

INDOOR AIR POLLUTANTS, LIMITED RESOURCE HOUSEHOLDS AND CHILDCARE FACILITIES

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ABSTRACT

This paper presents findings from an indoor air quality study of homes and childcare facilities in nonmetropolitan counties of New York State. Specific pollutants examined were lead, radon, carbon monoxide, asbestos, and mold. High pollutant levels were observed in some of the homes, and significant relationships between certain pollutants and household income were observed. High levels of pollutants were also observed in the childcare facilities survey, which raises questions about constant pollutant exposure to children. Recommendations are made for lowering exposure levels in low income households and childcare facilities.

INDEX TERMS

Indoor air quality, Limited resource households, Childcare facilities, Public policy, Risk reduction strategies.

INTRODUCTION

Disproportionate exposures to indoor air pollutants by limited resource households in their homes have been observed for reasons that are likely related to housing quality and socioeconomic status (Chi and Laquatra, 1990; Farr and Dolbeare, 1996; Evans and Kantrowitz, 2002). Older homes characterized by accelerated deterioration resulting from deferred maintenance are more likely than newer homes to exhibit chipping lead paint, friable asbestos, cracked foundations, and leaking combustion equipment. These features contribute to lead, asbestos, radon, mold, and combustion products as air pollutants, some of which are known asthma triggers. This situation creates problematic issues for public policy. While environmental and health officials engage in campaigns to raise awareness among the general public about residential indoor air quality, pollutant abatement remains a private responsibility. A systematic approach to assist limited resource households assess and address indoor air pollutant risks is missing from policy discussions about these issues. Housing tenure status of these households, who are more likely than those with more resources to be renters rather than owners, further complicates the problem. Whose responsibility is it to abate indoor air pollutants, and where will the resources to carry out these tasks come from without exacerbating problems of housing affordability? Although toxic tort litigation has been used as a strategy for compensation in cases involving indoor environmental contamination, on a widespread basis this is not a practical solution to the problem.

Roberts and Dickey (1995) cited studies that have documented the incidence of indoor air pollution and its negative impacts on children, including lead poisoning, leukemia, and allergies. For physiological and behavioral reasons, children are at higher risks than adults for adverse health effects from environmental toxicants (Goldman, 1995; Staes, Balk, Ford *et al.*, 1995). A strong need currently exists for a plan to reduce risks of exposure to these

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pollutants; and these risk reduction efforts should focus not just on the home environment, but also on childcare settings (Goodman, Sacks, Aronson, *et al.*, 1994). Community educators, physicians, and parents can play important roles in increasing awareness of indoor environmental risks and effectively managing them. But to get to that point, a greater understanding of the extent of potential risks is necessary.

METHODS

This paper discusses results of a study of indoor air pollutants in homes and childcare facilities in rural areas. Pollutants included were radon, asbestos, lead, combustion pollutants, and biological contaminants. A two-stage random sampling procedure was used to obtain a representative sample of households in all nonmetropolitan counties in New York State. A cluster analysis was performed on the twenty-four nonmetropolitan counties in the state, as defined by the 1990 Census. The analysis was conducted in order to determine similar groupings of counties to be used as categories in a stratified sampling design. The counties were grouped based on their similarity to six housing characteristics, and one county was randomly sampled from each cluster. The housing characteristics are: average number of persons per household, proportion of housing units in multiple family dwellings, proportion of manufactured homes, proportion of housing units occupied by renters, proportion of housing units built before 1979, and proportion of housing units built from 1980-89.

The counties were classified with a hierarchical cluster analysis using average linkage methods (Johnson and Wichern, 2002). A hierarchical cluster analysis was chosen because there was no *a priori* indication of the appropriate number or nature of clusters. To check the stability of the solutions, the analysis was repeated using single linkage and complete linkage methods. Both of these yielded similar six-cluster solutions. One county was randomly selected from each cluster. The counties selected were: Chenango, Columbia, Essex, Franklin, Wyoming, and Hamilton. To arrive at a total sample of approximately 350, weighted random sampling based on population was conducted in each county. The final sample size was n=328. Telephone surveys of the 328 were conducted with an adult head of household to determine demographic and housing characteristics. Each household was given the opportunity to have air quality tests conducted; and 132 households agreed to this. A technician visited the 132 houses during the heating season of 2000-2001 to conduct these tests. Demographic profiles of households in the sample are presented in Table 1.

RESULTS

Table 1. Demographic characteristics of the households in the sample

<i>Characteristic</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Mean</i>	<i>Std. Deviation</i>
Age of household head	22	86	53.61	14.25
Education level	Grade school	Post graduate	Technical or vocational school	---
Household income	< \$5,000	> \$50,000	\$23,900	\$9,750.05
Number of children	0	3	.58	.91

Radon levels were tested with activated carbon canisters in the lowest living area of the house. Carbon monoxide levels were tested with a Bacharach® sample draw carbon

monoxide analyzer for 10-15 minutes in the central living area of the houses; within 1.5 meters of the central heating system; and in the oven vent at oven start-up and when the oven reached 176°C. The technician made visual tests for asbestos and basement mold. Surface dust sampling, using a gauze pad moistened with distilled water, was used to test for lead on the floor beneath windows. Table 2 shows results of these tests.

Table 2. Test results

<i>Pollutant</i>	<i>Maximum Exposure Level*</i>	<i>Minimum Observed</i>	<i>Maximum Observed</i>	<i>Mean</i>	<i>Std. Deviation</i>	<i>N</i>
Radon	4 pCi/L	.03 pCi/L	19.70 pCi/L	1.64	2.75	114
Lead	3.72 ug/m ²	.004 ug/m ²	61.34 ug/m ²	1.57	6.60	125
CO, central heating	9 ppm	0 ppm	14 ppm	.70	2.36	96
CO, oven start-up spike	100 ppm	0 ppm	1544 ppm	185.75	341.83	126
CO, at oven temperature	25 ppm	0 ppm	213 ppm	18.04	32.2	46
CO, living/family room	9 ppm	0 ppm	14 ppm	.39	1.64	127

*Maximum exposure levels are from the following sources: Radon - U.S. Environmental Protection Agency; Lead - U.S. Environmental Protection Agency; CO in living space - U.S. Environmental Protection Agency; CO oven start-up spike and CO at oven temperature - Tsongas (1995).

Table 3. Visual identification results

<i>Pollutant</i>	<i>Affirmative</i>	<i>Negative</i>	<i>N</i>
Asbestos	20	107	127
Basement mold	11	102	113

Radon levels were regressed on income, the presence of mold in the basement, county, and whether a kitchen exhaust fan was ducted to the outdoors. The presence of mold was used as a proxy for general condition of the basement, county as a location indicator, and exhaust fan as a house depressurization indicator. Results from the radon regression are presented in Table 4.

Table 4. Regression of radon levels

<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t</i>	<i>p</i>
Constant	7.054	2.351	3.001	.005
Income	-.581	.228	-2.555	.015
Mold	-1.388	1.555	-.893	.378
County	-.003	.298	.126	.900
Fan	-.585	.701	.835	.409

R² = .167

The R² shows that the model explains only 17% of the variation of radon levels in the home, possibly because of the small sample size. The significant and negative relationship between household income and radon is likely due to lower quality housing among lower income

groups and housing deficiencies that create radon pathways, such as foundation cracks and dirt basement floors. General structural condition of the homes was rated by the technician and was seen to have a significant and negative relationship with income ($r = -.27$, $p = .004$). To avoid collinearity problems, this variable was not included in the regression. Regressions with carbon monoxide and lead levels, using independent variables related to age and condition of the house, did not show this relationship. This may be due to the small number of homes (7) with lead in floor dust above the U.S. Environmental Protection Agency's maximum allowable level of 3.72 ug/m^2 (40 ug/ft^2). However, a significant and negative correlation between income and carbon monoxide level at oven temperature was observed ($r = -.402$; $p = .01$). Issues related to kitchen exhaust fans were also examined. Twenty-six percent of the homes had no exhaust fan or operable window in the kitchen. Four percent had fans that did not work. Thirty percent had re-circulating fans. This represents 60 percent of the sample without operating exhaust fans in kitchens. The significant and negative relationship between income and carbon monoxide is likely due to this lack of operating exhaust fans, with lower income households more likely to be in that category. Lower income households are also more likely to have older cooking appliances that have not been maintained.

The childcare facilities participating in this study were selected by the following method. The Daycare and Child Development Councils in the six counties were contacted in order to obtain a listing of all childcare facilities, which include family daycare (up to six children cared for in the home of a provider), group family daycare (up to 12 children in a home), and daycare centers (located in a community facility, i.e. church). This process yielded a total of 500 facilities among the six counties. A letter describing the study and requesting participation was sent to 150 randomly selected facilities. This process was repeated a second time to obtain a final sample of 75 facilities. Directors of all 75 facilities completed a telephone administered survey. One of the questions in the survey was a request for permission to conduct indoor air quality tests. A total of 57 facilities initially agreed to participate in this portion of the study. However, once testing began, only 24 facilities followed up in setting up appointments. This unwillingness to participate is understandable given liability concerns. A technician visited the facilities during the heating season of 2000-2001 to conduct the air quality tests.

The breakdown of types of childcare facilities in this sample is as follows: In the total sample of 75, 13 were centers (church, community building, or a building designed as a childcare center); 52 were homes with one provider caring for up to six children; 10 were homes with two providers caring for up to 12 children. The breakdown for the 24 in which air quality tests were conducted is as follows: 7 were centers; 14 were homes with one provider caring for up to six children; and 3 were homes with two providers caring for up to 12 children.

Pollutants tested in the childcare facilities were radon, lead, asbestos, and basement mold. Because of this small sample size, frequencies from pollutant tests are presented in Tables 5 and 6.

Table 5. Test results from childcare facilities

<i>Pollutant</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Mean</i>	<i>Std. Deviation</i>	<i>N</i>
Radon	.30 pCi/L	6.90 pCi/L	1.62	1.87	13
Lead	.058 ug/m ²	22.30 ug/m ²	1.68	4.57	24

Table 6. Visual identification results

<i>Pollutant</i>	<i>Affirmative</i>	<i>Negative</i>	<i>N</i>
Asbestos	6	16	22
Basement mold	6	12	18

DISCUSSION

The finding of a significant and negative relationship between income and radon exposure in this sample is similar to the finding from Chi and Laquatra (1990). This should not be interpreted as meaning that low household income increases radon levels in a home, but rather that low income households live in lower quality housing than higher income households. In areas prone to high radon levels, those lower quality units are likely to have more radon pathways into the home. The significant and negative correlation between oven-produced carbon monoxide and income is an indication of an issue that warrants further study. This result was also observed by Tsongas (1995) in a study of indoor air quality in 23 low income homes. One-third of the homes in that study had ovens that caused carbon monoxide levels in the cooking area to exceed 9 ppm. Tsongas reported on several studies that have examined the issue of oven-produced carbon monoxide levels in homes. One recommendation from that research is a need to stress the importance of using exhaust fans while cooking to control carbon monoxide, not just cooking odors and moisture. As the sample from the current study demonstrates, however, this recommendation is not always practical. Sixty percent of the homes visited did not have operable kitchen exhaust fans.

Because of the two-stage random sampling procedure used in this study, the sample is representative of all nonmetropolitan counties in New York State. But the small sample size warrants a cautious interpretation of results. The significant relationships observed between lower income households and certain indoor air pollutants have been reported by other researchers and should be investigated in a larger follow-up study.

Although the number of childcare facilities in this study is small, the high levels of radon and lead that were observed and the presence of asbestos and mold are reasons for serious concern. The highest lead level observed (22.39 ug/m²) and radon level (6.9 pCi/L) were in two different centers. The presence of asbestos was affirmative in 3 centers and 3 homes; basement mold was observed in one center and 5 homes. The possibility that children are experiencing exposures in both their homes and their childcare facilities is a subject worthy of further investigation.

CONCLUSION AND IMPLICATIONS

The findings reported in this paper contribute to the growing discussion about indoor air quality in lower income households and childcare facilities. Health officials and policy makers agree that indoor air pollutants pose serious health risks; and they expend considerable resources to raise public awareness of these risks. But the fact that pollutant mitigation in privately owned homes remains a personal responsibility creates a policy dilemma. Rural areas of New York State have been characterized for years as being in a state of economic decline, which has negative impacts on household income and housing quality (Ziebarth, Prochaska-Cue, and Shrewsbury, 1997). For low income households, resources for pollutant abatement are nonexistent. A companion study currently underway at Cornell University is examining the effectiveness of teaching low income households strategies to minimize their risks of exposure to indoor air pollutants.

The issue of indoor air quality in childcare facilities should be an important concern of facility owners and the parents who send their children to them. A three-pronged approach may be necessary to bring public attention to this. At the policy level, indoor air quality standards could become a part of facility license granting and license renewals. Facility owners and directors could become educated about the issues now and thereby keep themselves ahead of the policy curve. At the same time, parents could be educated about the issues so that they can ask questions about indoor air quality before enrolling their children in childcare facilities.

Should public resources be made available, as low interest loans or grants, to low income households and childcare facilities for indoor air pollutant mitigation? In evaluating this question, the issue of overall cost to society should be examined. Lead poisoning in children leads to lowered intelligence and behavioral problems. Mold is a trigger for allergies and asthma, both of which lead to school and work absences, productivity losses, and increased health costs (Fisk, 2000). Exposures to asbestos, carbon monoxide, and radon lead to early death. An analysis of benefits and costs to society from improving indoor air quality for low income households and childcare facilities would be useful for providing guidance to policy makers about this issue.

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