Disparities in the Uptake of Colorectal Cancer Screenings: The Role of Education, Insurance, and Screening Type

By

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ABSTRACT: Preventative screenings hold the promise of detecting disease before it becomes fatal. However, they often have the unintended consequence of creating socioeconomic disparities because individuals with social and economic resources are the heaviest users. This research investigates education- and insurance-based disparities in colorectal cancer screening participation and how these associations change over time. I use data from the National Health Interview Survey (NHIS) to analyze trends in colorectal cancer screening participation for adults over 50 from 1992 to 2013 (n=51,385). Controlling for key sociodemographic factors, results suggest that education and access to insurance have become increasingly important predictors of screening participation over time. Specifically, the findings appear to primarily apply to endoscopy use, a more invasive and expensive type of colorectal cancer screening. By showing that education and insurance are more relevant for predicting endoscopy use, this study contributes to fundamental cause research on the uptake of medical innovations; the study shows that the use of complicated technologies is more heavily influenced by socioeconomic factors. I conclude by considering how policy changes can reduce socioeconomic disparities in cancer screenings.

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INTRODUCTION

Preventative screenings hold the promise of detecting disease before it becomes fatal. However, they often have the unintended consequence of creating health inequities because individuals with social and economic resources are the heaviest users (Chang & Lauderdale, 2009; Goldman & Lakdawalla, 2005; Link et al., 1998). For example, socioeconomic differences in colorectal cancer (CRC) mortality have widened following the development of effective screenings (Saldana-Ruiz, et al., 2012; Wang et al., 2012). If new medical technologies regularly increase health disparities, are there offsetting factors that may reduce these gaps? Working within the fundamental cause perspective (Phelan, Link, & Tehranifar, 2010), I use CRC screenings as an example to argue that social resources such as education and insurance are strongly linked to preventative health care usage, but that these resources are strongest for predicting use of screening types that require patient investment of time and effort.

This study aims to answer two primary research questions. First, how has the association between education or insurance and CRC screening participation changed over time? Second, how do the relationships between education or insurance and screening participation vary by screening type? Using a sample of adults over 50 from the National Health Interview Survey (NHIS), I use logistic regression and predicted probabilities to test if education and insurance have become stronger predictors of screening participation between 1992 and 2013. I disaggregate the analysis to separately predict the use of two tests that are equally recommended as CRC screens: endoscopies, which are invasive and expensive screenings, and fecal occult blood tests, which are inexpensive and can be performed at home. This is an important contribution to the literature on the fundamental causality of social conditions because the analysis directly compares the influence of social and economic resources for two tests that differ in level of complexity but are equally effective and recommended for detecting the same disease.

This research demonstrates that the association between social and economic resources and medical technology use may be most relevant for technologies that are invasive and expensive, such as endoscopies.

LITERATURE REVIEW

Colorectal Cancer Screenings

Since the 1980s, scientific consensus on the effectiveness of CRC screenings has grown. In the past twenty years, foundations such as the American Cancer Society and the American College of Gastroenterology have issued recommendations suggesting that CRC screens are highly effective in preventing CRC and should be utilized by all adults older than fifty. Most importantly, in 2008, the United States Preventative Services Task Force gave CRC screenings the highest grade recommendation, meaning they are highly effective in detecting CRC while posing little risk to the patient (Whitlock, Lin, Liles, Beil, & Fu, 2008). Insurance coverage of CRC screenings has also changed in response to growing recommendations. Insurance plans have gradually increased their coverage of screens: In 2001, Medicare began requiring screening coverage; in 2011, the Affordable Care Act required private insurance plans to cover screens; and in 2013, Medicaid was required to cover screens.

Although these screenings are highly recommended and covered, they continue to be substantially underused; in 2015, about 58% of adults complied with screening recommendations (Fedewa et al., 2015; NCHS, 2015). This lack of participation likely contributes to making CRC the second leading cause of cancer death in the United States (American Cancer Society, 2016). CRC mortality has become increasingly unequal between social groups since the screens were introduced; CRC mortality in high-SES areas has decreased at a sharper rate than low-SES areas leading to a widening disparity in mortality (Saldana-Ruiz et al., 2012; Wang et al., 2012). Scholars hypothesize that this widening disparity is due to uneven diffusion and uptake of CRC screenings across socioeconomic lines (Saldana-Ruiz et al., 2012; Wang et al., 2012). The present study will build on past area-level research by considering individual-level uptake of screens based on socioeconomic factors, aiming to determine whether individual level uptake is patterned by socioeconomic indicators.

There are two main types of CRC screenings: fecal occult blood test (FOBT) and endoscopies. While similarly effective in detecting cancer (Whitlock et al., 2008), they differ in their level of invasiveness and cost. FOBTs use a fecal sample to test for traces of blood, which suggests abnormal and cancerous polyps line the colon. These tests can be can be performed at home, requiring little time or financial investment. In contrast, endoscopies (including proctoscopy, flexible sigmoidoscopy, and colonoscopy) are invasive, requiring fasting, a long procedure and substantial recovery period (Gawron et al., 2014**)**. The benefit of colonoscopy tests is that cancerous polyps can be removed as they are detected, whereas cancers that are detected with FOBT tests must be removed in a further procedure. Furthermore, endoscopies only have to be performed every five to ten years while FOBTs should be performed annually. Because of these differences, physicians recommend colonoscopies over FOBTs, unless financial or local resources are limited (Doubeni et al., 2009; Klabunde et al., 2009; Levin et al., 2008).

Studying CRC screenings allows for the analysis of uptake of an effective screening over time, with the potential for analyzing (1) how rates of participation differ by socioeconomic factors and (2) how screening type moderates the link between socioeconomic factors and uptake. While past studies have found a widening socioeconomic gap in CRC mortality over time (Saldana-Ruiz et al. 2012, Wang et al., 2012), there has been no test of how socioeconomic differences predict individual screening participation, distinguishing by screening type. By studying odds of individual screening participation over time, I can capture how uptake—response to new medical knowledge—is patterned by individual socioeconomic characteristics.

Fundamental Cause and Uptake of Innovation

Socioeconomic status (SES) has profound impacts on health behaviors and health care usage (Pampel et al., 2010). The fundamental cause theory argues that SES acts as a social condition that fundamentally causes health differences (Link & Phelan, 1995). This relationship is demonstrated by the enduring association between SES and health across time, space, and disease. The theory argues that socioeconomic status provides social resources such as occupational status, social connections, knowledge, prestige, and geographic location (Link, 2008; Link & Phelan, 1995; Phelan, Link, & Tehranifar, 2010). These resources are general, multi-purposive, and transportable across changing conditions. Therefore, those with access to material and social resources will consistently be more effective users of health care, have beneficial health behaviors, and better health outcomes. I utilize the fundamental cause theory to frame how socioeconomic factors often become more important with the introduction of new medical recommendations by focusing on (1) the enduring effects of socioeconomic status in predicting screening participation, (2) how the links between socioeconomic factors and screening participation strengthen over time, and (3) how the link between socioeconomic factors and screening participation vary by screening type.

In this study, I include education as a crucial indicator of SES in health and mortality (Clouston et al., 2015; Cutler & Lleras-Muney, 2010; Glied & Lleras-Muney, 2008; Mackenbach et al., 2015; Masters, Hummer, & Powers, 2012; Miech, Pampel, Kim, & Rogers, 2011). Fundamental cause scholars argue that education acts as an enduring predictor of health behaviors because it is indicative of an individual's structural position in society, influencing where individuals live, work, and socialize (Clouston et al., 2015). Education provides individuals with structural and cognitive resources to initiate and adhere to healthy behavior changes (Margolis, 2013), to make behavior changes after a diagnosis (Hernandez et al., 2016), and to adhere to physician recommendations (Link, 2008; Lutfey & Freese, 2005; Polonijo & Carpiano, 2013). Furthermore, the resources associated with eduation are incremental, resulting in a graded relationship between educational attainment and beneficial health behaviors (Pampel et al., 2010). Therefore, conceptualizing CRC screening participation as a preventative health behavior, I expect education to act as a key predictor of screening participation, remaining robust after adjusting for financial, health, and demographic factors.

Hypothesis 1: Higher levels of educational attainment will be associated with higher odds of ever having a CRC screening.

SES is consistently linked to health as high-SES individuals take advantage of new medical knowledge more quickly (Link et al., 1998; Chang & Lauderdale, 2009). This can create or exacerbate SES-related health disparities with higher-SES individuals reaping the benefits of new medical innovations. For example, disparities have emerged in cholesterol levels after the introduction of statins to treat high cholesterol (Chang & Lauderdale, 2009); in HIV mortality after anti-retroviral treatment became available to treat HIV (Rubin, Colen, & Link, 2010); and in CRC following the invention of CRC screenings (Saldana-Ruiz et al., 2012; Wang et al., 2012). These studies highlight how social resources become increasingly important for diseases treated by new innovation and how this leads to growing educational and SES gradients in outcomes (Glied & Lleras-Muney, 2008; Phelan, et al., 2004). In the case of CRC screens, although they were originally recommended in the 1980s, federal and non-profit groups continue to issue new recommendations that strengthen the evidence that regular screenings are beneficial to health. This suggests that education may become increasingly relevant for predicting who responds to screening recommendations.

Hypothesis 2: The association between higher levels of education and CRC screening participation will grow between 1992 and 2013.

Fundamental cause research has focused primarily on how income or education shape individual response to new medical innovations with policy recommendations frequently suggesting a redistribution of SES-related resources in order to equalize socioeconomic differences (Link, Phelan, & Tehranifar, 2010; Freese & Lutfey, 2013). While education and income are difficult resources to redistribute, other factors such as health insurance may potentially minimize the relevance of SES. Health insurance reduces the financial burden of health care, allows regular access to a primary care physician, and encourages the use of preventative behaviors (McWilliams, 2009). As such, insurance may be an important predictor of screening participation, beyond the individual effects of education or income. Tracking the effects of insurance on CRC screening participation is also important because of the changes in insurance policy in the past twenty years. At the beginning of my study, there was no guarantee that insurance companies would pay for CRC screenings. However, by 2013, all insurance plans were required to completely cover CRC screenings. Therefore, having insurance has become a potentially more effective resource, which may result in expanded use of screenings for the insured. Based on these changes to insurance, I test how insurance influences screening participation, making two hypotheses:

Hypothesis 3: Those with insurance will be more likely to use CRC screenings, independent of other socioeconomic and control variables.

Hypothesis 4: The positive association between insurance and CRC screening participation will grow in magnitude between 1992 and 2013.

Studies consistently find that social factors (such as education or insurance) are important predictors of uptake of new technology (Link et al., 1998; Rubin et al., 2010). However, the nature of technological change influences the link between social factors and uptake (Chang & Lauderdale, 2009; Goldman & Lakdawalla, 2005). For example, Goldman and Lakdawalla (2005) differentiate between *complicating* and *simplifying* technologies: Complicating technologies are technologies that make patient effort more important because they require adherence to specific regimens, or demand extra investment of time, effort, skill, or money. Simplifying technologies, in contrast, make patient effort less important for health promotion by lessening the need to adhere to strict lifestyle changes or complicated regimens. Complicating technologies are more likely to exacerbate socioeconomic health disparities whereas simplifying technologies are more likely to reduce health disparities. For example, antihypertensive drugs (a simplifying technology) reduced socioeconomic disparities in hypertension complications while new HIV treatments (a complicating technology) exacerbated socioeconomic disparities in HIV outcomes (Goldman & Lakdawalla, 2005). Chang and Lauderdale (2009) use Goldman and Lakdawalla's (2005) findings to amend the fundamental cause theory, arguing that the nature of technological change may influence the link between socioeconomic resources and technology uptake. Technologies that lessen the value of SES-related resources give a relative gain to lower status individuals, thereby reducing disparities. Chang and Lauderdale (2009), however, found that even the introduction of statins, which they considered a possible simplifying technology, exacerbated socioeconomic disparities related to cholesterol.

Drawing from these two studies, CRC screenings offer a valuable case study because endoscopies and FOBT tests are equally recommended and equally effective but differ in their level of complication. Endoscopies require extensive patient effort, are invasive, require hospital attendance, and are relatively unpleasant (Gawron et al., 2014). In contrast, FOBT tests can be performed at home, are easy to use, and do not require extensive patient effort (Benton, Seaman, & Halloran, 2015). Because FOBTs are inexpensive and require little patient effort, Goldman and Lakdawalla's (2005) theory would suggest that they are more easily accessible by all segments of the population. Accordingly, I test if FOBTs minimize the relevance of social and economic resources.

Hypothesis 5: Education and insurance will have a larger marginal effect on predicting endoscopy usage compared to FOBT usage.

DATA & METHODS

Data & Analytic Sample

The data for this study are from repeated, cross-sectional survey data from the National Health Interview Survey (NHIS) sample adult file. The NHIS, conducted by the National Center for Health Statistics, is a nationally-representative household interview survey. The survey collects information on an array of health topics as well as individual demographic and socioeconomic characteristics. To analyze multiple years of data, I use the Integrated Health Interview Survey (IHIS) to harmonize data across the yearly surveys and create comparable variables across years (IHIS, 2016). All data are weighted to adjust for the complex survey design of the NHIS.

The analytic sample for this study uses data from 1992, 1998, 2003, 2008, and 2013; all other years are excluded because they do not contain information on CRC screens. The entire sample from these five years contains 498,101 respondents. After removing those younger than

50 because recommendations target adults aged 50 and older (360,759), those with missing data on CRC screening (85,166), and those missing data on any other covariates (791), I am left with a final analytical sample of 51,385 respondents.

Variables

Dependent. The interest of this study is predicting whether the respondent has ever had a CRC screen (referred to as "CRC screening participation"). There are two major types of screenings: endoscopies and fecal occult blood stool tests (FOBT). Endoscopy includes: proctoscopy, flexible sigmoidoscopy, and colonoscopy. Because the questions used in the NHIS differ over the sampling time frame, the specific tests included in the coding depend on the year. In 1992 and 1998, endoscopy represents a proctoscopy; in 2003 and 2008, endoscopy represents a proctoscopy, sigmoidoscopy, or colonoscopy. In 2013, endoscopy represents sigmoidoscopy or colonoscopy. I categorize all three tests together because they are all invasive procedures that feature using an endoscope to examine the gastrointestinal tract. The FOBT question in the NHIS has remained consistent over the years of interest, asking if the respondent has "ever had a blood stool test using a home kit test." Both the endoscopy and FOBT variable are coded as binary variables with those who have never received the test serving as the reference group.

Independent. The three main predictors of interest are (1) education, (2) insurance status, and (3) year. The IHIS dataset has educational attainment coded as distinct categories for completing kindergarten through Grade 12, and additional categories for 1 to 3 years of college, four years of college/Bachelor's degree, and 5 or more years of college (the IHIS does not distinguish between advanced degrees or a five-year bachelor's). I recode this variable to four categories: less than high school, high school (including those with some college), four years of college ("college"), and five or more years of college ("more than college"). This coding aims to capture the graded relationship between educational attainment and screening participation. High school is the reference category in order to compare the effects of more or less education to the most common level of education in my sample.

Insurance status is coded dichotomously, with the reference category including those with no insurance coverage. No insurance includes respondents who do not have private insurance, or any public health insurance coverage such as Medicaid, Medicare, or military health care. One important exception is that those covered by the Indian Health Service, or only a single-service plan (such as dental care) are included as uninsured. Year is included as a continuous variable, from 1992 coded as 0 to 2013 coded as 21.

Control. Several demographic and household factors influence screening participation and are included as covariates (Beydoun & Beydoun, 2008; Doubeni et al., 2009; Klabunde et al., 2011; Meissner, Breen, Klabunde, & Vernon, 2006; Walter et al., 2009). Household poverty status is dichotomously coded as households whose family-size adjusted incomes fall above the U.S. federal poverty threshold (reference) and the households whose income falls below the poverty threshold. Because 18 percent of households are missing responses for this variable, missing respondents are included as their own category. Race/ethnicity is categorical and coded as: non-Hispanic white (reference), non-Hispanic black, Hispanic, and other/multiple races. Age, measured in years, is modeled as a continuous variable from age 50-85, with 85 or older top-coded. Gender and marital status are both dichotomous variables with male and currently married as the respective reference categories.

Health-related factors also influence use of CRC screenings. Self-rated health, individual history of cancer, individual smoking status, and access to regular care, and use of the other type of CRC screenings are all included as covariates (Ahmed, Pelletier, Winter, & Albatineh, 2013; Beydoun & Beydoun, 2008; Klabunde et al., 2009). Self-rated health is a dichotomous variable with those reporting good, very good, or excellent health (as opposed to fair or poor) as the reference category. Individual history of cancer indicates whether a doctor has ever told the respondent that they have cancer, with no history of cancer as the reference category. Smoking status includes three categories: never smoked (reference), former smoker, or current smoker. Access to care is a dichotomous variable with individuals who have reported a place that they usually go when they are sick or need advice as the reference and those who do not have a usual place of care as the comparison group. Finally, I control for whether the individual has received the other screening type (endoscopy or FOBT) in order to adjust for those who have received multiple screenings, with one test potentially being the follow-up to another.

Analytic Strategy

The analysis proceeds in four main steps. First, I present descriptive statistics for the dataset (Table 1). I also report the conditional proportion using screens given each variable of interest. Wald chi-square tests test if the categories have significantly different proportions using each screening.

Next, in Table 2, I use logistic regressions (presented in odds ratios) to analyze the likelihood of using endoscopy tests based on my variables of interest. In Table 3, I perform the same process for predicating odds of using FOBT tests. In both tables, I present the models in three parts. The first model is an empty model with education as the main predictor, adjusting for demographic covariates: poverty status, gender, race/ethnicity, age, and marital status. Next, I introduce insurance status to the models, to test the independent effects of insurance, past the effects of education and income. In the third model, I adjust for the health-related covariates, testing if the effects of education and insurance on screening participation are explained by health and health care usage differences.

Third, I test the hypotheses regarding a widening gap in uptake over time by interacting the education and insurance variables with the year of survey (Table 4). I present the predicted probability of using endoscopy and FOBT tests based on insurance and educational attainment over time. Because logistic regression is a nonlinear model, coefficients should not be compared across models (Long, 2009; Long & Freese, 2014). Instead, using predicted probabilities allows me to compare groups because these measures are not influenced by group differences in residual variation (Long, 2009). I computed predicted probabilities using Stata's Margins command and present them in two figures to demonstrate the changing influence of education and insurance status across time.

Finally, I compare how the predicted probabilities of endoscopy and FOBT use are influenced by education and insurance. I compute the average marginal effects of insurance and education on the predicted probability of each screening participation, comparing how the effects differ for endoscopy and FOBT use. I calculate these figures from Stata's Margins, (dydx) command. To compute the average marginal change of the predicted probability when (1) when comparing a high school degree to less than a high school degree, a college degree, and more than a college degree while holding all other variables at their means and (2) moving from no insurance to insurance while holding all other variables at their means. Therefore, I am able to determine if education and income have a greater average marginal effect in predicting endoscopy use compared to FOBT use. I present these findings in a bar graph, Figure 5. All analyses were completed in STATA 14.0 (StataCorp, 2015).

RESULTS

Table 1 shows the summary statistics and conditional proportions of screening participation for all variables analyzed. The first column presents the weighted description of the sample across variables analyzed. In my sample, 38% report ever having had an FOBT and 51%

have ever had an endoscopy. Most respondents have health insurance (91%) and the majority have only a high school degree (59%). The second and third columns present the proportion using endoscopy and FOBT tests given the variable of interest, the 95% confidence interval for the statistic, and results of a Wald chi-square test. For both endoscopies and FOBTs, increasing levels of education correspond with significantly higher proportions ever using the screenings. The insured have significantly higher proportions ever using endoscopies (an increase of 23%) and FOBTs (an increase of 16%). These relationships, however, could be confounded by health- or demographic-related factors, so formal regression tests are performed below. Finally, there are opposing tends in participation over time for the two tests; the proportion of the sample ever using endoscopies increases over the years of interest while the proportion using FOBTs decreases.

Table 1. Weighted conditional proportions for ever had fecal-occult blood test (FOBT) or endoscopy for variables analyzed, NHIS (n=51385)

	Overall Proportion	Ever had FOBT	95% CI		Ever had Endoscopy	95% CI	
Endoscopy Use							
Never had Endoscopy	0.49	0.26	(0.25,0.26)	***			
Ever had Endoscopy	0.51	0.50	(0.49,0.50)	***			
FOBT Use							
Never had FOBT	0.62				0.41	(0.40,0.42)	***
Ever had FOBT	0.38				0.66	(0.66,0.67)	***
Education							
Less than high school	0.18	0.32	(0.31,0.33)	***	0.38	(0.37,0.39)	***
High school	0.59	0.38	(0.37,0.39)	***	0.50	(0.49,0.51)	***
College	0.14	0.39	(0.38,0.41)	***	0.58	(0.57,0.59)	***
More than college	0.10	0.46	(0.44,0.47)	***	0.65	(0.63,0.66)	***
Insurance Status							
No Insurance	0.09	0.23	(0.22,0.25)	***	0.30	(0.29,0.32)	***
Any Insurance	0.91	0.39	(0.39,0.40)	***	0.53	(0.52,0.53)	***
Year							
1992	0.04	0.60	(0.58,0.62)	***	0.39	(0.37,0.41)	***
1998	0.20	0.51	(0.50,0.53)	***	0.37	(0.36,0.39)	***
2003	0.23	0.37	(0.36,0.39)	***	0.44	(0.42,0.45)	***
2008	0.24	0.35	(0.34,0.36)	***	0.55	(0.54,0.56)	***
2013	0.29	0.28	(0.27,0.29)	***	0.63	(0.62,0.64)	***
Poverty status							
Not poor household	0.72	0.39	(0.39,0.40)	***	0.54	(0.53,0.54)	***
Poor household	0.10	0.28	(0.27,0.29)	***	0.39	(0.37,0.40)	***
Missing	0.18	0.36	(0.35,0.38)	***	0.44	(0.43,0.46)	***
Race/Ethnicity							
Non-hispanic white	0.80	0.40	(0.39,0.40)	***	0.52	(0.52,0.53)	***
Non-hispanic black	0.10	0.33	(0.32,0.35)	***	0.46	(0.45,0.48)	***
Latino	0.07	0.24	(0.23,0.26)	***	0.38	(0.37,0.40)	***
Other/ multiple races	0.03	0.30	(0.28,0.32)	***	0.43	(0.40,0.45)	***
Sex							
Men	0.42	0.37	(0.36,0.38)	***	0.52	(0.52,0.53)	***
Women	0.58	0.39	(0.38,0.39)	***	0.49	(0.49,0.50)	***
Mean Age (std dev)	64.96 (.067)						
Marital status							
Married	0.49	0.40	(0.39,0.40)	***	0.53	(0.52,0.54)	***
Not married	0.51	0.36	(0.35,0.37)	***	0.48	(0.48,0.49)	***
Smoking status							
Never smoked	0.49	0.37	(0.36,0.37)	***	0.50	(0.49,0.51)	***
Former smoker	0.34	0.43	(0.42,0.44)	***	0.57	(0.56,0.58)	***
Current smoker	0.17	0.31	(0.29,0.32)	***	0.40	(0.38,0.41)	***
Self-rated health							
Good/Excellent	0.79	0.38	(0.37,0.38)		0.51	(0.50,0.51)	
Fair/Poor	0.21	0.38	(0.37,0.39)		0.51	(0.49,0.52)	
Cancer History							
No history of cancer	0.84	0.36	(0.35,0.36)	***	0.48	(0.47,0.48)	***
History of cancer	0.16	0.49	(0.47,0.50)	***	0.67	(0.66,0.68)	***
Access to care							
Regular acces to care	0.93	0.39	(0.39,0.40)	***	0.53	(0.52,0.53)	***
No regular access to care	0.07	0.16	(0.15,0.17)	***	0.21	(0.19,0.22)	***

Wald chi-square test, *p≤05 **p≤.01 **p≤.001

Tables 2 and 3 present the results of a sequence of logistic regressions predicting whether the individual has ever used an endoscopy or FOBT test, respectively. Model 1, controlling for demographic factors, shows a graded effect of increasing educational attainment on odds of ever using endoscopies and FOBT tests. Compared to those with high school degrees, those with less than high school degrees are less likely to have ever had an endoscopy (OR=.58, p<.001) and an FOBT (OR=.80, p<.001). The odds of having an endoscopy increases for those with a college degree (OR=1.43, p<.001) and more than a college degree (OR=1.88, p<.001. Similarly, the odds of ever having an FOBT increases for those with a college degree (OR=1.10, p<.001) and more than a college degree (OR=1.40, p<.001). Therefore, for both endoscopy and FOBT use, education is a significant predictor of usage, with each higher level of educational attainment significantly increasing the odds of having a screening. Importantly, financial differences do not fully explain education-based differences in screening participation.

Table 2. Adjusted odds ratios for logistic regressions predicting ever used endoscopy for adults older than 50, 1992-2013.

	Model 1			Model 2			Model 3		
	OR		**95% CI**	**OR**		**95% CI**	**OR**		**95% CI**
Education (ref=high school)									
Less than high school	0.58	***	(0.54,0.61)	0.58	***	(0.55,0.61)	0.70	***	(0.66,0.74)
College	1.43	***	(1.35,1.52)	1.41	***	(1.32,1.49)	1.29	***	(1.21,1.38)
More than college	1.88	***	(1.75,2.01)	1.82	***	(1.70,1.95)	1.67	***	(1.55,1.80)
Insurance (ref=no insurance)				1.86	***	(1.71,2.01)	1.61	***	(1.48,1.76)
Poverty status (ref=not poor)									
Poor household	0.73	***	(0.68,0.79)	0.76	***	(0.71,0.82)	0.77	***	(0.71,0.83)
Missing	0.66	***	(0.62,0.70)	0.66	***	(0.62,0.70)	0.80	***	(0.76,0.85)
Race/Ethnicity (ref=non-hispanic white)									
Non-hispanic black	1.02		(0.95,1.10)	1.04		(0.97,1.11)	0.99		(0.93,1.07)
Hispanic	0.77	***	(0.72,0.83)	0.81	***	(0.75,0.87)	0.80	***	(0.74,0.86)
Other/Multiple	0.67	***	(0.60,0.75)	0.69	***	(0.61,0.77)	0.68	***	(0.60,0.77)
Sex (ref=men)	0.91	***	(0.87,0.94)	0.89	***	(0.85,0.92)	0.88	***	(0.84,0.92)
Age	1.04	***	(1.03,1.04)	1.03	***	(1.03,1.03)	1.02	***	(1.02,1.02)
Marital status (ref=married)	0.83	***	(0.79,0.86)	0.85	***	(0.81,0.89)	0.86	***	(0.82,0.91)
Smoking status (ref=never smoked)									
Former smoker							1.26	***	(1.19,1.32)
Current smoker							0.90	**	(0.84,0.96)
Self-rated health (ref=good/excellent)							1.13	***	(1.07,1.19)
History of cancer (ref=no hisory)							1.68	***	(1.59,1.79)
Access to care (ref=no access)							0.40	***	(0.36,0.45)
Year							1.09	***	(1.09,1.10)
Ever had FOBT							3.20	***	(3.05,3.36)
N	51385			51385			51385		

Note: Estimates are adjusted for survey design. Source is National Health Interview Survey.

*p≤05 **p≤.01 **p≤.001

Table 3. Adjusted odds ratios for logistic regressions predicting ever used fecal occult blood test (FOBT) for adults older than 50, 1992-2013

	Model 1			Model 2			Model 3		
	OR		95% CI	OR		95% CI	OR		95% CI
Education (ref=high school)									
Less than high school	0.80	***	(0.75,0.85)	0.80	***	(0.75,0.85)	0.75	***	(0.70,0.80)
College	1.10	**	(1.03,1.17)	1.08	*	(1.01,1.15)	1.08	*	(1.01,1.16)
More than college	1.40	***	(1.30,1.51)	1.37	***	(1.27,1.47)	1.27	***	(1.17,1.37)
Insurance (ref=no insurance)				1.57	***	(1.45,1.70)	1.06		(0.97,1.16)
Poverty status (ref=not poor)									
Poor household	0.72	***	(0.66,0.77)	0.74	***	(0.68,0.80)	0.80	***	(0.74,0.87)
Missing	0.83	***	(0.79,0.88)	0.84	***	(0.79,0.89)	0.79	***	(0.74,0.83)
Race/Ethnicity (ref=non-hispanic white)									
Non-hispanic black	0.90	**	(0.84,0.97)	0.91	**	(0.85,0.98)	0.99		(0.92,1.06)
Hispanic	0.59	***	(0.54,0.64)	0.61	***	(0.56,0.66)	0.75	***	(0.69,0.82)
Other/Multiple	0.67	***	(0.60,0.75)	0.69	***	(0.61,0.77)	0.88	*	(0.78,0.99)
Sex (ref=men)	1.12	***	(1.07,1.17)	1.10	***	(1.06,1.15)	1.14	***	(1.09,1.20)
Age	1.03	***	(1.02,1.03)	1.02	***	(1.02,1.03)	1.01	***	(1.01,1.02)
Marital status (ref=married)	0.82	***	(0.79,0.86)	0.84	***	(0.80,0.87)	0.93	**	(0.89,0.97)
Smoking status (ref=never smoked)									
Former smoker							1.17	***	(1.12,1.23)
Current smoker							0.93	*	(0.87,1.00)
Self-rated health (ref=good/excellent)							1.08	**	(1.02,1.15)
History of cancer (ref=no hisory)							1.34	***	(1.26,1.42)
Access to care (ref=no access)							0.43	***	(0.39,0.48)
Year							0.91	***	(0.91,0.91)
Ever had endosocpy							3.21	***	(3.06,3.37)
N	51385			51385			51385		

Note: Estimates are adjusted for survey design. Source is National Health Interview Survey.
*p≤.05 **p≤.01 **p≤.001

In Tables 2 and 3, Model 2 introduces health insurance, testing how insurance influences screening participation after adjusting for other socioeconomic differences. These models show that having insurance is a significant predictor of screening participation; it increases the odds of ever using an endoscopy by 86% and of ever using a FOBT test by 57%. When adjusting for insurance, education remains a significant predictor of screening participation, suggesting that the predictive power of education remains after adjusting for insurance differences.

Model three adjusts for health-related factors and year. After adjusting for health factors—smoking status, self-rated health, and history of cancer—and health care factors—use of another CRC screening or regular access to a physician—education remains a significant predictor of both endoscopy and FOBT use. This suggests that educational differences in screening participation are not only due to educational differences in health status or health care access. Finally, after adjusting for health and health care factors, the insurance coefficient is no longer significant for predicting FOBT use, suggesting that the predictive power of insurance for FOBT use is explained mainly by other health factors. However, the relationship between insurance and screening participation could vary across years, which is analyzed below.

The estimated effects of all other covariates are in the expected directions. Specifically, the odds of ever using both endoscopy and FOBT tests increase with age, those with fair or poor self-rated health, and former smokers. The odds of ever using the tests decreases with those living in a poor household, for racial and ethnic minorities, those not married, current smokers, and those with no regular access to care. Women have lower odds of using endoscopy and higher odds of using FOBTs. Two covariates, that are particularly important predictors of screening participation are individual history of cancer and if the individual has used the other screening type. This shows that individuals who are at risk of cancer may get more screenings and those who have received a screening in the past are more likely to get another.

Screening participation across survey year. Next, I analyze whether the relationship between education or insurance status and screening participation varies across years. Table 4 presents the results of interactions between the survey year and insurance status and then with educational attainment, adjusting for all covariates. The majority of the interaction coefficients are significant, suggesting that the effects of education and insurance do change across time. To illustrate these results, I calculate the predicted probability of ever using tests, holding all other variables at their mean (Figures 1 and 2) disaggregated by education (Panel A) and insurance (Panel B).

Table 4. Adjusted odds ratios for logistic regressions predicting ever use endoscopy and fecal occult blood test (FOBT) for adults older than 50, interacting education and insurance with year, 1992-2013.

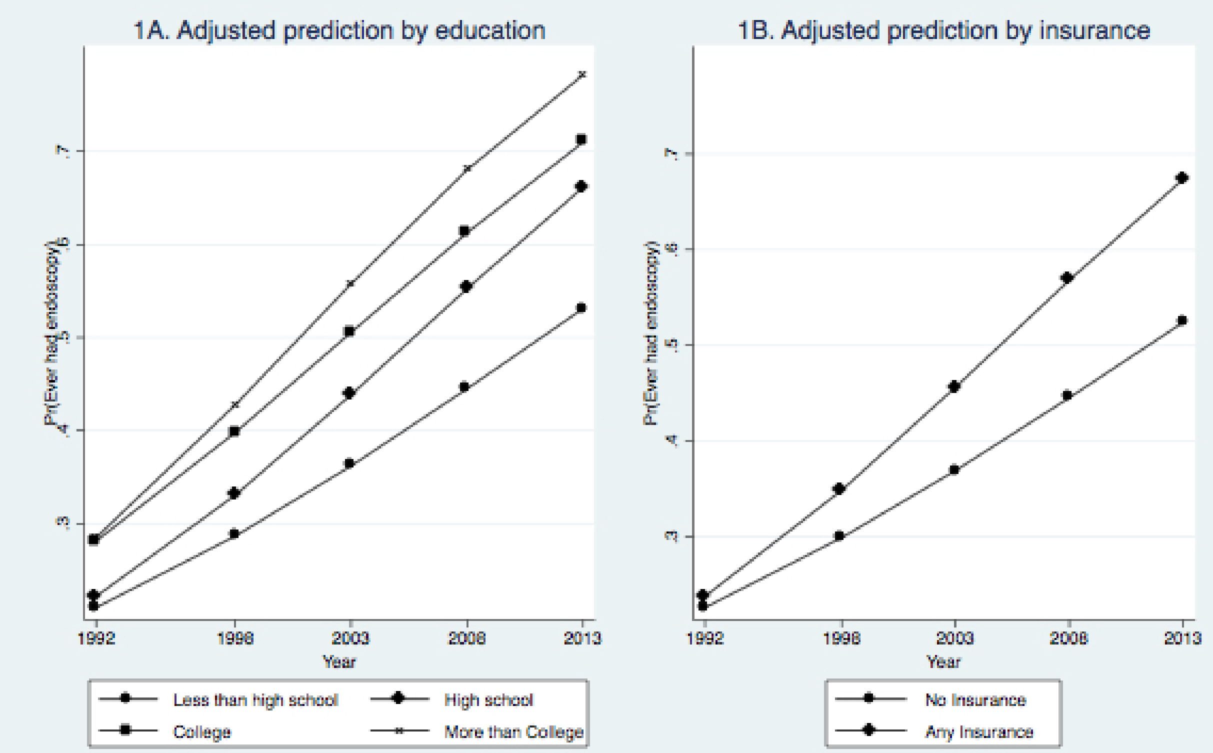
	Predicting Endosocpy				**Predicting FOBT**			
	Model 1		Model 2		Model 3		Model 4	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Education (ref=high school)								
Less than high school	0.70 ***	(0.66,0.74)	0.93	(0.82,1.05)	0.75 ***	(0.70,0.80)	0.74 ***	(0.66,0.84)
College	1.29 ***	(1.21,1.38)	1.37 ***	(1.19,1.58)	1.08 *	(1.01,1.16)	1.37 ***	(1.17,1.60)
More than college	1.67 ***	(1.55,1.80)	1.40 ***	(1.18,1.66)	1.27 ***	(1.17,1.37)	1.52 ***	(1.28,1.80)
Insurance (ref=no insurance)	1.07	(0.87,1.31)	1.62 ***	(1.48,1.77)	1.46 ***	(1.23,1.75)	1.06	(0.97,1.16)
Year	1.07 ***	(1.05,1.08)	1.10 ***	(1.09,1.10)	0.93 ***	(0.92,0.94)	0.91 ***	(0.91,0.92)
Interactions								
Insurance x Year	1.03 ***	(1.01,1.04)			0.98 ***	(0.96,0.99)		
Less than high school x year			0.98 ***	(0.97,0.99)			1.00	(0.99,1.01)
College x year			1.00	(0.99,1.01)			0.98 **	(0.97,0.99)
More than college x year			1.01 *	(1.00,1.02)			0.99 *	(0.98,1.00)
N	51385		51385		51385		51385	

Note: Estimates are adjusted for survey design, household poverty, race/ethnicity, sex, age, marital status, smoking status, self-rated health, history of cancer, access to care, and ever had other CRC screen. Source is National Health Interview Survey.

*p≤05 **p≤.01 **p≤.001

For predicting endoscopy use, the coefficient for less than high school interacted with year is negative and significant (OR=.98), while the more than college interaction term is positive and significant (OR=1.01). These coefficients indicate the additional effects that each year has on the relationship between education and screening participation. With each additional year, those with less than a high school degree are 2% less likely to use screenings and those with more than four years of college are 1% more likely to use screenings than those with only a high school degree. There is no significant difference between college and high school educated individuals over time. Figure 1A shows that all education groups saw increases in the predicted probability of using endoscopies, but at varying rates. Comparing less than high school and high school, there is little difference in the probability of endoscopy use in 1992. But by 2013, a clear disparity in predicted use is shown. A similar divergence occurs when comparing the predicted probabilities of college and more than college.

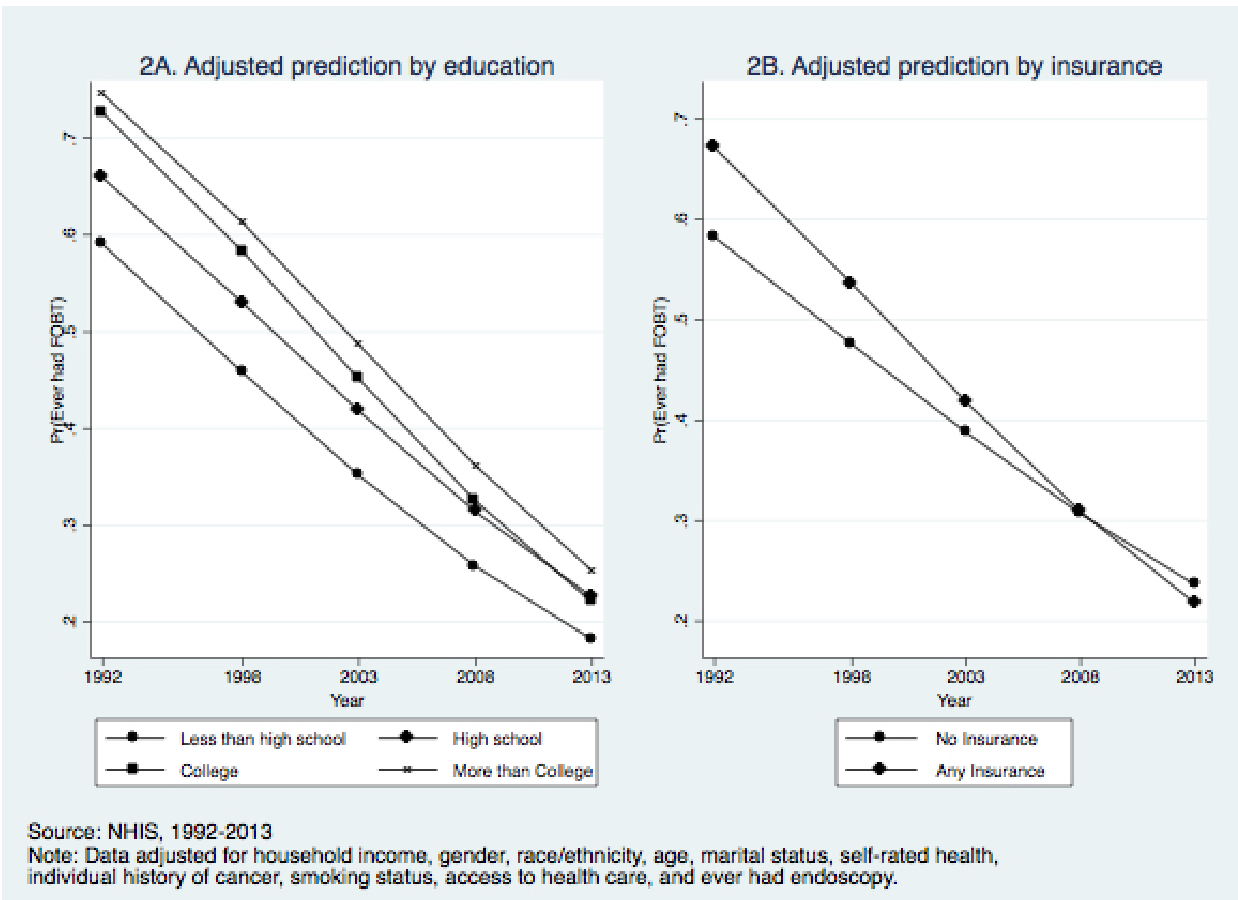
Figure 1. Predicted probability of endoscopy use by education and insurance.



Source: NHIS, 1992-2013
Note: Data adjusted for household income, gender, race/ethnicity, age, marital status, self-rated health, individual history of cancer, smoking status, access to health care, and ever had FOBT.

The interaction between insurance and year follows a similar trend when predicting endoscopy use. While in 1992, there is not a significant difference in endoscopy use by insurance status (indicated by the main effect of insurance), with each additional year, those with insurance have 3% higher odds of using screenings. Figure 1B shows this trend, demonstrating the diverging pattern by insurance status. Where there was little difference in predicted probability of endoscopy use by insurance in 1992, there is a clear disparity by 2013.

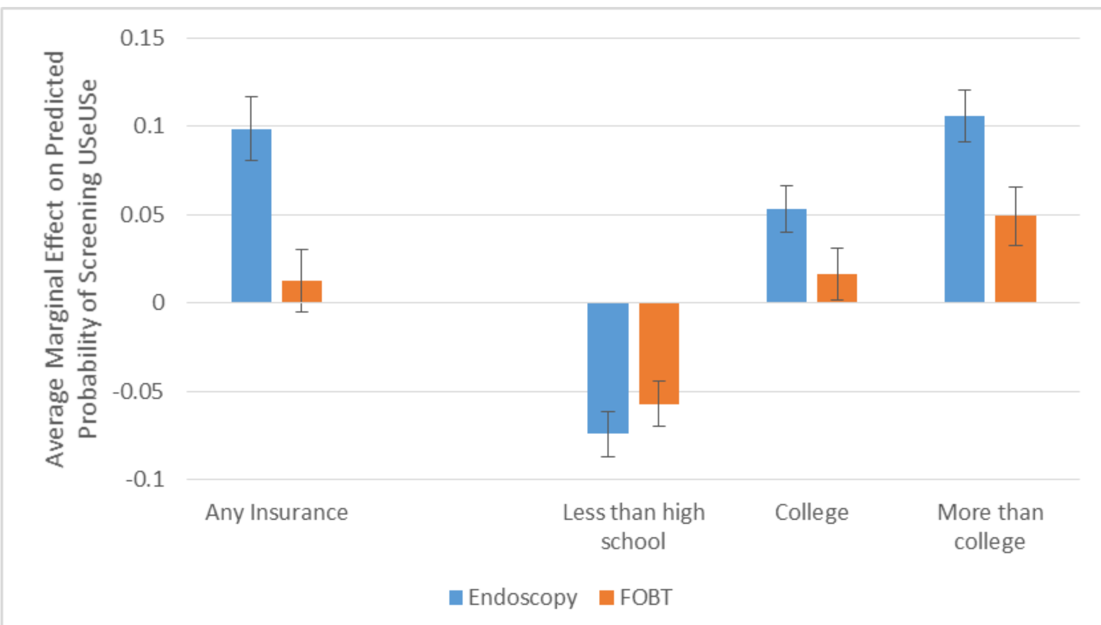
Figure 2. Predicted probability of fecal occult blood test use by education and insurance.



For the predicted probability of FOBT use, the educational disparity slightly shrinks over time. The odds of ever using an FOBT decrease by 2% each year for those with a college degree and by 1% for more than a college degree. There is no significant difference between less than high school and high school over time. Figure 2A shows these results; the converging pattern is only apparent for the disparity between a high school degree and a college degree. Otherwise, the effects of education do not vary across the years.

Finally, a similar converging pattern by insurance status is clear for FOBT use. In 1992, the odds of receiving an FOBT were 46% higher for the insured (indicated by main effect of insurance), but this disparity shrinks every year. The interaction term shows that with each additional year, those with insurance have 2% fewer odds of using FOBTs. Figure 2B shows that while an insurance-based disparity is detected in 1992, by 2008, the disparity in predicted FOBT use disappears.

Figure 3. Average Marginal Effect of Insurance and Education on the Predicted Probability of Endoscopy and FOBT Use for Adults over 50 between 1992 and 2013.



Note: Estimates from Table 2, Model 3 and Table 3, Model 3. Estimates adjusted for household poverty, race/ethnicity, sex, age, marital status, smoking status, self-rated health, history of cancer, access to care, and year. Reference categories are no insurance and a high school degree. Data from NHIS.

Screening type difference. Finally, the results presented in Figure 3 show that the effect size of education and insurance is larger for predicting endoscopy use compared to FOBT usage. This figure presents the average marginal effect of insurance and education attainment on the probability of using each of the two screenings, controlling for all covariates. For example, the "Any Insurance" bar shows the change in predicted probability of endoscopy and FOBT for those who have insurance, compared to those who do not. Likewise, the education bars show the contribution that education has on individual's predicted probability of getting an endoscopy or FOBT, with the comparison group as those with only a high school degree. The graph shows that for the average individual, having insurance, a college degree, and more than a college degree increases the predicted probability of getting an endoscopy significantly more than it increases the predicted probability of having an FOBT. While having insurance increases the predicted probability of getting an endoscopy by about 10%, it does not significantly increase the probability of getting an FOBT. Likewise, having a college degree increases the probability of using an endoscopy by about 5%, while increasing the probability of using an FOBT by 1.6%. A similar pattern occurs for having more than a college degree. These differences in effect sizes suggest that the probability of using an endoscopy is more strongly influenced by educational level and insurance status than the probability of using an FOBT.

DISCUSSION

While research has demonstrated clear emerging socioeconomic disparities in colorectal cancer mortality (Saldana-Ruiz et al., 2012; Wang et al., 2012), there are no known studies that have tested how individual use varies by socioeconomic factors over time or potential methods to minimize these disparities. This study analyzes the influence of education and insurance on use of CRC screenings, specifically considering how the association has changed over time and varies by screening type. The findings suggest that education and insurance are associated with use of CRC screenings and that this association has strengthened over time for endoscopy use. The findings have important implications for understanding the uptake of medical innovations and for the fundamental cause theory.

First, this study finds that differences in educational attainment endure as strong predictors of screening participation across all years, providing support for Hypothesis 1. I find that for both endoscopy and FOBT use, the effects of education are graded, with significant differences in odds of use between each educational group. This finding demonstrates the structural resources that are associated with educational attainment, robust after controlling for material conditions, health differences, and demographic differences. This confirms past research on the strong effects of education for influencing health behaviors because of the social resources that are distributed across educational lines (Lutfey & Freese, 2005; Phelan, Link, & Tehranifar, 2010). These resources, based on where individuals live, work, and socialize, in addition to cognitive resources that come with education, allow individuals to have access to information on screening recommendations and the ability to likely adopt the most recent recommendation.

Second, the educational disparities in endoscopy use appear to be slightly widening over time, lending partial support to Hypothesis 2. The analysis shows that while all educational groups see increases in the probability of having an endoscopy between 1992 and 2013, those with more than a college degree have a steeper increase while those with less than a high school degree's increase is more gradual. This is consistent with previous research that shows how SES disparities in CRC mortality emerged in the 1990s, after the invention of CRC screenings (Saldana-Ruiz et al., 2012; Wang et al., 2012), but goes beyond broad area-level SES and mortality measures to test individual-level use of screenings. I confirm that educational disparities in screening grew over the 1990s and 2000s, and show that this is due to the differences in the extreme ends of the educational attainment spectrum and are primarily due to differences in endoscopy use over time (and not FOBT use).

The growing educational disparity in the use of endoscopies may be partially explained by the growing scientific consensus in the effectiveness of CRC screenings. For example, in 2008, United State Preventative Services Task Force published recommendations that concluded with stronger evidence that CRC screenings are effective and not harmful. While most research on the SES-disparities in the uptake of innovation considers the time period when the the technology was invented (for example Saldana-Ruiz et al., 2012), my findings suggest that education becomes increasingly relevant between 1992 and 2013 with new scientific evidence of effectiveness.

Third, this study considers the relationship between insurance and screening participation over time. I find that insurance is a significant predictor of both endoscopy and FOBT use, and its influence has grown over time for predicting endoscopy use. These findings lend support for Hypothesis 3 and partial support for Hypothesis 4. Insurance is likely linked to screening type usage because it decreases the financial burden of health care and because it allows for more regular contact with primary care physicians, who often recommend preventative screenings (Zapka et al., 2002; Seef, 2004). Insurance may have become more influential over time because of changing insurance policies over the periods between 2001 and 2013 as insurance policies began covering CRC screenings, making insurance a stronger financial resource. This finding contributes to the fundamental cause theory by introducing access to insurance as a financial resource associated with behavioral changes. This study shows how access to insurance can act as a financial resource that influences health care usage, independent of education and income. Future research on the uptake of innovation must consider how social conditions, beyond traditional measures of SES, predict technology diffusion or uptake including considerations of social factors such as welfare state policies, geography, and race or ethnicity.

Finally, this study finds that education and insurance appear to be more relevant for predicting endoscopy use compared to FOBT use, providing support for Hypothesis 5. Both education and access to insurance led to widening disparities for endoscopy use over time, while there were diminishing or unchanging insurance-based and educational disparities for FOBT use. Furthermore, insurance and educational resources had a larger marginal effect in predicting endoscopy use compared to FOBT use. These findings suggest that social and economic resources are more consequential for predicting use of technologies that are complicated, expensive, or invasive. This finding provides evidence for modifying the fundamental cause theory's prediction on how technology uptake is linked to social and economic resources. The original statement of the theory suggests that social and economic resources will be tied to the uptake of *all* new medical information or technology (Link et al., 1998; Phelan et al., 2004). The present study, however, shows that the type of technology is also of interest. The technology type may make social resources more or less important, leading to larger socioeconomic disparities for use of complicated technologies. Chang and Lauderdale (2009) introduced this modification while studying statin use, but did not find that statins—potentially a simplifying technology—minimized SES disparities in cholesterol. This study develops their theory by comparing two tests for the same disease that are equally recommended. In comparing the use of endoscopies and FOBT tests, complicating and simplifying respectively, I find support for the hypothesis that social and economic resources are more strongly tied to the use of complicated technology. This suggests that simple technologies could make socioeconomic status less relevant for health outcomes.

In addition to these important findings, there are several limitations to this study. First, the analysis only studies change between 1992 and 2013. If data were available, tracing uptake of screenings from their inception in the 1980s would give a fuller picture of the influence of social factor. Additionally, the data do not capture the full impact of the Affordable Care Act, which has major implications for the democratization of access to insurance and screenings. Future studies should consider the effects that expanded access to insurance has on use of health care and preventative screenings. The findings from this study suggest that democratized access to insurance will facilitate increased use of preventative health care, lending support to expanded insurance coverage for health screenings in the face of future reforms. However, as access to insurance is expanded, policy makers must be cognizant that those without insurance will likely be further isolated and excluded from access to preventative health care. Future research can also examine the ways that expanded access to insurance changes the relationship between education and screening participation.

Second, my data only provide a cross-sectional representation of individual use of CRC screenings. Therefore, I am not able to follow people through time to capture the frequency of screening participation. The FOBT tests are currently recommended yearly, while flexible sigmoidoscopies are recommended every five years and colonoscopies every ten years. This analysis does not capture if individuals are fully in compliance with current recommendations. Instead, it captures whether a respondent has *ever* used a screening, giving only one indication of technology uptake. Although I control for history of cancer and use of another screening, the analysis cannot conclude if all screening were used as a preventative measure or whether the test was used to diagnose cancer or follow-up after a surgery.

Finally, the analysis does not differentiate by insurance type. Medicare began covering CRC screenings much earlier than both private plans and Medicaid, so specific insurance plans are likely influences on screening uptake. Specifications of insurance plans are not captured in this analysis because the NHIS changed insurance-specific questions in 1997, making specific comparison before and after 1997 difficult (IHIS, 2016). Furthermore, 91% of the sample reports having insurance, leaving a smaller comparison group, which is a source of methodological concern. While this study does not make comparisons between private and public forms of insurance, it does show that access to any type of insurance influences screening participation, providing support for expanding access to insurance regardless of funding source.

CONCLUSION AND POLICY IMPLICATIONS

This study finds that the CRC screening participation is shaped by social factors such as insurance status and education. Compared to FOBT use, education and health insurance are more strongly linked to endoscopy use, likely because it is complicated, invasive, and expensive. The study's findings suggest certain policy changes could increase the use of preventative health screenings. Education remains an important predictor of technology use, even after taking into account access to insurance and technology type. Education acts as a pervasive and consistent resource for encouraging preventative health care usage. Though policy makers can address intervening factors such as access to insurance, they must not forget these root causes of disparities in health care usage. Also, access to insurance is important for preventative health care usage. Policy makers should continue to work to further expand access to insurance, especially insurance policies that reduce cost-sharing mechanisms for preventative health. Finally, policy-makers must consider the types of technologies to invest in. All technologies may not have the same disparity-creating potential: social factors are likely less relevant for predicting use of simplifying technologies (like FOBTs). Screenings that can be used at home and are inexpensive will encourage widespread use. Therefore, policy makers should invest in and reward innovation focused on simple, easily accessible, and inexpensive new technologies.

Social conditions are fundamental causes of health inequalities, which means structural social conditions endure in creating health inequalities. In order to equalize use of screenings, the unequal distribution of resources across society must be addressed. While these types of structural changes seem politically infeasible, this study finds that more measured policies should be protected. Protecting and expanding access to education, protecting and expanding access to insurance, and investing in easy-to-use technologies are three important steps to take.

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