

The Montana Radon Study: Social Marketing via Digital Signage Technology for Reaching Families in the Waiting Room

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Indoor radon exposure accounts for 21 000 deaths (15% of lung cancer deaths) in the United States each year and is the second leading cause of lung cancer behind smoked tobacco.¹ Radon causes 100 times more deaths than carbon monoxide poisoning² and is the leading environmental cause of cancer in North America.³ Although lung cancer can be treated, the survival rate is one of the lowest for all cancer types. The estimate that Americans spend more than 90% of their time indoors further underscores the need to reduce residential exposures.⁴

Montana, like other states in the Rocky Mountain Region, is a high-radon geographic area with all but 7 of Montana's 56 counties designated by the Environmental Protection Agency as having the most serious radon risk (i.e., Zone 1).⁵ Although 49 of Montana's 56 counties share the Zone 1 designation, only 4 have a Montana Department of Environmental Quality–funded radon program. Started in 1993, these state funds were appropriated to the health departments in the 4 fastest-growing counties in the state: Gallatin, Ravalli, Flathead, and Missoula counties. Health department administrators used these funds to purchase radon test kits, provide education and outreach, and manage a database of reported radon concentrations.

A recent evaluation of the Gallatin County radon program showed that participants were predominantly nonsmoking, older, well-educated, and middle-class homeowners.⁶ A social marketing campaign was identified as a potential way to expand radon program participation to other high-priority groups. Social marketing is a strategy that has been effective across a wide range of topics, settings, and audiences including sexual health,^{7,8} asthma in older adults,⁹ and fruit and vegetable consumption in Special Supplementary Nutrition Program for Women,

Objectives. I tested a social marketing intervention delivered in health department waiting rooms via digital signage technology for increasing radon program participation among priority groups.

Methods. I conducted a tricounty, community-based study over a 3-year period (2010–2013) in a high-radon state by using a quasi-experimental design. We collected survey data for eligible participants at the time of radon test kit purchase.

Results. Radon program participation increased at the intervention site ($t_{38} = 3.74$; $P = .001$; 95% confidence interval [CI] = 4.8, 16.0) with an increase in renters ($\chi^2_{1,228} = 4.3$; $P = .039$), Special Supplementary Nutrition Program for Women, Infants, and Children families ($\chi^2_{1,166} = 3.13$; $P = .077$) and first-time testers ($\chi^2_{1,228} = 10.93$; $P = .001$). Approximately one third (30.3%; $n = 30$) attributed participation in the radon program to viewing the intervention message. The intervention crossover was also successful with increased monthly kit sales ($t_{37} = 2.69$; $P = .01$; 95% CI = 1.20, 8.47) and increased households participating ($t_{23} = 4.76$; $P < .001$; 95% CI = 3.10, 7.88).

Conclusions. A social marketing message was an effective population-based intervention for increasing radon program participation. The results prompted policy changes for Montana radon programming and adoption of digital signage technology by 2 health departments. (*Am J Public Health*. Published online ahead of print August 14, 2014: e1–e7. doi:10.2105/AJPH.2014.302060)

Infants, and Children (WIC) participants.¹⁰ Health department WIC clinics were identified as an ideal place to reach younger, lower-income families with children, and renters—subgroups not well represented among baseline radon program participants. In support of the goal to expand radon program participation to priority groups, the aim of the Montana Radon Study (MRS) was to test the efficacy of a social marketing intervention for increasing radon program participation by lower-income families, first-time testers, and families who rented their homes. Although current and former smokers are the groups at greatest risk of radon-related lung cancer, they were not specifically addressed in this intervention message designed to appeal to all residents of high-radon counties.

METHODS

We conducted a 3-site community-based trial with crossover in the combined health

department and WIC waiting areas of 3 radon Zone 1 Montana counties. I approached health officers of the 4 county health departments with state-funded radon programs to participate in the MRS. Missoula County declined to participate because of personnel shortages. Ravalli County agreed to participate if assigned to the control site, also citing personnel shortages. I assigned the experimental control and crossover site to Flathead County and the initial intervention site to Gallatin County. The average monthly participation of adults and children at these WIC clinics in 2012 was 728 in Ravalli, 1654 in Flathead, 1160 in Gallatin, and 2507 in Missoula.¹¹

Digital signage technology (DST) is a contemporary approach to health messaging that uses flat-panel monitors to display “media rich” messages¹² in “dwell zones.” Proposed as a solution to address the short shelf-life of printed materials and the limited interaction time of health care providers^{13,14} I selected DST as the

best medium for delivering the intervention message. Radon program bulletin boards and hand cards, defined as the standard of care, were available in both the pre- and postintervention phases at all sites. I assigned the experimental control site DST messaging without the radon message. The waiting room configuration was equivalent for viewing DST in the intervention and experimental control sites. The DST was not provided at the control site.

Radon Intervention

The design and tailoring of the radon message was guided by social marketing principles and the Precaution Adoption Process Model.¹⁵ Current theories in neuroscience and psychology supported this integration of theories focused on the cognitive and affective domains.^{16,17} The study met Andreasen's¹⁸ 6-benchmark criteria for social marketing research. For example, I based the intervention on formative consumer research⁶ and attended to behavioral determinants such as costs associated with accepting or rejecting the action and alignment of the action with internal and external values.^{17,19}

I used a mixed-frame approach to convey both the benefits (e.g., peace of mind) of radon testing and the costs (e.g., risk of lung cancer) of unmitigated exposure to radon.²⁰ The message targeted parent, homeowner, and renter subgroups and concluded with a call to action. Viewers in the waiting room were encouraged to participate in the radon program conveniently located in the environmental service office. Price was addressed in terms of the convenience of mailing completed tests from home in a postage-paid envelope. No information about the research study, the dollar cost of the radon test kits, or participant incentives was included in the message. The intent was for people to be persuaded to action by the information alone—the preferred outcome of a social marketing approach.²¹

Vericom Communication's ChannelCare was the subscription-based DST vendor and graphic designer selected for the MRS. The radon message (2:52 minutes) was a fixed component of a 10-minute message loop in the intervention community. I based the 10-minute message loop on the average amount of time clients spent in the waiting room ($n = 23$; mean = 8.17 minutes, SD = 6.10; range 2–21 minutes). A variety of nonintervention messages

including announcements about local events and timely health topics were included to complete the content loop and trained health department staff updated them regularly. The repeating loop was broadcast on two 42-inch monitors in the WIC waiting rooms of the intervention and experimental control sites.

All messages were silent and relied exclusively on graphics and text to convey information. Although silent messages require that the audience member is able to read, this is preferred over audio messages that may be turned off or muted to keep from disrupting families and clinic staff.²² An animated black-and-white design (Figure 1) was used to acknowledge the heterogeneity of individuals in the waiting room. Information was presented at a sixth-grade literacy level²³ and informational graphics were used to supplement numeric information.²⁴

Procedure

Baseline data collection commenced at all 3 sites in advance of the intervention (Figure 2). Data sources for this project included survey data and time-of-purchase data from each county as well as lab results for completed indoor radon tests. Trained county employees assessed individuals who came to the Environmental Services Office in all 3 counties for eligibility in the MRS. If the individual was a member of the household they planned to test (i.e., rather than a real-estate agent, property manager, or home inspector) they were eligible to participate (Figure A, available as

a supplement to the online version of this article at <http://www.ajph.org>).

Consenting participants who met the criterion were invited to complete the 5- to 10-minute survey. Participants purchased their test kit (\$6 for short-term and \$11 for long-term) and received a \$15 gift card as a token of appreciation for survey completion. The survey included questions on sociodemographic and cognitive variables. I derived the cognitive variables from studies of health behavior.^{25,26} The variables were radon knowledge (19 items), risk perception (8 items), and self-efficacy (7 items). The construct definitions for each of these 3 variables and item statistics were reported in previous research.^{6,27} Briefly, the laboratory reported completed radon concentrations to both the research team and the participant. Referral to the Montana Radon Hotline and the Environmental Protection Agency Citizen's Guide to Radon²⁸ were included with each test result.

Data Analysis

At the completion of data entry and cleaning, I generated a random selection of 10% of cases and checked them against the entered data to ensure accuracy of the database. I scored and recoded the knowledge, risk perception, and self-efficacy items before analyzing the missing data (missing values analysis, SPSS version 16.0, SPSS Inc, Chicago, IL). I then checked by hand 10 surveys against the calculated values to ensure the accuracy of the recoding instructions. Next, I used software to highlight patterns of missing values (SPSS version 21.0, IBM, Armonk, NY). I confirmed every instance of missing data against the source data and either corrected or confirmed it as missing. I used the expectation maximization method to impute missing data on scale variables. This is the preferred method for treating missing data as case deletion would bias the data set in favor of the outcome behaviors of people who were attitudinally homogenous to sharing personal information.

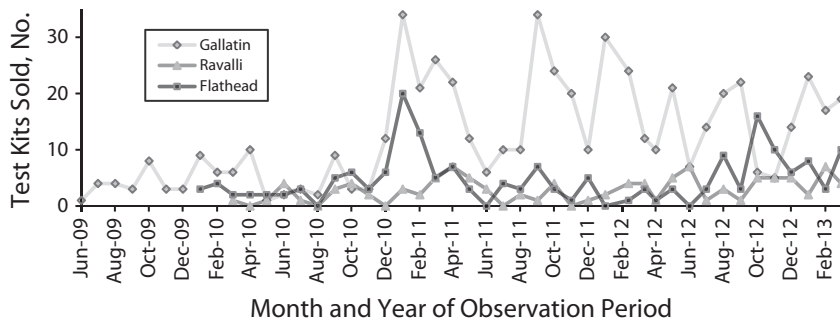
RESULTS

Participants reported their racial and ethnic background as White ($n = 216$; 94.3%), Native American ($n = 1$; 0.4%), Hispanic ($n = 4$; 1.7%), and Asian or Pacific Islander ($n = 1$; 0.4%).



Note. The silent message (2:52 minutes) was displayed on a flat-panel monitor as part of a 10-minute message loop in the Women, Infant, and Children Clinic waiting room of the intervention county.

FIGURE 1—Screenshot of 1 frame of the radon intervention message displayed with digital signage technology: Montana Radon Study.



Note. Pre-intervention data collection began in Gallatin County February 1, 2009, in Ravalli County May 1, 2010, and in Flathead County April 5, 2011. The radon risk-communication message delivered via digital signage technology began in Gallatin County August 22, 2011. During a 13-month period ending September 30, 2012, Gallatin County was the intervention site, Flathead County was the experimental-control site, and Ravalli County was the standard-control site. Beginning October 1, 2012, the intervention was extended to Flathead County. Ravalli County continued as the control site for the 6-month crossover observation period. I conducted an independent-samples *t* test to evaluate program participation before and after the intervention in the 3 settings during the initial 13-month observation. The test was significant for the intervention county ($t_{38} = 3.74$; $P = .001$; 95% confidence interval [CI] = 4.8, 16.0) and was not significant in either the experimental control ($t_{31} = -1.8$; $P = .08$; 95% CI = -.31, 5.25) or the standard control ($t_{29} = -.30$; $P = .76$; 95% CI = -1.7, 1.3) counties. I conducted an independent-samples *t* test to evaluate program participation in Flathead County before and after the intervention crossed over. The test was significant for Flathead County ($t_{37} = 2.69$; $P = .011$; 95% CI = 1.2, 8.5) and was not significant at the standard control site ($t_{35} = 1.96$; $P = .06$; 95% CI = -0.72, 3.9).

FIGURE 2—Radon test kit sales as a measure of health department radon program participation in 3 Montana counties: Montana Radon Study, 2010–2013.

Participants reported having children aged 18 years or younger at home in less than half of the cases ($n = 94$; 41.8%). Between 72% and 90% of participants had an adult partner in the home depending on the phase of the study. Although partnership status dropped at a significant level in Ravalli County ($P = .047$), the mean number of adults in the home did not reflect a significant change. The frequency distribution of dependent children was 1 ($n = 32$; 14.2%), 2 ($n = 43$; 19.1%), 3 ($n = 13$; 5.8%), 4 ($n = 5$; 2.2%), and 6 ($n = 1$; 0.4%). Participants included current ($n = 12$; 5.6%) and former WIC clients ($n = 16$; 7.4%). Eleven (4.8%) participants reported never having heard about the health risks from radon. Participant characteristics are reported in Table 1.

The most significant finding of this study was the increase in radon test kit purchases in the intervention county (Figure 2). I conducted an independent-samples *t* test to evaluate program participation before and after the intervention in the 3 settings. The test was significant for the intervention county ($t_{38} = 3.74$; $P = .001$; 95% confidence interval [CI] = 4.8, 16.0) and was not significant in either the experimental control ($t_{31} = -1.8$; $P = .08$; 95%

CI = -0.31, 5.25) or the standard control ($t_{29} = 0.30$; $P = .76$; 95% CI = -1.7, 1.3) counties. I conducted an independent-samples *t* test to evaluate program participation in Flathead County before and after the intervention crossed over. The test was significant for Flathead County ($t_{37} = 2.69$; $P = .01$; 95% CI = 1.2, 8.5) and was not significant at the standard control site ($t_{35} = 1.96$; $P = .06$; 95% CI = -0.72, 3.9).

The most significant change in participant characteristics was the postintervention increase in first-time testers and families who rented their homes. I conducted a χ^2 ($P < .05$) analysis to evaluate the change in pre- and postintervention participants who stated that they had “never tested any home for radon before.” The test was significant for the intervention county alone ($\chi^2_{228,1} = 10.9$; $P = .001$; odds ratio [OR] = 2.46; 95% CI = 1.44, 4.23). Twenty-three of the 65 first-time testers in the intervention county (35.4%) learned about the radon program from the waiting room intervention. The χ^2 ($P < .05$) analysis was also significant for the change in participation by renters ($\chi^2_{227,1} = 4.3$; $P = .04$; OR = 0.49; 95% CI = 0.24, 1.02).

Participants recorded how they learned that test kits were available (Table 2). To assess intervention fidelity, I conducted a Kruskal–Wallis test to determine if participants cited learning about the program differently as a function of the intervention timeframe (pre–post). Results indicated a statistically significant difference in how people learned about the radon program as a function of the intervention in Gallatin County ($H_{162,4} = 25.9$; $P < .001$) and in Flathead County during crossover of the intervention ($H_{57,4} = 26.3$; $P < .001$). Posthoc comparisons of pre–post distributions by response category for “How did you learn that test kits were available here?” in Gallatin County were significant for “posters in other county buildings” ($t_{161,4} = 43.6$; SD = 13.2; $P = .001$), “newspaper, radio, and television” ($t_{161,4} = 46.6$; $P < .001$), and “word-of-mouth from friend, neighbor, relative, realtor, etc.” ($t_{161,4} = 35.8$; $P < .001$) compared with the reference method “radon message playing in the waiting room.” Posthoc comparisons of pre–cross distributions by response category for “How did you learn that test kits were available here?” in Flathead County were significant for “newspaper, radio, and television” ($t_{57,4} = 28.5$; $P < .001$) and “word-of-mouth from friend, neighbor, relative, realtor, etc.” ($t_{57,4} = 19.4$; $P < .001$) compared with “radon message playing in the waiting room.” In other words, an appreciable increase in radon program participation was explicitly attributed to the intervention in both the intervention and the crossover sites. No significant differences were found at either the experimental or standard control sites in how participants learned of the radon program before or after the intervention. Word of mouth ($n = 116$; 40.4%) was the most common source of information on the radon program in all 3 counties.

Radon concentrations (Gallatin: $n = 156$; mean = 5.94 picocuries per liter [pCi/L]; SD = 9.82; Flathead: $n = 15$; mean = 6.65 pCi/L; SD = 7.41; Ravalli: $n = 44$; mean = 7.25 pCi/L; SD = 10.88) did not differ between the pre–post groups at the intervention site ($F_{2,149} = 0.20$; $P > .05$), at the experimental control site ($F_{15,2} = 1.82$; $P > .05$), or the standard control site ($F_{2,48} = 0.02$; $P > .05$). The mean indoor radon concentration for all sites was 6.3 pCi/L ($n = 215$; SD = 9.8; range = 0–84.2).

TABLE 1—Comparison of Key Variables at the Intervention, Experimental Control, and Standard Control Sites: Montana Radon Study, 2010–2013

Participant Data	Gallatin (Intervention)		Flathead (Experimental Control)			Ravalli (Standard Control)	
	Pre (n = 130), No. (%) or Mean ±SD	Post (n = 99), No. (%) or Mean ±SD	Pre (n = 9), No. (%) or Mean ±SD	Post (n = 17), No. (%) or Mean ±SD	Cross (n = 31), No. (%) or Mean ±SD	Pre (n = 45), No. (%) or Mean ±SD	Post (n = 29), No. (%) or Mean ±SD
Female	63 (50.0)	60 (60.0)	5 (55.6)	8 (47.1)	17 (56.7)	27 (60.0)	19 (65.5)
Adult partner	100 (78.7)	75 (77.3)	7 (77.8)	13 (76.5)	24 (80.0)	38 (90.5)	21 (72.4)*
Own	113 (89.0)	79 (79.0)*	8 (88.9)	16 (94.1)	25 (80.6)	44 (97.8)	27 (93.1)
New testers	55 (43.0)	65 (65.0)**	4 (44.4)	13 (76.5)	24 (77.4)	35 (81.4)	22 (75.9)
WIC family	4 (6.06)	15 (15.1)	0 (0.0)	1 (5.9)	3 (10.0)	2 (4.5)	3 (10.3)
White	123 (96.1)	93 (96.9)	9 (100)	16 (94.1)	29 (93.5)	39 (90.7)	25 (89.3)
Age	50.1 ±14.5	49.2 ±14.8	56.9 ±19.0	55.0 ±16.1	53.52 ±16.9	55.6 ±12.4	54.5 ±14.9
Education	4.7 ±1.2	4.8 ±1.2	4.3 ±1.23	4.24 ±1.30	3.93 ±1.46	3.84 ±1.51	3.90 ±1.40
Income	6.0 ±2.8	6.0 ±2.9	6.56 ±3.13	6.13 ±3.20	5.08 ±2.71	5.67 ±2.9	5.77 ±3.0
Children aged < 18 years	0.72 ±1.10	0.93 ±1.2	0.11 ±0.33	0.53 ±0.94	0.60 ±0.89	0.59 ±1.0	0.62 ±1.0
Adults at home	1.94 ±0.60	1.90 ±0.48	1.78 ±0.44	2.06 ±0.56	2.17 ±0.83	2.18 ±0.69	1.93 ±0.59
Current smokers	0.07 ±0.32	0.15 ±0.65	0 ±0	0.18 ±0.53	0.13 ±0.43	0.38 ±0.73	0.11 ±0.42
Former smokers	0.35 ±0.63	0.30 ±0.57	0.22 ±0.44	0.65 ±0.99	0.53 ±0.82	0.40 ±0.70	0.52 ±0.87
Radon knowledge	0.90 ±0.08	0.90 ±0.08	0.91 ±0.07	0.83 ±0.15	0.86 ±0.07	0.89 ±0.07	0.89 ±0.10
Radon risk perception	1.08 ±0.86	1.10 ±1.05	0.84 ±1.00	1.09 ±0.97	1.11 ±1.03	1.21 ±0.86	1.06 ±0.76
Radon self-efficacy	80.9 ±14.8	80.4 ±15.7	86.2 ±9.90	87.8 ±10.9	80.4 ±16.4	86.3 ±11.1	80.5 ±15.3
Monthly radon program households	8.4 ±6.3	13.0 ±5.0*	2.3 ±2.1	1.6 ±2.0	7.3 ±3.7**	2.9 ±2.3	2.4 ±2.0
Monthly radon program kit sales	11.0 ±8.1	19.1 ±8.1*	4.6 ±4.6	3.0 ±2.7	8.8 ±4.4**	3.0 ±2.4	2.5 ±2.1

Note. WIC = Special Supplemental Nutrition Program for Women, Infants, and Children. Variable values reported as No. (%) were based on total original responses rather than imputed data. I applied Mann-Whitney U comparisons to test for significant (.05) differences between pre, post, and cross groups at Flathead County. I used χ^2 analyses to compare pre-post groups at Gallatin and Flathead counties. Gallatin County had significant increases in participants who were new testers ($\chi^2_{228,1} = 10.9$; $P = .001$; odds ratio [OR] = 2.46; 95% confidence interval [CI] = 1.44, 4.23) and renters ($\chi^2_{227,1} = 4.27$; $P = .039$; OR = 0.49; 95% CI = 0.24, 1.02). Monthly test kit sales increased with the intervention ($t_{38} = 2.94$; $P = .006$; 95% CI = 2.51, 13.6) as did participating households ($t_{37} = 2.31$; $P = .027$; 95% CI = 0.57, 8.66). The intervention crossed over to Flathead County on October 1, 2012. For t test comparisons in Flathead County, I combined the “pre” and “post” groups and compared them to the “crossover” as these groups represent pre- and postintervention phases for that site. The crossover of the intervention was also successful in Flathead County with increased monthly kit sales ($t_{37} = 2.69$; $P = .01$; 95% CI = 1.20, 8.47) and increased households participating ($t_{23} = 4.76$; $P < .001$; 95% CI = 3.10, 7.88). The sample size was $n = 360$. * $P < .05$; ** $P < .001$ (mean differences).

The average was greater than the 4 pCi/L action level at all sites in support of the Environmental Protection Agency (EPA) Zone 1 risk designation of the participating counties. The values here reflect the 65.6% ($n = 215$) of program participants who returned their test kits to the laboratory. Six additional test kits were returned but had been exposed longer than the 96-hour maximum and could not be analyzed.

Most radon program participants were neither current ($n = 291$; 91.2%) nor former smokers ($n = 235$; 72.3%). Households with current smokers ($n = 28$; 8.8%) reported 1 ($n = 15$), 2 ($n = 11$), 3 ($n = 1$), and 5 ($n = 1$) individuals who smoked in the home. Households with former smokers in the home ($n = 90$; 27.7%) likewise reported 1 ($n = 60$),

2 ($n = 28$), and 3 ($n = 2$) individuals who smoked formerly in the home.

I scored and standardized radon knowledge to a percentile. Mean knowledge scores for the 3 sites were (Gallatin: $n = 229$; mean = 89.8%; SD = 0.08; range = 52%–100%; Flathead: $n = 30$; mean = 85.1%; SD = 14.4%; range = 44%–96%; Ravalli: $n = 72$; mean = 89.3%; SD = 8.1%; range = 47%–100%). We assessed radon knowledge on 3 aspects of the construct definition with 4 agent-level questions, 6 health effects questions, and 9 risk-appraisal questions with average scores ($n = 333$) of 97.3% (SD = 8.8), 91.5% (SD = 20.3), and 78.2% (SD = 12.2%) in Gallatin, Flathead, and Ravalli, respectively. Analysis of these findings suggested the radon program participants had high levels of information

about radon as a carcinogen and lung cancer as the primary health effect but demonstrated less knowledge about actions to increase or decrease exposure to indoor radon. Participants were asked to identify whether an action would increase their family’s exposure to radon or not. Keeping doors and windows closed tightly (mean = 64.2%; SD = 48.0) and “Living or working near a uranium mine” (mean = 19.3%; SD = 39.5) were not identified correctly as often for increasing exposure as “Installing a radon-approved ventilation system” (mean = 97.9; SD = 14.4) was for decreasing exposure.

The scales for risk perception and self-efficacy were refinements of scales also used previously.^{6,27} In the reported study, the internal consistency reliability of the radon risk-perception

TABLE 2—Participant Responses to the Question, “How Did You Learn Radon Test Kits Were for Sale Here?” by Study Phase and County: Montana Radon Study, 2010–2013

Response Choice	Gallatin (n = 162)		Flathead (n = 57)			Ravalli (n = 68)		Total (n = 287), No. (%)
	Pre (n = 63), No. (%)	Post (n = 99), No. (%)	Pre (n = 9), No. (%)	Post (n = 17), No. (%)	Cross (n = 31), No. (%)	Pre (n = 41), No. (%)	Post (n = 27), No. (%)	
Radon message (DST)	0	30 (30.3)**	0	0	18 (56.2)**	0	0	48 (16.7)
Environmental services staff	6 (9.5)	10 (10.0)	2 (22.2)	2 (11.7)	5 (16.1)	7 (17.1)	3 (11.1)	35 (12.2)
Posters in other buildings	7 (11.1)	6 (6.1)*	0	1 (5.9)	1 (3.2)	17 (41.5)	10 (37.0)	42 (14.6)
Word of mouth	31 (49.2)	39 (39.4)	5 (55.5)	10 (58.8)	7 (22.6)**	11 (26.8)	13 (48.1)	116 (40.4)
Newspaper, radio, TV	19 (30.2)	14 (14.1)**	2 (22.2)	4 (23.5)	0 (0.0)**	6 (14.6)	1 (3.7)	46 (16.2)

Note. DST = digital signage technology. I performed a Kruskal–Wallis non-parametric analysis of independent samples to determine if participants learned about the radon program as a result of the intervention ($H_{162,4} = 25.9$; $P < .001$). I reported variable values as No. (%) based on total original responses rather than imputed data. I added the question “How did you learn” to the Gallatin survey in May 2010 to coincide with the start of baseline data collection in Ravalli County so the number of Gallatin “pre” responses is less than that for other variables where data collection began in February 2009. I performed an additional Kruskal–Wallis test to determine if the significant findings for this question in Gallatin County were duplicated in Flathead County. The result indicated a significant finding in Flathead County as well ($H_{57,4} = 26.3$; $P < .001$). The sample size was $n = 287$.

* $P < .05$; ** $P < .001$ (differences from Kruskal–Wallis post-hoc comparisons indicating a change before and after the intervention on how participants learned of the radon program compared to the radon message).

scale ($n = 311$; $\alpha = 0.81$) was similar to coefficients reported in other studies.⁶ Respondents ranked their perception of radon risk on 8 statements by using a 7-point scale ranging from strongly disagree (−3) to strongly agree (+3). Lower numbers indicated a lower perception of risk from radon. Radon risk-perception scores (Gallatin: $n = 229$; mean = 1.1; SD = 0.94; Flathead: $n = 30$; mean = 1.07; SD = 1.25; Ravalli: $n = 72$; mean = 1.10; SD = 0.86) were reported in the full range with the scale averages indicating participants “slightly agreed” with the risk statements. Participants ($n = 333$) indicated the highest level of agreement with the statement, “Because of risks from radon, landlords should provide documentation of safe radon levels for their renters” (mean = 1.93; SD = 1.2). Participants indicated the lowest level of agreement with the risk statement, “Radon risks are serious enough that windows should be cracked in the winter to improve ventilation” (mean = 0.32; SD = 1.54). Participants slightly agreed that children’s playtime in the basement should be limited (mean = 0.68; SD = 1.47) or that children should not sleep in basements to avoid radon exposure (mean = 0.65; SD = 1.50)—both low-cost solutions to reducing radon risk to children.

Participants indicated their radon self-efficacy on a 0-to-100 confidence scale (low to high). In the reported study, the internal consistency reliability of the self-efficacy scale ($n = 309$; $\alpha = 0.71$) was similar to coefficients reported in other studies.^{6,27,29} Radon self-efficacy

scores (Gallatin: $n = 229$; mean = 80.6; SD = 15.1; Flathead: $n = 30$; mean = 84.4; SD = 14.1; Ravalli: $n = 72$; mean = 83.8; SD = 13.4) were reported in the full range with scale averages indicating participants were generally confident in their ability to protect themselves and their families from radon gas. Participants reported the highest degree of self-confidence to the question, “How confident are you that you can properly perform the radon test you have just purchased” (mean = 94.5; SD = 11.8) and the least to “Identify potential health effects to children caused by exposure to radon” (mean = 63.7; SD = 33.9) and “Identify structural characteristics of your home that put you at risk for radon exposure” (mean = 71.5; SD = 29.9).

DISCUSSION

The major finding of this study was that monthly radon program participation increased by more than 50% at the intervention site without placing additional demands on the patient–provider interaction. This increase occurred during a time when monthly program participation declined at both control sites despite the use of a small financial incentive at all sites. Participation by renters and first-time testers improved significantly with a positive trend for reaching WIC families.

Participants in the intervention county learned of the radon program from the DST radon message in one third of the cases; second

only to word of mouth. Marketing researchers have reported that word-of-mouth communication can measure the “downstream impact” of a marketing campaign and suggested that a multimedia approach is the best way to reach a broader audience as people tend to respond to one method over another.³⁰ Message recall and effective risk communication are enhanced with multimedia approaches.^{31,32} An expected outcome of including more first-time testers in the county radon program is that the proportion of completed test kits decreased to 64.6% during the study period. The rate of tests performed incorrectly also increased. Although this implies the need for more instruction and follow-up from public health professionals, it is clear from the data on word-of-mouth communication that news of the program will be diffused through a broader cross-section of the community. Completed testing and correct testing are measures for assessment and a follow-up intervention.

The radon programs overwhelmingly served a White, nonsmoking, well-educated, middle-class, and partnered cohort who were mostly finished raising families. Nissen et al.³³ reported similar demographics for radon testers in their intervention study. In the era of addressing health disparities through tailored messages to high-risk groups, analysis of our results call into question issues of cost-effectiveness and equity in the radon programs as they currently serve a relatively low-risk group.

Stakeholders from the MRS along with specialists in the Montana Tobacco Use Prevention Program and radon program coordinators from the Montana Department of Environmental Quality convened to consider these results. Because 85% of radon-induced lung cancers occur in current or former smokers,^{28,34} research teams have^{33,35} recommended that radon communications be tailored for and delivered to current and former smokers to yield the greatest benefit in the most efficient manner. The Canadian campaign, “Another Reason to Quit”³⁶ and the work of Lichtenstein et al.³⁷ are examples of this focused strategy demonstrating in both cases that radon risk is useful in promoting household smoking bans. We are currently integrating a radon testing opportunity into the state-sponsored cessation program as a pilot program. The aim is to measure participation and the rate of completed testing in a sample of Montanans who have voluntarily initiated a smoking cessation attempt.

Although program participation increased, analysis of the data revealed a lack of sensitivity across the dependent variables of radon knowledge, risk perception, and self-efficacy scores to the educational elements of the intervention message. All 3 are cognitive variables important in adopting behavior change.³⁸ The consistently high scores on these variables supported the tenets of the Precaution Adoption Process Model that individuals must progress through knowing about the agent, perceiving risk, and having confidence in their ability to perform the adopted behavior before adopting the behavior. In a 2012 study by Nissen et al.,³³ the participants reported that not knowing how to perform their radon test was a significant barrier to radon testing. From the analysis of the radon knowledge items in the MRS, it seems clear that radon program participants have adequate agent-level and health effects information, but had far less knowledge about lower-cost or alternative methods for reducing exposure.³⁹ Findings from both of these studies suggest that the “how to” components of any education campaign cannot be omitted.

At the conclusion of the MRS, both the intervention county and the experimental control county elected to continue using DST to promote public health. Gallatin County has

added emergency preparedness and cancer control messaging to its content loop and Flathead County expanded its use of DST to include an additional monitor in its federally qualified health center waiting area. In that setting, DST is a way to notify clients of age- and gender-based preventive care recommendations required by the National Committee for Quality Assurance for recognition of the federally qualified health center as a patient-centered medical home.⁴⁰

Limitations

A threat to the internal validity of DST as an intervention modality is the uncertainty surrounding dose. In a report on uptake of auditory and visual DST messages, Good-Health TV was watched by 79% of waiting room clients in Indian Health Service Clinics.²² Although this is similar to the 71.5% observation rate made of WIC clients in this study, the number of cases I observed was very small ($n = 14$). Waiting room clients as an aggregate may be watching their children, reading other materials, using mobile devices, or may be too anxious about the medical environment to engage with the televised messages resulting in an audience that is not universally exposed.

A second threat to internal validity in a prospective study is that current events will influence the behavior of participants and obscure the effect of the independent variable. The MRS captured an example of this “history bias” during baseline data collection in the fall of 2010 and winter of 2011. Note in Figure 2 the significant decrease in pre- and post-intervention participants who identified television, radio, and newspapers as their source of referral to the radon program. The Dr. Oz Show and the Montana CBS News recognized “Radon Awareness Month” in January 2012⁴¹ and “Radon Awareness Week” in October 2011.⁴² News in both print⁴³ and broadcast media are likely explanations for the atypical peaks in preintervention program participation (Figure 2). The positive impact of these news events corroborated the findings of other researchers who recommended a multimedia approach in promoting behavior change.^{7,32} In the case of radon awareness and testing, the EPA⁴⁴ may be the best resource for public service announcements for all media outlets.

Conclusions

I used a community-based trial to compare the influence of social marketing for increasing radon testing among priority groups in a high-radon-potential state. Radon concentrations reported as part of this study supported the EPA designation of the 3 participating counties as high-radon geographic areas. The intervention was associated with increased test kit sales and numbers of participants in the intervention and crossover counties with increased participation by first-time testers and renters in the intervention county. The intervention was not associated with increased outreach to the highest risk groups—smokers and nonsmokers. Digital signage technology was effective for delivering environmental health information and changing behavior in waiting room participants. This modality has potential for being a valuable health promotion tool with the capacity to display a variety of messages to priority subgroups within the viewing audience. Digital signage technology is a contemporary approach to achieving health promotion and disease prevention goals—the cornerstones of public health. ■

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Human Participant Protection

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References

1. Environmental Protection Agency. Radon: the health hazard with a simple solution. 2013. Available at: <http://www.epa.gov/radon/index.html>. Accessed December 6, 2013.

2. Environmental Protection Agency. Radon causes 100 times more deaths than carbon monoxide poisoning. 2008. 2013. Available at: <http://yosemite.epa.gov/opa/admpress.nsf/b1ab9f485b098972852562e7004dc686/16f240cc3212ef2e852573cc00552cfb!OpenDocument>. Accessed February 14, 2014.
3. Environmental Protection Agency. Protecting people and families from radon: a federal action plan for saving lives. 2011. Available at: http://www.epa.gov/radon/pdfs/Federal_Radon_Action_Plan.pdf. Accessed December 6, 2013.
4. Hancock T. Indicators of environmental health in the urban setting. *Can J Public Health*. 2002;93(suppl 1):S45–S51.
5. Environmental Protection Agency. EPA map of radon zones. 2013. Available at: <http://www.epa.gov/radon/zonemap.html>. Accessed December 6, 2013.
6. Larsson LS, Butterfield P, Hill WG, Houck G, Messecar DC, Cudney S. Radon testing for low-income Montana families. Proceedings of the 2011 International AARST Symposium. Available at: http://www.aarst.org/proceedings/2011/RADON_TESTING_FOR_LOW-INCOME_MONTANA_FAMILIES.pdf. Accessed February 14, 2014.
7. Flowers P, McDaid LM, Knussen C. Exposure and impact of a mass media campaign targeting sexual health amongst Scottish men who have sex with men: an outcome evaluation. *BMC Public Health*. 2013;13(1):737.
8. Wei C, Herrick A, Raymond HF, Anglemeyer A, Gerbase A, Noar SM. Social marketing interventions to increase HIV/STI testing uptake among men who have sex with men and male-to-female transgender women. *Cochrane Database Syst Rev*. 2011;(9):CD009337.
9. Evers U, Jones S, Iverson D, Caputi P. “Get Your Life Back”: process and impact evaluation of an asthma social marketing campaign targeting older adults. *BMC Public Health*. 2013;13(1):759.
10. Havas S, Anliker J, Damron D, Langenberg P, Ballesteros M, Feldman R. Final results of the Maryland WIC 5-a-Day Promotion Program. *Am J Public Health*. 1998;88(8):1161–1167.
11. Montana Department of Public Health and Human Services. Montana WIC Program Participation Report May 2013. 2013. Available at: <http://www.dphhs.mt.gov/wic/newsletters/2013/documents/N-06-24-13June12May13.pdf>. Accessed December 6, 2013.
12. Loeb R. Right message at the right time: digital signage delivers information hospitals and patients want. *Mark Health Serv*. 2008;28(4):10–14.
13. Weaver NL, Brixey SN, Williams J, Nansel TR. Promoting correct car seat use in parents of young children: challenges, recommendations, and implications for health communication. *Health Promot Pract*. 2013;14(2):301–307.
14. Stansbury M. Electronic displays a sign of the times. *eSchool News: Technology News for Today's K-20 Educator*. 2008.
15. Weinstein ND, Lyon JE, Sandman PM, Cuite CL. Experimental evidence for stages of health behavior change: the precaution adoption process model applied to home radon testing. *Health Psychol*. 1998;17(5):445–453.
16. Slovic P, Finucane ML, Peters E, MacGregor DG. Risk as analysis and risk as feelings: some thoughts about affect, reason, risk, and rationality. *Risk Anal*. 2004;24(2):311–322.
17. Gainforth HL, Cao W, Latimer-Cheung AE. Message framing and parents' intentions to have their children vaccinated against HPV. *Public Health Nurs*. 2012;29(6):542–552.
18. Andreasen A. *Marketing Social Change: Changing Behavior to Promote Health, Social Development, and the Environment*. San Francisco, CA: Jossey-Bass; 1995.
19. Kennedy MG, Crosby RA. Prevention marketing: an emerging integrated framework. In: Diclemente RJ, Crosby RA, Kegler MC, eds. *Emerging Theories in Health Promotion Practice and Research: Strategies for Improving Public Health*. San Francisco, CA: Jossey-Bass; 2002: 255–284.
20. Akl EA, Oxman AD, Herrin J, et al. Framing of health information messages. *Cochrane Database Syst Rev*. 2011;(12):CD006777.
21. McDermott RJ. Social marketing: a tool for health education. *Am J Health Behav*. 2000;24(1):6–10.
22. Abe S, Gray J, Dy SK, Trottier J, Meggerud T. *GoodHealth TV as a Tool for Health Education*. Paper presented at: Native American Research Centers for Health; November 13, 2008; Bethesda, MD.
23. Institute of Medicine. *Health Literacy, eHealth, and Communication: Putting the Consumer First*. Washington, DC: National Academies Press; 2009.
24. Sprague D, LaVallie DL, Wolf FM, Jacobsen C, Sayson K, Buchwald D. Influence of graphic format on comprehension of risk information among American Indians. *Med Decis Making*. 2011;31(3):437–443.
25. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. *Psychol Rev*. 1977;84(2):191–215.
26. Weinstein ND, Sandman PM. The precaution adoption process model and its application. In: Diclemente RJ, Crosby RA, Kegler MC, eds. *Emerging Theories in Health Promotion Practice and Research: Strategies for Improving Public Health*. San Francisco, CA: Jossey-Bass; 2002:16–39.
27. Hill WG. *Development and Early Evaluation of the Self-Efficacy for Environmental Risk Reduction Instrument*. Paper presented at: Meeting of the American Public Health Association; November 4–8, 2006; Boston, MA.
28. Environmental Protection Agency. A citizen's guide to radon: the guide to protecting yourself and your family from radon. 2012. Available at: <http://www.epa.gov/radon/pubs/citguide.html#overview>. Accessed December 6, 2013.
29. Butterfield PG, Hill W, Postma J, Butterfield PW, Odom-Maryon T. Effectiveness of a household environmental health intervention delivered by rural public health nurses. *Am J Public Health*. 2011;101(suppl 1):S262–S270.
30. Gombeski W Jr, Britt J, Wray T, Taylor J, Adkins W, Riggs K. Spread the word. Word of mouth is a powerful, but often undervalued, marketing strategy—here's how to harness it. *Mark Health Serv*. 2011;31(1):22–25.
31. Viswanath K, Randolph Steele W, Finnegan JR Jr. Social capital and health: civic engagement, community size, and recall of health messages. *Am J Public Health*. 2006;96(8):1456–1461.
32. Fitzpatrick-Lewis D, Yost J, Ciliska D, Krishnaratne S. Communication about environmental health risks: a systematic review. *Environ Health*. 2010;9(67):2–15.
33. Nissen MJ, Leach JW, Nissen JA, Swenson KK, Kehn H. Radon testing and mitigation: an intervention in a primary care setting. *J Cancer Educ*. 2012;27(3):566–572.
34. Centers for Disease Control and Prevention. Radon testing in households with a residential smoker—United States, 1993–1994. *MMWR Morb Mortal Wkly Rep*. 1999;48(31):683–686.
35. Lantz PM, Mendez D, Philbert MA. Radon, smoking, and lung cancer: the need to refocus radon control policy. *Am J Public Health*. 2013;103(3):443–447.
36. Health Canada. Radon—another reason to quit. Available at: http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/radon_smokers-fumeurs/index-eng.php. Accessed December 6, 2014.
37. Lichtenstein E, Boles SM, Lee ME, Hampson SE, Glasgow RE, Fellows J. Using radon risk to motivate smoking reduction II: randomized evaluation of brief telephone counseling and a targeted video. *Health Educ Res*. 2008;23(2):191–201.
38. Weinstein ND, Rothman AJ, Sutton SR. Stage theories of health behavior: conceptual and methodological issues. *Health Psychol*. 1998;17(3):290–299.
39. Larsson LS. Risk-reduction strategies to expand radon care planning with vulnerable groups. *Public Health Nurs*. 2014; Epub ahead of print.
40. Health Resources Services Administration. FY 2012 supplemental funding for quality improvement in health centers. 2013. Available at: <http://www.hrsa.gov/grants/apply/assistance/pcmh/pcmhsupplementalfunding.pdf>. Accessed September 13, 2013.
41. Sanitarian. Bozeman area ranks in highest class for radon content. Montana CBS News. January 4, 2011.
42. Radon Awareness Week: People urged to check their homes for this gas. Montana CBS News. October 12, 2011.
43. Schontzler G. MSU nursing professor wins \$350,000 to fight deadly radon. *Bozeman Daily Chronicle*. September 12, 2010.
44. Environmental Protection Agency. EPAs indoor environments media campaigns: Green Sox. 2012. Available at: <http://www.epapsa.com/campaigns/greensox>. Accessed December 6, 2013.