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## **BASEMENT RADON RESEARCH**

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### **ABSTRACT**

The relationship between basement and first-floor resident occupancy and radon measurements is investigated in this study of a regionally-stratified random sample of homes throughout Minnesota. Occupants of the houses were asked to complete a seven-day activity diary and concurrent radon measurements in both levels of their house. Several methods of recruiting respondents were used with varying success rates. Problems related to data collection are discussed including high humidity levels during the non-heating season. Wide variability is found in the level of detail in reporting activities by the household members. Preliminary results indicate that in some houses, household members spend significant amounts of time in the basement, including sleeping in basement bedrooms.

### **INTRODUCTION**

The purpose of this investigation is to better characterize the issue of radon exposure of occupants in houses with basements. Scientists differ in their opinions about the merits of performing radon measurements in basement levels of residences because of the uncertainty of the residents' use of these spaces. Information about occupants' use of basement spaces is needed for policy decisions in Minnesota because of the prevalence of basements in this region. Radon measurements and occupant activities in the basements of about 700 homes will be compared to radon levels and activities on the next higher level of the homes. Almost half of these homes have been surveyed from March, 1994 through July, 1994. The other half of the homes will be surveyed in the fall and winter of 1994. This is a report of the success of the methods used for collecting data on both household activities and radon levels.

Radon risk assessments have been done using data from national occupancy studies or occupancy studies performed in warmer climate areas where houses typically do not have basements (Wiley, 1991). Few studies document time spent in basements where radon levels are usually higher than in upper housing levels.<sup>1</sup> In a recent study of houses in one Minnesota city, it was found that many residents live in their basements for significant periods of time, performing a variety of activities (Fuoss, 1994). Most homes in Minnesota have basements resulting in the issue of where to make radon measurements a particularly critical one (National Association of Home Builders, 1981).

### **MATERIALS AND METHODS**

The study is an investigation of a state-wide sample of about 700 houses. A sample of names, telephone numbers, and addresses was purchased from a survey sampling company. This random sample consisted of 20 households from each of 87 counties that live in single-family dwellings on a non-seasonal basis. Ten households per county were contacted for the first wave of data collection between March and July, 1994. The remaining households will be contacted in the fall of 1994.

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<sup>1</sup>Nero, A. V. December 10, 1991 letter and attachments to the Radon Program Review Panel, Environmental Protection Agency, 401 M. Street, SW, Washington, DC, 20460.

To compare the occupants' exposure to radon on differing levels of the dwelling, an activity diary was developed. The diary calls for each household member to record their activities and the amount of time spent doing those activities on the basement level of the house and the next highest lived-in level of the house for a one-week period. Self-reporting of activities have been found in other studies to have some limitations when compared to reporting by an on-site observer (Franklin, 1980; Szalai, et al., 1972). Other methods of gathering data about the daily activities of household members include recall by the participant being prompted by an interviewer, either in person or by phone, or by a group facilitator. Because activities may vary from weekday to weekend or from workdays to non-workdays, participants in this study are being asked to record activities for a 7-day period. It is not feasible to have observers or interviewers calling for daily recall of activities with a reporting period of this length.

During that same week, activated charcoal radon measurement devices are put in place on each of the two levels, the basement and the next highest lived-in level. The occupants are responsible for following the directions for putting the radon devices in place and for giving the information called for to analyze the devices. In addition to the activity diary and the radon measurements, the respondents fill out a short questionnaire recording information about the basic characteristics of the house and demographic information about the household.

An initial letter was sent to the potential respondents explaining the purpose of the study and how they were selected to participate. They were told that they would receive free and completely confidential tests of radon occurrence on two levels of their homes. The procedures for recording activities were also outlined. A return postcard was included in the letter for the households to indicate if they had a basement, making them eligible to participate, and then to indicate if they were willing to participate.

Recruitment of respondents for the first wave of testing during the heating season was facilitated by cooperation of the Minnesota Extension Service county educators. They were asked to cooperate in the recruitment of respondents by co-signing and sending the letter from the county extension office to the households selected in their area requesting the households' participation in the survey. It was thought that residents would feel a closer connection to county extension staff than to university researchers and would be more willing to participate if the request came from a local person (Finnegan, Bracht & Viswananth, 1989).

Thirty-one county agents covering 73 counties cooperated by sending out the letters. In addition, county educators covering 61 counties followed-up with the households that agreed to participate in their areas by calling them soon after they received their packet with the activity diary and the radon detectors to see if they had any questions and to encourage them to start the test. All counties were sent Public Service Announcements for educators to put in their local newspapers announcing that a research project was being conducted in their county by the University of Minnesota and encouraging those contacted to participate.

In those counties in which there was no county educator participation, the letters were signed by the university researchers conducting the investigation and follow-up calls to those agreeing to participate were made by the researchers.

When a postcard was received from a resident willing to participate in the study, a packet with the research components and a stamped return envelope was mailed. Each household that was sent a packet was contacted by phone after the packet arrived to assure that they had received it, understood the directions, and planned to start the test. As noted earlier, in some cases these calls were made by county extension educators who had sent the letters. A second call was made to the household at the time the test should have been completed to remind the participant to return the radon devices and written information.

The radon measurement devices were purchased from Air Chek<sup>2</sup> and included the manufacturer's directions

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<sup>2</sup>Air Chek, Inc. Arden, NC 28704

sealed inside the plastic packaging with the measurement device. Some confusion resulted because the directions included with the questionnaire asked the respondents to leave the devices in place for seven days whereas the manufacturer's instructions specified leaving them in place for only four days. Our instructions were for the devices to be mailed back to the university with the questionnaire and activity diary whereas the manufacturer's instructions were that the devices should be mailed back to the laboratory for analysis. Some of the participants mailed the detectors directly to the lab without all of the information recorded on the detector that is required for analysis. When detectors were mailed back to the university, the researchers could check to assure that all of the necessary information had been recorded, and if not, call the participant to ask for the necessary information. That information included the starting and ending dates, starting and ending times, the temperature of the room in which the device was placed, and the level of the room (basement, etc.). When measurement devices were sent to the lab without all of the information, the laboratory charged an additional fee for entering that information later and calculating the results.

To meet quality control standards, every fifth participant received an additional detector (a duplicate) to be placed in the basement next to the other device measuring radon in the basement. Three non-exposed detectors (blanks) for each 100 detectors tested were also sent to the laboratory for analysis.

Following the method described, 870 households received letters inviting participation in the study. One hundred fifty households returned postcards with positive responses indicating that they were eligible and would take part in the survey. The goal for the first wave was to test in at least 350 homes. To recruit additional participants, all households in the sample that did not return postcards were called to ask again for their participation. This re-contact resulted in a total of 412 households agreeing to participate. Of the 870 households contacted, some were ineligible for various reasons, some could not be reached and others declined to take part (Table 1).

Those who agreed to participate were sent the packet and the same procedure was used to follow-up and assure that they had received the packet and then again to remind them that it was time to send the packets back. Contacting the households by phone plays an important role in the project, not only to encourage participants and remind them, but also to ensure the quality of the activity diaries and the radon tests. Even with the reminder calls, many of the tests are invalidated because participants failed to follow the correct procedures (Table 2).

The results of the radon tests for spring and summer or non-heating periods suggest that moisture in Minnesota houses may pose a problem for testing during these months. Although participants are instructed not to place the radon devices in rooms that have excess levels of humidity such as laundry rooms, bathrooms, or kitchens, several of the test results during June and July indicate that moisture levels in the devices are too high and the test is not valid; 13 of the invalid tests were conducted in basements only, 2 on the first floor only, and 5 households had invalid tests due to high moisture levels on both floors. This information is not helpful in characterizing exposure to radon, but is an indication that humidity levels in some Minnesota homes may be too high for short-term tests during the summer (Table 2)

The laboratory sends the results of the analysis back to the researchers and they inform the participants of their radon measurements. In addition, literature from the Minnesota Department of Health about radon is enclosed with the results. Residents with measurements of 4 pCi/l or greater are encouraged to retest. Participants with measurements of 10 pCi/l or greater are called and asked if their name can be given to the Minnesota Department of Health who will provide another free test device to the respondent for follow-up testing.

## PRELIMINARY RESULTS

At the time this report was written, the total number of responses is 301 or 73% of those who agreed to participate. The demographic characteristics of the responding households appears to be representative of the state population (Table 3).

One of the key questions of the study is to find out how many people spend substantial amounts of time in the basement, including sleeping in the basement. Of the 301 households, a total of 98 individuals sleep in basements. Thirty-eight are adults and 60 are children under 18 years of age.

## DISCUSSION

In the fall, the second group of 870 participants will be contacted to request participation in the study. To make the recruitment of participants more efficient, there are several changes in the procedure that are being made based on the lessons learned from the first wave of testing. Contrary to our assumption, using county extension educators to sign and send the recruitment letters did not result in a better participation rate than sending the letters directly from the university. Although the county educators who agreed to cooperate seemed to be eager to do so, there was often a delay of several days to a week or more in getting the letters out to the potential respondents. We asked for the participants to test during March and some did not receive the letters from the counties until the end of March and assumed it was too late to participate.

The Public Service Announcement in the local newspapers resulted in both the county extension educators and the university researchers receiving calls from people who read the announcement and were volunteering to participate. Many were disgruntled when told that we could not use volunteers who were not part of the random sample selection process.

The most positive result of using the county extension educators as cooperators in the recruitment process was that many were called by persons who received the letters inviting their participation asking for verification that the research was legitimate and not a "come-on" to purchase something. After receiving the reassurance, a number agreed to participate who might otherwise have not. In the next wave of recruitment, we will not be asking the county educators to send out the letters but to serve as a resource for potential participants who have questions.

The activity diary is somewhat problematic in that it requires the residents of the household to record their activities on the two levels of their house and the duration of those activities. This results in considerable variation of the reporting of activities with some respondents painstakingly recording each change in activity and the time it takes for each of the seven days and other respondents lumping activities together (such as fixing meals/eating/cleaning up) for one day and then recording "Same as the first day" for the other days. Although the telephone calls to the respondents include a discussion of how to fill in the diary and a written example is provided with the diary, many respondents find the recording of the activities tedious and burdensome. A few do not provide any information about their activities.

## CONCLUSIONS

The letter that is sent in the fall will ask the potential participants which month they would be willing to participate (September through December 15). It is hoped that with this flexibility more potential respondents will choose to take part. All of the letters will be sent from the university rather than from the county offices.

The researchers feel that the increase of 244 households who agreed to participate as a result of the re-contact by phone to be cost-effective, averaging approximately four dollars per additional participant. This procedure will be continued in the next wave of data collection.

Although the activity diaries are difficult to code because of the variability in the detail of recording activities, other methods have not been found for improving the procedure in a self-reporting format.

All results are preliminary as only half of the data have been collected. However, these results seem to indicate that the heating season is the best time to test for radon in Minnesota homes because of the problems with

excess moisture during the non-heating season. The results also indicate that in some homes, significant amounts of time are spent by the household members in the basement.

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**Table 1. Results of inviting 870 households to participate in the research.**

Letters of invitation sent	870
Ineligible residences, such as mobile homes, homes with no basements, apartments	80
Disconnected phones and/or returned by post office as undeliverable	65
No house/house being demolished	3
Seasonal dwellings	5
Not a Minnesota resident (household lived in a border state but had a Minnesota zip code)	3
Householder incapacitated or deceased	24
<b>Total potential participants</b>	<b>690</b>
Refusals or not able to contact after many attempts	246
Agreed to participate but returned materials without responses	12
Miscellaneous refusals with a reason	20
<b>Total who agreed to participate and have been sent a packet</b>	<b>412</b>
<b>Participants who have returned responses as of July 12</b>	<b>301</b>
Participation rate (412/690)	59.7%
Response rate of participants (301/412)	73.1%

**Table 2. Problems that invalidated the radon tests.**

<b>Problem with Radon Test</b>	<b>N</b>
Sampler damaged by participant	4
Excessive decay time	24
Too wet for results	6
Long exposure & too wet	1
Short exposure & excessive decay time	1
Too wet & delayed in arrival at lab	4
Excessive decay time & too wet	1
Too wet & damaged sampler	2
Short exposure & excessive decay time & wet sample	1
<b>Total number of invalidated tests</b>	<b>44</b>

**Table 3. Demographic characteristics of the respondents.**

<b>Household Type</b>	<b>N %</b>
1 person households	39 (13%)
2 person households	109 (36%)
Households with children ages 6 through 18	90 (30%)
Households with children age 5 and under	47 (16%)
Households with children who did not report ages but children were reported in school	15 (5%)
Households with one or more persons aged 65 or older	49 (16%)
Households with one or more persons aged 75 or older	22 (7%)
Households with one or more persons aged 85 or older	3 (<1%)