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THE FORGOTTEN SIDE OF THE EXPOSURE MODEL: USE OF AUTOBIOGRAPHICAL MEMORY IN RETRIEVAL OF PERSONAL MOBILITY PATTERNS

Chris Peterson Brus, Burton C. Kross, and Charles F. Lynch
University of Iowa Department of Preventive Medicine and Environmental Health
Iowa City, IA

ABSTRACT

Precise residential radon exposure assessment is, by necessity, dependent upon the coupling of in-home radon measurements and personal mobility data. To evaluate the impact of collecting individual occupancy data rather than assigning a constant for percent time 'in-home', thirty study participants were queried using a standard decade table format. Over 50% of participants refused to **attempt** completion of the initial format. A second methodology was then devised in which autobiographical memory events, supplied by the participant, were used to create a contextual framework in which retrieval of mobility data could be accomplished. Ninety-two percent of those retested (n=26) found Method Two more acceptable, reporting a significant increase in accuracy (Wilcoxon Sign Rank Test, $p < 0.01$). Although percent time 'in-home' across the entire sample approximated the 70% standard routinely used in ^{222}Rn exposure modeling (mean 73.7% ± 12.4) the range of reported 'in-home' time (53.0 with a minimum and maximum of 41.6 and 94.6% respectively) was large enough to warrant assessing the impact of percent time variability on exposure classification. Time-weighted average exposure for years at latest residence (33.7 yrs ± 10.1) were calculated for each participant using reported hours spent 'in-home' and secondarily, incorporating reported hours spent 'outside' and 'in another building' to yield a 'total time' exposure. The mean for 'in-home' exposure (3.4 pCi/l ± 3.8) was then compared with that for 'total time' exposure (2.7 pCi/l 2.7) using a paired t-Test and found to be significantly different ($p < 0.01$). The rank order of individual data points did not remain stable after weighting exposure by individually reported percent time in the 'total time' exposure model.

INTRODUCTION

With the increase in epidemiologic research of chronic diseases with long latent periods, use of the case-control study design has become more prominent. This design relies on creating a two-sided exposure model: one side consisting of quantitative, mechanistically derived data; the other utilizing participant reported levels of the exposures and confounders of interest. Often this model relies heavily on the subjects' ability to accurately retrieve pertinent information over a time span of several decades. Differential memory retrieval then becomes a major impediment to correct categorization of study participants leading to substantial misclassification bias. It is often difficult to determine the directionality of misclassification with any degree of assuredness, and although directional misclassification may be reported as a possible source of bias, differential memory retrieval is often accepted as non-directional, having only the effect of demonstrating a less significant relationship between exposure and disease.

Precise residential radon exposure assessment is, by necessity, dependent upon the coupling of in-home radon measurements and personal mobility data. Advancements in radon measurement technology are driven by a need to minimize measurement error and enhance precision. Collection techniques and devices are closely monitored by an external regulatory agency to ensure that quality assurance/quality control guidelines are being met. There are no such safeguards for the other side of the model. Although researchers often state that time spent in different areas of the home may affect their proposed model (1,2), it is standard practice to factor in a 'constant' for percent of occupancy. This 'constant' can vary substantially between studies. A review of present literature reveals use of a 'constant' occupancy factor anywhere from 65% to 80% (3,4,5,6,7), with Lees, et al.(8) reporting a dichotomous occupancy factor based on 'worker' (65%) vs. 'non-worker' status (85%). It would seem that a factor as integral to accurate radon dose assessment as mobility would be as important to retrieve on an individual basis as is data concerning smoking, occupational exposures and other confounders. This paper will compare two methodologies that were used to retrieve individual mobility pattern data and express the finding as they relate to methodologic acceptability, ease of retrieval, and participant reported accuracy.

MATERIALS AND METHODS

Mobility data was collected from thirty study participants involved in the Household Radon Exposure Assessment Methods Study conducted in Iowa during 1991-92. The study population consisted of 13 female lung cancer cases ascertained through the State Health Registry of Iowa, a participant in the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Program, and 17 female controls who were randomly selected from current Drivers License (DL) tapes. Rapid-reporting of female lung cancer cases was not employed in this study resulting in delayed contact of eligible cases. Of the 13 cases enrolled, five were alive for the duration of the study, and eight were represented by a proxy respondent. All participants were female Iowa residents between the ages of 40 and 84 having a minimum 20 year residency in their latest home (mean = 33.7 yrs ± 10.1). Although participants were asked if they had previously tested their homes for radon, they were not excluded unless they had mitigated.

Data Retrieval - Method One

All thirty pilot study participants were initially asked to supply mobility histories using a standard decade table format in a mailout questionnaire (Method 1). Retrieval was present to past, by decade, in each of seven tables. Seasonal variability tables were constructed in four thirteen week blocks. Reported hours across those four tables were then added by the study participant. The sum was expected to match the number of hours the participant supplied in the previous table. Over 50% of participants refused to **attempt** completion of this section of the questionnaire, with several consenting participants declining to remain in the study after reviewing the mobility section. Math anxiety, inappropriateness of seasonal divisions, and compartmentalization of the requested information were most often cited as impediments to accurate data retrieval. The two participants who actually completed the mobility section of the questionnaire reported completion times of three hours forty minutes, and four hours, respectively. Average facilitation time required for the mobility section of the questionnaire during the home installation visit was 14.8 minutes with participants often refusing to go beyond the decade of the 1980's, requesting the facilitator to answer 'same' for the rest of the tables. During facilitation it became clear that the participants were able to retrieve the desired mobility information but were unable and increasingly unwilling to process the information through several steps necessary to make it fit the format requested. Using a participant-rated accuracy scale, eleven study participants reported the information they supplied in the mobility tables (Method 1) as 'best guess'. It became obvious that no matter how sophisticated radon measurement technology became, gross misclassification of study participants was occurring due to the inaccuracy of the other side of the model.

Autobiographical Memory

In an attempt to facilitate the collection of accurate mobility data and find a format that was more acceptable to the study population, a second methodology was derived using the extensive body of literature on memory deposition and retrieval found in psychology and sociology. To better understand the concepts involved, it is important to recognize that information deposited in long-term memory takes a variety of forms. Psychologists recognize two distinct categories of memory: *semantic memory*, or those memories which allow for the use of language and general functioning in the world, and; *episodic memory*, the body of personal, experiential knowledge specific to the individual. The existing body of work in the area of memory deposition and retrieval is primarily based on the testing of a subjects' ability to memorize a set or list given to them by an investigator. After a given time period, subjects are asked to reproduce the set or list as closely to the original as possible. These functions are part of the domain of semantic memory, whereas autobiographical memory, or personal experiential memory, is a function of episodic memory. Research in the area of autobiographical memory should be followed with interest by epidemiologists because individual exposure data must be retrieved from this class of memory. The use of autobiographical memory to facilitate accurate retrieval of exposure data may produce a shift in research techniques toward a respondent driven methodology. In other words, the researcher may need to abstain from creating small, standardized boxes which the respondent must fill, instead allowing the respondent to freely access, self-associate and prioritize within a set of unique episodic memories. The closer the memory remains to its point of retrieval, and the more imbedded in context it remains, the more accurate it is felt to be. It then becomes the challenge of the researcher, not the participant, to process the information into the desired data points.

Data Retrieval - Method Two

Nine to eleven months after the first attempt to retrieve mobility data, methods study participants were mailed a 'Home Usage Patterns' form which asked them to remember personal events that would have significantly altered the time they spent within their home or in different areas of their home. Participants were prompted with examples of changes that were of interest to the exposure model, such as a change in the placement of their bedroom, additions built onto the existing structure, changes in their employment status, and retirement of the subject or their spouse. They were then asked to enter the month and year they moved into their current home and move forward in time recording those personal events that would have significantly altered their mobility patterns. They continued moving forward in time, identifying significant events, until the present. Within two weeks of receiving the 'Home Usage Patterns' form, a field assistant visited the participants home to conduct a face-to-face interview using the participant reported time period blocks, and autobiographical memory cues as the basis for facilitating retrieval of mobility data.

To ensure comparability of data collection across a broad spectrum of participant responses, a Mobility Interview Dialogue was evolved for use with this methodology. Following the written dialogue, retrieval then proceeded from past to present, in participant-reported time blocks, with 168 hours per week represented in three broad categories: hours spent 'in another building'; hours spent 'outside'; and hours spent 'in-home'. The last category of hours (in-home) was then retrieved by task-based recall. Sociologists report that spatial and temporal recall is greatly enhanced when tied to a concrete activity i.e., time spent doing laundry per week (site-specific) is fairly easy for most women to recall with a fair degree of accuracy, as opposed to asking, "How many hours did you spend in your basement last year?" This form of recall is also appropriate for retrieval of hours spent outside of the home. If you ask the question, "How many hours, on the average, did you spend outside per day in the 1980's?", it is doubtful that the answer, even if one was forth coming, could be accepted as credible. If, however, you were to ask a series of questions based on activities supplied from the participants own experiential knowledge base, the information retrieved would have been processed in a relevant contextual format leading to increased credibility. The field assistant role was to ground the participant in the desired time period using an autobiographical memory cue, ascertain events significant to the exposure model, probe for clarification, retrieve hours spent in different activities, and record hours spent per week onto the Cumulative Radon Exposure Worksheet. Options included time spent in three major categories ('in another building', 'outside', 'in-home') retrieved by workdays (weekdays) and non-workdays (weekend days). Seasonal variation was designated by the participant (usually retrieved as warm months vs. cold months) and was reported separately for each participant reported time period block. One of the most significant features of this methodology is that all 168 hours per week are accounted for in each time period block. The implications of a total time exposure model will be presented in the discussion section.

RESULTS

Following the above methodology, mobility data was collected from 26 of the original 30 methods study participants nine to eleven months after initial retrieval using Method One. Two offspring proxy respondents were not retested because they had not lived with or near the deceased case for a period of greater than fifteen years making retrieval of mobility data pointless. One proxy respondent was hospitalized and terminal when data collection was scheduled. Another proxy respondent refused the second mobility interview because it was 'too hard the first time' and he didn't want to remember. For the most part, the two methods were so disparate that study participants did not associate one with the other until after the mobility interview had been completed and the participant ease and accuracy ratings were being ascertained. This lack of association paired with the length of elapsed time between Method One and Method Two retrieval, lessened the possibility of bias based on a learning curve. Comparative results will be presented here in terms of participant acceptability.

Participant Rated Facility

After completion of the second mobility interview (Method Two), participants were shown the section of their original mailout questionnaire that corresponded with Method One. The interviewer then asked if they felt one method had been easier for them than the other. 92% of respondents reported Method Two as easier, 8% reported no difference. Participants were then asked to compare the acceptability and preferability of basic methodological differences in the two strategies (Table 1).

Table 1. Basic Methodological Differences in Mobility Data Retrieval Strategies

Method One	Method Two
Decade Time Blocks	Participant Reported Time Blocks
Predetermined Seasonal Variation	Participant Reported Seasonal Variation
Multiple Table Recall	Integrated Time Period Recall
Present to Past Retrieval	Past to Present Retrieval
Participant Math Burden	Interviewer Math Burden
Mailout Questionnaire Format	Facilitated Interview Format

- All participants identified the preferability of self reported time blocks. The average number of time blocks reported using Method Two was 2.5, with an average of 13.4 years per time block (range 1-31).

- All participants identified the preferability of self reported seasonal variation, with 77% of respondents reporting a seasonal variation for at least one time period. Four participants (15%) identified three different seasonal patterns over the decades of retrieved data.

- Integrated time period recall was consistently reported as easier because it allowed for retrieval of all necessary data within one contextual framework. Average time required to facilitate Method Two was 17.5 minutes.

- Past to present retrieval was consistently characterized as 'more natural'. One participant stated it was much easier to remember events in the same direction that you actually lived them. Another pointed out that although the decade table format proceeded from present to past, the way you actually retrieve those memories is to go to the beginning of the decade, move forward to the end of the decade, then go back 20 years to the beginning of the previous decade and again move forward to the end of that decade.

- Math anxiety was reported as a significant factor in study participants unwillingness to attempt Method One initially. Method Two relieved them of that burden and allowed them to concentrate on memory retrieval instead of performing addition.

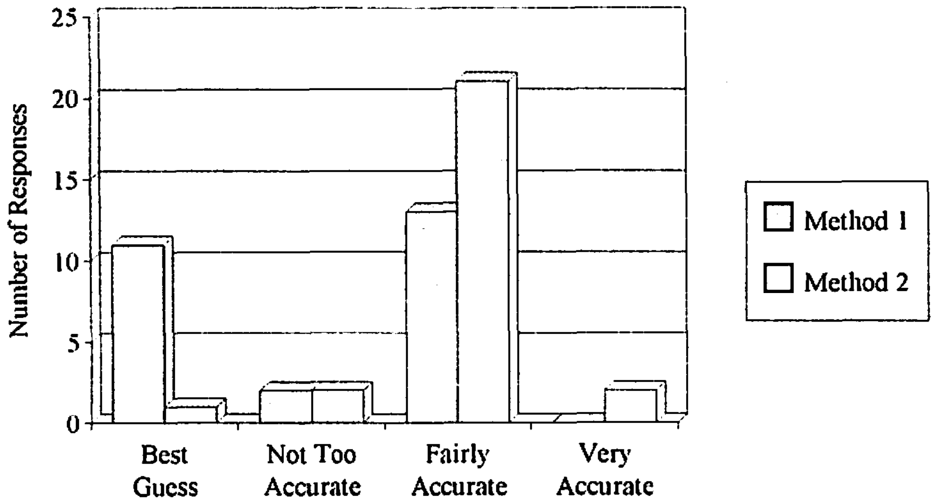
- The interview format was preferred to the mailout format. Basically, the comments revolved around the feeling of wanting to share their life experiences with another human being. Many of the study participants lived alone and enjoyed the interaction.

One unanticipated benefit of the use of autobiographical memory in data retrieval methodology was an often reported feeling of empowerment. Participants stated a neutralization of the perception of right or wrong answers because the information they provided the interviewer was specific to them as an individual. Participants also found it refreshing that the interviewer functioned more as the listener, probing for clarification, and providing direction but not controlling the content of the interaction.

Participant Reported Accuracy

After completion and review of all data collection forms during the initial home visit, study participants were asked to report their perception of the accuracy of their responses to different sections of the mailout questionnaire, including the mobility section (Method One). The field interviewer explained that this information would be used as a tool to help the researchers spot problems with the way questions were asked and was not intended to be a reflection of the mental competency of the participant. The response categories for participant reported accuracy were 'very accurate', 'fairly accurate', 'not too accurate', and 'best guess'. After completion of the accuracy form, it was taken back to the study offices and placed in the participants file. Nine to eleven months later, after completing the mobility interview (Method Two), the participant was again asked to provide information about the perceived accuracy of mobility data derived using autobiographical cues and task-based retrieval. The interviewer and participant were blinded to the responses given months earlier and the initial accuracy form remained in the participants file until paired with the second completed report. Distribution of the participant reported accuracy for Method One vs. Method Two is found in Figure 1. Using the Wilcoxon Sign Rank Test, the change in the distribution of responses from Method One to Method Two, was found to be significantly different ($p < 0.01$, two-tailed test). The most striking improvement in participant reported accuracy, appeared to be the significant decrease in participants reporting the accuracy of given mobility data as 'best guess', from 42.3% down to 3.8%. A 50% positive change in reported accuracy and greatly increased participant acceptability suggests that the use of autobiographical memory to facilitate retrieval of non-verifiable exposure data is a valid methodologic option.

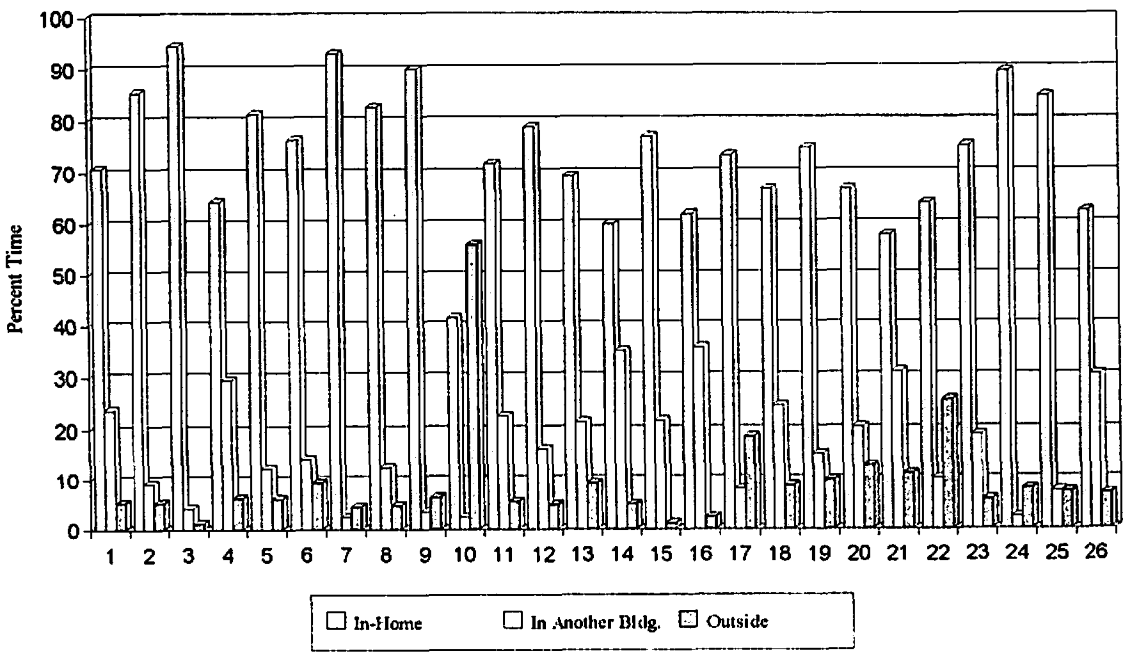
Figure 1. Distribution of Participant Reported Accuracy. Method One vs. Method Two



DISCUSSION

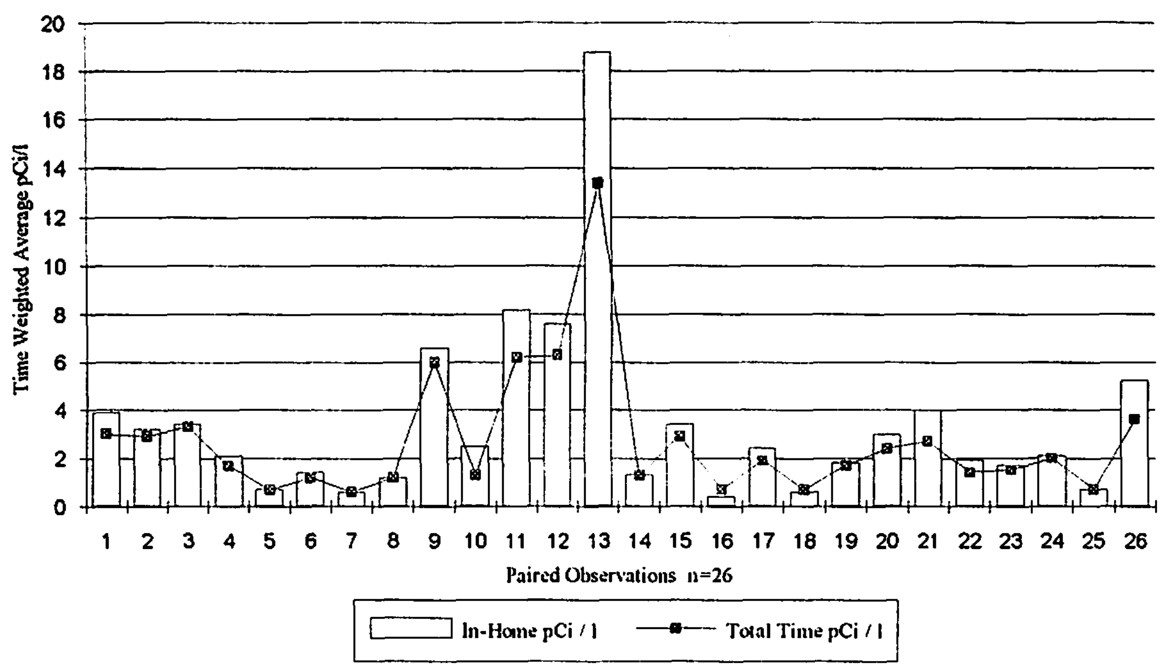
Mobility data collected using autobiographical memory cues was analyzed in terms of percent time spent in the three major retrieval categories. At issue was evaluating the appropriateness of assigning a constant in-home percent time for use in ^{222}Rn exposure modeling. Figure 2 shows the individual percent times reported by study participants averaged across all years in latest residence. Although the mean 'in-home' percent of 73.7, was not considerably different than the 70% constant often used in exposure models, a standard deviation of 12.4 with minimum, maximum range of 41.6 to 94.6 required further evaluation.

Figure 2. Distribution of time reported by individual study participants 'in-home', 'in another building', and 'outside'. Total percent time accounted for, time-weighted by season and across all reported time period blocks.



To assess the possibility of misclassification of study participants based on individual differences in distribution of time spent, mobility data was coupled with year long ^{222}Rn measurements taken within the study participants home. To correspond with the radon dosimetry placement protocol, in-home hours were retrieved for the participants current and, if applicable, historic bedroom, in-home work area, and for all living levels of their home. It was then possible, with a 1:1 correlation between dosimetry sites and reported in-home hours per week, to calculate a time-weighted average in-home exposure over the years in latest residence. If you assume a constant for percent time in-home, these average exposure levels would then be used to categorize study participants into exposure units. Rather than assuming a constant for percent time 'in-home', the most commonly used method, secondary calculations were performed using total hours reported in the three categories of time spent. Hours reported 'outside' were paired with a ^{222}Rn concentration of 0.4 pCi/l, and hours 'in another building' were multiplied by a value of 1.3 pCi/l as set out in the Citizens Guide. All hours were time-weighted across seasons, time period blocks, and according to the percent time distribution in the three categories as reported by individual participants during the Mobility Interview. Time-Weighted Average Total Time ^{222}Rn exposure (mean 2.7 pCi/l $\pm$ 2.7) was then compared with Time-Weighted Average In-Home ^{222}Rn exposure (mean 3.4 pCi/l $\pm$ 3.8) using a Paired t-Test. The sample means of the two measures of exposure were found to be significantly different ($p < 0.006$, two-tailed test). Figure 3 shows the variation in individual Time Weighted Average ^{222}Rn exposure using In-Home vs. Total Time methodology. It is interesting to note, that although the mean was lower for the Time-Weighted Average Total Time ^{222}Rn exposure value, individual exposures varied above and below the Time-Weighted Average In-Home ^{222}Rn exposure value.

Figure 3. Time Weighted Average In-Home ^{222}Rn exposure vs. Time Weighted Average Total Time ^{222}Rn exposure



CONCLUSIONS

Exposure assessment is by necessity dependent upon the interface between hard and soft science. Environmental monitoring may produce an accurate measurement of the exposure of interest, but until it is combined with participant reported levels of exposure to both the agent of interest and accompanying confounders, an accurate assessment of dose and health effects cannot be made. Residential ^{222}Rn exposure assessment clearly falls into this category. Without collecting data on individual mobility; it seems an impossible task to appropriately classify study participants into meaningful exposure categories. However, retrieval of mobility data on an individual level can pose problems for those researchers who either assume participants do not have the desired information available, or feel that a closed, inflexible format is desirable for data consistency. Memory retrieval techniques need to be acceptable to and supportive of study participants individual mechanism for gathering information in a personal, contextual format. The methodology presented here is an attempt to address misclassification of study participants based on imprecise measurement of the non-verifiable side of the exposure model. Great significance can not be given to the results of this or any study based on a study population of 26 subjects, but the use of autobiographical memory as a useful research tool merits further investigation. It is my humble contention that good things do not always come in little boxes.

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