Published in final edited form as:

Cancer. 2017 April 15; 123(8): 1382–1389. doi:10.1002/cncr.30499.

Text Message Reminders Increased Colorectal Cancer Screening in a Randomized Trial with Alaska Native and American Indian People

Clemma Jacobsen Muller, PhD¹, Renee Robinson, PharmD, MPH^{2,3}, Julia Smith, MS², Meghan Jernigan, MPH¹, Vanessa Hiratsuka, PhD², Denise A. Dillard, PhD², and Dedra Buchwald, MD¹

¹Partnerships for Native Health, Washington State University

²Southcentral Foundation, Anchorage, Alaska

³United States Public Health Service

Abstract

Background—Alaska Native and American Indian people (AN/AIs) have high incidence of colorectal cancer (CRC) and CRC-related mortality. Screening can prevent death from CRC, but screening rates are low in racially and ethnically diverse populations. We conducted a randomized controlled trial using text messaging to increase CRC screening among unscreened AN/AIs in a tribal healthcare system in Anchorage, Alaska.

Methods—The intervention entailed up to three text messages one month apart. We randomized 2,386 AN/AIs aged 40–75 years old who were eligible for CRC screening to the intervention or usual-care control conditions. Screening status was ascertained from electronic health records three and six months after the last message. We estimated hazard ratios (HR) to evaluate the intervention's effectiveness, stratified by age and sex.

Results—The intervention increased CRC screening for people ages 50–75 (HR = 1.42, 95% CI = 0.97–2.09) and ages 40–49 (HR = 1.24, 95% CI = 0.95–1.62). Within both age groups the HRs were higher for women (HR = 1.69, 95% CI = 1.02–2.80; and HR = 1.37, 95% CI = 1.01–1.88) than for men (HR = 1.09, 95% CI = 0.59–1.99; and HR = 0.90, 95% CI = 0.54–1.53). Interaction analysis yielded *p* values of 0.55 and 0.09 for age and sex, respectively.

Corresponding author: Clemma Muller, PhD, 4309 42nd Ave S, Minneapolis, MN 55406, 612-327-7237, Fax: 206-708-8611, clemma.muller@wsu.edu.

The authors have no conflicts of interest to disclose.

Clinical Trials Registration: NCT02843217

Author Contributions

Dr. Muller: Conceptualization, Formal analysis, Writing

Dr. Robinson: Conceptualization, Supervision, Writing

Ms. Smith: Data curation, Writing

Ms. Jernigan: Project administration, Writing

Dr. Hiratsuka: Conceptualization, Methodology, Writing

Dr. Dillard: Conceptualization, Funding acquisition, Writing

Dr. Buchwald: Conceptualization, Funding acquisition, Writing

Conclusions—A simple text messaging intervention increased CRC screening in AN/AIs, a group with high CRC morbidity and mortality. Text messaging may be a cost-effective means of reducing CRC screening disparities in AN/AIs and other populations.

Keywords

Colorectal cancer; cancer screening; text messaging; Native Americans; American Indians; randomized controlled trial

INTRODUCTION

Colorectal cancer (CRC) is the third-leading cause of cancer-related mortality in the US. In 2016, more than 130,000 people will be diagnosed with CRC, and nearly 50,000 people will die from this condition.¹ Most CRC can be prevented by screening procedures that remove pre-cancerous polyps and detect disease at early stages, when five-year survival rates are much higher.² Guidelines recommend screening for average-risk adults beginning at age 50, and for adults at higher risk beginning at younger ages.³ In 2013, 58% of the general population met CRC screening standards, with the highest prevalence in non-Hispanic Whites.⁴ Recommended timelines for re-screening vary by modality. Hemoccult methods (fecal occult blood testing (FOBT) and fecal immunochemical testing (FIT)) require annual re-screening; flexible sigmoidoscopy requires re-screening every 5 years; and colonoscopy requires re-screening every 10 years.

Racial disparities in CRC incidence and survival are well established, but most research has compared rates in Blacks and Whites. Studies report conflicting results for disparities experienced by Alaska Native and American Indian people (AN/AIs). Many—but not all—studies using data from the Surveillance, Epidemiology, and End Results Program find that AN/AIs have lower CRC incidence than Whites and Blacks,^{5–8} but racial misclassification in these and other population-based data sources can lead to underestimating CRC burdens for AN/AIs.^{9,10} Other studies, in contrast, have reported that some AN/AI groups have among the highest CRC incidence in the US.^{11,12} Currently, AN/AIs are diagnosed with CRC at younger ages than the general population, and more frequently present with advanced rather than localized disease.^{13,14} In the last 3 decades CRC incidence declined for most racial groups, but increased in AN/AIs, most notably for people younger than 50 years old.¹⁵ ANs have the highest CRC incidence of all AN/AIs,^{5,11} although one study suggests that incidence among ANs may now be declining.¹⁶ Nevertheless, CRC is the most frequently diagnosed cancer and the second-leading cause of cancer-related death for ANs.¹⁷ AN/AIs in the aggregate have lower screening than other racial and ethnic groups,^{4,18,19} although national statistics may not be reliable for this population.²⁰

The US Community Preventive Services Task Force has identified effective patient-oriented strategies to promote CRC screening.²¹ Using findings on FOBT, the task force recommends reminders delivered by letter, postcard, email, or telephone to advise people that they are due for CRC screening. Although recommendations did not mention reminders in the form of text messaging by mobile phones, studies have reported promising results with text messaging interventions for other types of cancer screening.^{22,23} An increasing number of

mobile health (mHealth) interventions are being implemented with such technologies as text messaging, smartphone apps, and wireless or remote medical technology to improve healthcare in diverse settings and populations.²⁴ Existing data are currently insufficient to predict whether mHealth will be widely successful for promoting preventive services.²⁵ Text messaging might therefore be useful to address health disparities in populations who face barriers in accessing personal computers and the Internet but have high rates of mobile phone use.

In this study, we designed a text messaging intervention to increase CRC screening among AN/AIs ages 40–75 years old in the Southcentral Foundation (SCF) healthcare system in Anchorage, Alaska. Patients 40–49 years old were included due to the high CRC incidence in ANs younger than 50. We implemented a two-arm randomized controlled trial comparing CRC screening uptake in a group receiving text messaging (intervention) to a group receiving usual care (control).

MATERIALS AND METHODS

Human Subjects Protections

All SCF patients are given the opportunity to enroll in an electronic health messages program, and can sign forms giving consent to be included in research studies. This study was approved by the Alaska Area Institutional Review Board and by tribal leadership of SCF and the Alaska Native Tribal Health Consortium. All necessary tribal approvals were obtained before manuscript submission.

Study Setting: Southcentral Foundation

SCF is a tribally owned and operated healthcare organization that offers primary care services to ~65,000 AN/AIs in Anchorage, Alaska. Inpatient and tertiary care services are provided at the Alaska Native Medical Center, a 150-bed facility co-owned and co-managed by SCF and the Alaska Native Tribal Health Consortium. Recipients of care are designated “customer-owners” instead of “patients,” reflecting the cooperative ownership structure.²⁶ A 2011 survey found that 89% of SCF customer-owners ages 50 years and older had a mobile phone, and 75% of this group used text messaging.²⁷

CRC screening services are provided to all eligible customer-owners and are considered prepaid on the basis of past treaties with the federal government. In 2014, SCF policies redefined the minimum age for CRC screening eligibility as 40 instead of 50 years old, given the higher rates of CRC incidence and earlier ages at onset in ANs compared to the general population. Current SCF guidelines promote colonoscopy over flexible sigmoidoscopy or hemoccult testing, and customer-owners already receive screening reminders by telephone and surface mail, as well as by physician referral during in-person clinic visits. In 2015, approximately 30% and 60% of customer-owners ages 40–49 and 50–75 years, respectively, were up-to-date with SCF’s CRC screening recommendations, lower than the 80% goal set by the National Colorectal Cancer Screening Roundtable and endorsed by the Centers for Disease Control and Prevention.^{28,29}

Text Messaging Intervention

Our intervention was integrated into an existing SCF program started in 2013. Customer-owners who attend any clinic visit can sign up to receive electronic messages with personalized reminders for various preventive services. People who sign up provide written informed consent to enroll, and endorse their willingness to receive text messages by mobile phone. The informed consent documents contain a separate line item giving permission to be included in de-identified research to evaluate the effectiveness of electronic health messages in improving care.

For the present study, text messages were designed to align with national and local SCF guidelines for CRC screening. To develop message content, we first developed a preliminary set of text messages based on our literature review, key informant interviews with SCF customer-owners and providers, and meetings with tribal leadership. Next, we conducted focus groups with customer-owners and other SCF stakeholders. Based on focus group feedback we revised the final set of text messages (Table 1), which were approved by SCF staff and the SCF Medical Services Division. Of note, in this instance the cultural tailoring process resulted in text messages that are not obviously culturally-specific (e.g., do not incorporate words from Native languages).

Participant Eligibility

Our study sample comprised all SCF patients who were enrolled in the existing electronic health messaging program and were eligible for CRC screening at the time of randomization. Eligibility criteria for the randomized trial were ascertained from electronic health records. Inclusion required 1) AN or AI heritage documented in the electronic health record; 2) empanelment to an SCF primary care provider; 3) enrollment in the SCF electronic health messaging program; 4) possession of a text-enabled mobile phone; 5) signing the optional consent to participate in research on the effectiveness of electronic health messaging for health promotion; 6) no history of CRC or colectomy; 7) current eligibility for CRC screening; and 8) aged 50 years or older. Between the first and second waves of randomization (see below), the age criterion was reduced to 40 years and older to reflect SCF's revised policies on CRC screening.

Randomization

Randomization for the trial was performed in two waves, with eligible customer-owners randomized in a 1:1 ratio to the intervention or control conditions. The first wave began in November 2013, and the second wave began in March 2014 with the lower age limit of 40 years old. For each wave, the study biostatistician used computer-generated pseudo-random numbers to assign study group status. Because randomization for all participants was performed at the same time for each wave, no method of allocation concealment (e.g., sealed envelopes) was necessary.

Randomized Controlled Trial

We collaborated with CRC staff and tribal leadership to develop a protocol for sending CRC screening reminders, endeavoring to ensure its compatibility with routine clinical practice. All customer-owners were blinded to study group assignment, and outcome data were

collected by using health record queries executed by staff who were unaware of group assignment. Participants in the intervention group during the first wave of randomization were sent a pre-intervention text message informing them that they would receive texts about CRC screening and providing an opportunity to opt out. Because only 3% of participants in this group opted out, the pre-intervention text message was eliminated for the second wave of randomization. After one month, the first CRC screening message was sent to those who did not opt out. Approximately one month after the first CRC screening message, a follow-up query of health records was performed to ascertain current screening status. For participants who remained unscreened and had not opted out, the second text message was sent. Approximately one-month later the process was repeated for the third and last time, for a maximum of three text messages over a two-month period. For efficiency, health records were queried and text messages were sent only once per month. Three and six months after the final text message, screening status queries were again performed for both the intervention and control groups. The *a priori* goal was to determine the intervention's effect among all participants, with exploratory analyses evaluating modification by age and sex.

Measures

CRC screening was defined as FIT or FOBT, flexible sigmoidoscopy, or colonoscopy documented in electronic health records on or before the final ascertainment of screening status. We originally intended data collection to include date of screening, but for privacy reasons we were unable to access this information. Therefore, we created a categorical variable indicating the interval during which screening occurred (after randomization but before sending the first CRC screening message, first message to second message, second message to third message, third message to first follow-up query, first to final follow-up query). Additional analytic factors included age, sex, marital status, and eligibility for Medicare and Medicaid. Anonymous identification numbers were used for primary care provider and primary clinic to identify potentially correlated observations for the statistical analyses. We did not assess potential harms associated with CRC screening, because outcomes such as perforated colon are extremely rare, and screening benefits outweigh the potential for adverse events.³⁰

Statistical Analysis

Descriptive statistics were calculated using counts and frequencies for categorical variables, and stratified by age (40–44, 45–49, 50–75) based roughly on tertiles for the full cohort. If any variable appeared unbalanced between study groups, we included that factor as a covariate in sensitivity analyses. We followed an intent-to-treat approach, using data on all participants regardless of whether they opted out of text message contact. Our original plan was to use Cox regression to estimate hazard ratios (HR) for the intervention's effect on CRC screening, however, we were not able to use this approach due to the interval-censored nature of the data we ultimately received from SCF. Therefore, we instead estimated HRs using complementary log-log regression, which can accommodate an outcome specified as intervals with different durations rather than requiring the exact date of screening.³¹ This approach generates HRs with the same interpretation as Cox regression models, with the added assumption that screening procedures in a given interval are evenly distributed within that interval. Results are presented as HRs with 95% confidence intervals. For the primary

analysis, we compared the effect of text messaging on CRC screening in people ages 50–75, to align with screening recommendations for the general population. Results are also presented for people 40–49 years old and for the entire sample combined. For both age groups we estimated intervention effects separately for women and men, and ran models for the full sample with formal interaction terms for age group and sex. We did not perform *a priori* power calculations, because the study design entailed randomizing the entire population of SCF customer-owners who met inclusion criteria. Stata version 14.1 (StataCorp, College Station, TX) was used for all analyses.

RESULTS

Randomization and study implementation are shown in Figure 1. We identified 808 eligible participants in wave 1, and 1,578 additional participants in wave 2. Among the 2,386 total participants, 25 (12 in the intervention group, 13 in the control group) received CRC screening in the brief interval between randomization and sending the first CRC screening text message. Under the intent-to-treat model, these participants were included in the statistical analysis. Of the 145 customer-owners in the intervention group who opted out of text messages, 22 (15.2%) received CRC screening during the study period. All covariates appeared adequately balanced between the two study groups at baseline (Table 2).

From baseline to final ascertainment of screening status, 181 (15.2%) intervention participants completed CRC screening (Table 2), compared to 142 (11.9%) control participants. Differences were more pronounced among people ages 50–75 than for people in the younger age groups. Colonoscopy was the primary screening method, accounting for > 90% of procedures. Lacking indication of covariate imbalance at baseline, we did not perform confounder-adjusted sensitivity analyses. In the primary inferential analysis, the text messaging intervention was associated with higher screening rates among customer-owners ages 50–75 years old (HR = 1.42, 95% CI = 0.97–2.09, $p = 0.07$), with positive effects of smaller magnitude for ages 40–49 (HR = 1.24, 95% CI = 0.95–1.62, $p = 0.12$) and in the full sample combined (HR = 1.30, 95% CI = 1.04–1.62; $p = 0.02$). The HR estimates were higher for women than for men in both age groups (Figure 2). In analyses with the full sample, p values for interaction did not fall below 0.05 for age ($p = 0.55$) or sex ($p = 0.09$).

DISCUSSION

We found that a simple text messaging intervention increased CRC screening by 42% compared to usual care in a clinical population of AN/AIs ages 50–75 years old, and by 24% for people 40–49 years old. Although the absolute difference between groups was not large, these findings suggest that text messaging may be an inexpensive means of reaching people who do not require intensive outreach to be screened. In the intervention group, the small number who opted out of text message receipt had overall screening rates similar to those of their counterparts who received text messages. Two potential explanations are that participants who scheduled or received CRC screening did not realize messages would automatically stop after their electronic health record was updated, or that the messages were still effective even if participants did not like receiving them. Our findings strongly suggested the intervention was only effective for women (69% and 37% higher screening

rates for ages 50–75 and 40–49, respectively), with no apparent effect in men. Although the formal interaction analysis did not reach the standard $p = 0.05$ threshold for strong statistical evidence, the point estimates and confidence intervals (Figure 2) provide compelling support for a likely difference in the intervention's effectiveness by sex and underscore the importance of investigating differences between AN/AI men and women in decision-making relevant to CRC screening.³²

Because 50% of SCF customer-owners (ages 40–75 combined) were already adherent to CRC screening guidelines at baseline, our target population was adults who do not respond to existing efforts to promote CRC screening, or who may have been unaware of the need for preventive screening. Even a small effect could therefore provide a cost-effective means of increasing CRC screening, while allowing more resource-intensive outreach to be directed at people for whom text messaging is ineffective. However, our sample also included customer-owners who only recently became eligible for screening because of their age or the expiration of a previous screening procedure. Many of these participants would probably undertake screening without additional intervention, as reflected by the 12% uptake in our control group. Unfortunately, we had no access to individual-level data that would permit us to distinguish this subgroup from those who require additional intervention. Furthermore, although we were not able to contact customer-owners in the intervention group to verify receipt of text messages, from the perspective of a pragmatic trial these individuals would be included in the group of people for whom the intervention is not effective and would be randomly distributed across study groups.

Although mHealth shows promise for reducing cancer-related health disparities in the US,³³ an AN/AI sample experienced notable barriers to using text messaging and smartphone apps in a recent weight loss intervention.³⁴ Issues included frequent sharing of mobile phones among friends and family, as well as legal obstacles that prevented researchers from providing phones to study participants. Our study avoided some of these barriers by integrating the intervention with an existing mHealth program for which enrollees had already provided telephone numbers and confirmed their ability and willingness to receive text messages. It seems clear that people who already possess and use mobile technologies are also the most likely to benefit from mHealth interventions. In that context, our study was a pragmatic trial designed for a self-selected population of mobile phone users.

To our knowledge this was the first large randomized trial of text messaging to increase CRC screening within a healthcare system, although at least one study is forthcoming.³⁵ In another study, a randomized trial of primarily Hispanic, Black, and White patients in a Texas healthcare system found that a combination of mailed and telephone outreach was more effective than usual care in increasing CRC screening with FIT as well as colonoscopy.³⁶ Although the intervention did not include text messaging, its findings support a tiered model that optimizes efficiency by progressing from less costly and resource-intensive outreach (e.g., text messaging) to more costly and intensive methods (e.g., personal telephone calls).

Our study has several limitations that might affect the validity and generalizability of results. First, we lacked access to detailed individual-level data for evaluating predictors of positive response to the intervention. However, our relatively simple study design and parsimonious

data collection were appropriate to address our scientific question regarding the overall intervention effect on CRC screening uptake. Second, we could not assess potential contamination between the intervention and control groups. Contamination might have occurred if participants shared text messages or if the screening behavior of control participants was influenced by the experience or outcomes of intervention participants, and is not prevented by randomization. It is possible that the screening uptake achieved by the control group (12%) reflected such contamination, which would bias our results. However, it is reasonable to expect that contamination would enhance rather than reduce screening in the control group. In that case, our findings would represent a conservative estimate of the true intervention effect on CRC screening. Third, the study was restricted to a single healthcare system, and to patients within the system who possessed text-enabled mobile phone and had consented to participation in research. Therefore, results might not generalize to other settings in which AN/AIs receive healthcare.

Our study also has substantial strengths. First, our sample was derived from a clinic-based population for which electronic medical records were available and services were offered without requiring out-of-pocket payments. This factor removed insurance and other financial barriers to CRC screening, while enabling us to obtain accurate data on final screening status for nearly 100% of randomized participants. Second, our use of focus groups to collaboratively create the study protocol and the text messaging content ensured the local relevance and cultural acceptability of our communication strategy. Even though the final set of text messages did not include Native language or explicit culturally-specific references, the purpose of cultural tailoring is to ensure that the community will benefit from the intervention. Its success was demonstrated both by the small fraction of intervention participants who opted out of text message reminders and by the similarity in screening rates between people who did and did not opt out. Third, our study was made possible by excellent collaboration between SCF clinical staff and health researchers, and external academic researchers. Based on principles of trust and respectful collaboration we successfully balanced the need for scientific rigor with SCF policies and preferences regarding research participation and patient confidentiality. Another strength is that our intervention can be implemented and sustained, as designed, in the frequently overburdened and underfunded settings experienced by many tribal healthcare systems.

We found that text messaging is a useful addition to the public health toolkit for achieving national goals in CRC screening. We also observed that cultural tailoring is needed for such messaging among AN/AIs, and specifically that this process might result in content that differs from external researchers' expectations for cultural tailoring. We also observed that targeting messages to match individual-level characteristics, including age and gender, should be considered. These findings are aligned with recent qualitative research in AN/AIs.³⁷ A recent study found that increasing population-level screening adherence to 80% could prevent as many as 280,000 new CRC cases and 200,000 CRC-related deaths over the subsequent 20 years.²⁸ Interventions targeting historically underrepresented racial and ethnic minority groups are essential for achieving this 80% goal. Our findings illustrate the potential importance of tailoring content to specific subgroups, such as AN/AI men.³⁸

Acknowledgments

This study was funded by the National Cancer Institute (grant # U54CA153498). We thank Lily Gadamus, Carrie Nass, and Sarah Simpson for assistance in project administration; Raymond Harris for assistance with copy editing and preparing figures; and anonymous reviewers for their valuable insights and suggestions.

References

1. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2016. *CA Cancer J Clin.* 2016; 66(1):7–30. [PubMed: 26742998]
2. Levin B, Lieberman DA, McFarland B, et al. Screening and surveillance for the early detection of colorectal cancer and adenomatous polyps, 2008: a joint guideline from the American Cancer Society, the US Multi-Society Task Force on Colorectal Cancer, and the American College of Radiology. *Gastroenterology.* 2008; 134(5):1570–1595. [PubMed: 18384785]
3. Smith RA, Andrews K, Brooks D, et al. Cancer screening in the United States, 2016: A review of current American Cancer Society guidelines and current issues in cancer screening. *CA Cancer J Clin.* 2016
4. Sabatino SA, White MC, Thompson TD, Klabunde CN. Centers for Disease C, Prevention. Cancer screening test use - United States, 2013. *Mmwr.* 2015; 64(17):464–468. [PubMed: 25950253]
5. Espey DK, Wu XC, Swan J, et al. Annual report to the nation on the status of cancer, 1975–2004, featuring cancer in American Indians and Alaska Natives. *Cancer.* 2007; 110(10):2119–2152. [PubMed: 17939129]
6. Henley SJ, King JB, German RR, et al. Surveillance of screening-detected cancers (colon and rectum, breast, and cervix) - United States, 2004–2006. *MMWR Surveill Summ.* 2010; 59(9):1–25.
7. Paltoo DN, Chu KC. Patterns in cancer incidence among American Indians/Alaska Natives, United States, 1992–1999. *Public Health Rep.* 2004; 119(4):443–451. [PubMed: 15219802]
8. Rim SH, Seeff L, Ahmed F, King JB, Coughlin SS. Colorectal cancer incidence in the United States, 1999–2004 : an updated analysis of data from the National Program of Cancer Registries and the Surveillance, Epidemiology, and End Results Program. *Cancer.* 2009; 115(9):1967–1976. [PubMed: 19235249]
9. Jim MA, Arias E, Seneca DS, et al. Racial misclassification of American Indians and Alaska Natives by Indian Health Service Contract Health Service Delivery Area. *American journal of public health.* 2014; 104(Suppl 3):S295–302. [PubMed: 24754617]
10. Espey DK, Wiggins CL, Jim MA, Miller BA, Johnson CJ, Becker TM. Methods for improving cancer surveillance data in American Indian and Alaska Native populations. *Cancer.* 2008; 113(5 Suppl):1120–1130. [PubMed: 18720372]
11. Perdue DG, Haverkamp D, Perkins C, Daley CM, Provost E. Geographic variation in colorectal cancer incidence and mortality, age of onset, and stage at diagnosis among American Indian and Alaska Native people, 1990–2009. *American journal of public health.* 2014; 104(Suppl 3):S404–414. [PubMed: 24754657]
12. Brown MO, Lanier AP, Becker TM. Colorectal cancer incidence and survival among Alaska Natives, 1969–1993. *International journal of epidemiology.* 1998; 27(3):388–396. [PubMed: 9698125]
13. Cueto CV, Szeja S, Wertheim BC, Ong ES, Tsikitis VL. Disparities in treatment and survival of white and Native American patients with colorectal cancer: a SEER analysis. *J Am Coll Surg.* 2011; 213(4):469–474. [PubMed: 21723155]
14. Rahman R, Schmaltz C, Jackson CS, Simoes EJ, Jackson-Thompson J, Ibdah JA. Increased risk for colorectal cancer under age 50 in racial and ethnic minorities living in the United States. *Cancer Med.* 2015; 4(12):1863–1870. [PubMed: 26471963]
15. Edwards BK, Ward E, Kohler BA, et al. Annual report to the nation on the status of cancer, 1975–2006, featuring colorectal cancer trends and impact of interventions (risk factors, screening, and treatment) to reduce future rates. *Cancer.* 2010; 116(3):544–573. [PubMed: 19998273]
16. Kelly JJ, Lanier AP, Schade T, Brantley J, Starkey BM. Cancer disparities among Alaska native people, 1970–2011. *Preventing chronic disease.* 2014; 11:E221. [PubMed: 25523352]

17. Kelly JJ, Alberts SR, Sacco F, Lanier AP. Colorectal cancer in alaska native people, 2005–2009. *Gastrointest Cancer Res.* 2012; 5(5):149–154. [PubMed: 23112882]
18. Johnson-Jennings MD, Tarraf W, Xavier Hill K, Gonzalez HM. United States colorectal cancer screening practices among American Indians/Alaska Natives, blacks, and non-Hispanic whites in the new millennium (2001 to 2010). *Cancer.* 2014; 120(20):3192–3299. [PubMed: 25123695]
19. Burnett-Hartman AN, Mehta SJ, Zheng Y, et al. Racial/Ethnic Disparities in Colorectal Cancer Screening Across Healthcare Systems. *American journal of preventive medicine.* 2016; 51(4):e107–115. [PubMed: 27050413]
20. Gupta S, Sussman DA, Doubeni CA, et al. Challenges and possible solutions to colorectal cancer screening for the underserved. *J Natl Cancer Inst.* 2014; 106(4):dju032. [PubMed: 24681602]
21. Community Preventive Services Task Force. [Accessed October 26, 2016] Increasing cancer screening: client reminders. <https://www.thecommunityguide.org/sites/default/files/assets/Cancer-Screening-Client-Reminders.pdf>
22. Lee HY, Koopmeiners JS, Rhee TG, Raveis VH, Ahluwalia JS. Mobile phone text messaging intervention for cervical cancer screening: changes in knowledge and behavior pre-post intervention. *J Med Internet Res.* 2014; 16(8):e196. [PubMed: 25164545]
23. Vidal C, Garcia M, Benito L, Mila N, Binefa G, Moreno V. Use of text-message reminders to improve participation in a population-based breast cancer screening program. *J Med Syst.* 2014; 38(9):118. [PubMed: 25073694]
24. Fiordelli M, Diviani N, Schulz PJ. Mapping mHealth research: a decade of evolution. *J Med Internet Res.* 2013; 15(5):e95. [PubMed: 23697600]
25. Vodopivec-Jamsek V, de Jongh T, Gurol-Urganci I, Atun R, Car J. Mobile phone messaging for preventive health care. *Cochrane database of systematic reviews (Online).* 2012; 12:CD007457.
26. Gottlieb K. The Nuka System of Care: improving health through ownership and relationships. *Int J Circumpolar Health.* 2013:72.
27. Robinson RF, Dillard DA, Hiratsuka VY, et al. Formative evaluation to assess communication technology access and health communication preferences of Alaska Native people. *International Journal of Indigenous Health.* 2015; 10(2):88–101. [PubMed: 27169131]
28. Meester RG, Doubeni CA, Zauber AG, et al. Public health impact of achieving 80% colorectal cancer screening rates in the United States by 2018. *Cancer.* 2015
29. Centers for Disease Control and Prevention. [Accessed October 26, 2016] http://www.cdc.gov/cancer/crccp/pdf/CRCCP_FactSheet.pdf
30. Rutter CM, Johnson E, Miglioretti DL, Mandelson MT, Inadomi J, Buist DS. Adverse events after screening and follow-up colonoscopy. *Cancer Causes Control.* 2012; 23(2):289–296. [PubMed: 22105578]
31. Allison, P. *Survival analysis using SAS: a practical guide.* 2. Cary, NC: SAS Institute, Inc; 2010. Chapter 7: Analysis of tied or discrete data with PROC LOGISTIC.
32. Borenstein M. The case for confidence intervals in controlled clinical trials. *Control Clin Trials.* 1994; 15(5):411–428. [PubMed: 8001360]
33. Rivers BM, Bernhardt JM, Fleisher L, Green BL. Opportunities and challenges of using technology to address health disparities. *Future Oncol.* 2014; 10(4):519–522. [PubMed: 24754582]
34. Nelson LA, Zamora-Kapoor A. Challenges in conducting mHealth research with underserved populations: Lessons learned. *J Telemed Telecare.* 2015
35. Hirst Y, Kerrison R, Kobayashi LC, et al. Text Reminders in Colorectal Cancer Screening (TRICCS): Protocol for a randomised controlled trial. *BMC Public Health.* 2016; 16(1):74. [PubMed: 26809344]
36. Singal AG, Gupta S, Tiro JA, et al. Outreach invitations for FIT and colonoscopy improve colorectal cancer screening rates: A randomized controlled trial in a safety-net health system. *Cancer.* 2016; 122(3):456–463. [PubMed: 26535565]
37. Filippi MK, Perdue DG, Hester C, et al. Colorectal Cancer Screening Practices among Three American Indian Communities in Minnesota. *J Cult Divers.* 2016; 23(1):21–27. [PubMed: 27188017]

38. Kreuter MW, Lukwago SN, Bucholtz RD, Clark EM, Sanders-Thompson V. Achieving cultural appropriateness in health promotion programs: targeted and tailored approaches. *Health Educ Behav.* 2003; 30(2):133–146. [PubMed: 12693519]

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Figure 1.
Study design and implementation

Figure 2.
Intervention's effect on colorectal cancer screening with 95% confidence intervals

Table 1

Text message content for colorectal cancer screening intervention

Message	Phrasing
1	Did you know that colorectal cancer is the leading cause of new cases of cancer among Alaska Native people? According to our records you are over 50 * and/or have a family history of colorectal cancer, contact the Alaska Native Medical Center Colorectal Cancer Screening Patient Navigators at xxx-xxx-xxxx. If you no longer want to be texted reminders about overdue colorectal cancer screening via text, please reply STOP to this message.
2	Screening for colon cancer saves live. Call the Alaska Native Medical Center Colorectal Cancer Screening Patient Navigators at xxx-xxx-xxxx to set up your appointment to get screened. If you are no longer want to be texted reminders about overdue colorectal cancer screening via text, please reply STOP to this message.
3	Colon cancer screening is one of the most important things you can do for yourself and your loved ones. Please call the Alaska Native Medical Center Colorectal Cancer Screening Patient Navigators at xxx-xxx-xxxx today to set up your screening appointment. If you are no longer want to be texted reminders about overdue colorectal cancer screening via text, please reply STOP to this message.

* Age threshold changed to 40 years old for second wave of text messages

Table 2

Descriptive statistics and colorectal cancer screening results

	Age 40–45		Age 45–49		Age 50–75	
	Intervention (n = 405) %	Control (n = 404) %	Intervention (n = 384) %	Control (n = 385) %	Intervention (n = 404) %	Control (n = 404) %
Sex						
Female	61.5	59.2	59.6	58.4	58.9	55.9
Marital status						
Married	48.1	43.1	43.0	38.0	39.7	40.8
Single	44.9	49.4	48.8	54.5	46.7	47.1
Divorced/widowed/separated	7.0	7.5	8.2	7.6	13.6	12.2
Public insurance						
Medicaid eligibility	15.6	15.1	14.8	17.1	24.0	20.1
Medicare eligibility	4.2	3.2	6.3	8.6	31.2	29.2
Colorectal cancer screening						
Any screening	15.8	10.2	14.1	14.6	15.6	11.1
By type:						
Colonoscopy [*]	14.3	9.4	13.8	14.3	13.4	10.2
Hemoccult [†]	1.5	0.7	0.3	0.3	2.2	1.0

^{*} Includes flexible sigmoidoscopy in cases where patients were unable to complete a full colonoscopy[†] Fecal occult blood testing or fecal immunochemical testing