms, Sør-Trøndelag, Hordaland, Buskerud og Vest-Agder. Teknisk Hygienisk Forum (THF), Trondheim/Kristiansand (in norwegian).

2. Inneklima. Helsemessige aspekter. Veiledning. Saksbehand-ling.(Indoor Climate. Health Aspects. Recommendations.) Helsedirektoratet, Veiledning nr.1, 1987. Teknisk Hygienisk Forum, Oslo, Norway 1987 (in norwegian).

3. Att förebygga Allergi/överkänslighet (To Prevent Allergy/hypersensitivity). Betänkande av allergiutredningen. SOU 1989:76, Stockholm 1989 (in swedish).

4. Andrae S, Axelson O, Björkstén B, Fredriksson M, Kjellman NIM (1988). Symptoms of bronchial hyperreactivity and asthma in relation to environmental factors. Arch Dis Child 63:473-8.

5. Franck C (1986). Eye symptoms and signs in buildings with indoor climate problems ("office eye syndrome"). Acta Ophthalmologica 64:306-311.

6. Statgraphics (STSC) version 2.6. Statistical graphics system by Statistical graphics corporation. STSC, Inc. 2115 East Jefferson Street, Rockville, Maryland 20852, USA 1987.

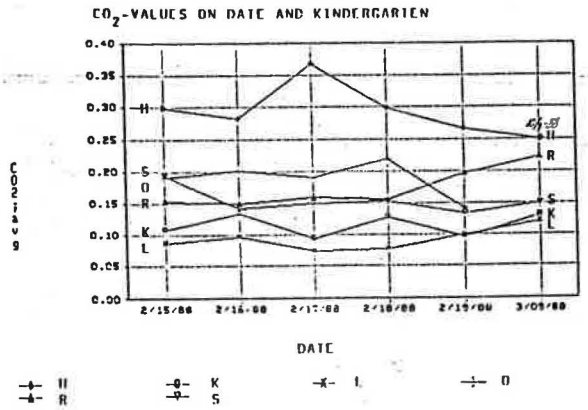

Fig. 1

This figure show a plot based on the average CO_2-value (vol %) measured each day in the kindergartens. We had to wait until 9th and 10th of march to get a "representative cold day".

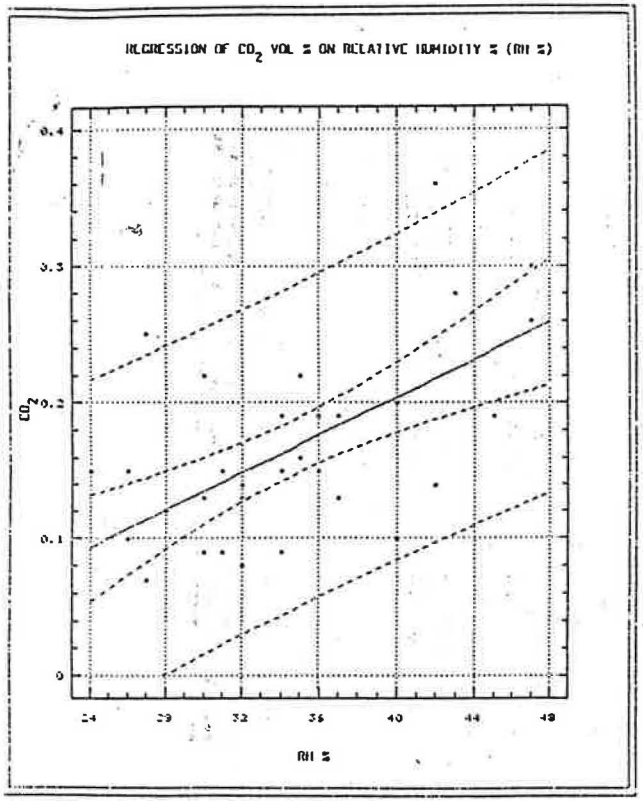

Fig. 2

The regression of CO_2-values on relative humidity in the total material indicate a certain relationship and that both values may correlate to reduced indoor air quality in this investigation.

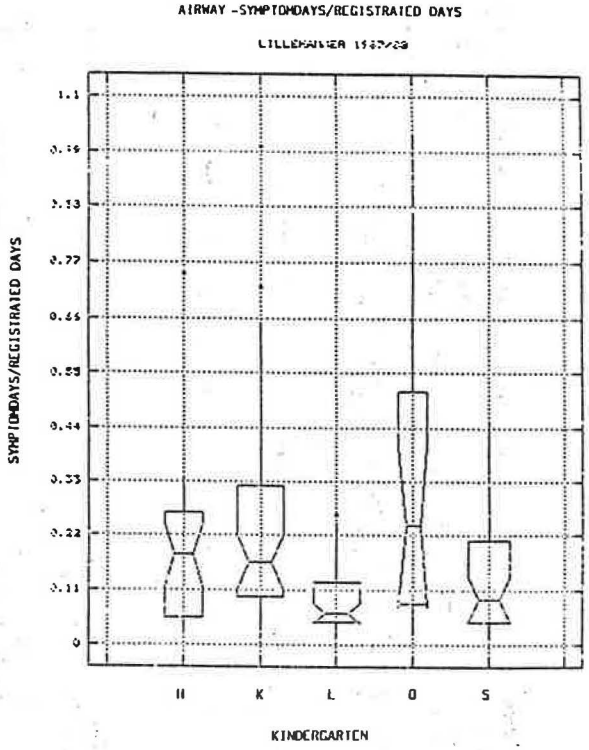

Fig 3.

Multiple, Notched Box-and-Whisker Plot (6) showing differences between kindergartens regarding days with airway symptoms divided on total registered days. The confidence level on the notches is set to allow pairwise comparisons to be performed at the 95% level by examining whether two notches overlap. Lillehammer, the one in the middle had the best indoor climate. Holme, the first from left, and Oversveen, the fourth, were the most inferior. The difference between Lillehammer and Holme/Oversveen is significant at the 95% confidence level.