

Implementation of a radon measurement protocol and its communication plan by child care centre managers in Québec

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ABSTRACT

OBJECTIVES: To invite and support managers of child care centres to measure radon concentrations in their buildings. Their ability to carry out a measurement protocol and communication plan was also evaluated as well as the intention of parents and educators to test for radon at home.

PARTICIPANTS: Managers, parents and educators of child care centres.

SETTING: 36 child care centres located in two priority investigation areas in Québec.

INTERVENTION: A kit containing radon detectors with installation and recovery instructions was shipped by mail in addition to factsheets intended for parents and educators. Site visits and phone calls were also conducted with a sample of child care centres and participants.

OUTCOMES: The instructions related to detector installation were generally well respected. Afterward, more than half (18) of the 34 parents and educators interviewed said that they had been directly informed of this radon testing by managers or other educators, and not by the factsheet provided. This radon measurement intervention was considered very relevant by 91% of them and a quarter (26%) expressed their intention to test for radon at home, while 6% had already done so. Two child care centres (5.5%) had at least one measurement above the Canadian guideline level of 200 Bq/m³.

CONCLUSION: This intervention has demonstrated the ability of child care centre managers to carry out this type of autonomous procedure, which can be centralized to minimize costs. This type of intervention may influence parents to become more familiar with this contaminant and measure their family's exposure at home.

KEY WORDS: Child care centres; radon testing; Québec; perception

La traduction du résumé se trouve à la fin de l'article.

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Radon is produced by the radioactive decay of uranium naturally present in the earth's crust. This gas can infiltrate into buildings where it can sometimes reach high concentrations associated with increased health risks.^{1,2} When radon disintegrates, it produces radon daughters (most notably ²¹⁸Po and ²¹⁴Po) which are themselves radioactive. When radon or its daughters are inhaled, they can emit high-energy ionizing radiation (alpha particles) which may damage bronchial cell chromosomes and ultimately may induce lung cancer.^{3,4}

Radon and its radioactive daughters are recognized as a proven human carcinogen by the United States Environmental Protection Agency (US EPA) and the International Agency for Research on Cancer (IARC).^{5,6} Cancer risk is directly related to radon concentration as well as the length of the exposure period.² In Canada, it has been estimated that 16% of lung cancer deaths are attributable to indoor radon exposure.⁷

Based on combined analysis,^{8,9} Health Canada, in collaboration with the provinces and territories, lowered its guideline's action level from 800 to 200 Bq/m³ in June 2007.¹⁰ To implement this federal recommendation, both federal and Québec provincial health authorities have developed strategies to protect the population against indoor radon exposure.

Despite efforts to inform the population and to promote radon measurement, radon exposure through indoor air remains an unrecognized source of risk and radon concentration measurements are still a rare practice. In 2011, 40% of Canadian households had heard of radon, while only 5% had tested for radon in their homes.¹¹ Available information has shown that persuading the population to carry out radon tests is challenging. Skepticism regarding the risks associated with radon as well as difficulty in obtaining adequate information on mitigation measures and their costs are among the reasons given for the lack of home radon tests.¹²

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RADON MEASUREMENT PROTOCOL AND COMMUNICATION PLAN

Indoor radon exposure is often considered as a problem that only concerns private homeowners. However, children spend many hours per day at child care centres or school and this exposure happens at an early age. Consequently, even though there are limited epidemiological data suggesting a greater sensitivity to radon in childhood, these indoor environments can contribute significantly to a child's cumulative exposure that should be reduced to decrease the lifetime risk.^{1,13} According to a recent risk analysis of the entire Québec population to evaluate the effectiveness of various radon testing programs in reducing lung cancer mortality, universal testing in public buildings such as all primary and secondary schools in the province could prevent more than three times the number of deaths that might be prevented by the promotion of universal testing in dwellings.¹⁴ Moreover, according to the World Health Organization, the key elements of a national radon program should include radon control measures in several types of buildings and especially in buildings where the public is likely to be exposed for long periods, such as schools, preschools, government-owned (or rented) buildings, and accommodation facilities.¹

In August 2011, following a pilot project conducted in 65 schools located in three priority investigation areas in Québec,¹⁵ the Ministry of Education mandated the 72 school board administrators of the province to measure radon in all their schools by the year 2014. In this context, the Ministry of Family then decided to undertake the measurement of radon concentrations in a significant sample of child care centres (*centres de la petite enfance, or CPE*) located in priority investigation areas. Given the higher number of buildings involved, and the lack of an administrative body such as a school board, it was necessary to

evaluate the ability of child care centre managers to conduct these procedures in an autonomous manner.

The objectives of this intervention were to: 1) invite and support managers of child care centres to measure radon concentrations in their buildings, and 2) assess the autonomy of child care centre managers in the implementation of a radon measurement protocol and communication plan. In addition, this project provided an opportunity to verify whether radon testing could increase radon awareness among parents and increase home testing. Parents with young children may be in the early stages of making choices about buying or renting a house; radon awareness could be particularly effective before house purchases.

SETTING, INTERVENTION AND MEASURES

Intervention sites

Based on geological indicators and indoor radon measurements, certain inhabited sectors with a relatively high ground radon emission or exhalation potential have been identified.¹⁶ According to the criteria, three distinct regions of the province of Québec (Gaspésie, Laurentides and Outaouais) were recognized as *priority investigation areas*. However, taking into account financial, organizational and geographical constraints, only the Laurentides and Outaouais regions were included in the current intervention. An announcement presenting the study was first sent to all managers of the 166 child care centres located in these two regions. Based on maps of the areas with a high radon emission potential,¹⁷ 36 child care centres (19 and 17 in the Laurentides and the Outaouais regions respectively) were then selected to obtain sites in both rural and urban areas (Figure 1).

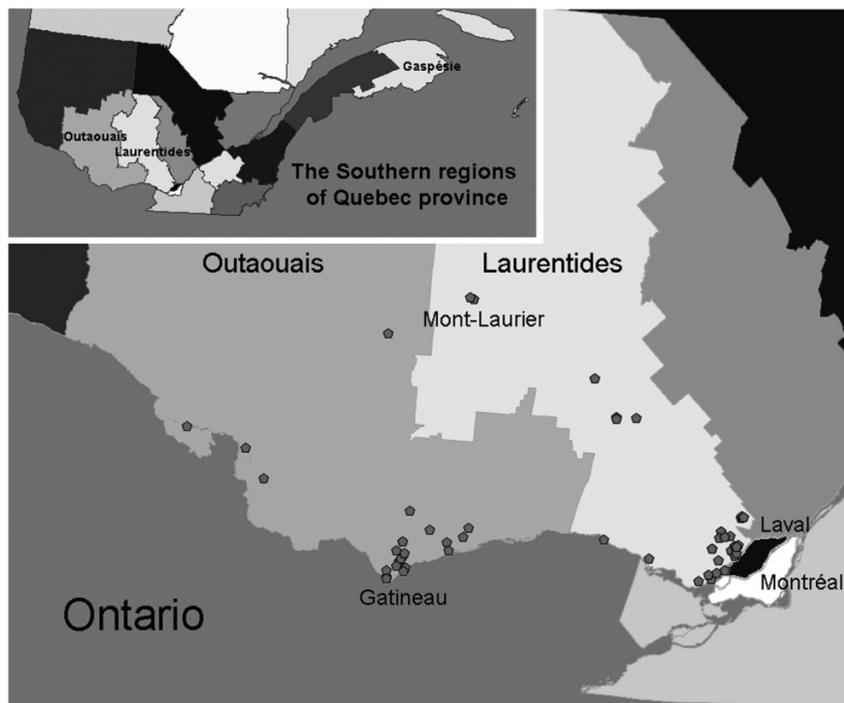


Figure 1. Map of the selected child care centres in the priority investigation areas (Laurentides and Outaouais regions) of the province of Quebec.

Since some child care services are located in several buildings, a total of 54 buildings were investigated.

Intervention

Following a two-hour introductory briefing on the radon problem (in January 2012), the managers of the selected child care centres were contacted by the research team to determine the number of detectors they needed to carry out radon measurements in their buildings. Managers received (in mid-February) a radon measurement kit by mail containing radon detectors with installation and recovery instructions, notices reminding employees not to move radon detectors while measurements were conducted, and factsheets for parents and educators. One month after measurements started (mid-March), the research team conducted a second series of phone calls to evaluate the manager's satisfaction level with the information tools that had been provided. Site visits were also carried out in 24 easily accessible child care centres located in 35 buildings (at the end of March) in order to verify whether all detectors were installed correctly and whether information sheets had been sent to intended recipients. A second letter was then distributed to parents and educators to announce an upcoming telephone survey to verify their knowledge, perceptions and behaviour regarding radon. Volunteers were invited to write their name and phone number on a sheet posted on the main bulletin board of the child care centres, and they were then called between mid and late April. At the end of May 2012, radon detectors were collected by child care centre staff and mailed back to the research team, who sent them to a certified laboratory.

Collection and processing of additional information

Two different phone surveys were used to collect five types of information from the child care centre managers (M), parents or educators (P/E; these two groups were merged because some educators were also the parent of a child attending the child care centres studied), or all of them (M + P/E). Questions addressed to these volunteers concerned the relevance of this radon measurement project (M + P/E), the quality of the information and material (M), radon-related knowledge (M + P/E), individual behaviour about radon testing at home (M + P/E) and socio-demographic status (M + P/E). The surveys developed for managers and for parents and educators were composed of 27 and 23 questions respectively, including some subquestions. While the major portion of the surveys consisted of closed-ended questions in the form of multiple choice, there were also some open-ended questions. Satisfaction and perception were measured with a Likert scale with four options (i.e., very, moderately, less, or not satisfied/relevant). These surveys were administered by research team members during the daytime and weekday evenings and took about 10 minutes to be completed.

The answers from the two participant samples were grouped when relevant and possible. Some variables with low frequencies were grouped dichotomously.

Radon measurements

Child care centre managers were invited to install *Alpha Track* type detectors in each room normally occupied (i.e., more than four hours per day by at least one person), on the lowest floors of the building (i.e., ground floor and basement) for a period of

approximately three months during the winter/spring season, in closed-building conditions.^{15,18} Indoor air radon volumetric activity (or concentration) was presented as a time-averaged measurement expressed in Becquerels per cubic metre (Bq/m³). For the calculations, values of 15 Bq/m³ were assigned to results under the detection limit.¹⁹ The results were reported regardless of the floor where the measurements were taken. For descriptive purposes, the radon concentration in each investigated room was processed to obtain the arithmetic average of all measurements in the building. Whether or not to proceed with mitigation measures was, however, based on results obtained in each room. For buildings with a maximum radon concentration between 200 and 225 Bq/m³, there was an option to take annual measurements before applying mitigation measures.

RESULTS

Adherence to measurement protocol and communication plan

The 36 child care centres that had been selected all accepted to participate, but only 18 of them sent managers to the training session presented by the scientific team at the beginning of the study. A total of 368 radon detectors were deployed for a mean duration of 97 days (min.–max. 42–142). The mean number of tested rooms per building was 8 (min.–max. 2–15). Thirteen of the 54 investigated buildings had some measures taken in basements (for a total of 46 detectors). In the vast majority of cases, the personnel correctly installed the radon detectors, except that the correct distance to an interior wall and the use of adhesive tape (provided in the installation kit) were frequently neglected (Table 1). In addition, it was necessary to communicate with six child care centre managers to remind them to ship back their detectors at the end of the measurement period. A total of seven detectors were lost or damaged (~2% of deployed detectors, including duplicates). Overall, the site visits allowed us to observe that the factsheet prepared by the research team to announce this intervention was not always sent to parents and educators; some managers preferred to display the factsheet on the board typically used to transmit general interest information to their clients.

Assessment of radon measurement approach

With the exception of age, the two groups surveyed had relatively similar profiles. The majority of the managers ($n = 28$) and parents/educators ($n = 34$; 17 parents and 17 educators, including 7 who were also the parent of a child attending the child care centre) were women, non-smokers, had university degrees and had a gross annual household income of over \$80,000 CAD (see Table 2).

This intervention was deemed very relevant by 86% of the managers surveyed, while a high satisfaction level with the intervention in general was reported by 93% of them (Table 3). A very high satisfaction level was also reported by 89% of the managers surveyed for all information received whereas 11% still had difficulty in understanding the detector installation instructions, and 46% experienced some difficulty in installing them as directed. Regarding parents/educators, this testing was considered very relevant by 91% of them, but only 53% were

Table 1. Adherence to measurement protocol and communication plan

	Laurentides (19 buildings) (%)	Outaouais (16 buildings) (%)	Both regions (35 buildings) (%)
Location of detectors			
Normally occupied rooms*	89	100	95
Lowest occupied floor of the building†	89	100	95
Distance from the floor ranging between 0.8 and 2.0 m	95	100	98
Distance from the roof exceeding 0.5 m	100	100	100
Distance from an exterior wall exceeding 0.5 m	100	88	94
Distance from an interior wall exceeding 0.4 m	58	56	57
Distance from any object exceeding 0.2 m	84	75	80
Shelter from any direct heat sources	95	100	98
Adequate attachment	74	63	69
Measurement conditions			
Detectors moved, altered or damaged	11	13	12
Log sheet completed	100	81	91
Communication tools			
Letter sent to concerned parents	58	69	64
Reduced-format posters used	79	69	74
Accessibility of the consent form related to telephone survey addressed to parents and educators	100	94	97

* The expression *normally occupied* referred to any area occupied by the same person at least 4 hours per day.

† i.e., ground floor and basement.

Table 2. Characteristics of surveyed respondents

Socio-demographic variables		Managers (N = 28)		Parents/educators (N = 34)		All respondents (N = 62)	
		<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Age (years)	25–34	2	7	8	23	10	16
	35–44	10	36	20	59	30	49
	45–54	14	50	6	18	20	32
	55–64	2	7	–	–	2	3
Sex	Female	26	93	28	82	54	87
	Male	2	7	6	18	8	13
Smoking	Yes	4	14	4	12	8	13
	No	24	86	30	88	54	87
Annual salary (\$CAD)	<\$80,000	8	29	9	26	17	28
	≥\$80,000	19	68	19	56	38	61
	Don't want to answer	1	3	6	18	7	11
Schooling	Secondary	–	–	1	3	2	3
	College	8	29	14	41	22	35
	University	20	71	19	56	39	62

very satisfied with the information received. It should, however, be noted that the majority of parents were informed of the radon testing by managers or educators (53%) rather than by the factsheet prepared for this purpose (35%).

Half of the managers and parents/educators had already read or heard about radon prior to this intervention (43% and 56% respectively). Managers were better than parents/educators at properly identifying the source of radon (82% and 56% respectively) and at recognizing the carcinogenic properties of radon, whether or not they mentioned the target organ (86% and 26% respectively). Managers were also more likely than parents/educators to know that an exposure period corresponding to a decade significantly increases health risks (64% vs. 6%), while a minority of respondents from both groups identified smokers as a high-risk population (43% vs. 12%). Otherwise, the federal guideline was generally unknown.

Finally, only two managers (7%) and two parents/educators (6%) had measured radon levels in their homes, while the proportions of

those who intended to do home radon testing in the next months were 21% and 26% respectively.

Child care centres' radon concentrations

Overall, 98% of the rooms had radon concentrations below 200 Bq/m³ and radon measurements were generally consistent for all the rooms of the same building. Two child care centres (4% of investigated buildings) had at least one result above the Health Canada guideline: one child care centre located in the Laurentides area and one in the Outaouais region, which had minimal, average (arithmetic) and maximum levels of 100, 173, 244 and 170, 194, 218 Bq/m³ respectively (Table 4).

DISCUSSION

Centralized measurement approach

The capacity of the child care network to support this type of centralized radon testing was very satisfactory in terms of both

Table 3. Knowledge of targeted groups about this radon testing intervention and different aspects related to radon

		Managers (N = 28)		Parents/educators (N = 34)		All respondents (N = 62)	
		n*	%	n*	%	n*	%
Perception of the relevance of the intervention	Relevant [†]	24	86	31	91	55	89
	Less or not relevant	4	14	2	6	6	10
Satisfaction level concerning the information received	Satisfied [†]	25	89	18	53	43	69
	Less or not satisfied	3	11	14	41	17	27
Satisfaction level concerning the intervention's progression	Satisfied [†]	26	93	–	–	–	–
	Less or not satisfied	2	7	–	–	–	–
Satisfaction level concerning the radon measurement kit	Satisfied [†]	22	79	–	–	–	–
	Less or not satisfied	3	11	–	–	–	–
Difficulty in understanding detector installation instructions	Yes	3	11	–	–	–	–
	No	25	89	–	–	–	–
Difficulty in installing radon detectors	Yes	13	46	–	–	–	–
	No	15	54	–	–	–	–
Knowledge of radon prior to this intervention	Yes	12	43	19	56	31	50
	No	16	57	15	44	31	50
Knowledge about the origin of radon	Yes	23	82	19	56	42	68
	No	5	18	15	44	20	32
Knowledge about health effects related to radon	Yes	26	93	16	47	42	68
	No	2	7	18	53	20	32
Knowledge of the main effects related to radon exposure [‡]	Lung cancer	19	68	1	3	20	32
	Cancer	5	18	8	24	13	21
	Respiratory diseases	1	4	3	9	4	6
	Other	0	0	1 [§]	3	1	2
Knowledge of the duration of exposure that can induce cancer development [‡]	Months	1	4	3	9	4	6
	Years	7	25	9	26	16	26
	Decades	18	64	2	6	20	32
Knowledge of the highest risk group	Pregnant women	0	0	9	26	9	15
	Children	8	29	27	79	35	56
	Old person	2	7	11	32	13	21
	Asthmatic person	2	7	5	15	7	11
	Smoker	12	43	4	12	16	26
Knowledge of the radon federal guideline	Yes	4	14	0	0	4	6
	No	24	86	34	100	58	94
Knowledge of radon testing carried out in child care centres	Yes	20	71	15	44	35	56
	No	8	29	19	56	27	44
Information source related to child care centre radon tests	Letter	–	–	12	35	–	–
	Managers	–	–	16	47	–	–
	Educators	–	–	2	6	–	–

* Some values do not add to column totals due to blank responses and/or "other" responses.

[†] Very or moderately.

[‡] Percentages for that subquestion apply to the total number of respondents.

[§] Infertility.

Table 4. Radon measurement results from different kinds of buildings located in the two investigated regions (all floors, expressed in Bq/m³)

	Laurentides			Outaouais		
	Child care centres* (N = 185)	Dwellings [†]	Schools [‡]	Child care centres* (N = 183)	Dwellings [†]	Schools [‡]
Minimum	15	–	15	15	–	15
Maximum	244	–	453	218	–	206
Arithmetic average	59	26	98	55	27	55
5 th percentile	21	–	17	28	–	15
95 th percentile	152	–	311	162	–	147

* Measurements carried out in each occupied room of the lowest floor of the building.

[†] Measurements carried out on the ground floor of private residences.¹³

[‡] Measurements carried out on the ground floor of schools.¹⁵

communication and technical aspects. The factsheet used to announce this intervention was sent or displayed by all child care centre managers where site visits were conducted. Although a significant number of managers reported some difficulty in

understanding the installation instructions or installing the radon detectors (11% and 46% respectively), the inspections showed that the personnel had correctly installed the radon detectors in the vast majority of cases and no indications of

frustration were apparent in the follow-up interviews. A large proportion of the managers (93%) were very satisfied with the overall progress of the procedures related to the intervention whereas 89% of all respondents felt that the intervention was very relevant and 69% were very satisfied with the information received. It is, however, possible that some participants only said that they considered this intervention relevant because they trust public health authorities or out of fear of being accused of not wanting a healthy living environment for children.²⁰

There is some concern that many parents/educators (53%) were informed of this intervention by personnel working in the investigated child care centres and not by the factsheet. The inherent limitations of verbal information relayed by an intermediary may explain the difficulty some parents/educators had in understanding the main health issue associated with radon exposure, especially about the type of cancer caused by radon and the length of exposure required to develop this disease.

It is also interesting to note that despite the generally favourable perceptions of this intervention, only 24% of respondents (21% of managers and 26% of parents/educators) expressed the intention to perform a radon test in their home during the following months (excluding 6% of them who had already conducted a radon test in their own home). Although this proportion may seem low, it remains significant when compared to the proportion of Canadian households willing to engage in radon testing in their home, which is 6%, according to a national survey carried out in 2007.²¹

Child care centres' radon concentrations

Overall, radon concentrations measured in child care centres (arithmetic mean of 55 and 59 Bq/m³ in buildings located in the Laurentides and Outaouais regions respectively) were relatively low considering the high radon emission potential of the investigated sectors, but some results above 200 Bq/m³ could occur. By comparison, the average concentrations described here are comparable with the average value (59.9 Bq/m³) measured in 13 child care facilities during the heating season in non-metropolitan counties of New York State.²² Nevertheless, the average concentrations obtained in the current study were higher than the ones measured in 781 private residences throughout Québec on an annual basis (18 and 34.6 Bq/m³ on the ground floor and in basements respectively).¹⁶ However, it is difficult to explain why the average measurements obtained in child care centres in the current study were higher than those compiled in private homes of the same regions (Table 4). These data seem surprising since it is known that the radon concentration decreases with increasing building indoor air volume and dilution capacity. For the same reason, one might expect higher radon concentrations in childcare centres than in schools. For example, in a study conducted in 30 kindergartens and 36 schools of the Tomsik region, the arithmetic mean was slightly higher in kindergartens than in schools (60 vs. 50 Bq/m³).²³ The relatively small size of the selected childcare centres in the current study combined with the fact that many child care centres were equipped with a central ventilation system might partly explain these unexpected results.

Our results also show that 4% of the investigated buildings had some radon measurements exceeding the federal guideline. This proportion is relatively low considering that based on all available data (INSPQ; unpublished results), it is estimated that ~15%–20%

of buildings in priority investigation areas may have radon concentrations exceeding the federal guideline. This proportion is even lower than the proportion observed by Health Canada in dwellings in the province of Québec (10.1%, after a three-month measurement, not necessarily during winter time, at the lowest level regularly occupied).²⁴ Once again, high air exchange rates in the investigated child care centres could explain this result.

CONCLUSION

Given the ubiquity of radon and its carcinogenic potential, the results of this study should encourage all Québec child care centre managers to test for this radioactive gas, regardless of where their buildings are located. This intervention began with a briefing offered to all managers by the research team, but this type of training does not seem essential considering that no association was found between compliance or respondents' satisfaction and whether or not they participated in this training session (data not shown). Radon testing in child care centres will become even more relevant with the aging of buildings as it has been observed that renovations and new construction methods result in an increased air-tightness of buildings, which is accompanied by an accumulation of radon.²⁵

To address minor difficulties regarding the radon tests and certain gaps in the communication approach in the current intervention, some adjustments could be made to the tools used. The first task would be to determine lay people's relevant beliefs.²⁶ In addition to the factsheet, the development of an information leaflet or a short online video could reach a wider range of people and give access to accurate and more complete information about radon, particularly with regard to the target organ, the duration of exposure of concern and the interaction with smoking. These tools could also suggest additional information sources, which was one of the elements that managers (57%) and parents/educators (27%) would like to see improved (data not shown). It would also provide an opportunity to incorporate narrative messages (such as testimonies of participants in this study), which hold people's attention more effectively and more easily address the concerns of people compared to a technical paper mainly based on scientific facts.²⁷ In this intervention, however, parents or educators did not raise concerns about this issue.

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RÉSUMÉ

OBJECTIFS : Inviter les gestionnaires de centres de la petite enfance (CPE) à mesurer les concentrations de radon dans leur bâtiment et les soutenir dans leur démarche. Leur capacité à appliquer le protocole de mesure et le plan de communication a également été évaluée de même que l'intention subséquente des parents et éducateurs de mesurer le radon à domicile.

PARTICIPANTS : Gestionnaires, parents et éducateurs de CPE.

LIEU : 36 CPE situées dans deux zones d'investigation prioritaire au Québec.

INTERVENTION : Des trousseaux contenant des dosimètres avec des directives d'installations et de récupération ont été envoyées par la poste de même que des feuillets d'information destinés aux parents et éducateurs. Des visites de contrôle et des appels téléphoniques ont également été complétés auprès d'un échantillon de CPE et de participants.

RÉSULTATS : Les directives de manient des dosimètres ont été généralement bien suivies. Plus de la moitié (18) des 34 parents et éducateurs interrogés ont rapporté avoir été informés de ce dépistage par les gestionnaires ou d'autres éducateurs plutôt que par le feuillet distribué à cette fin. Cette intervention a été considérée comme très pertinente par 91 % d'entre eux et 26 % ont exprimé leur intention de mesurer le radon à domicile alors que 6 % l'avaient déjà mesuré. Deux CPE (5,5 %) ont présenté au moins une mesure au-dessus de la ligne directrice canadienne de 200 Bq/m³.

CONCLUSION : Cette intervention a démontré l'autonomie des gestionnaires de CPE à dépister le radon dans leur installation, permettant ainsi de réduire les coûts associés. Parmi les retombées, on compte également une meilleure sensibilisation des parents à ce contaminant accompagnée du désir chez plusieurs de le mesurer à domicile.

MOTS CLÉS : centres de la petite enfance; dépistage du radon; Québec; perception