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IVAIRE Project: Study of the Impacts of Ventilation on Indoor Air Quality in the Home and on the Respiratory Health of Asthmatic Children

HIGHLIGHTS AND SUMMARY

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The IVAIRE project was carried out by the Institut national de santé publique du Québec and the National Research Council of Canada in cooperation with the Asthma Clinic at the Centre mère-enfant of Centre hospitalier universitaire de Québec. The project was made possible through support from the Ministère de la Santé et des Services sociaux (MSSS) [Quebec's ministry of health and social services], the Canada Housing and Mortgage Corporation and Health Canada. The study is the subject of a scientific publication in the magazine, Indoor Air 2015; 25(6):582-97 (online January 21, 2015; DOI: 10 .1111/ ina.12181).

Highlights

The objectives of the Impact de la Ventilation sur l'Air intérieur et la Respiration des Enfants asthmatiques dans les habitations (IVAIRE) project were to evaluate the impact of ventilation on indoor air quality and the frequency of respiratory symptoms in asthmatic children living in single family homes. The two-phase project was broken down into two one-year periods: the pre-intervention phase (Phase I) to complete a descriptive study of all participants recruited and the selection of participants eligible for the randomized study on improved ventilation, and the post-intervention phase (Phase II) to follow up with participants in the randomized study.

In cooperation with the Asthma Clinic at the Centre mère-enfant (CME) of Centre hospitalier universitaire de Québec (CHUQ) [the mother-child centre at the Québec university hospital centre], and with the consent of the families involved, the research team recruited 115 children from ages 3 to 12. For an entire year, these potential candidates were followed and different tools were used to assess their indoor home environments. One hundred and eleven (111) children completed the observation period.

At the end of the first phase, 83 participants (75%) living in homes with low levels of ventilation were selected to participate in the randomized study. In June 2010, the participants in the intervention group (n=43) and the control group (n=40) were assigned randomly. The intervention to improve ventilation took place in the homes of the intervention group during the summer and at the beginning of fall. All study parameters were re-assessed during the second observation year.

- From the very start, a fairly high percentage (65%) of the single family homes evaluated during the study were already equipped with a mechanical ventilation system (MVS), usually a heat recovery ventilator (HRV). This represents almost double the proportion reported among the general population.

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- The quality of indoor air was generally good in most of the homes when compared to average concentrations of several traditional contaminants: mite allergens, mold spores, fine particles ($PM_{2,5}$) and nitrogen dioxide (NO_2), for example.
- A significant proportion (30%) of these homes presented mean formaldehyde concentrations that exceeded the guideline of 50 µg/m^3 for 8 hours recommended by Health Canada to prevent respiratory symptoms in asthmatic children.
- A high proportion (70%) of the homes presented a ventilation rate below 0.30 air changes per hour, the nominal ventilation rate recommended in the National Building Code of Canada (NBC) and the Construction Code of Québec (CCQ).
- The professional installation and use of a MVS such as a heat recovery ventilator (HRV) or an energy recovery ventilator (ERV) significantly improved the ventilation rate and indoor air quality in the homes of the intervention group, compared to the control group, and totally controlled guideline excesses for formaldehyde during the fall and winter.
- During the fall and winter following the ventilation intervention, the researchers observed no significant decrease in the number of days of asthma symptoms among children in the intervention group compared to the control group. However, compared to the control group, they did observe a significant decrease of 22% in the proportion of children in the intervention group having experienced one or more episodes of wheezing, and 20% for children having had four or more episodes during the following 12 months.
- On the basis of the difference of risk observed between the two groups, it was estimated that the ventilation intervention carried out in five homes in the study sample prevented formaldehyde from exceeding the guideline of 50 µg/m^3 for 8 hours in a home and prevented one or more episodes of wheezing affecting an asthmatic child during the year.
- Given the small size of the sample and limits of the study, a study with a larger number of participants would be advisable.

Summary

The objectives of the IVAIRE project were to evaluate the impact of ventilation on indoor air quality and the frequency of respiratory symptoms in asthmatic children living in single family homes. The two-phase project was broken down into two one-year periods: the pre-intervention phase (Phase I) to complete a descriptive study of all participants recruited and the selection of participants eligible for the randomized study on improved ventilation, and the post-intervention phase (Phase II) to follow up with participants in the randomized study.

The first phase began in October 2008. In cooperation with the Asthma Clinic at the Centre mère-enfant (CME) of Centre hospitalier universitaire de Québec (CHUQ), and with the consent of the families involved, the research team recruited 115 children aged 3 to 12. For an entire year, these prospective candidates for the randomized study were followed and their indoor home environments were evaluated using the following tools: standardized questionnaires covering health and the environment indoors; sampling devices to measure ventilation and air contaminants in the homes during the summer, fall and winter; daily journal of symptoms with peak expiratory flow rate (PEFR) measurements completed by the parents from November to March; and, spirometry and allergy skin tests carried out in the course of medical follow-up. One hundred and eleven (111) children completed the observation period.

The results of the descriptive study revealed that the children presented respiratory symptoms on average 5.6 days over a 14-day period, a rate indicating suboptimal asthma control. Forty-eight percent (48%) of the children were atopic; 76% had gone to emergency and 43% had been hospitalized for asthma during the previous year. Fifteen percent (15%) took four or more doses of relief medication (β2 –agonist) per week, which also represents a criterion of suboptimal asthma control. A large proportion (66%) of the homes were equipped with a mechanical ventilation system (MVS). This proportion of MVS is two times greater than the proportion observed in earlier studies carried out among the general population of Québec City (Gilbert et al., 2006) as well as in California (Offermann, 2009). However, the average ventilation rate measured in the 111 homes revealed 0.21 air changes per hour (ACH), which is below the

0.30 ACH nominal ventilation rate prescribed in the National Building Code (NBC, 2010). The ventilation rate measured in the homes equipped with an MVS was also lower than 0.30 ACH. Air quality in the homes under study was generally satisfactory and the average relative humidity ranged within the limits recommended by Health Canada. Concentrations of common allergens (mites, cat, dog) and most of the chemical contaminants were relatively low compared to values observed in Canadian homes and elsewhere in the world. The concentrations observed for the large majority of the contaminants concurred with guidelines and reference values currently in force. However, with respect to formaldehyde, a large percentage of the residences (summer: 63%; fall/winter: 23%) exceeded the guideline of 50 µg/m^3 for 8 hours recommended by Health Canada to prevent respiratory symptoms among children. Formaldehyde concentrations were generally higher in the summer.

At the end of the first phase, 83 participants (75%) living in a home with a low ventilation rate (2 ventilation results < 0.3 ACH or 1 result < 0.25 ACH measured using perfluorocarbon tracer gas [PFT] or sulphur hexafluoride [SF_6]) were selected to participate in the randomized study. In June 2010, the participants in the intervention group (n=43) and the control group (n=40) were assigned randomly. The intervention to improve ventilation took place in the homes of the intervention group during the summer and at the beginning of fall. It consisted of installing an HRV or an ERV in homes not equipped with an MVS and optimizing the system existing in homes already equipped with an MVS. The aim of the intervention was to increase the ventilation rate by an average 0.15 ACH in each of the homes. A technician supervised by a working group specializing in ventilation conducted a technical assessment of the ventilation that included air-flow rate measurements. Thereafter, a detailed list of corrections to undertake was prepared. Each of the home-owners in the intervention group was offered an information session on the use and adequate maintenance of an MVS. No intervention took place in the homes of the control group. During Phase II and in all the participants' homes, the environmental and health parameters measured during Phase 1 were measured again using the same protocols.

The randomized study revealed that a targeted intervention to improve ventilation in the homes with a low ventilation rate effectively corrected the shortcomings identified. The intervention significantly increased the ventilation rate in the homes of the intervention group compared to the control group and in most cases resulted in the achievement of the recommended 0.30 ACH ventilation rate. Improvements to the ventilation also significantly decreased the average concentrations of several volatile organic compounds (VOCs), including formaldehyde and mold spores in the homes. In particular, with respect to formaldehyde, the study showed that improved ventilation in the homes had prevented them from exceeding the guideline of 50 µg/m^3 for 8 hours during the fall-winter season.

In terms of the children's respiratory health, when compared to the control group, the study revealed no significant effect resulting from the improved ventilation in the homes of the intervention group on the number of days with asthma symptoms per 14-day period during fall and winter. However, when compared to the control group, the study did reveal a significant decrease of 22% in the proportion of children in the intervention group having experienced one or more episodes of wheezing, and 20% for children having had four or more episodes during the 12 months following the intervention. The authors cannot exclude the possibility that this result may be linked to multiple comparisons. On the other hand, the fact that the decrease in wheezing and the downward trend in the use of relief medication observed among children in the intervention group are linked to the same clinical phenomenon, suggests that the effect of improved ventilation on decreased wheezing is not a coincidence. Moreover, in conjunction with the results of indoor air quality, it was estimated, using a statistical model, that a 50% reduction in formaldehyde concentrations would likely result in 14.8%, 20.4%, and 16.0% reductions, respectively, in the proportions of children affected by wheezing, night cough and trips to emergency departments during the 12 months following improvements to ventilation in the homes.

The IVAIRE study was carried out by a multidisciplinary team among a priority clientele followed under real conditions in the field. Many environmental and respiratory parameters were measured during the two years of observation. The limitations of the study are related mainly to small sample size. A larger study with

sufficient power would be advisable to more properly study the short-term effect of improved ventilation in homes on the daily frequency of symptoms, as well as the frequency and severity of asthma exacerbation, particularly during the fall-winter period when children are more exposed to indoor air pollution. The results of the study clearly highlight that it is important for occupants to ensure sufficient ventilation in their homes. The study also shows that in the fall and winter, an increase in the ventilation rate is an effective way to reduce the indoor air concentrations of several contaminants that irritate the respiratory tract, in particular formaldehyde. This measure helps decrease occupants' exposure to these contaminants and reduces the risk of wheezing among children suffering from asthma-related symptoms. In light of these results, it would appear relevant that owners ensure adequate ventilation and proceed with necessary changes, as required.

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