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Knowledge and social engagement change in intention to be screened for colorectal cancer

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Abstract

Objective—Innovative technologies have been used to promote colorectal cancer (CRC) screening among the underserved. However, the impact of these innovative technologies on knowledge and social engagement likelihood as they relate to subsequent intention to be screened across different populations has not been fully explored.

Design—Using a pre-post test design with an inflatable walk-through colon, we assessed changes in knowledge and social engagement likelihood across populations and their associations with intention to be screened in two community settings. One was a community setting in Washington State (WA); the other, a college campus in New Mexico (NM). Differential effects on knowledge and social engagement likelihood were examined across demographic groups (race/ethnicity, gender, age, education, insurance status, and geographic region). Finally, we assessed if changes in knowledge and social engagement likelihood was associated with CRC screening intention.

Results—NM males had greater gains in CRC knowledge than NM females; in WA, Hispanics, younger, less educated, and uninsured participants had greater gains in knowledge. NM females and younger WA participants were more likely to discuss CRC with their social networks than NM males and older WA participants. In WA, Hispanics and older adults reported greater intention to be screened for CRC. Change in social engagement likelihood, but not knowledge, was associated with intention to be screened.

Conclusions—The effectiveness of health promotion technologies on knowledge and social engagement may vary across different demographic characteristics. Further, the importance of social engagement likelihood in interacting with intention to be screened was substantiated.

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Keywords

colorectal cancer; CRC screening; innovative intervention; screening intention; Hispanics; American Indians/Alaska Natives

INTRODUCTION

Colorectal cancer (CRC) is the third most common cause of cancer incidence and mortality among men and women in the United States.(American Cancer Society 2014) To reduce this burden, the United States Preventive Services Task Force (USPSTF) recommends screening for CRC using fecal occult blood testing or fecal immunochemical testing, sigmoidoscopy or colonoscopy in adults beginning at age 50 and continuing until age 75.(U.S. Preventive Services Task Force 2008) Regular screening with any of the recommended methods can reduce CRC incidence and mortality.(Hamza et al. 2014, Schoen et al. 2012, Zauber et al. 2008, Zauber et al. 2012, Maciosek et al. 2006, Yang et al. 2014) Increasing the proportion of adults who receive a CRC screening is considered a high health priority and has been designated as a leading health indicator objective in *Healthy People 2020*.(Koh 2010)

Over the last decade, CRC incidence and mortality rates have been decreasing, which has been attributed to increases in CRC screening. (Edwards et al. 2010) Nevertheless, disparities exist in CRC knowledge, screening, and burden across different social identities, including race/ethnicity, gender, age, socioeconomic status, and geographic regions in the US.(American Cancer Society 2012, 2014, Joseph et al. 2012, Carney et al. 2012) In general, having access to healthcare does not ensure CRC screening; people need to be engaged by their healthcare providers or others to learn about screening.(Holden et al. 2010) More specifically, minority individuals, who have lower socioeconomic status and lack health insurance, are less likely to obtain CRC screening as recommended.(McAlearney et al. 2008, Ayanian 2010, Andaya et al. 2013) For example, National Center for Health Statistics data show that among adults aged 50 and older in the US, American Indians/Alaska Natives (AI/AN) and Hispanics have lower screening rates by either fecal occult blood test (FOBT) or endoscopy (48.1% and 47% respectively) compared to non-Hispanic whites (NHWs) (61.5%).(American Cancer Society 2014)

Behavioral Risk Factor Surveillance Survey (BRFSS) data between 2006–2008 indicates that among adults aged 50 years and older, Hispanics in Washington State (WA) were less likely to have received CRC screening (50.1%) compared to NHWs (65.9%).(American Cancer Society 2011) Additionally, in WA, AI/AN and Hispanics ages 18 and older are more likely than NHWs to: not have health insurance (33% and 45% respectively compared to 19%), have educational attainment less than high school (16% and 39% respectively compared to 10%), have income below the federal poverty level (26% and 28% respectively compared to 13%) and have no medical care due to cost (18% and 27% respectively compared to 16%) (WADOH 2015); WA residents with these socio-demographic indicators were less likely to meet CRC screening recommendations.(Butler 2013) In New Mexico (NM), the population living in the US-Mexico border, a region composed of primarily underserved Hispanic populations, CRC screening rates are as low as 21% among Hispanics

compared to 45% for NHWs.(Sanchez et al. 2013) For the AI/AN population in the state, a significantly lower percentage of AI adults in NM between the ages of 50 and 75 reported being up-to-date with CRC screening recommendations (36%) compared to NHWs (63.5%). (NMDOH 2014) Studies recommend engaging disparate populations in culturally appropriate education in community and healthcare settings to increase awareness of and participation in CRC screening within these diverse underserved groups.(Daley et al. 2012, Filippi et al. 2013, James et al. 2013, Wang et al. 2013)

The effective use of communication by public health professionals and the health care industry can help build health knowledge and skills to increase usage of preventive services, knowledge about disease management, and improved health outcomes.(HP2020HP2010) Unfortunately, such messages are often phrased at high literacy levels. Because half of the US population reads at the 9th grade level or lower, such messages may not be accessible to everyone.(Doak, Doak, and Root 1996) In addition to literacy barriers, such formats may also be helpful for reducing other independent and interdependent barriers to health (e.g., socioeconomic disadvantage; language access). Further, those who are functionally illiterate are more likely to belong to the vulnerable groups described above (e.g., racial/ethnic minorities, less educated, uninsured).(Davis et al. 2001, Davis et al. 2002) For those with limited literacy, alternative formats for health information, such as pictures, videos, and interactive exhibits may facilitate the dissemination of health information and increase understanding of health messages.(Houts et al. 2006, Kountz 2009)

One innovative approach to increasing CRC screening with such an alternative format is the inflatable colon, a walk-through model of a human colon complete with simulated polyps and cancers. This interactive and visual education tool has been evaluated in Alaska (Redwood et al. 2013), NM (Sanchez et al. 2014), and WA States (Briant et al. 2014). These studies demonstrated the inflatable colon to be an innovative way to attract and educate individuals, including vulnerable groups, on CRC risk factors, disease progression and screening.

The relative efficacy of inflatable colon education interventions across different sites however has not been explored. Such research is warranted, given the interest in replicating cancer equity interventions across different geographic contexts (Erwin et al. 2003), the ongoing process of translating cancer equity interventions into programs in other areas (Glasgow et al. 2004), as well as funders' increasing calls for partnerships that enable cross-geographical projects within and across different regions such as the National Cancer Institute's (NCI) Geographic Management Program (Robinett, Harbach, and Vogel 2014, Wells et al. 2014) and the National Institutes of Health Centers for Population Health and Health Disparities Program (Cooper et al. 2015).

These studies have also not compared the effectiveness of the intervention across different demographic groups. Such exploration is necessary to estimate the potential for this type of intervention to reduce cancer health disparities. For example, it may be that more advantaged groups have smaller intervention-based gains in knowledge because they possess greater knowledge at baseline due to greater access to information. Less advantaged groups may not be privy to such information. In this case, interventions such as the inflatable colon

may be particularly helpful for ‘closing the gap’ on modifiable determinants of cancer disparities.

Another gap in the literature concerns the impact of interventions on participants’ engagement of their social networks. Indeed, interventions such as the inflatable colon that utilize such diverse, innovative approaches may have a larger community-wide impact than standard interventions, as individuals may be more likely to engage their social networks. This increased engagement may have important impacts at the community level, as advice from family members or friends, can serve as a facilitator to cancer screening. Although a number of innovative interventions have attempted to influence screening intentions and practices through educational strategies and increases in knowledge (Basch et al. 2015, Percac-Lima et al. 2009, Shankaran et al. 2007), little is known about the consequences of such engagement for an individual’s own CRC screening practices. The one previous study to examine this relationship found that participants’ motivation to engage their networks has been tied to increased screening intention, suggesting changes in social engagement may lead to individual and community level behavior change.(Scheel et al. 2015) More work however is needed to confirm this relationship, especially research that includes other predictors of screening intention, such as sociodemographic factors and changes in knowledge.

To address these gaps in the literature, we relied on the rich data available through a decade-long partnership between Fred Hutchinson Cancer Research Center (FHCRC), an NCI-designated comprehensive cancer center, and New Mexico State University (NMSU), a minority serving institution. Through an NCI-funded U54 partnership between a cancer center (FHCRC) and a minority-serving institution (NMSU), there have been successful efforts to develop, implement, and evaluate cancer outreach programs in underserved communities across regions. In a recent outreach collaboration, each site employed the use of a walk-through inflatable colon, complete with simulated healthy colon tissue, polyps, malignant polyps, and advanced CRC, as a tool to provide CRC information and education to their local populations in the states of WA and NM. Both FHCRC and NMSU used pre/post intervention study design to measure change in knowledge and intention to be screened. (Briant et al. 2014, Sanchez et al. 2014)

The purpose of this study is to compare the effectiveness of the inflatable colon as a CRC educational tool across diverse distinct populations. First, the study adds to the literature by examining how changes in knowledge and social engagement likelihood vary across race/ethnicity (non-Hispanic Whites, Hispanics, AI/AN), gender (women, men), age (<50, 50+), and socioeconomic status (education, insurance status) across two geographically distinct regions (WA and NM). Second, we assess if post-intervention intention to obtain screening varies by socio-demographic factors, changes in knowledge, and changes in social engagement likelihood.

METHODS

Setting

In WA, FHCRC staff displayed the inflatable colon at 47 community events, including health fairs and tribal gatherings, throughout communities in three rural counties in the eastern part of the state between March 1 and October 13, 2012. Individuals who attended these events were invited to participate in the study. Many of the towns in these counties are majority-minority (Hispanic) and overall the area is 67% Hispanic.(U.S. Census Bureau 2014) There is also a federally recognized tribal reservation, the Confederated Tribes of the Yakama Nation, in the area.

In NM, NMSU faculty, staff and students were invited to participate at events at various locations on the NMSU campus during five days in March 2012 (Colorectal Cancer Awareness Month). The NMSU main campus in Las Cruces enrolls over 18,500 students of whom 50% self-report as minority (3% African American, 2% Native American, and 49% Hispanic). This ethnic distribution of the NMSU student population is similar to the population in NM as a whole.(New Mexico State University 2013)

Inflatable colon

The inflatable colon is an innovative, visual, and interactive walk-through replica of the human colon, approximately 20 feet long, 12 feet wide, and 10 feet high. The colon depicts four stages of CRC and includes normal tissue, polyps, malignant polyps, colorectal cancer and advanced CRC. Display signs inside the colon explain the progression of CRC from normal tissue to advanced stage CRC. A tour through the inflatable colon provides individuals with information about risk factors for CRC and recommended lifestyle changes to prevent and reduce CRC risk, highlighting the importance of age-appropriate CRC screening in order to detect polyps and CRC at its earliest stages when it is most treatable. Both sites, FHCRC and NMSU, acquired an inflatable colon. Signs describing the colon tissue, CRC stages and progression and recommended screening tests were created and displayed inside the colon in English and Spanish. Health educators leading the tours were bilingual in English and Spanish.

Study Measures

A pre- and post-test intervention study design was utilized to measure participants' awareness and knowledge of CRC and CRC screening, intention to get CRC screening, and likelihood to discuss CRC with others (social engagement) before and after walking through the inflatable colon. CRC awareness and knowledge items consisted of 'yes' or 'no' responses. The pre-test asked about past screening behavior, demographic variables (gender, age, education, race/ethnicity), and whether they had health insurance. (Table 1). The specific questions in the pre-/post-tests are available in a previous publication.(Sanchez et al. 2014)

CRC knowledge was assessed by a scale with five items, where respondents were asked if they knew what a colon polyp was, what CRC was, what a cancer screening test was, what the different types of CRC screening tests were, and whether patients could survive CRC if

it was found early and removed (For both sites: 0 = No, 1 = Yes). Reliability for these binary items among these samples was adequate for pre- and post-survey responses as determined by the Kuder-Richardson 20 formula (0.69–0.87). Participants were included if they completed at least 80% of items for both pre- and post-tests. Items were then summed, resulting in an actual range of 0–5 for pre-test and post-test scores. We then created a change variable to assess the magnitude of pre-post change in knowledge through the difference of post- and pre-test scores (Actual Range: –5 to 5).

Social engagement likelihood was measured by an index with six items, wherein participants were asked about likelihood to discuss CRC with others (parents, grandparents, relatives, peers, community members, and individuals at risk). The two sites used different response categories: NMSU used a 5-point (1 = Very Unlikely, 2 = Somewhat Unlikely, 3 = Neutral, 4 = Somewhat Likely, 5 = Very Likely), whereas FHCRC used a 3-point Likert scale (1 = Not Likely, 2 = Somewhat Likely, 3 = Likely). Following preliminary review of frequency distributions, we collapsed categories across sites to a 3-point Likert scale. Participants were included if they completed at least 80% of items for both pre- and post-tests. Items were then summed, resulting in an actual range of 6–18 for pre-test and post-test scores. We subsequently created a change variable to assess the magnitude of pre-post change in social engagement likelihood through the difference of post- and pre-test scores (Actual Range: –12 to 12).

For post-intervention CRC screening intention, similar to social engagement likelihood, NMSU and FHCRC used respectively 5-point (1 = Very Unlikely, 2 = Somewhat Unlikely, 3 = Neutral, 4 = Somewhat Likely, 5 = Very Likely) and 3-point Likert scales (1 = Not Likely, 2 = Neutral, 3 = Likely). Given preliminary distribution of the data, we collapsed categories, such that 0 = Less/Equally Likely and 1 = More Likely.

Analysis

Analyses were performed using IBM SPSS 19.0. First, we examined geographic differences in individual-level demographics. If there were significant findings, we stratified subsequent analyses.

Our first objective was to examine how changes in knowledge and social engagement likelihood vary across race/ethnicity (non-Hispanic Whites, Hispanics, AI/AN), gender (women, men), age (<50, 50+), and socioeconomic status (education, insurance status). We used Generalized Estimating Equations (GEE) models to assess outcomes separately. For each analysis, we included the pre-test and post-test scores as outcome variables. Predictors included: time (pre- to post-test), socio-demographic variables (race/ethnicity, gender, education, age, insurance, geographic region), previous receipt of CRC screening, and interaction terms of time x each socio-demographic variable (time x race/ethnicity, time x gender, time x education, time x age, time x insurance, time x geographic region). Interaction terms in this case represent differential intervention effects on knowledge and social engagement likelihood based on demographic characteristics. For example, a significant time x gender interaction for knowledge would indicate that the amount of knowledge gained from the intervention differed between male and female participants. To make final model decisions about variable distribution and correlation structure, we

examined the relative quasi-likelihood information criteria (QIC) model fit among GEE using varying assumptions.(Pan 2001) The best fitting models defined both knowledge and social engagement likelihood as having a gamma distribution and assumed an exchangeable correlation structure. Further, given potential ceiling effects, we also conducted logistic regressions with dichotomized change scores to confirm GEE models. Change scores were dichotomized based on 66/33 split of the continuous variables.

Our second objective was to examine if post-intervention intention to obtain screening varies by socio-demographic factors, previous receipt of CRC screening, changes in knowledge, and changes in social engagement likelihood. We conducted a multivariable logistic regression model. The outcome was the dichotomized post-intervention intention variable. Predictors included socio-demographic variables (race/ethnicity, gender, education, age, insurance, geographic region) and change variables (post-pre test scores for knowledge and social engagement likelihood).

RESULTS

Table 1 depicts study characteristics by study site and overall. All demographic characteristics varied significantly by study site ($p<.0001$). Relative to NM residents, WA residents were more likely to identify as Hispanic, female, 50+ years old, having less than a high school education, uninsured. They were also more likely to indicate they had obtained a CRC screening in their lifetime. Given these findings, subsequent analyses were stratified by geographic region.

Knowledge

Pre and post knowledge scores, unstandardized regression coefficients and 95% confidence intervals for interaction terms by geographic region are found in Table 2. Among NM participants, males had greater gains in knowledge from visiting the inflatable colon relative to females. Among WA residents, participants who were Hispanic, younger, less educated, and uninsured had greater gains in knowledge from visiting the inflatable colon when compared to participants who were NHW, older, more educated, and insured. We next conducted a multivariable logistic regression, wherein the outcome variable was time-based change in knowledge (-5 to 3 = no/less knowledge gained; $4-5$ = more knowledge gained). As revealed in Table 3, most findings were comparable to GEE models with two exceptions. First, among WA residents, AI/AN participants had greater odds of exhibiting more knowledge gained relative to NHW participants. Second, among WA residents, insurance status was not associated with gains in knowledge.

Social Engagement Likelihood

Pre and post social engagement likelihood scores as well as unstandardized regression coefficients and 95% confidence intervals for interaction terms by geographic region are found in Table 2. Among NM residents, female participants reported they were more likely to discuss CRC with more members of their social network after visiting the inflatable colon than male participants. Among WA residents, younger individuals reported they were more likely to discuss CRC with more members of their social network after visiting the inflatable

colon than were older participants. We next conducted a multivariable logistic regression, wherein the outcome variable was time-based change in social engagement likelihood (−12 to 1 = no/less engagement likelihood gained; 2–12 = more engagement likelihood). As revealed in Table 3, findings were comparable to GEE models.

Screening Intentions

Table 4, stratified by geographic region, examines the association between post-intervention screening intention by socio-demographic characteristics, and changes in knowledge and social engagement likelihood. Among WA participants, Hispanic and older participants exhibited greater odds of intending to obtain CRC screening in the future (post intervention). For both NM and WA participants, changes in social engagement likelihood, but not changes in knowledge, were associated with odds of intending to obtain CRC screening in the future.

DISCUSSION

We assessed the inflatable colon as an effective CRC educational tool across distinct underserved populations in two geographic regions (NM and WA), and specifically identified interactive effects with socio-demographic characteristics (race/ethnicity, gender, age, education, insurance status) using a pre-post intervention study design. Such information is relevant, given increasing interest in national and regional partnerships as well as efforts to adopt and replicate evidence-informed interventions across the nation. Importantly, we found that relative intervention efficacy varied by geographic region – this evidence aligns with a growing reliance on socio-ecological models and the importance of considering both individual- and contextual-level factors when designing cancer disparities interventions. Further, we examined the relative strengths of socio-demographic characteristics, changes in knowledge, and changes in social engagement likelihood on screening intention. This information is helpful in understanding the mechanisms by which individual-level interventions may result in increased screening for early cancer detection at individual and community levels.

Changes in knowledge varied by individual demographics – although, importantly, this differed by geographic region. Among NM participants, except for gender, there were largely no differences in knowledge change from pre to post. Among WA participants, there appeared to be greater changes in knowledge for those particularly affected by CRC; that is, racial/ethnic minorities and socioeconomically disadvantaged individuals (e.g., less educated). Differential effectiveness may be due to greater levels of knowledge at baseline for more advantaged groups and those less affected by CRC in WA. These differences at baseline may be due to a number of reasons, including health literacy and access to informational resources. Thus, the use of the inflatable colon can be seen as “leveling” the knowledge of CRC between under-represented individuals compared to individuals in the mainstream culture for certain geographic regions. Results also demonstrated that WA individuals who are younger are likely to benefit from CRC education through the inflatable colon. Perhaps, younger people in WA know less about CRC because screening for the general population does not start until age 50; thus, younger people are less likely to have been exposed to information about the disease during their interactions with others or the

healthcare system. This may not have occurred in NM due to limited statistical power, in that there were a small proportion of individuals who were aged 50 years or older. Exposing individuals <50 to CRC screening messages may play a role in increasing screening intention and participation at the recommended age. (Cooper, Gelb, and Hawkins 2014, Greaney et al. 2014)

There were also significant interactive effects on social engagement likelihood, which similarly varied by geographic region. Among NM respondents, female respondents indicated a stronger likelihood of engaging others in the future relative to male respondents. This result, in conjunction with our finding about change in knowledge, suggests the importance of future research to characterize gender differences in perspectives and experiences with CRC. Among WA respondents, younger people were more likely to note they would discuss CRC with others in the future than older people. Such findings may be due to the greater amounts of knowledge younger participants gained through the intervention.

Our preliminary study reinforces a high-impact approach to the evaluation of health equity programs that is based on traditional epidemiological techniques.(Woodward 2005) Notably, there are a few reasons why effect modification may have varied across different geographic regions. First, the NM sample may have been underpowered, especially in the case of educational attainment and age differences. Second, geographically distinct populations may experience differences in which certain segments of the population benefit from health promotion interventions more than others. For example, NM male respondents in particular, appeared to benefit from the inflatable colon tour relative to female counterparts; gender differences did not however exist among WA residents. Future research is warranted, especially statistically powered trials designed to assess interactive effects.

Indeed, findings from this study reinforce the need to assess effect modification as part of intervention evaluation and highlight the issue of generalizability when replicating interventions in different contexts or translating interventions into practice. Intervention efficacy may vary across sub-groups and this must be included in standard approaches to intervention evaluation, including programs that may be more generalizable, such as randomized trials that use population-based sampling strategies. Such an approach is important, given the growing interest in replicating interventions and translation of interventions into practice across different contexts and subpopulations.(Erwin et al. 2003, Glasgow et al. 2004, Cooper et al. 2015, Robinett, Harbach, and Vogel 2014) Further, our work provides an important model for national and regional partnerships, wherein protocols may be shared across different geographic regions as well as for different priority populations.

While our work provides worthwhile suggestions about intervention evaluation, there are important next steps that also need to be taken in future research. Specifically, our work provides a model to assess the role of specific socio-demographic characteristics on pre-post intervention effects; nonetheless, there may also be interdependent effects across multiple socio-demographic characteristics. For example, it may be the case that education was a mediator in the relationship of age and knowledge.

In terms of intention to be screened for CRC, socio-demographic differences were found among WA respondents. Specifically, Hispanic and older individuals indicated greater odds of obtaining CRC screening in the future relative to NHW and younger individuals. While the finding for Hispanic individuals aligns with our findings concerning differential gains in knowledge among WA respondents, there was not a significant association with knowledge gained and intention to obtain screening among WA and NM populations.

Nonetheless, the likelihood of social engagement was significantly related to the intention to be screened among both WA and NM populations. Lower levels of social influence are a factor associated with lack of CRC screening and adherence.(Shelton et al. 2011, Wang et al. 2013) In this study, odds of intending to obtain CRC screening were associated with differences in the likelihood of social engagement such that the more likely one was to engage in conversations about CRC, the more likely that s/he intended to be screened. This is similar to other recent work documenting changes in social engagement from an intervention as a facilitator for breast cancer screening intention.(Scheel et al. 2015) Perhaps, while thinking about expressing their own personal opinions about CRC and CRC screening, individuals believed they should “practice what they preach”. In addition, individuals who were more likely to discuss CRC with others may have had higher health literacy, which also could play a role in intention to screen.

This study thus offers important findings for future health education and health promotion. The inflatable colon may simultaneously lead to changes in the spread of CRC information across communities through increased social engagement likelihood at individual levels, and further, this type of engagement is strongly predictive of screening intention for those individuals. Such work can be considered in light of the beneficial effects of volunteerism and promotion for health in other contexts.(Ramirez-Valles and Brown 2003, Weitzman and Kawachi 2000) Increased social engagement may be a useful proxy for the salience and importance a person perceives CRC screening to be, which may consequently influence their motivation levels and intentions to obtain screening. Future work is warranted to further explore this relationship and identify underlying psychological mechanisms. Simultaneously, greater assessment of how social engagement leads to communitywide changes in CRC awareness is warranted through social network analysis and community scans.

Limitations

This study has some limitations. This was an observational study and was not designed as a randomized control trial, therefore it is subject to bias and does not control for confounding. CRC knowledge was promoted through convenience-based sampling in two different settings, a university in NM and rural communities in WA, which attributed to a higher percent of participants being younger than 50 years of age in the NM sample compared to the WA sample. Generalizability may thus be limited, especially with regard to our documented interaction effects. While a prior study has shown greater increases in CRC knowledge among participants who took part in an inflatable colon tour compared to participants who did not, (Briant et al. 2015) a randomized control trial with a control group would provide further insight as to whether it was the inflatable colon, or simply the provision of information that was associated with increased knowledge as well as intention

to discuss and intention to screen for CRC. Further, comparative effectiveness research approaches may be helpful to determine the additive value of the inflated colon relative to simpler, more traditional interventions.(Iglehart 2009)

The limited sample sizes prevented the use of more advanced modeling to control for confounding. We did not assess the potential of higher order interactive effects (e.g., 3- and 4-way interactions) that may be influencing knowledge, social engagement likelihood, and intention to be screened. Simultaneously, we did not assess potential confounding of socio-demographic factors on interactive effects. Pre-post changes in knowledge and social engagement may be affected by linear and non-linear confounding modification as well as double effect modification across various socio-demographic characteristics. Given our limited cell sizes across these variables, it is difficult to assess these different patterns. That said, it is important to examine confounding, mediation and double effect modification with different predictor variables to understand more comprehensively the nuanced interplay of different characteristics on intervention-based pre-post changes in knowledge and social engagement. More sophisticated multivariable modeling is warranted in future studies to understand more closely the complex interplay of these different demographic factors on intervention effectiveness and related changes in knowledge, social engagement, and screening.

Another limitation is that two variables were administered differently across sites; our reclassification scheme may have resulted in misclassification bias, which we were unable to determine. Although we captured information on intention/likelihood to obtain CRC screening and intention is necessary for behavior change, it is not sufficient. Questionnaires were anonymous and we were not able to follow-up to see if participants aged 50 and older who said they were likely to obtain CRC screening after touring the inflatable colon, actually followed up to do so.

CONCLUSIONS

The inflatable colon seems an effective educational tool developed to promote CRC knowledge among diverse populations. In WA, we found that Hispanics and AI/ANs had greater gains in CRC knowledge relative to NHW participants. Results also suggested that individuals who were younger, less educated, or uninsured were more likely to benefit from CRC education through the inflatable colon in WA. The inflatable colon also seems to function as an effective health communication tool for females in NM and younger adults in WA; in this study they were more likely to indicate greater intention to discuss CRC with members of their social network after visiting the inflatable colon. Screening intention was more likely to be associated with changes in social engagement rather than changes in knowledge from pre- to post-test. The inflatable colon may simultaneously lead to changes in the spread of CRC information across communities through increased social engagement at individual levels, and further, this type of engagement is strongly predictive of screening intention for those individuals. Future research could investigate the dissemination of CRC information via social networks after visiting the inflatable colon, as well as the association between intention to screen after walking through the inflatable colon, with actual screening.

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Table 1

Study Sample Characteristics (n = 1432)

Characteristic	Total N (%)	New Mexico State N (%)	Washington State N (%)	p-value
Race/Ethnicity [/]				<0.0001
NHW	267 (19)	151 (35)	116 (13)	
Hispanic	965 (67)	247 (58)	718 (79)	
AI/AN	103 (7)	30 (7)	73 (8)	
Gender				<0.0001
Female	1041 (73)	323 (67)	718 (77)	
Male	382 (27)	162 (33)	220 (23)	
Age				<0.0001
<50 years old	1089 (76)	478 (99)	611 (71)	
50+ years old	260 (18)	7 (1)	253 (29)	
Education				<0.0001
<HS/GED	446 (31)	6 (1)	440 (47)	
HS/GED or greater	965 (67)	466 (99)	499 (53)	
Insurance				
Uninsured	533 (37)	114 (24)	419 (45)	
Any	877 (61)	368 (76)	509 (55)	
Geographic region				--
New Mexico	485 (34)	--	--	
Washington State	947 (66)	--	--	
History of CRC Screening				<0.0001
No	1246 (88)	463 (96)	783 (84)	
Yes	166 (12)	20 (4)	146 (16)	

[/] NHW = Non-Hispanic White, AI/AN = American Indian/Alaska Native.

Table 2

Pre-Post-test scores in knowledge and social engagement likelihood by race/ethnicity, gender, age, education, and insurance status, stratified by geographic region.

	Knowledge											
	New Mexico State						Washington State					
	Pre ²		Post ²		Time*Demographic interaction ³		Pre ²		Post ²		Time*Demographic interaction ³	
	Mean	SE	Mean	SE	B (95% CI)	p-value	Mean	SE	Mean	SE	B (95% CI)	p-value
Race/Ethnicity ⁴												
NHW	2.16	0.41	5.06	0.03	REF	REF	2.66	0.13	4.58	0.08	REF	REF
Hispanic	1.89	0.35	4.97	0.02	0.02 (−0.18, 0.22)	0.86	1.95	0.06	4.34	0.06	0.23 (0.06, 0.39)	0.007
AI/AN	2.13	0.44	5.07	0.04	−0.10 (−0.30, 0.10)	0.32	2.09	0.16	4.51	0.10	−0.03 (−0.19, 0.13)	0.72
Gender												
Female	2.25	0.43	5.03	0.03	REF	REF	2.26	0.08	4.48	0.06	REF	REF
Male	1.88	0.36	5.04	0.03	0.18 (0.07, 0.30)	0.002	2.16	0.11	4.48	0.09	0.04 (−0.06, 0.15)	0.43
Age												
<50 years old	2.08	0.30	4.99	0.02	REF	REF	2.09	0.10	4.56	0.07	REF	REF
50+ years old	2.03	0.58	5.07	0.04	0.04 (−0.46, 0.54)	0.87	2.34	0.10	4.40	0.08	−0.15 (−0.25, −0.05)	0.002
Education												
<HS/GED	1.88	0.57	5.08	0.03	REF	REF	1.91	0.10	4.32	0.09	REF	REF
HS/GED or greater	2.24	0.29	4.99	0.02	−0.20 (−0.74, 0.35)	0.48	2.56	0.09	4.65	0.06	−0.22 (−0.33, −0.11)	<0.0001
Insurance												
Uninsured	2.05	0.39	5.05	0.03	REF	REF	2.04	0.09	4.45	0.08	REF	REF
Any	2.07	0.39	5.01	0.03	−0.02 (−0.13, 0.08)	0.77	4.51	0.07	4.38	4.65	−0.15 (−0.25, −0.05)	0.004
Social Engagement Likelihood ⁵												

Social Engagement Likelihood ⁵															
	Pre ²			Post ²			Time*Demographic interaction ³			Pre ²			Time*Demographic interaction ³		
	Mean	SE		Mean	SE		B	(95% CI)	p-value	Mean	SE		B	(95% CI)	p-value
NHW	9.89	1.33		12.96	1.77		REF		REF	9.70	0.37		11.84	0.39	REF
Hispanic	9.37	1.23		12.51	1.67		0.04 (-0.07, 0.14)		0.52	11.01	0.21		13.59	0.21	0.03 (-0.07, 0.13)
AI/AN	8.97	1.28		12.18	1.72		0.04 (-0.09, 0.12)		0.76	9.51	0.42		12.00	0.43	0.02 (-0.07, 0.11)
Gender															
Female	9.02	1.21		12.53	1.70		REF		REF	10.18	0.23		12.69	0.24	REF
Male	9.80	1.30		12.56	1.71		-0.08 (-0.02, -0.15)		0.02	9.92	0.31		12.22	0.31	-0.01 (-0.08, 0.05)
Age															
<50 years old	9.63	0.59		12.73	0.79		REF		REF	9.92	0.26		12.85	0.26	REF
50+years old	9.18	2.24		12.37	3.06		0.02 (-0.25, 0.29)		0.89	10.19	0.28		12.07	0.30	-0.09 (-0.16, -0.02)
Education															
<HS/GED	9.22	1.55		13.00	2.22		REF		REF	9.94	0.31		12.16	0.30	REF
HS/GED or greater	9.59	1.14		12.11	1.47		-0.11 (-0.32, 0.09)		0.29	10.17	0.23		12.75	0.25	0.03 (-0.04, 0.09)
Insurance															
Uninsured	9.33	1.26		12.63	1.73		REF		REF	9.87	0.28		12.25	0.30	REF
Any	9.48	1.27		12.46	1.68		-0.03 (-0.10, 0.04)		0.43	10.24	0.25		12.67	0.25	-0.003 (-0.06, 0.06)

¹ Range of knowledge scores was 0–5.

² Adjusted for other predictors.

³ Unstandardized regression coefficients, 95%CI confidence intervals, and p-values represent interaction terms from Generalized Estimating Equations (GEE) models.

⁴ NHW = Non-Hispanic White, AI/AN = American Indian/Alaska Native.

⁵ Range of social engagement scores was 4–18.

Table 3

Logistic regression models assessing changes in knowledge and social engagement by race/ethnicity, gender, age, education, and insurance (stratified by geographic region)

	Knowledge							
	New Mexico				Washington State			
	No/Less ¹ N (%)	More ¹ N (%)	OR (95%CI)	p-value	No/Less ¹ N (%)	More ¹ N (%)	OR (95%CI)	p-value
Race/Ethnicity ²								
NHW	112 (75)	39 (25)	REF		95 (83)	20 (17)	REF	
Hispanic	165 (67)	82 (33)	1.43 (0.90, 2.27)	0.13	431 (60)	285 (40)	1.78 (1.01, 3.13)	0.05
AI/AN	21 (70)	9 (30)	1.10 (0.46, 2.64)	0.83	48 (66)	25 (34)	2.11 (1.00, 4.44)	0.05
Gender								
Female	243 (75)	80 (25)	REF		446 (62)	269 (38)	REF	
Male	94 (58)	68 (42)	1.95 (1.26, 3.03)	0.003	152 (69)	68 (31)	0.75 (0.51, 1.09)	0.13
Age								
<50 years old	331 (69)	147 (31)	REF		366 (60)	243 (40)	REF	
50+ years old	6 (86)	1 (14)	1.09 (0.09, 12.85)	0.95	191 (76)	61 (24)	0.49 (0.34, 0.71)	<.0001
Education								
<HS/GED	2 (33)	4 (67)	REF		241 (55)	197 (45)	REF	
HS/GED or greater	323 (69)	143 (31)	0.51 (0.07, 3.79)	0.52	358 (72)	140 (28)	0.59 (0.42, 0.82)	0.002
Insurance								
Uninsured	77 (68)	37 (33)	REF		240 (58)	177 (42)	REF	
Any	258 (70)	110 (30)	1.03 (0.63, 1.68)	0.91	352 (69)	156 (31)	0.78 (0.57, 1.07)	0.13
Social Engagement Likelihood ³								
	New Mexico				Washington State			
	No/Less ³ N (%)	More ³ N (%)	OR	p-value	No/Less ³ N (%)	More ³ N (%)	OR	p-value
Race/Ethnicity ²								
NHW	141 (97)	5 (3)	REF		60 (53)	53 (47)	REF	

Social Engagement Likelihood ³								
	New Mexico				Washington State			
	No/Less ³ N (%)	More ³ N (%)	OR	p-value	No/Less ³ N (%)	More ³ N (%)	OR	p-value
Hispanic	233 (96)	10 (4)	1.02 (0.32, 3.20)	0.98	316 (45)	388 (55)	1.41 (0.88, 2.23)	0.16
AI/AN	28 (97)	1 (3)	0.80 (0.09, 7.35)	0.84	37 (51)	36 (49)	1.04 (0.55, 1.99)	0.90
Gender								
Female	308 (98)	8 (3)	REF		319 (45)	383 (55)	REF	
Male	142 (92)	13 (8)	6.76 (2.10, 21.78)	0.001	106 (49)	111 (51)	0.99 (0.70, 1.39)	0.94
Age								
<50 years old	443 (96)	21 (5)	REF		248 (41)	353 (59)	REF	
50+ years old	7 (100)	0 (0)	-- ⁴	-- ⁴	137 (56)	109 (44)	0.59 (0.42, 0.82)	0.002
Education								
<HS/GED	6 (100)	0	REF		207 (48)	222 (52)	REF	
HS/GED or greater	433 (96)	20 (4)	-- ⁴	-- ⁴	218 (44)	273 (56)	1.27 (0.91, 1.77)	0.15
Insurance								
Uninsured	107 (95)	6 (5)	REF		192 (47)	216 (53)	REF	
Any	340 (96)	15 (4)	0.48 (0.16, 1.43)	0.19	229 (46)	274 (55)	1.10 (0.81, 1.50)	0.54

¹ Knowledge dichotomized such that -5 to 3 = No/Less and 4-5 = More, based on a 66/33 split of continuous change score.

² NHW = Non-Hispanic White, AI/AN = American Indian/Alaska Native.

³ Social engagement likelihood dichotomized such that -12 to 1 = No/Less and 2-12 = More, based on a 66/33 split of continuous change score.

⁴ Comparisons were not modeled, given cells with 0 frequencies.

Table 4

Logistic regression models assessing screening intention by race/ethnicity, gender, age, education, insurance, changes in knowledge, and changes in social engagement likelihood (stratified by geographic region)

	New Mexico				Washington State			
	Less/Equally Likely N (%)	More Likely N (%)	OR (95%CI)	p-value	Less/Equally Likely N (%)	More Likely N (%)	OR (95%CI)	p-value
Race/Ethnicity ¹								
NHW	84 (56)	67 (44)	REF		80 (71)	32 (29)	REF	
Hispanic	141 (57)	106 (43)	0.94 (0.61, 1.44)	0.77	393 (56)	314 (44)	1.88 (1.13, 3.12)	0.01
AI/AN	15 (50)	15 (50)	1.29 (0.58, 2.86)	0.54	53 (74)	19 (26)	0.81 (0.40, 1.64)	0.56
Gender								
Female	173 (54)	150 (46)	REF		409 (58)	294 (42)	REF	
Male	103 (64)	59 (36)	0.82 (0.53, 1.27)	0.38	133 (61)	84 (39)	0.89 (0.63, 1.27)	0.53
Age								
<50 years old	275 (58)	203 (43)	REF		374 (62)	227 (38)	REF	
50+ years old	1 (14)	5 (86)	2.66 (0.24, 30.12)	0.43	125 (51)	121 (49)	2.16 (1.53, 3.05)	<0.0001
Education								
<HS/GED	3 (50)	3 (50)	REF		234 (54)	198 (46)	REF	
HS/GED or greater	271 (58)	195 (42)	0.73 (0.10, 5.30)	0.76	307 (63)	182 (37)	0.89 (0.65, 1.22)	0.72
Insurance								
Uninsured	67 (59)	47 (41)	REF		235 (57)	177 (43)	REF	
Any	207 (56)	161 (44)	1.02 (0.65, 1.62)	0.93	303 (61)	196 (39)	1.01 (0.93, 1.10)	0.76
	Mean (SE)	Mean (SE)			Mean (SE)	Mean (SE)		
Change in Knowledge	2.77 (0.08)	2.49 (0.09)	0.88 (0.75, 1.03)	0.11	2.33 (0.08)	2.45 (0.10)	1.01 (0.93, 1.10)	0.76
Change in Social Engagement	2.10 (0.19)	2.89 (0.22)	0.94 (0.88, 0.99)	0.03	1.95 (0.20)	3.89 (0.24)	1.10 (1.06, 1.14)	<0.0001