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Using radon risk to motivate smoking reduction II: randomized evaluation of brief telephone counseling and a targeted video

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Abstract

Radon and cigarette smoking have synergistic effects on lung cancer risk. Electric utility company bill stuffers offered free radon test kits to households with at least one smoker. Participating households (n = 1364) were randomized within a 2 × 2 design to evaluate the main effects of brief telephone counseling and a targeted video on smoking cessation and the establishment of new household smoking bans. Phone counseling was associated with cessation at 3-month follow-up but neither intervention led to 12-month or sustained cessation. While neither intervention had a significant effect on new bans, there were trends in the predicted direction and the combination of the two significantly increased new bans compared with no intervention. The presence of children in the household was associated with new bans. While few households had high levels of radon, such levels were associated with radon mitigation behaviors. Together with a previous study, these results suggest radon risk is a useful and inexpensive way to engage smoking households in risk reduction behaviors, especially the institution of household smoking bans.

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Introduction

Research and expert consensus panels continue to identify radon as the second leading cause of lung cancer after smoking [1]. While high concentrations of radon are present in only 6–7% of homes in the United States, the far more numerous low readings have synergistic or submultiplicative effects for cigarette smokers, thereby greatly increasing the numbers of citizens or households at risk [2]. Nonsmokers radon risk often is mitigated by frequent changes in their place of residence while smokers' elevated risk from the combination of radon and smoking moves with them [3].

As formal smoking prohibitions increase in public places and the workplace, the home remains an entrenched smoking area. Although home environmental tobacco smoke exposure (ETS) has declined significantly since 1992, 25% of homes with children in the United States contain ETS [4]. The synergy of radon and smoking increases the risk for smokers—and possibly nonsmokers—in these households [5]. The identification of novel opportunities for presenting risk information in cost-effective ways to motivate smokers is now a priority, since most smokers have been exposed to nonsmoking messages in the media and through health care providers. Exposure to information about the synergistic risk of radon and smoking is one such motivating opportunity. For the great majority of households with smokers, smoking cessation or banning smoking in the home yields much greater risk reduction benefits than does structural mitigation to reduce radon concentrations [6]. This is especially so for households testing below the action level (<4 pCi/l) for radon since it is difficult

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and expensive to reduce radon concentrations further. Even with a radon level of 2 pCi/l, there is a 15-fold difference in relative lung cancer risk between smokers and nonsmokers. Both studies in our research program emphasized the value of quitting smoking or reducing environmental tobacco smoke.

In a prior study, we approached households about radon and smoking through a partnership with a local electric utility company [7]. Households with radon levels below <4 pCi/l were randomized to either experimental intervention strategies or to receive standard Environmental Protection Agency (EPA) materials and compared on the dependent variables of quitting smoking and banning or restricting smoking in the home. The EPA guide and a specially developed pamphlet—intended to raise awareness of the radon-smoking synergy—yielded similar and nonsignificant outcomes at follow-up. However, brief telephone counseling (one or two short calls) led to significantly more new household smoking bans compared with a pamphlet only. The utility company recruitment strategy was successful in that ~40% of the estimated smoking households returned the coupons and ~25% entered the study, compared with an estimated 2% recruitment for population-based programs [8, 9].

In this article, we report on both a partial replication and an extension of the first study. The replication lies in the inclusion of the same telephone counseling procedure as in our prior study. While telephone counseling for smoking cessation has become a major intervention modality with most states currently sponsoring helplines, such services have not been linked with utility company-sponsored programs [10]. In prior research in health care settings, we have employed targeted videos as part of brief interventions [11, 12]. We reasoned that a video would be a compelling way to depict the hazards of radon and the radon-smoking synergy. Therefore, we created a 15-min video on radon and smoking which served as a second intervention. We hypothesized that both telephone counseling and the targeted video would have significant effects on cessation and the establishment of new household smoking bans.

The study extended our prior work in three additional ways. Whereas, our prior study was implemented in only one utility, here we recruited from several utility companies from diverse areas of the state. Second, we included households with radon levels above the action level of ⩾4 pCi/l. Third, we conducted cost analyses for the two interventions. These low-intensity interventions can be delivered conveniently through electric utility companies and it would be useful to estimate their cost-effectiveness.

Methods

Design

Eligible households were randomized within a 2 × 2 design to evaluate the effectiveness of counseling versus no counseling and a targeted video versus no video. Eligibility was defined as having at least one smoker in the home and returning a baseline survey and consent form. Eligible households were entered into a project management database. Each week new households were sequentially randomized to one of the four experimental conditions, subject to stratification on test status (tested for radon—valid result <4.0 pCi/l; >4.0 pCi/l; tested for radon—invalid result; did not test). All participating households received radon test results, a cover letter explaining the results and their action implications and a copy of the EPA ‘Citizen Guide to Action’.

Recruitment of utility companies

We approached 11 public utilities to participate. Recruitment consisted of an initial phone contact, followed by written materials specifying the benefits to the utilities and their customers (free radon tests and feedback on radon and smoking; assistance with smoking cessation or implementation of household smoking bans for those customers who so chose) and copies of the inserts and other materials, along with a trade newsletter article describing our successful collaboration with a utility company in our prior study. Five utilities agreed to participate. They were similar to those which did not in number of customers, rural versus urban settings and municipal or cooperative ownership. Further details on recruitment of utilities are presented elsewhere [8].

Recruitment and characteristics of smoking families

Informational coupons enclosed with customers' utility bills invited households with at least one smoker to request a free radon test kit by completing and returning the coupon along with their utility payment. In some utility companies, a repeat coupon enclosure was sent to increase response rate. Households returning the coupon were sent a radon test kit and a baseline survey, assessing the demographic characteristics and smoking habits of household members. A $2 bill was included as an incentive for returning the survey. All procedures were approved by the Institutional Review Board. To ensure compatibility with our previous work, those few households recruited via newspaper ads (n = 47) were excluded, leaving 1364 households available for analyses. Figure 1, based on CONSORT recommendations [13] and adapted from Glasgow *et al.* [8] summarizes the recruitment, assignment, participation and follow-up of households.

The 1364 households contained 1823 cigarette smoking adults, 1394 nonsmoking adults and 498 children under the age of 18 years. Reflecting the ethnic characteristics of the area, respondents, for the most part, were white (91.5%), with 2.3% American Indian and 1.7% Latino.

Table I summarizes the key demographic and smoking characteristics for participating households by condition. Inspection of the values in Table I indicates the conditions were very similar on baseline characteristics. The households had an average of 1.3 (SD = 0.59) smokers per household who smoked an average of 18.6 (SD = 10.8) cigarettes per day. The mean contemplation ladder score [14] for smokers was 5.59 (SD = 3.5), indicating considerable variation in readiness to quit. At baseline, 72.6% of households had rules about indoor smoking and 29.1% had a rule completely banning smoking inside the house. Based on estimated smoking prevalence rates, we recruited ~11% of the smoking families served by these utilities [8].

Intervention

The intervention was intended to be both effective and disseminable [15]. We hypothesized that the radon issue would arouse motivation to engage in risk reduction actions and both the phone counseling and video would direct those actions primarily toward smoking reduction and secondarily toward structural mitigation.

Telephone counseling consisted of one or two brief phone calls and the protocol was very similar to that employed in our prior study [7]. Counselor training included role playing and regular meetings with a supervisor. Of the three counselors, one had conducted the bulk of the counseling in the prior study. The first call was delivered shortly after the household received their radon test result. The counselor clarified the combined risk of radon exposure and smoking and encouraged quitting smoking or not smoking in the home if quitting seemed not acceptable. The call was brief, supportive and nonconfrontational. Depending on interest, a second call was scheduled. Of the households assigned to phone counseling, 569 (84%) received one or more calls.

Households in the video condition received a 15-min video developed for this project, using animation, an exemplar family that included two children and a narrator. Animation illustrated the flow of radon from the ground mixing with cigarette smoke into household members' lungs. The family interaction depicted a smoking father who, initially, dismisses the radon report because the observed radon level was low, but is then persuaded that the combination of smoking and radon requires him to take action. To encourage viewing of the video, we enclosed a stamped, self-addressed postcard asking for their opinions about its quality. Returning the postcard would enter them in a drawing by which they could win a $100.00 prize.

All households received the EPA pamphlet, 'A Citizens Guide to Radon', and a cover letter explaining their results and implications for action. The cover letters varied depending on the radon levels observed. Households with radon levels <4 pCi/l were reminded that there was still significant

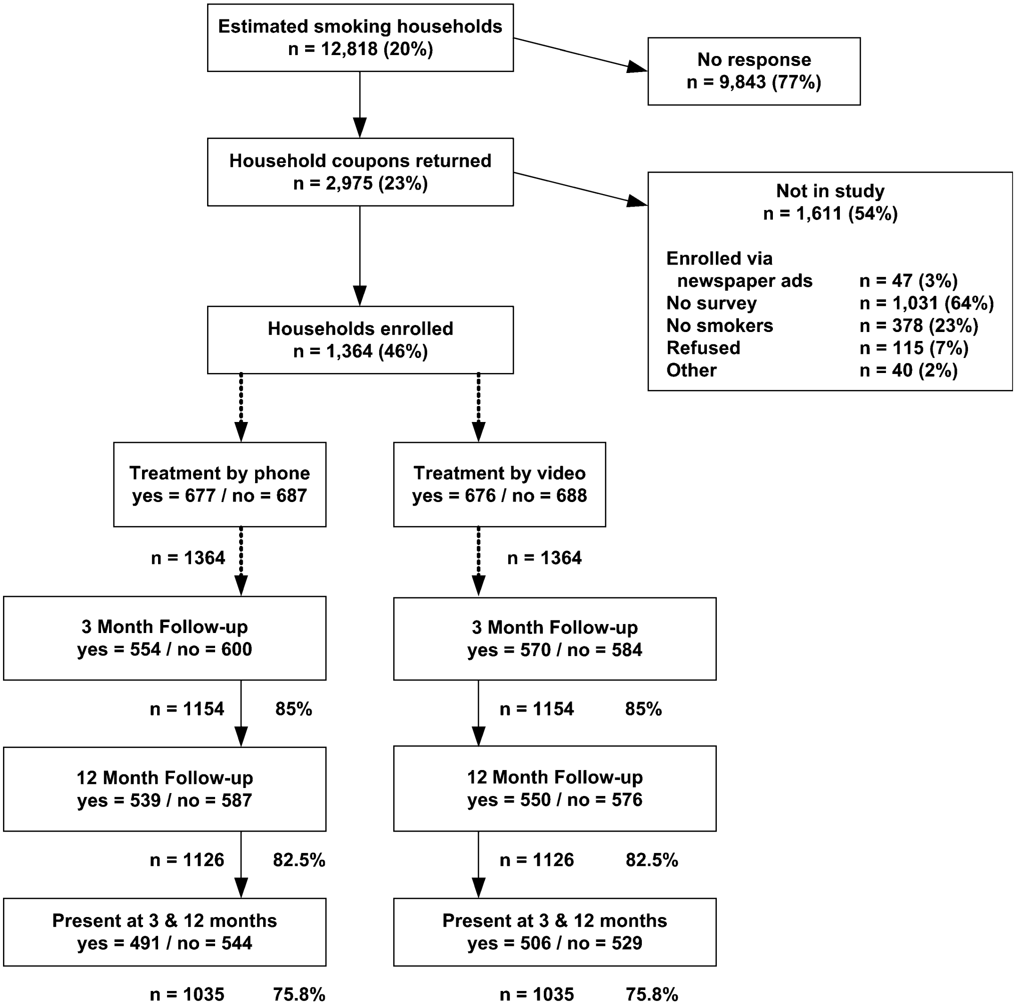

Fig. 1. Recruitment, participation, assignment, and follow-up of households.

risk because of the combination of radon and smoking that could be addressed by reducing smoking. Households with high radon levels were also told that reducing smoking clearly was the best way to reduce risk and were further informed that radon levels could be reduced by structural mitigation.

Assessment

Households were assessed both at 3 months and 12 months after intervention via a mailed questionnaire with a cover letter and a $2 bill as a 'thank you' for returning the questionnaire. After 2 weeks, a second questionnaire was mailed and, if the household failed to respond within another two weeks, we attempted to complete the assessment by telephone. As shown in Fig. 1, 85% of households completed the 3-month assessment, 83% (of the original sample) completed the 12-month assessment and 76% completed both 3- and 12-month assessments.

Table I. *Demographic and baseline smoking history variables by condition*

Variable	Intervention condition			
	Telephone counseling		Video	
	Yes $n = 677$	No $n = 677$	Yes $n = 676$	No $n = 678$
Households				
Respondent's education (% > high school)	61.5	64.2	63.9	61.8
% single family owned homes	78.8	82.0	78.9	82.0
% previously tested for radon	2.7	1.9	2.5	2.0
% with more than one smoker in the home	29.2	30.8	30.9	29.1
% banning smoking in the home	28.2	30.2	28.3	30.0
Individual smokers				
Mean cigarettes smoked/day (SD)	18.76 (10.87)	18.41 (10.71)	18.74 (11.26)	18.43 (10.31)
Mean intent to quit, 0–10 (SD)	5.52 (3.11)	5.66 (3.84)	5.56 (3.88)	5.62 (3.09)

The primary outcomes were: (i) smoking cessation defined by no smoking in the past 7 days and (ii) eliminating or restricting smoking inside the home. The survey respondent was asked to list all members of the household and their current smoking status. Thus, some of the information on smoking outcomes comes from proxies, a procedure sometimes used in prevalence surveys [16]. Each smoker's interest in quitting was assessed by means of the 'contemplation ladder', an 11-point Likert scale [14]. Smoking restrictions in the home were assessed with a single item asking the respondent to circle the statement that best described 'the current smoking rules in your home' (no smoking in house; no smoking when certain people—for example, children—present; restricted to certain areas; no rules). Changes in radon mitigation behavior—e.g. improving ventilation under the home and changes in smoking behavior short of quitting were assessed as secondary outcomes at the 3-month follow-up only. The 3-month survey also included items asking about the helpfulness of the written materials and phone calls. Both the 3- and 12-month surveys contained risk perception items and the 3-month survey contained personality trait items which are reported on elsewhere [17].

Statistical analysis

Consistent with the analyses adopted in an earlier paper [7], outcomes are reported as the main effects in our 2 × 2 design, and we report on simple differences in proportions of quits or new bans. (In the cost analyses the cells were compared since it was of interest to distinguish video and telephone counseling costs.) This approach, called 'time naive'[18] may be appropriate for measures such as 'consecutively reported bans', but is not when data are missing and observations (e.g. smoking status) are nested within households. Both of these conditions obtain for data reported upon here and led us to employ nested longitudinal analyses and propensity measures to account for these influences [19]. We confirmed the simple analyses using analogous longitudinal models and report the findings from the latter as odds ratios where these inform the simple analyses.

To accommodate attrition of households, logistic regression analyses were first used to construct a propensity measure [20] of attrition at 3 or 12 months. Baseline predictors included treatment factor levels, baseline radon level, length of residence, whether home was owned or rented, whether home had a ban on indoor smoking at baseline, the gender of the respondent and whether the home had children under the age of 18. Two predictors were related to loss at 3 or 12 months—phone treatment (27% missing) versus no phone treatment (21%), ($\chi^2 = 8.26$, df = 1, $P \leqslant 0.004$, OR = 1.44, CI = 1.12, 1.85) and whether the home was rented (33%) or owned (21%), (χ^2 = 17.37, df = 1, $P \leq 0.004$, OR = 1.83, CI = 1.37, 2.44). The predicted values from the analysis were used as propensity scores which were entered as the first covariate in all subsequent regression analyses.

The second analysis consideration was dictated by the fact that although household was the unit of randomization and analysis for some of the reported outcomes (e.g. smoking bans), other outcomes associated with individual behaviors (e.g. smoking status) required accounting for the effect of multiple individuals nested within some but not all households. About one-third of households contained more than one smoker. An examination of intrahousehold dependence for smoking status at each follow-up for these multiple smoker homes found intraclass correlations for 3-month, 12-month and both 3- and 12-month reported abstinence of 0.25, 0.42 and 0.28, respectively. To accommodate multiple smokers within some, but not all, households we created repeated measures analyses and corrected the covariance matrix for sampling design by clustering on household [20]. These complex analyses yielded results generally consistent with simple analyses—e.g. chi square.

For the smoking cessation analyses, we restricted the data to those persons identified as smoking at baseline and, for bans analyses, to those households with no ban at baseline. For the outcome of household smoking bans, households were both the unit of assignment and the unit of analysis. Analysis of this outcome was similar to that for cessation, but did not incorporate a correction for nesting. The regression analyses entered the propensity score, the two intervention factors, the time contrast and time intervention interactions. As was the case with the first paper, both primary outcomes, cessation and bans, use 'intent-to-treat' imputation, where participants or households lost to follow-up are considered smokers (or to not have a ban). Finally, the chi-square tests of the two interventions use a corrected alpha of 0.017(0.05/3), to account for directional hypotheses and correction for multiple testing.

Results

Implementation of intervention

The 3-month follow-up survey provided information on receipt of intervention components and their perceived helpfulness. Table II summarizes these findings.

Respondents reported reading the written materials and finding them helpful. There was more

Table II. *Self-reported receipt/helpfulness of intervention components by condition*

Variable	Intervention condition			
	Telephone counseling		Video	
	Yes n = 554	No n = 600	Yes n = 570	No n = 584
% received written information	96.2	89.0	93.9	91.2
Amount of material read (1–5; 5 = all)	4.19 (1.20)	4.25 (1.12)	4.15 (1.22)	4.28 (1.11)
% others in home read material	45.1	38.8	43.9	40.0
Mean helpfulness of materials (1–5; 5 = very)	4.00 (1.10)	3.97 (1.12)	3.96 (1.10)	4.01 (1.12)
Mean helpfulness of phone calls (1–5; 5 = very)	4.15 (1.03)			
Mean supportiveness of phone call (1–5; 5 = very)	4.22 (1.06)			
% received video			86.0	
Amount of video watched (1–5; 5 = all)			3.66 (1.78)	
% others in household watched video			39.1	
Mean interesting/informative (1–5; 5 = very)			4.09 (0.93)	
Mean helpfulness of understanding combined risk of radon and smoking (1–5; 5 = very)			4.35 (0.86)	

variability in watching the video, relative to the written materials, but the video was rated as both interesting and helpful. Both the written materials and the video were seen by someone in the home other than the respondent in ~40% of the households. The mean duration of the first telephone call was 5 min (SD = 3.8); for the second call it was 3.8 min (SD = 3.0). These durations reflect our intent that the calls be motivational and supportive with only modest levels of interactive counseling.

Cessation

Table III displays quit rates for all baseline smokers (n = 1823) at 3-month (two outlying cases on multiple baseline variables removed, n = 1821) and 12-month follow-up (respondents reported three deceased smokers, n = 1818). Inspection of Table III indicates that neither phone calls nor the targeted video increased quit rates at either 12 months—point prevalence—or 3 and 12 months—sustained quitting. The quit rates at 3 months for telephone counseling (9.1% versus 7.1%) were in the predicted direction and analysis accounting for multiple smokers within households and the propensity of household data to be missing showed a small effect [OR = 1.62 (1.03, 2.56)].

Household smoking bans

Table IV presents follow-up data on smoking bans for the 967 households reporting no ban at baseline, again using an intent-to-treat analysis. Inspection of Table IV indicates a trend for brief phone counseling to be associated with an increase in new bans at 3-months, 12-month and both 3- and 12-month assessments, but the differences are not significant: e.g. for bans at both 3- and 12-month follow-up (χ^2 = 2.05, df = 1, P < 0.16). While there were no significant video effects at 3 months, 12 months or 3 and 12 months, trends were similar to those found for phone calls. The logistic regression analyses that included a propensity score for missing data were highly consistent with the chi-square analyses.

Table III. *Percent (n/N) quit rates at 3 and 12 months for all smokers identified at baseline (intent-to-treat)*

Variable	Telephone		Video	
	Yes	No	Yes	No
3 month[a]	9.1% (82/905)	7.1% (65/916)	7.3% (66/902)	8.8% (81/919)
12 month[b]	13.1% (118/902)	12.2% (112/916)	12.2% (110/900)	13.1% (120/918)
3 and 12 month	5.1% (46/905)	4.6% (42/916)	4.2% (38/902)	5.4% (50/919)

No significant differences between conditions.
[a]Two outlying cases on multiple baseline variables removed.
[b]Proxies reported three smokers were deceased at 12 months.

Table IV. *Percent of households that allowed smoking in the home at baseline with household bans at 3 and 12 months (intent-to-treat)*

Variable	Telephone		Video	
	Yes n = 487	No n = 480	Yes n = 485	No n = 482
3-month follow-up	17.0% (83)	14.0% (67)	15.3% (74)	15.8% (76)
12-month follow-up	21.15% (103)	17.5% (84)	21.4% (104)	17.2% (83)
Both 3- and 12-month follow-up	11.3% (55)	8.5% (41)	11.3% (55)	8.5% (41)

No significant differences between conditions.

Given this pattern of results, we performed a *post hoc* analysis wherein households receiving both the video and phone counseling ($n = 251$) were compared with households which received neither ($n = 246$). Households which received both interventions were more likely to have instituted new bans at 12 month (22% versus 14%, $\chi^2 = 5.05$, df = 1, $P < 0.03$).

Relation between bans and quitting

The relationship between smoking bans and quitting smoking at 3 months was found to be highly significant. Of those households with a new household ban at 3 months, 27% had at least one smoker in the household who quit. In contrast, among those households that did not institute a ban, only 4% had at least one smoker who quit ($\chi^2 = 96.32$, df = 1, $P < 0.001$). At 12 months with follow-up the comparable values were 35% and 7% ($\chi^2 = 109.82$, df = 1, $P < 0.001$).

Radon mitigation and effects of radon level

We examined radon mitigation behaviors at 3-month follow-up in relation to the two interventions. The video intervention significantly affected only one of the five radon mitigation behaviors asking for more radon information ($\chi^2 = 4.24$, df = 1, $P < 0.04$). Telephone counseling significantly affected three behaviors: asking for radon information ($\chi^2 = 3.96$, df = 1, $P < 0.05$); retesting for radon levels ($\chi^2 = 5.72$, df = 1, $P < 0.02$) and trying to fix the house themselves ($\chi^2 = 4.12$, df = 1, $P < 0.05$). In all cases, only a small number of households engaged in these behaviors.

Across both interventions, relatively few households, 63, had radon test levels of 4 pCi/l or higher, the EPA threshold for considering home remediation. Compared with low radon homes, households with radon levels of ⩾4 pCi/l were more likely to have a new ban at 12 months ($\chi^2 = 3.36$, df = 1, $P < 0.07$), but not at 3 months and more likely to have a quitter in the home at 3 months ($\chi^2 = 3.59$, df = 1, $P < 0.06$), but not at 12 months. High radon levels, not surprisingly, were associated with radon mitigation behaviors assessed at 3-month follow-up: asked for more information on radon ($\chi^2 = 108.0$, df = 1, $P < 0.001$); retested to check radon results ($\chi^2 = 382.9$, df = 1, $P < 0.001$); asked for information about fixing home ($\chi^2 = 23.4$, df = 1, $P < 0.001$) tried fixing home themselves ($\chi^2 = 18.2$, df = 1, $P < 0.001$) and spend reduced time in basement ($\chi^2 = 32.8$, df = 1, $P < 0.001$). High radon levels were also associated with avoiding smoking in the home ($\chi^2 = 9.04$, df = 1, $P < 0.003$). Because so few households (4.5%) had actionable radon levels (⩾4 pCi/l) or engaged in mitigation behaviors, it was not feasible to examine interactions with intervention or potential moderators.

Effects of children in the home

We suspected that households with children would be more likely to institute new bans. The association of children aged 0–6 or 7–17 with new bans at 3-month and 12-month follow-up was examined after the propensity score and the two interventions were stepped into the regression analyses. At 3 months, for households with children 6 or under the nonsignificant OR was 1.77 (CI = 0.91–3.45); for children 7–17, OR = 1.79 (CI = 1.07–3.00). At 12 months, the OR for households with children aged 0–6 was 2.10 (CI = 1.15–3.82); for children aged 7–17, OR = 2.26 (CI = 1.42–3.60).

Cost analyses

We estimated total development and delivery costs for each intervention and the incremental cost-effectiveness of each active intervention compared with baseline. Program replication costs were assessed from a societal perspective and included all labor, facility and supply costs associated with intervention development, utility company and patient recruitment and intervention delivery. However, we did not include the costs of participant time spent receiving the intervention. Time spent completing the interventions was minimal and took place during nonwork hours. Total and average costs were calculated for each intervention arm. For the cost-effectiveness analysis, we estimated the incremental program costs per additional household smoking ban at 12 months for each intervention compared with brochure only, recognizing that neither intervention reached statistical significance. Cost-effectiveness ratios were not estimated per incremental quit because the interventions did not increase long-term quit rates compared with the control group.

The total cost per household of each intervention was $29 for the EPA brochure only, $82 for brief telephone counseling, $232 for video only and $285 for video and telephone counseling combined (Table V). Excluding this cost, the per household costs were $34 for the video and $87 for the video and phone. Compared with the brochure only intervention, telephone counseling cost $1152 per additional household ban, video cost $4178 per additional ban and video plus phone counseling cost $4072 per added ban. These results include the costs of developing the video and the phone counseling protocol. However, when we assessed the value of replicating intervention elsewhere (i.e. excluding the $64 000 video development costs), the incremental cost-effectiveness favored the video-only intervention. Compared with brochure only, the video cost $107 per additional household smoking ban, while the video plus phone counseling cost an additional $913 per ban.

Discussion

In spite of difficulties in the energy industry (i.e. sharply rising rates), we obtained the cooperation of five of 11 of the utility companies we approached and through them obtained participation of ~11% of estimated smoking households [8]. Although this was a much lower percentage of smoking homes than we reached in our prior study with one utility—where we were able to repeat the bill stuffer three times—it is still an efficient way to recruit smoking households. Once again, participants were co-operative with 76% of households completing both 3- and 12-month assessments.

Neither telephone counseling nor the targeted video had a significant effect on longer term smoking cessation. Our prior study [7] reported a non-significant trend between telephone counseling and quit rates, but a different analysis team incorrectly calculated the intraclass values and did not adjust for the intraclass correlations. The corrected values in our prior study are 0.39, 0.50 and 0.55 for 3-month, 12-month and both 3- and 12-month reported abstinence—similar to the values in this report. Application of analytic procedures correcting for the Intraclass Correlations to these earlier data show no significant effect of phone counseling on quitting. Telephone counseling was intentionally brief—the mean time of the first call was only 5.8 min—considerably less than provided by quit-lines serving smokers seeking help to quit [21]. Although phone counseling was related to 3-month cessation in this study, together our two studies show that very brief telephone counseling does not enhance longer term or sustained cessation in smoking households recruited because of their concerns about radon levels.

Both interventions, however, tended to increase the establishment of new household bans, although

Table V. *Cost and cost-effectiveness of new household smoking bans, by intervention*

	Brochure (baseline)	Telephone counseling	Video	Video and phone
Total intervention cost				
Total	$10 424	$28 985	$81 829	$99 083
Per household	$29	$82	$232	$285
Per home smoking ban	$301	$571	$1618	$1819
ICER	$—	$1152	$4178	$4092
Replication costs				
Total	$10 424	$28 985	$12 065	$30 307
Per household	$29	$82	$34	$87
Per home smoking ban	$301	$571	$239	$554
ICERs	$—	$1,152	$107	$913

they did not reach conventional levels of statistical significance. These results are consistent with the findings in our prior study [7]. Those households which received both phone counseling and the video were especially likely to have a new ban at 12 months. Over both conditions, ~19% of households reported a new ban at the 12-month assessment. Common to all conditions was experiential engagement with radon testing and received feedback and this may have increased bans. It is also likely that households selecting themselves into the study were predisposed to take risk reduction actions.

Quitting smoking and establishing new bans were strongly associated as they were in our prior study. New bans were associated with the presence of younger and, especially, older children in the household. In our prior study [7] using the same analytic procedures, we found no relationship between children in the home and new bans. The demographic and smoking histories of the participants in the two studies were very similar as were the baseline levels of smoking bans. This discrepancy between the two studies suggests the need for replication. However, the substantial relationship between children in the home and new bans in this study supports the meaningfulness of bans as an outcome since they appear to protect children from ETS. Given increased concerns about home ETS exposure for children, a radon-smoking intervention aimed at smoking households with children could be quite productive [22].

It was disappointing that so few of our households had radon levels above the action level set by EPA. The major utility we worked with was expected to have ~20% of its residences at high radon levels (based on radon mapping data from our geologist consultant), but relatively few of these found their way into our study. In spite of the low numbers, high radon levels were strongly associated with radon mitigation actions as well as with some changes in smoking behavior. It would be of great interest to test the intervention approach used here in residential areas where high radon levels are more prevalent.

The economic evaluation showed that the interventions were delivered at modest cost and were a cost-effective means of increasing household bans compared with the EPA brochure only. While we were able to assess the incremental cost-effectiveness of the interventions in terms of smoking bans, we were not able to assess the impacts the additional bans had on future medical care costs, productivity and life-years saved. The cost-effectiveness of efforts to reduce smoking has been well established, particularly compared with other health interventions [23–25] Smoking cessation is considered the 'gold standard' for preventive services [26]. There are no published studies that have estimated these affects for household smoking bans. To the extent that the bans are maintained over the long term, benefits will likely accrue to nonsmokers who would have continued to be exposed in the home.

Some limitations of this study must be noted. We relied on self-reports for both quitting smoking and for assessing smoking bans. While quit rates may be slightly inflated, differential false reporting is likely to be minimal and not differential given the limited intervention contact [27]. Few studies have examined the validity of self-reported smoking bans. Correlations between reports of number of cigarettes smoked in the home and ambient nicotine levels collected via a passive monitor have generally ranged from 0.73 to 0.86, suggesting relatively accurate reporting [28–30]. A recent study reported a correlation of .49 in a sample of southern California households containing asthmatic children [4]. The review of Hovell *et al.* 2000, reported ETS exposure does recommend biological markers but many of the studies covered in their review used more intensive interventions compared with ours [31]. While some households may report new smoking bans because of social acceptability, the two low-intensity interventions seem unlikely to have influenced reports of bans especially at the 12-month follow-up.

Public Utility companies are an attractive, convenient medium for reaching smoking households and the radon-smoking synergy appears to attract the attention of smokers who may be jaded about the usual risks of smoking. Focusing on smoking households with children may be a particularly powerful way of exploiting the combined risks of radon and smoking. Such a targeted approach could be implemented in a managed care organization with a quality electronic medical records system.

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