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Predictors of Colorectal Cancer Screening Among Maryland Adults, Aged 50–75 Years

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Walden University
2020

Abstract

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by

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MS, Thomas Jefferson University, 2003

BS, Thomas Jefferson University, 2001

Dissertation Submitted in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy
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Abstract

Screening plays an essential role in reducing colorectal cancer (CRC) incidence and mortality rates, yet CRC screening use remains low in Maryland and lower in some age and racial/ethnic groups with limited resources to participate in CRC screening programs. The purpose of this quantitative, cross-sectional study is to investigate whether age group, sex, race/ethnicity, education level, income level, health insurance coverage, and access to health care professional can predict an individual, 50–75 years of age, in Maryland to take action to fully meet the United States Preventive Services Task Force CRC screening test recommendation within the recommended time interval. The health belief model and the fundamental cause theory provided the framework for this study. Secondary data of 2014, 2016, and 2018, from 3134 respondents in the Behavioral Risk Factor Surveillance Systems database, were analyzed using the Pearson chi-square test of independence and multiple logistic regression techniques. Stratified random sampling was used to select cases. The results revealed statistically significant ($p < .05$) association between age, race/ethnicity, education level, access to health care professional, and CRC screening use. However, non-significant ($p > .05$) association was found between income level, health insurance plan, and CRC screening use. Age group and race/ethnicity were confounders on the association, but sex had no effect on the odds ratios. By identifying the predictors of CRC screening use, findings from this research could have positive social change and guide policy decisions by informing public health practitioners on the design and implementation of tailored CRC screening programs with modalities that target groups with lower CRC screening use.

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Dedication

This dissertation project is dedicated to my late mother Mama Miriam Muyang Asangong, who passed on to glory in 1979 and did not have the least opportunity to see me grow nor enjoy the fruits of her labor. A special dedication goes to my father Pa Peter Asangong who had always believed I was his doctor and wished to officially address me “Doctor”. He passed away on July 19th, 2017 while I was already in the Ph.D. program; hence could not physically attend my third graduation of what he had termed “People’s Highest Degree”. My father lived a very humble life while working tirelessly to single handedly raise 7 children of whom I am the lucky 6th. With not much academic education, because his parents could not afford it, my father’s emphasis on the importance of education to his children was something to admire, and that gave me the zeal to embark on this academic journey. I could not have done this without the inspiration from my parents. Your memory will continue to remain in my heart.

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Chapter 1: Introduction to the Study

Introduction

The National Cancer Institute (NCI) pointed out that cancer of the colon and the rectum have similar features (NCI, 2019). Hence the term *colorectal cancer* (CRC) is commonly used to describe cancer of the colon and/or the rectum (Bray et al., 2018). CRC is the third most common cancer diagnosed (Macrae, 2019; Simonson, 2018); and the second leading cause of cancer-related death among men and women in the United States (Ansa, Coughlin, Alema-Mensah, & Smith, 2018). According to the American Cancer Society (ACS), the lifetime risk for developing CRC is about 1 in 22 (4.49%) for men and 1 in 24 (4.15%) for women, showing a higher risk in men than in women (ACS, 2019). CRC is rare in children and relatively? common among adults, 45 years of age and older (Cardoso, Niedermaier, Chen, Hoffmeister, & Brenner, 2019); it is considered one of the most preventable and most treatable forms of cancer if detected early (Sauer, Siegel, Jemal, & Fedewa, 2019; Zauber et al., 2018). Therefore, increasing screening rates across all groups could ultimately save lives (Doubeni et al., 2019).

Researchers have determined that sociodemographic factors are predictors and those of lower socioeconomic status (SES) have lower odds of participating in or completing CRC screening programs (DeMoor et al., 2018; Miranda et al., 2017; Burnett-Hartman, Mehta, & Zheng, 2016; Wilder & Wilson, 2016). Given the benefits of screening and early detection of precancerous polyps, the objective of this study is to quantitatively determine predictors of CRC screening use, by utilizing sociodemographic and socioeconomic data derived from the Behavioral Risk Factor Surveillance System

(BRFSS) database. Although concerted public health efforts to prevent CRC have led to increases in CRC screening rates, disparities in CRC screening still persist in the United States (Burnett-Hartman, Mehta, & Zheng, 2016; Liss & Baker, 2014), with access to preventive health care service, such as health insurance coverage and access to physician services, at the forefront of barriers to CRC screening uptake among minority populations (DeGroff et al., 2018; Satsangi & DeGroff, 2016). Also, factors such as income (Woudstra, Smets, Verdam, & Fransen, 2019; Rodriguez, & Smith, 2016) and education level (Cross et al., 2019; Lee, Natipagon-Shah, Sangsanoi-Terkchareon, Warda, & Lee, 2019) play a significant role in CRC screening differences across groups.

This study was needed because it addresses an under-researched area of CRC screening use across different groups in Maryland (Maryland Department of Health 2016-2020 Cancer Report). Also, by identifying predictors of CRC screening through this study, community based screening programs tailored to specific groups can be implemented to reduce CRC related death in Maryland. Some researchers have suggested that organized mass screening could be a better approach to reduce deaths from CRC, than averting risk factors of CRC (Macrae et al., 2019; Cardoso, Niedermaier, Chen, Hoffmeister, & Brenner, 2019). In its efforts to reduce the CRC incidence and mortality rates, the National Colorectal Cancer Roundtable (NCCR) set a goal: to increase CRC screening rate in the U.S. from 58.6% in 2013 to ≥80% by 2018 (Ransohoff, & Sox, 2016), and pointed out that compliance with screening recommendations could reduce mortality and improve patients’ health and well-being (Bibbins-Domingo et al., 2016). This dissertation has the potential for positive social change by providing ways for public health professionals to design effective CRC screening programs that target groups with lower CRC screening use. By identifying the predictors of CRC screening use, clinicians could offer opportunistic and appropriate CRC screening modalities when patients visit the doctor’s office for other reasons. This research could also help Maryland to set new CRC screening priority strategies based on its current 2019–2021 cancer prevention plan.

The remainder of this chapter covers the following topics: the background information related to CRC screening as an effective method to reduce CRC incidence, the problem statement, purpose of the research, the research questions and hypotheses that identify the study objectives, an outline of the theoretical and conceptual framework that ground this study, nature of the study, definition of variables, assumptions, limitations, the scope and delimitations, and significance.

Background/Context

CRC is a serious public health problem in the U.S. (Bray et al., 2018). There is overwhelming evidence from the literature that screening can prevent CRC through early detection and removal of colorectal polyps before they become cancerous (Cardoso et al., 2019; Doubeni et al., 2019; Sauer, Siegel, Jemal, & Fedewa, 2019; Jeol et al., 2018; Levin et al., 2018; Li et al., 2018; Simonson et al., 2018; Bibbins-Domingo et al., 2016; Ransohoff, & Sox, 2016; Simon, 2016; Meester et al., 2015). CRC screening has also been identified as the most effective strategy to reduce economic burden related to CRC (Sharma, DeGroff, Scott, Shrestha, Melillo, & Sabatino, 2019; Zauber, 2012). Data from the NCI Surveillance, Epidemiology, and End Results (SEER) report showed an overall decrease in the CRC death rate (Noone et al., 2018); yet up to 145,600 new cases and

51,020 deaths from CRC was estimated in 2019 (ACS, 2019; Macrae, 2019). Although screenings have been credited for the drop in CRC incidence and mortality rates in the last ten years (Maxon, 2018; Simonson et al., 2018), participation in CRC screening remains a challenge in the U.S. (Wittich et al., 2019; Gonzales, Qeadan, & Mishra, 2017; Lin, McKinley, Sripipatana, & Makaroff, 2017; Burnett-Hartman, Mehta, & Zheng, 2016), and a hurdle in Maryland (Watkins et al., 2018; Ahmad, Hayes, Rich, & Stern, 2015; Richardson, King, Dwyer, Parekh, & Lewis, 2015).

There is substantial evidence from epidemiologic and modeling studies that statistically significant ($p < 0.001$) relationships exist between sociodemographic factors, socioeconomic factors, and CRC screening use (Cardoso et al., 2019; Macrae et al., 2019; O’Leary et al., 2019; Sauer, Siegel, Jemal, & Fedewa, 2019). Observational studies and systematic reviews have shown that programs that provide public funding for CRC screening and systematic access to physician counseling have a significant role in improving CRC screening rates and reduce disparities according to race/ethnicity and education (Simkin, Ogilvie, Hanley, & Elliott, 2019; DeGroff, et al., 2018; Singh et al. 2015). In a systematic review of CRC screening programs across all jurisdictions in Canada, 92% of those who did not undergo CRC screening were not counseled by their health care professional (Wee, McCarthy, & Phillips, 2005).

Results from a 2015 cross-sectional study using multiple logistic regression analysis revealed a statistically significant ($p < 0.001$) association between age group, health insurance coverage, and CRC screening uptake (De Moor et al., 2018). Among the 50–64-year age group, those with employer-sponsored insurance were more likely

(62.2%) to be screened compared to those with private direct purchase plans (50.9%) and the uninsured (24.8%); while among the 65–75-year age group, those with Medicare and private insurance were more likely (76.3%) to be screened, compared to those with Medicare (68.8%) and no supplemental insurance (De Moor et al., 2018). Furthermore, another cross-sectional study of screen-eligible adults revealed that, compared to insured adults, the underinsured and never-insured women were less likely (47%) to receive CRC screening; while the underinsured and never-insured men were less likely (52%) to receive CRC screening (Zhao, Okoro, Li, & Town, 2017). Moreover, Rogers et al. (2017) found that among the Black race group, those with public health insurance were more likely (90%) to be screened for CRC compared to those without health insurance.

Consistent with observational studies, researchers conducting retrospective and prospective studies have revealed a strong association between variables such as age, sex, race/ethnicity, income, education level completed, and CRC screening uptake (Ran et al., 2019; Liang & Dominitz, 2019; Molina-Barceló et al., 2018; Arana-Arri, et al., 2017; Holme et al., 2017; Kang & Son 2017; Lin, McKinley, Sripipatana, & Makaroff, 2017; Burnett-Hartman, Mehta, & Zheng, 2016; Mehta, Jensen, & Quinn, 2016). Likewise, factors such as lack of awareness, access to routine clinic visits (O'Leary et al., 2019; DeGroff, et al., 2018; Jackson, Goel, Kho, & Keswani, 2016; Wilder & Wilson, 2016), and inadequate access to a health care professional, have been associated with low prevalence of CRC screening among adults, 50–75 years of age (Simkin, Ogilvie, Hanley, & Elliott, 2019; Wong, 2015; Holden et al., 2010).

The United States Preventive Services Task Force (USPSTF) has recommended several tests for CRC screening, including stool-based and endoscopic methods known to be effective for CRC screening in average risk individuals, 50–75 years of age (USPSTF, 2018; Wolf et al., 2018). However, results from the 2015 National Health Interview Survey (NHIS) indicated that only 62.4% of individuals, age 50–75, received CRC screening according to the USPSTF recommendations (White et al., 2017). According to the National Institutes of Health, CRC screening is underused, and disparities in screening rates are apparent (Verma, Sarfaty, Brooks, & Wender, 2015). Despite increase access to health insurance with no cost-sharing for most health plans, many eligible adults in the U.S. (White et al., 2017; Wools, Dapper, & de Leeuw, 2016) and in Maryland (Watkins et al., 2018; MDH 2018 Cancer Report) are not screening according to USPSTF guidelines. In 2016, only 67.3% of age-appropriate individuals in the U.S. were up to date with CRC screening (CDC BRFSS, 2017). It is estimated that achieving the NCCR ≥80% CRC screening goal would result in 19% fewer CRC deaths (Simon, 2016), prevent 280,000 new CRC cases, and save 200,000 lives in the U.S. by 2030 (Meester et al., 2015). Nevertheless, Maryland is yet to meet its ≥80% CRC screening target (MDH 2016-2020, cancer report). Strategic efforts to increase CRC screening use and reduce differences in screening rates across groups are important to improve overall population health. The goal of this research is to obtain valid evidence regarding the hypothesis that there is a statistically significant relationship between socioeconomic factors, access to preventive health care services, and CRC screening use in Maryland.

Maryland is a state of diverse racial/ethnic subgroups, and a growing adult population. This study will fill a gap in knowledge and improve understanding in CRC screening practices across groups, by identifying the variables that predict CRC screening among men and women age 50–75 years. This study is unique, because it examines predictors of CRC screening use and provides evidence of the differences in CRC screening use across groups in the State. Results from this research will highlight the importance of early detection, and help public health professionals to gauge a careful plan, and design appropriate CRC screening programs with strategies to improve screening rates for specific groups. By identifying the predictors of CRC screening use through this research, public health policies could be initiated to support targeted, screening programs that are necessary to reduce the disease burden for the State.

Problem Statement

Despite evidence that screening and early detection were the clear reason for a drop in CRC-related incidence and mortality rates in Maryland between 2004–2014 (Richardson, King, Dwyer, Parekh, & Lewis, 2015), current literature reveals that, as of 2018, the overall CRC screening rate for Maryland was lower (68.6%) than state target of ≥80% and even lowest among Asians (53.6%) living in Maryland (Platz, 2018). Although previous studies on the predictors of CRC screening use illuminate significant findings, to the best of my knowledge, no prior research exists that quantitatively examines the sociodemographic and socioeconomic variables that predict CRC screening in the State of Maryland. The problem is that little information is available on factors that contribute to CRC screening use in Maryland (MDH, 2016–2020 cancer report). Given this fact, further research is justified to investigate the documented problem of low CRC screening use in Maryland (Brun & Kanarek, 2018; MDH, 2016–2020 cancer report; Platz, 2018; Watkins et al., 2018).

Purpose of the Study

The purpose of this study was to identify factors that can predict CRC screening use to improve understanding of CRC screening practices in Maryland. To address this gap, I employed a quantitative approach with a cross-sectional design using secondary data from the CDC BRFSS to determine whether the independent variables of age, sex, race/ethnicity, education level, household income, health insurance coverage, and access to healthcare professionals are associated with the dependent variable: CRC screening use in Maryland. In addition, age, sex, and race/ethnicity were used as covariates in the multiple logistic regression analysis to estimate associations and effect modification. These variables were important because previous studies, including systematic reviews, have shown statistically significant ($p < 0.001$) relationships between them and adherence to CRC screening (Cardoso et al., 2019; Macrae, 2019; O’Leary et al., 2019). Hence, it was essential to investigate their role in CRC screening use in Maryland.

Research Questions and Hypotheses

The research questions and hypotheses used in this study are as follows:

Research Question 1: Is there any association between socioeconomic status measured by education level, household income, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity?

H_{01}: There is no statistically significant association between socioeconomic status measured by education level, household income, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

H_{a1}: There is a statistically significant association between socioeconomic status measured by education level, household income, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

Research Question 2: Is there any association between access to preventive health care service measured by health insurance coverage, access to health care professional, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity?

H_{02}: There is no statistically significant association between access to preventive health care service measured by health insurance coverage, access to health care professional, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

H_{a2}: There is a statistically significant association between access to preventive health care service measured by health insurance coverage, access to health care professional, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

All variables were measured as categorical variables and coded during analyses for simplicity. Details of how these variables were measured and coded are described in chapter three of this dissertation; and the results, interpretation and discussion are provided in chapters four and chapter five respectively.

Theoretical Foundation and Conceptual Framework for the Study

The theoretical foundation and conceptual framework that guide this study are grounded in the health belief model (HBM), and the fundamental cause theory (FCT). Both the HBM and the FCT were best for this Maryland-based study because they have been successfully used to explore CRC screening predictors across groups (Hurtado et al., 2015). Additionally, using both the HBM and the FCT provided clues to answer research questions that could guide whether the state of Maryland would achieve and sustain its ≥80% CRC screening target (MDH, 2016–2020 cancer report).

Theoretical Foundation of the Health Belief Model

The HBM is a sociopsychological framework developed in the early 1950s by Hochbaum, Rosenstock, and Kegels to explain why only few people participate in programs to prevent and detect disease (Rosenstock, 1974). The HBM was later updated with more constructs to emphasize the motivational factors that encourage individuals to take action towards their health (Rosenstock, Strecher, & Becker, 1988). Key constructs of the HBM are perceived susceptibility, perceived severity, benefits, barriers, cues to action, and self-efficacy (Glanz, Rimer, & Viswanath, 2015). Among the six elements of the HBM, this study focused on the construct of cues to action, used to address research question of whether age, sex, race/ethnicity, and education level can predict individuals' action towards CRC screening after recommendation by a healthcare professional.

Conceptual Framework of the Health Belief Model

The HBM is a theoretical concept of proposed behavior designed to reduce health risk by identifying factors that can predict the likelihood of a person? to undergo a preventive action necessary to improve health (Rosenstock, Strecher, & Becker, 1988). There is extensive research that supports the use of the HBM as an effective conceptual framework to explain health behaviors across groups (Williams, Wilkerson & Holt, 2018; Heiniger, Sherman, Shaw, & Costa, 2015; Lee, Stange, & Ahluwalia, 2015; Sohler, Jerant, & Franks, 2015) and to increase CRC screening compliance across socioeconomic communities (Abuada et al., 2018; Bernardo et al., 2018; Almadi et al., 2015).

Researchers have successfully used the HBM to determine factors that predict CRC screening uptake across age, sex, race/ethnicity and socioeconomically deprived groups (Helander et al., 2018; Heiniger, Sherman, Shaw, & Costa, 2015) and suggested that components of the HBM can be used individually or in combination to explain health behaviors (Williams, Wilkerson & Holt, 2018; Heiniger, Sherman, Shaw, & Costa, 2015; Glanz, Rimer & Viswanath, 2015; Turner, Hunt, Dibrezzo & Jones, 2004). The construct of cues to action has been used to determine factors related to CRC screening uptake in the U.S. (Doubeni et al., 2012) and to facilitate understanding of screening behaviors through a recommended action that lead to positive CRC outcomes (Williams, Wilkerson & Holt, 2018). In relation to my research, the HBM construct of cues to action align with the research question of whether there is association between age, sex, race/ethnicity, education level, access to healthcare professional and CRC screening use.

Theoretical Foundation of the Fundamental Cause Theory

The FCT was formulated by Link and Phelan in 1995 to explain why the association between socioeconomic status (SES) and mortality persisted despite knowledge of risk factors that explain diseases (Link & Phelan, 1995). The major proposition of the FCT is that SES is a fundamental cause of health inequality (Link & Phelan, 1995). According to Link and Phelan, SES influences multiple disease outcomes through its association with multiple risk factors for disease and death (Phelan, & Link, 2005). The authors' justification is that social states, such as race and SES, contribute to disease outcomes because they impact available key resources, like knowledge, money, power, prestige, and beneficial social connections that are needed to combat disease (Phelan, Link & Tehranifar, 2010; Phelan, Link, Diez-Roux, Kawachi, & Levin, 2004). In line with the FCT, I sought to explain differences in CRC screening use among age, sex and race groups, and to identify which variables can predict CRC screening use based on income level and health insurance coverage as an available resource.

Conceptual Framework of the Fundamental Cause Theory

The FCT has been used to explain the implications of SES and social inequalities in cancer screening (Vanthomme, & Gadeyne, 2019; Vanthomme, Vandenheede, Hagedoorn, & Gadeyne, 2018; Hurtado et al., 2015; Goldberg, 2014; Shariff-Marco, Breen, Stinchcomb, & Klabunde, 2013). Researchers have successfully used it to investigate the effect of social inequality of factors such as age, sex, race, and socioeconomic quintile on CRC screening participation among adults aged 45–75 years (Shariff-Marco, Breen, Stinchcomb, & Klabunde, 2013). In line with the FCT, this study posited that those from minority race groups may have limited economic and financial resources to participate in CRC screening programs that can prevent disease (Araghi et al., 2019; Cross et al., 2019). Details of how the HBM and the FCT are applied in this study are explained in Chapter 2.

Nature of the Study

In this study I employed a quantitative methodology with a cross-sectional design that is descriptive in nature. The focus was on a predictive approach to determine association between the independent variables (education level, household income, health insurance coverage, access to healthcare professional), covariates (age, sex, race/ethnicity), and the dependent variable (CRC screening use). A quantitative approach was employed because it emphasizes objective and precise measurements of data (Kerry & Huber, 2018) and because it allowed me to determine differences, relationships and patterns between groups. Most importantly, the quantitative cross-sectional design allowed for data manipulation, such as creation of subgroups and coding of variables (Rudestam & Newton, 2015).

Secondary data were collected from the CDC BRFSS and analyzed using multiple logistic regression to determine associations between the predictor and the outcome variables. By using a multiple logistic regression model, this study was in line with other studies that utilized secondary data analysis on demographic and socioeconomic variables—such as age, sex, race, education level, health insurance, income, access to health care professional, marital status, employment and CRC screening test methods—as predictors of CRC screening uptake in community-based populations (Sharma et al., 2019; DeGroff et al., 2018; De Moor et al, 2018; Kang & Son 2017; Lin, McKinley, Jackson, Goel, Kho, & Keswani, 2016; Mehta, Jensen, & Quinn, 2016).

Definition of the Operational Variables

The following variables were defined to ensure full comprehension of this study:

Age: Corresponds to a categorical variable for adults 50–75 years of age, resident in Maryland, and participants of the BRFSS survey between 2014–2018. During analysis three subgroups of the age variable were created and recoded as; 1 = 50–59, 2 = 60–69, and 3 = 70–75.

Sex: Is a quantifiable statistic of the study population that is necessary to characterize and identify the variables as either a male or a female. During analysis the variable was coded as 1 = Male, and 2 = Female.

Race/ethnicity: A nominal categorical variable that corresponds to participant's race or ethnicity as categorized in the BRFSS codebook. Four race groups were used in this study and coded as; 1 = White, 2 = Black, 3 = Asian, 4 = Hispanic, 5 = Other. Native Hawaiian/Pacific Islander, American Indian/Alaska Native, and multiracial were grouped as Other race because there was not enough of each race group to warrant a regression.

Education level: Is a measure of individuals' highest grade of school completed (BRFSS, 2018). In this study, EDUCA was measured as a categorical variable coded as; 1 = Did not complete high school; 2 = Completed high school; 3 = Some college or Technical school; and 4 = College graduate.

Household income level: Is a measure of the total annual dollar amount of money from all sources earned by all members in the household (BRFSS, 2018). Income level was measured as a categorical variable and coded as 1 = $0-<$35,000 (Low-income), 2 = $35,000-<$75,000 (Middle-income), and 3 = $75,000 or more (High-income).

Health insurance coverage (HIC): Is a measure of individuals' resource availability as relates to taking care of their health (Miranda et al., 2017). In this study HIC was used as a socioeconomic resource that facilitates timely participation in CRC screening. HIC was measured as a categorical variable according to health insurance plan and recoded as; 0 = Other health insurance plan, 2 = Private plan, 3 = Public plan.

Access to healthcare professional (HCP): Corresponds to timely use of health care services through access to healthcare professionals to achieve CRC screening goals for the best possible health outcome (Healthy People 2020, n.d.) The HCP variable was measured as a categorical variable and coded as; 0 = No health care professional, 1 = Access to one health care professional; 2 = More than one health care professional.

CRC screening use (CRCSU): This is the dependent variable, and corresponds to fully meet the USPSTF recommendation by receiving one or more of the CRC screening test within the recommended time interval (BRFSS, 2018). Measured as a dichotomous variable (0/1), and coded as: 0 = Did not fully meet the USPSTF CRC recommendation, and 1 = Fully meet the USPSTF CRC recommendation.

Assumptions

One assumption made in this research was that the BRFSS survey instrument was reliable and had a strong internal validity for survey response and no interviewer bias at the time of primary data collection. I also assumed that missing data were not due to the dependent variable, CRCSU, and hence, missing at random. Considering that experimental designs have stronger internal validity compared to non-experimental designs (Frankfort-Nachmias & Nachmias, 2015), these assumptions were necessary in the context of this study, because questionnaires used in the BRFSS survey were validated by state and national standards (Maryland BRFSS, 2018).

Scope and Delimitations

The scope of this study encompassed sociodemographic variables that were potential predictors of CRC screening use in Maryland. The focus was on seven specific variables because previous studies have revealed their association with participation in CRC screening programs (Araghi et al., 2019; Cross et al., 2019; Doubeni et al., 2019; Witch et al., 2019). The internal validity was addressed by examining the relationship between the predictors (age, sex, race, Education, income, HIC, HCP) and the outcome (CRCSU) variable. Threats to internal validity were minimized by controlling for variables such as age, sex, and race, and by excluding missing or unknown data from the analysis. For example, data with unknown sex were excluded. This study was limited to residents of Maryland, aged 50–75 years, who participated in the BRFSS survey between 2014 and 2018.

Although theories such as the social cognitive theory (SCT), theory of planned behavior (TPB), social-ecological model (SEM), and the social learning theory (SLT) were reviewed on the basis of cancer screening (Ajzen, 1991; Rosenstock, Strecher, & Becker, 1988), their relationship to CRC screening use is not well understood (Besharati et al., 2018; Serra et al., 2017). Hence, to address the issue of external validity, I utilized the HBM and the FCT, which encompass a more inclusive approach to understand whether the identified variables are associated with CRC screening use. Both frameworks are useful for predicting how specific groups in the study population view the need to screen for CRC based on available resources. The results from this study maybe generalized to the Maryland population because I improved the external validity, by using minimal exclusion criteria, and data collected from all 24 counties of the state.

Limitations

This study was subject to three limitations. The first limitation was access to the most recent BRFSS survey data for Maryland. Typically, survey data are uploaded to the website a couple of years after the actual survey was conducted (CDC BRFSS, n.d.). Since much may have changed from the time the survey was conducted, the reliability and relevance of the results to current day practice may not be enough to draw conclusions from the findings. Secondly, by using secondary data from self-reported questionnaires, there is a potential for recall bias because respondents were reporting on past events and may not remember, for example, if or when a CRC screening was done. Thirdly, limitations from confounders not addressed, such as marital status, could affect the external validity, and the proportion of sample distribution across groups may not be reflective of the entire population. Limitations of secondary data were addressed during analysis by treating the data as a homogenous group, creating subgroups, coding variables, and excluding partial or missing data.

Issues with potential construct validity were limited by employing the Pearson chi-square goodness-of-fit test to ascertain the reliability and validity of the results (Frankfort-Nachmias & Nachmias, 2015). Due to the complex nature of preventive health behaviors such as CRC screening, and its relation to SES, there was a potential threat to external, internal and construct validity in this study. However, these threats were addressed by performing descriptive statistics such as standard deviation and frequency distribution to ensure reliability of the results (Szklo & Nieto, 2014).

Significance of the Study

Contribution to Advancing Public Health Knowledge on CRC Screening

There is strong evidence from systematic reviews using meta-analysis that screening helps primary prevention of CRC (Cardoso et al., 2019). This study contributes to advancing public health knowledge by addressing the gap in an under-researched area of the documented issues around low CRC screening use in Maryland (MDH 2016-2020 cancer report). In this study, I identified the variables that predict CRC screening use and examined results for men and women separately. Also, multiple logistic regression model used provides a useful framework for problems that have a multifactorial structure, such as CRC screening (Merlo et al., 2018). Findings from this study will advance public health knowledge, and elucidate where the focus should be to improve CRC screening rates and to evaluate progress in CRC screening use since the ≥80% goal was set.

Contribution to Advancing Public Health Practice on CRC Screening

Compared to all other cancers, CRC is a good candidate for screening programs, and yet only 65% of U.S. adults, and less than 50% of some race/ethnicity groups, are compliant with CRC screening recommendations (Simon, 2016). Prevalence of non-adherence to CRC screening is high (38.7%) among men and women aged 50–75 years (Seibert, Hanchate, Berz, & Schroy, 2017), making it unclear if the 80% target is achievable or sustainable (Bibbins-Domingo et al., 2016). According to the MDH, CRC screening rates across age groups, gender, race/ethnicity and those without health insurance coverage were lower (68.0%) than expected for 2017 (Platz, 2018)—a finding that marks a gap in public health practices on CRC screening programs in the state.

This research is meaningful and significant because identifying groups with low CRC screening use will provide much-needed insights into the processes needed to increase participation and adherence to surveillance screening programs. Results from this study will contribute to public health practice by providing indispensable acuity for public health officials to design timely, and equitable screening programs that target at-risk groups and encourage more adults to participate in CRC screening outreach efforts. Through public health efforts, the MDH funds free and low-cost screening programs for all screen-eligible adults in Maryland (Palmer, Chhabra & Mckinney, 2011).

Contribution to Advancing Public Health Policy for the State

By identifying the predictors of CRC screening use in Maryland, new public health policies could be initiated, and the structure of existing policies could be reshaped to provide additional targeted screening programs for specific groups in the state. Insights from this study will enhance CRC screening policies that emphasize improvements with a focus on at-risk groups with lower CRC screening use. Through this study, I laid the groundwork for future research by identifying groups that need intervention to achieve, sustain, and surpass the state-set ≥80% screening goal. This project would inform policy makers in Maryland on where the focus should be to increase funding for tailored CRC screening programs and other cancer prevention efforts.

Social Change Implications

CRC screening has been a force for positive social change because it has been identified as the most efficient and cost-effective way to detect CRC early, when it is more treatable (Araghi et al., 2019; Cross et al., 2019; Rosenberg, 2019;). This research has the potential to affect positive social change by advancing knowledge on the factors surrounding low CRC screening rates among groups (Doubeni, 2019). Findings from this study can be used by public health officials to determine the best design for effective social and population-based screening programs. Public health practitioners can collaborate with volunteer organizations to improve behavioral changes through public sensitization that promote CRC screening. For example, sensitization can involve a mission to provide free test kits using mobile vans in low SES neighborhoods or in densely populated minority areas such as Baltimore City.

Timely, effective, and equitable population-based CRC screening programs are essential to provide the best possible outcomes on CRC incidence and mortality (Mehta et al., 2016). To continue on its recorded 30 years' progress on cancer incidence and mortality (Brun & Kanarek, 2018), this research will help the MDH to enhance its CRC priority strategies from its current 2019–2021 cancer prevention plan. A recommendation is that further studies be conducted to investigate whether other screening modalities will produce different results in the same target sample used in this study. Regardless of the factors that may predict CRC screening, public health officials in the Maryland Division of Cancer Control and Prevention must do more to promote screening programs in the population.

Summary

CRC is a deadly disease; but screening and removal of colorectal polyps can prevent it. It is evident from the literature that, CRC screening rates in the U.S. and in Maryland are still below the national recommended goal of ≥80%. The literature reveals statistically significant ($p < 0.001$) relationships between socioeconomic groups and CRC screening use. Lowest screening rates were seen among minority groups and those of low SES, who often lack the resources necessary to participate in preventive healthcare measures like CRC screening. To improve public health practices and to enhance existing or inform new policies, it is essential to identify the variables that predict CRC screening use.

In this study, I employed a quantitative methodology with a cross-sectional design using multiple logistic regression technique to identify predictors of CRC screening use; by determining the association between the independent variables (education level, household income, health insurance coverage, access to healthcare professional), covariates (age, sex, race/ethnicity), and the dependent variable (CRC screening use) in Maryland. Details of previous studies and how other researchers have shown the effect of socioeconomic factors and access to health care resources on CRC screening use are provided in Chapter two. In chapter three, I described the research methodology that I used to analyze the secondary data. In chapter four, I provided information on data collection, data analysis, and the results from the analyses. Finally, the interpretation of my results, discussions from the findings, social change implications and the conclusions drawn from this study are provided in chapter five.

Chapter 2: Literature Review

Introduction

Colorectal cancer (CRC) is the third most common cancer diagnosed in the United States (Simonson, 2018) and the second leading cause of cancer-related deaths among men and women (Ansa, Coughlin, Alema-Mensah, & Smith, 2018). In Maryland, cancer represents the second-leading cause of death following heart disease and CRC accounts for 9% of all cancer death in the state (Brun & Kanarek, 2018). According to the Maryland Department of Health (MDH), improvements in screening, early detection, and removal of precancerous polyps were the main reasons for the drop in the CRC incidence and death rates in 2004-2014 (Ahmad et al., 2015). Yet screening rates remain unacceptably lower (68.6%) than the state's set goal of ≥80% (Ahmad et al., 2018).

Synopsis of Current Literature on Colorectal Cancer Screening

Prevention approaches, such as CRC screening, are necessary for public health research. Both national and state data suggest an increase in CRC screening rates in the last 10 years in Maryland (SEER Stat, 2018; Noone et al., 2018; Brun & Kanarek, 2018). Yet when compared across groups, CRC screening rates are lower in some demographic and socioeconomic subgroups than others in the state (Ahmad et al., 2018; Richardson et al., 2015). During the annual Maryland Cancer Collaborative meeting, Dr. Elizabeth Platz (2018) pointed out that, in Maryland, the CRC screening rate for women (70.2%) was higher than for men (65.2%) and that rates for Whites (72.5%) were substantially higher than for Asians (53.6%). Results from multiple logistic regression analyses have shown that factors that contribute to low CRC screening rates are multifactorial, including age group, sex, race/ethnicity (Sava, Dolan, May, & Vargas, 2018; Burnett-Hartman, Mehta, & Zheng, 2016), education level completed (Lee, Natipagon-Shah, Sangsanoi-Terkchareon, Warda, & Lee, 2019; Rodriguez, & Smith, 2016); income level (Simkin, Ogilvie, Hanley, & Elliott, 2019; Satsangi & DeGroff, 2016); health insurance (DeMoor et al., 2018; Miranda et al., 2017); and access to a health care professional (Sharma et al., 2019; DeGroff et al., 2018; Jackson, Goel, Kho, & Keswani, 2016).

The overall purpose of this study was to identify factors that predict CRC screening use in Maryland. The objective was to quantitatively assess the predictor variables (age, sex, race/ethnicity, education level completed, household income level, health insurance coverage, and access to healthcare professional), using data derived from the CDC BRFSS database. This research is expected to improve understanding in CRC screening practices by identifying the factors that could predict CRC screening uptake in Maryland.

Major Sections of the Chapter

This chapter covers the following topics: the literature search strategy; an overview of, and epidemiology of, CRC; a description of the theoretical and conceptual frameworks on which this study was built; a detailed description of the literature as it relates to the specific independent and dependent variables, and covariates; the methodologies used in previous studies, and how previous researchers approached the CRC screening problem; the summary and conclusion.

Literature Search Strategy

I conducted an in-depth literature review of the topic to determine predictors of CRC screening in Maryland. I reviewed a wide range of knowledge on CRC screening measures, as well as resources on cancer control topics from the MDH, the Maryland Comprehensive Cancer Control Plan (MCCCP), the Maryland Cancer Collaborative (MCC), and the Maryland Patient Navigation Network (MPNN). I searched the SEER websites for relevant statistics. The following databases were used to locate and access relevant articles: Google, Google Scholar, Science Direct, ProQuest, Medline, CINAHL, EBSCO Host, and PubMed.

Key Search Terms

According to Creswell & Creswell (2018) using key terms to search the literature is essential to obtain resources that are more appropriate to answer the research questions. The keywords that I used for the searches included *colorectal cancer screening-programs, -health insurance, -healthcare professional, -age, -sex, -race, -education, -income,* and *USPSTF recommendation*.

Scope of the Literature Search

I found ProQuest, Medline, CINAHL, EBSCO Host, and PubMed databases most useful to my search, because it produced thousands of peer-reviewed journal articles, links to other articles related to my topic, and review papers arranged in logical order based on my search terms. The ProQuest, Medline, CINAHL, EBSCO Host, and PubMed databases also allowed me to filter my search by peer-reviewed articles, and date ranges. Although I reviewed and referenced relatively fewer articles older than 5 years; most of the materials used for my literature review were from peer-reviewed articles published between 2015 and 2019. There were few current studies that identified factors that hinder CRC screening in Maryland; studies done on related topics in Maryland were older than 5 years from the time of this study. To mitigate for the limited number of current peer-reviewed journal articles specific to Maryland, recent articles on similar topics in the U.S. were used. I also included information on a few current seminal presentations, handbooks, and conference proceedings in Maryland. For example, I used conference proceedings from the 2018 annual MCC meeting, the 2019-2021 MCCCP workgroups, and information from the MDH 2016-2020 Cancer Report.

Theoretical Foundation and Conceptual Framework

This study is grounded on two theoretical and conceptual frameworks namely; the Health Belief Model (HBM), and the Fundamental Cause Theory (FCT). Although theories such as the social cognitive theory (SCT), theory of planned behavior (TPB), social-ecological model (SEM), and the social learning theory (SLT) were reviewed on the bases of cancer screening (Rosenstock, Strecher, & Becker, 1988); their relationship to CRC screening uptake are not well understood (Besharati et al., 2018; Serra et al., 2017). Hence the HBM and the FCT were the frameworks that best explained CRC screening differences across the identified variables in this study. Applying both theories provide a potential to motivate individuals to take actions towards CRC screening and will assist the State in designing, targeted, culturally tailored CRC screening programs and policies for Marylanders.

Origin of the Health Belief Model

The HBM is a theory of health behavior, formulated by Hochbaum, Rosenstock, and Kegels in the early 1950s for the United States Public Health Service (Rosenstock, 1974). The HBM was first used to address beliefs essential to yield desirable health behaviors (Rosenstock, Strecher, & Becker 1988); and later advanced to the current instantiation of six constructs, to emphasize the motivational factors that mold individuals to take action towards their health (Rimer & Glanz, 2014). The theory was successfully used in the 1970s to explain the failure of free tuberculosis screening programs in the US (Sharma, & Romas, 2011). Since then, the HBM has been the most widely used theoretical model to guide health promotion and disease prevention programs (Helander, Heinävaara, Sarkeala, & Malila, 2018; Williams, Wilkerson & Holt, 2018); and to explain why only few people participate in disease prevention programs (Glanz, Rimer & Viswanath, 2015; Giorgi et al., 2015).

Major Propositions of the Health Belief Model

The key elements of the HBM are perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy (Glanz, Rimer & Viswanath, 2015). Experts like Lee, Stange, & Ahluwalia, (2015); Sohler, Jerant, & Franks, (2015); and Purnell et al., (2010) have described the constructs as follows: Perceived susceptibility is defined as one’s belief of the ability to develop or be at risk of developing a disease. Severity refers to the extent of understanding the threat associated with the seriousness of a disease. Benefit refers to the belief that acting towards a health recommendation will reduce the seriousness of the disease. Barriers are related to sociodemographic barriers which may affect an individual’s inclination towards a beneficial health behavior. Cues to actions refer to the strategies, forces, or triggers used to activate one’s readiness towards a behavioral change. Self-efficacy is an individual’s resource ability, to act towards health behavioral changes.

According to propositions of the HBM, people will comply with any health-related action if they assess the disease as preventable when a particular action is taken (Glanz, Rimer & Viswanath, 2015). Researchers have used components of the HBM to assess the likelihood of acting towards disease prevention (Abuadas et al., 2018; Sohler, Jerant, & Franks, 2015); and suggested that constructs of the HBM can be used individually or in combination to explain health behaviors (Williams, Wilkerson & Holt, 2018; Rimer & Glanz, 2014; Turner, Hunt, Dibrezzo & Jones, 2004). This dissertation is focused on the construct of barriers and cues to action.

The ability to influence health outcomes through proper actions are essential to preventive behaviors (Lee, Stange, & Ahluwalia, 2015). Despite demographic barriers, the HBM construct of cues to action facilitates an understanding of health behaviors through a recommended action that leads to positive outcomes (Williams, Wilkerson & Holt, 2018; Heiniger, Sherman, Shaw, & Costa, 2015; Lee, Stange & Ahluwalia, 2015). The basic idea of the HBM is that, if people know about a serious health threat, feel at risk of the threat, and think that the benefits of taking an action outweighs the risk associated with the action, they will do whatever it takes to reduce their risk of the threat (Glanz, Rimer, & Viswanath, 2015). The construct of cues to action posits that if individuals are aware of the health benefits of a recommended action, they will participate in the beneficial health behavior associated with their action (Glanz, Rimer, & Viswanath, 2015). The strategy towards cues to action addresses the aspect of healthcare professional recommendation (HPR) for screening as uncovered by the scope of this literature. For example, HPR for CRC screening may motivate individuals to participate in free and low-cost CRC screening outreach programs available in Maryland (Palmer, Chhabra, & McKinney, 2011; Gilbert & Kanarek, 2005). The HBM would be used in this study to address the research question of whether individuals act towards CRC screening after healthcare professional recommendation.

Application of the Health Belief Model in Previous Studies

The HBM is known as the most popular model for analyzing individuals' decision making about using any health service (Glanz, Rimer, & Viswanath, 2015; Rimer & Glanz, 2014); and has been used to promote compliance in screening programs across several health issues (Abuadas et al., 2018; Bernardo et al., 2018; Almadi et al., 2015). Prospective studies have revealed that based on the HBM component of cues to action, factors such as age, race, gender, marital status, income, education level, knowledge based on perceived susceptibility, severity, and benefits, can contribute to an individual's likelihood to act towards CRC screening (Helander, Heinävaara, Sarkeala, & Malila, 2018; Jih et al., 2018; Rat et al., 2017; Rogers et al., 2017; Almadi et al., 2015). Also, knowledge, cultural perceptions, personal views, beliefs about CRC and socioeconomic barriers to CRC screening uptake have been associated with the utilization of CRC screening services and low screening compliance among various groups (Abuadas et al., 2018; Almadi et al., 2015; Fernández, et al., 2015).

To explain gender differences as predictors of CRC screening, the literature reveals that more women participate in CRC screening because they belief in the benefit of screening, after being encouraged by a health care professional to take action towards screening (Abuadas et al., 2018; Helander, Heinävaara, Sarkeala, & Malila, 2018). To determine the factors associated with willingness to undergo CRC screening Almadi et al., (2015) used concepts of the HBM in a cross-sectional study in Riyadh, Saudi Arabia and found that only 6.7% of males 50-55 years of age had undergone CRC screening compared to 7.5% for females. Using data from the Texas BRFSS to examine perceptions of CRC and to determine if health literacy is associated with CRC screening use among Hispanic adults, Fernández et al., (2015) found that 59% of participants, reported never been screened due to lack of knowledge about CRC screening as a prevention strategy.

The differences in CRC screening rates in Maryland could be described as a disagreement between barriers and action, which I sought to explain using the HBM. In realm of the HBM, this research argues that more men will take action towards CRC screening if they receive recommendation from a healthcare professional. The HBM for this study also suggest that, those from minority race groups often at the low income level and without access to a health care professional are less likely to participate in CRC screening. The HBM is an appropriate model to determine if there is an association between age, sex, race/ethnicity, education level, income level, health insurance coverage, access to health care professional, and CRC screening use in Maryland.

Limitations of the Health Belief Model

Despite the wide use of the HBM in epidemiological studies, some researchers have argued that health behaviors are influenced by many factors such as socioeconomic status (SES), marital status and education, and not just by health beliefs (Moore et al., 2015). The HBM had been described as “reductionistic” because it does not include emotional, social and other environmental factors such as culture (Dutta, & Basu, 2011; Abbatangelo-Gray, Cole, & Kennedy, 2007). Others have suggested that the HBM is a “rational exchange” model where individuals systematically weigh the barriers and benefits of a behavior, without making decisions based on individual rules of thumb (Thaler, & Sunstein, 2009). Essentially, it is difficult to design appropriate tests of the HBM to compare results across studies, since studies can use different research questions to investigate the same beliefs (Yoo, Kwon, & Pfeiffer, 2013). This study minimized the impact of these issues by using the FCT to compensate for the gaps in the HBM.

Origin of the Fundamental Cause Theory

The FCT was first proposed in 1995 by two medical sociologists, Link and Phelan in an article titled, “Social Conditions as Fundamental Causes of Disease” (Link & Phelan, 1995). The FCT seeks to explain why the association between SES and mortality persist, despite improvements in the risk factors known to cause morbidity and mortality in low SES individuals (Goldberg, 2014; Link & Phelan, 1995). Link and Phelan argued that, low SES is strongly correlated with countless diseases, as the poor are known to live with the worse health and die younger than the wealthy (Goldberg, 2014; Phelan, Link & Tehranika, 2010). For example, in the 19th century, adequate sanitation and sewerage were key risk factors for disease in the US; however, availability of sanitation during this period was along a social gradient with lower rates of waterborne disease among the affluent compared to the less affluent individuals (Goldberg, 2014). Based on the FCT, the persistence of socioeconomic health disparities is so clear that even the eradication of diseases, like typhoid fever and tuberculosis did not change health inequalities in most societies (Phelan, Link & Tehranika, 2010).

Major Propositions of the Fundamental Cause Theory

The broad generality of the FCT is that, there is an ongoing association between SES and disease outcomes; because social states embody the availability and accessibility of many resources through multiple mechanisms (Adams & White, 2004; Link & Phelan, 1995). A major proposition of the FCT is that, SES is a fundamental cause of health inequality; because it demonstrates four essential features of health inequalities; first, there is evidence that SES influences multiple disease outcomes; secondly SES is tied to multiple risk factors for disease and death; thirdly, an association exist between SES and health, because of disparity in deployment of resources; and fourthly that the association between SES and mortality changes constantly via the emergence of new intervening mechanisms (Phelan, Link & Tehranika, 2010).

Key resources that lower SES individuals lack include knowledge, money, power, prestige, and beneficial social connections (Phelan, Link & Tehranika, 2010). The FCT posit that because resources change constantly, the lack of resources such as health insurance coverage persists, and at any given SES level, it is the social connections that serve to protect health, regardless of the resource mechanism used to combat diseases, (Phelan, Link & Tehranifar, 2010; Adams, & White, 2004). Despite advances in technology and improvements in CRC screening techniques, the basic fact is that people from low SES communities often lack resources to protect and improve their health (Qasim, 2016; Goldberg, 2014). A real question of whether the SES-health gradient favors high SES individuals even after the development of new knowledge as relates to CRC screening is not clearly understood (Doubeni, et al., 2012; Preston, & Wang, 2006). Therefore, this study was grounded by in the third proposition of the FCT that there is an association between SES and health, because of disparity in deployment of resources.

Although empirical data supports the proposition that SES is vital to maintaining good health, it is the utilization of available resources that becomes critical in maintaining health and prolonging life (Tehranifar et al., 2009). The idea that resources held by higher SES individuals prevent disease and death leads to the prediction that at any given time, more resources will produce better health (Horne et al., 2015; Phelan, Link, Diez-Roux, Kawachi, & Levin, 2004). Consistent with these predictions, researchers have found that socioeconomic inequalities in death are significantly more evident for highly preventable causes of death such as lack of CRC screening use (Vanthomme, & Gadeyne, 2019; Pellat, Deyra, Coriat, & Chaussade, 2018; Horne et al., 2015; Doubeni et al., 2012). Results from a prospective study using the National Institutes of Health-Diet and Health survey data showed that SES is associated with the risk of CRC in adults 50-71 years of age in the US; with a significantly ($p < .05$) higher overall CRC incidence among those who lived in low-SES neighborhoods, compared to those of the highest-SES groups, even after adjusting for other risk factors (Doubeni et al., 2012).

The FCT can be used to explain why emphasis on intervening factors such as screening would be ineffective if structural determinants of the disease are left untouched (Vanthomme, Vandenheede, Hagedoorn, & Gadeyne, 2017). For example, if provision of sanitation in the 1970s was suboptimal because there was a lack of simultaneous attention to socioeconomic conditions (Goldberg, 2014; Phelan, & Link, 2005). Therefore, in relation to my research, recommending CRC screening without concomitant attention to whether individuals have the resources such as health insurance coverage to go for screening maybe suboptimal as well. It is not only the availability of health insurance as a socioeconomic resource, but the simultaneous provision of CRC screening options by a healthcare professional that determines participation in CRC screening programs. In realm of the FCT, this study posits that minority race groups, those at lower education level, lower income level, those without health insurance or access to a health care professional will be less likely to screen for CRC regardless of age, or sex.

Application of the Fundamental Cause Theory in Previous Studies

The FCT is an essential framework to identify sections of public health programs that are most likely to improve overall population health and compress health inequalities (Goldberg, 2014). The FCT has been used to explain the implications of SES and social inequalities in cancer screening (Vanthomme, & Gadeyne, 2019; Vanthomme, Vandenheede, Hagedoorn, & Gadeyne, 2018; Pellat, Deyra, Coriat, & Chaussade, 2018); to determine factors related to CRC screening uptake (Doubeni et al., 2012); and to investigate the effect of social inequality and individual level factors such as sex, race/ethnicity, and socioeconomic group on CRC screening participation (Wilder &

Wilson, 2016; Hurtado et al., 2015). Results of multiple logistic regression models to estimate CRC screening use based on socioeconomic quintiles, revealed that among women, the highest (71.5 %) CRC screening use was in the third socioeconomic quintile and the lowest (65.7 %) was in the first and least disadvantaged socioeconomic quintile (Hurtado et al., 2015). However, among men, the lowest (60.2%) CRC screening use was identified in the fifth most disadvantaged socioeconomic quintile (Hurtado et al., 2015).

On the contrary Desantis et al., (2016) argued that, SES does not fully explain racial/ethnic disparities in CRC screening rates. Using the 2006-2015 data from the NCI, the National Center for Health Statistics (NCHS) and the North American Central Cancer Registry, Desantis et al., (2016) found that the overall CRC incidence rate decreased faster in black men (2.4%) than in white men (1.7%), and black females (2.6%) than in white females (1.6%). To better understand the race/ethnic differences in CRC screening, public health administrations must ensure that individuals and families of lower SES have access to adequate health care resources and high-quality prevention services necessary to participate in CRC screening (Wilder & Wilson, 2016).

Other studies have revealed a disproportionately higher burden of CRC among those of the socioeconomically disadvantaged group (Shariff-Marco, Breen, Stinchcomb, & Klabunde, 2013). Factors such as, lower education, less income, less fruits and vegetables intake, increased biological susceptibility, and inadequate healthcare resources contribute to racial disparities in CRC screening uptake (Feng et al., 2017; Tammana & Laiyemo, 2014). Although adoption of a lifestyle that include routine physical activity and intake of plant based diet among minority race groups could not be proven to reduce susceptibility to CRC in randomized trials (Feng et al., 2017); modification of screening modalities for specific race/ethnic groups (Levin et al., 2018), and implementation of organized screening programs that include public health campaigns and patient navigation may be necessary to improve CRC screening rates across groups (Tammana & Laiyemo, 2014).

The literature reveals that though a relatively newer health theory, the FCT is likely to present new mechanisms through which the connections between low SES and poor health are perpetuated over time (Vanthomme, & Gadeyne, 2019; Vanthomme, Vandenheede, Hagedoorn, & Gadeyne, 2017). Although no framework has been developed specifically for SES as mediator of CRC screening uptake, education, income, and health insurance access as available socioeconomic resources had been used to mediate the association between sociodemographic factors and CRC screening (Lo, Waller, Vrinten, Kobayashi & Wagner, 2015; Wagner, Good, Whittaker, & Wardle, 2011). For my dissertation, predictions of CRC screening use based on the FCT were determined from the effect of age, race/ethnicity, on the association between education level, income and CRC screening use. To the extent of the FCT, this study hypothesized that CRC screening use will favor those with high income and access to more than one health care professional, and more likely for women than men. Findings from this dissertation will not only guide an agenda for future research on CRC; but will provide a platform for the MDH to design and implement policies that prioritizes CRC screening use for those without resources such as health insurance coverage.

Limitations of the Fundamental Cause Theory

Despite the evident-based knowledge of the role of resources to disease outcomes, critics of the FCT argued that it is difficult to test the importance of resources, because it requires separation of the socioeconomic resources from SES itself (Tehranifar et al., 2009). Others argued that the FCT is not the best model because, observed tests of the FCT are not straightforward, as it involves an amalgamation of effects across multiple processes and conditions (Adams, & White, 2004). It is suggested that prioritizing downstream determinants of health may have less impact on future population health and instead expand health inequities (Goldberg, 2014). Therefore, to design public policies to improve cancer outcomes, there may be competing interest that supersedes health (Qasim, 2016; Adams, & White, 2004). However, more studies are needed to further elucidate the role of the FCT on CRC screening use.

Rationale for Using the Health Belief Model and the Fundamental Cause Theory

Given that screening ultimately requires an individuals' action to go for any of the United States Preventive Services Task Force (USPSTF) recommended screening test, it is essential to understand the factors that may impose suboptimal CRC screening use in Maryland. The HBM and the FCT were selected for this study because they complement each other and have been applied across a wide range of compliance issues to predict human behavior in preventive health and promotion strategies (Vanthomme, & Gadeyne, 2019; Helander, et al., 2018; Holme et al., 2018; Vanthomme, Vandenheede, Hagedoorn, & Gadeyne, 2017; Qasim, 2016; Wilder & Wilson, 2016; Glanz, Rimer, & Viswanath, 2015; Hurtado et al., 2015; Goldberg, 2014; Tammana & Laiyemo, 2014).

In relation to my dissertation, the HBM will go with the premises that despite a person's knowledge of the risk, seriousness, consequences of CRC, nor knowledge of the benefits of screening, there might still be other socioeconomic factors that may hinder CRC screening use among individuals. The HBM is an appropriate framework because my hypothesis that there is a statistically significant association between age, sex, race, education level, income, health insurance coverage, access to a health care professional, and CRCSU aligns with the HBM construct of cues to action. The FCT is used in this research to explain differences in CRC screening use across groups, based on income, and health insurance coverage, as a resource acquisition. The FCT framework is also used to guide data analysis; and as a starting point for designing tailored CRC screening programs and policies in Maryland.

The overarching finding from the literature review is that, constructs from the HBM and FCT are linked with health behavior and SES. It could be argued that both conceptual frameworks cannot be used without the other as they both compensate for the gaps in each other. Given that none of these theoretical models were developed specifically for CRC screening use, and that CRC screening outcomes have several predictive factors that are different from other preventive approaches, the observation that these models account for CRC screening use is essential for understanding how individuals make decisions to screen for CRC. Findings from this research could provide an indication of whether the state would achieve and sustain its ≥80% screening target.

Colorectal Cancer Overview

Colon cancer and rectal cancer have many similar features, hence they are often grouped together as CRC (NCI, 2019). CRC usually starts as a benign growth and gradually grows via a multistep process involving molecular, histological, cytological, morphological, and genetic changes over a period of 10 to 20 years into cancer cells (Mayo Clinic, 2019; NCI, 2019). CRC pathogenesis have been described as “a heterogeneous disease with different paradigms” (Li, 2018). The two main types of polyps are the most common hyperplastic and inflammatory non-cancerous polyps; and the adenomatous polyps that lead to cancer (ACS, 2018). Up to 96% of CRC are caused by adenocarcinomas; and the remaining 4% are either carcinoid tumors, gastrointestinal stromal tumors (GIST), lymphomas or sarcomas (ACS, 2018). Most colorectal tumors develop over time; making screening an important strategy to prevent the disease through early detection and removal of precancerous polyps (Simon, 2016). The anatomy of the colon includes; the ascending, transverse and the descending lobes (Figure 1).

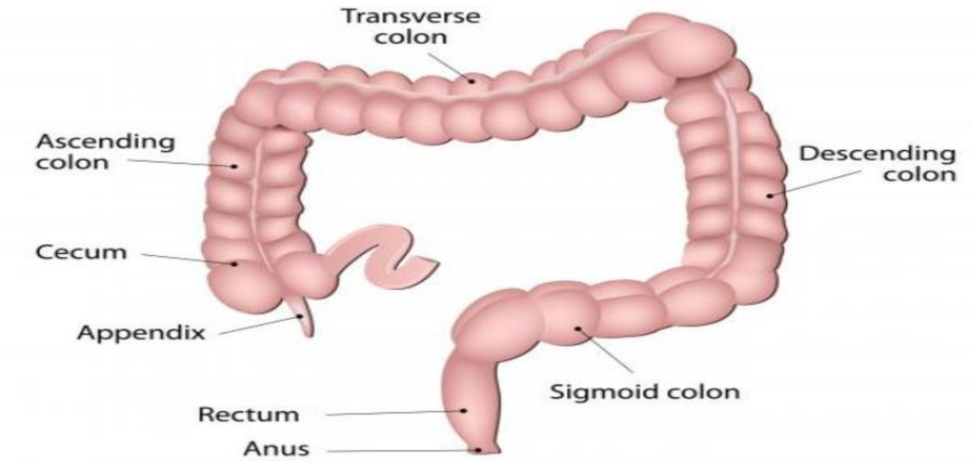

Figure 1. A diagram showing the anatomy of the large intestine including segments of the colon to the rectum. Adapted from Medical News Today by Chun, C. and Brazier, Y. *Journal of Gastroenterology*, p. 22. Copyright (2018) by Mayo Clinic Foundation.

Pre-cancerous polyps can be identified in the colon during colonoscopy exam (Figure 2).

Figure 2. A diagram showing a large pedunculated colorectal polyp as seen during a colonoscopy exam. Photos courtesy of Louis M. Wong Kee Song, Mayo Clinic. Adapted from “Colorectal cancer development and advances in screening” by Simon, K. *Journal of Clinical Interventions in Aging, 11* (11), p. 967. Copyright (2016) by authors.

Colorectal Cancer Epidemiology

According to the International Agency for Research on Cancer (IARC), CRC is the third most common cancer diagnosed worldwide (Macrae, 2019); and represents about 10% of annual global cancer incidence (Araghi et al., 2019; Lauby-Secretan, Vilahur, Bianchini, Guha, & Straif, 2018). CRC is ranked fourth of all cancer-related deaths, with an estimated increase to 2.2 million new cases and 1.1 million CRC-related deaths by 2030 (Arnold et al., 2017). The American Institute for Cancer Research (AICR) pointed out that CRC is one of the most transparent markers of the epidemiological and nutritional transition of cancer that is easy to interpret (AICR, 2019). Yet global statistics, show an estimated 1.8 million new CRC cases, and over 880,000 deaths from CRC in

2018 (IARC, 2019; Macrae, 2019). However, the CRC incidence and mortality rates vary remarkably across populations with substantially higher (25%) rates in males than in females; with higher incidence seen among individuals with specific inherited conditions that predisposes them to the disease (Macrae, 2019); and approximately 20% higher in African Americans than in Whites (Jemal, Siegel, Xu, & Ward, 2010). Data from some cancer registries show that CRC incidence is increasing in individuals below 50 years of age, and decreasing in the older groups (SEER Stat, 2018; Howlader, Noone, & Krapcho, 2016). An estimated 35% of CRC cases in young adults are associated with known hereditary syndromes from causes that are yet to be understood (Mork et al., 2015; Ahnen et al., 2014). Studies on the genetic epidemiology revealed an increased risk in first-degree relatives of patients with inherited CRC syndromes (Yu, & Hemminki, 2019; Li, 2018; Zhu et al., 2017; Folprecht, 2014; Vogelstein et al., 2013).

With a wide distribution of CRC, the global burden of the disease is expected to increase by 60% to an estimated 2.2 million new cases and 1.1 million deaths by 2030 (Arnold et al., 2017). High CRC incidence rates are expected in countries undergoing rapid societal and economic changes (Fitmaurice & Allen, 2017); predominantly those linked to western lifestyles in medium-to-high-income countries (Bray, Ferlay, & Soerjomataram, 2018; Arnold et al., 2017; Siegel et al., 2017). In 2018 Hungary had the highest overall CRC incidence rate at 51.2% for both sexes, and South Korea was next at 44.5% (AICR, 2019). Predictions of the future burden of CRC would inform public health experts and raise awareness of the need for CRC control actions, such as mass screening programs for at risk groups (Araghi et al., 2019; WHO, 2018).

Colorectal Cancer Epidemiology in the United States

Despite the availability of prevention methods, early detection, and improvements in treatment strategies, CRC remains the second leading cause of cancer death in the United States (Doubeni et al., 2019; Jeon et al., 2019). The overall risk for developing CRC is 4.49% in men, and 4.15% in women (Siegel, Miller, & Jemal, 2019). It is estimated that 145,600 new cases and about 51,020 deaths from CRC will be reported in the US in 2019, with slightly higher rates expected for men than women (ACS, 2019; Macrae, 2019). The risk for developing CRC is multifactorial. Modifiable behaviors such as physical inactivity, unhealthy diet, smoking, and obesity are known to account for an increased risk of CRC (Rosenberg, 2019; Chang et al., 2018). But disparities still exist when compared across groups (Wittich et al., 2019; Cronin et al., 2018; Burnett-Hartman, Mehta, & Zheng, 2016; Wilder, & Wilson, 2016; Liss & Baker, 2014). Low SES has been associated with an increased risk for developing CRC and lower CRC screening rate (Bernardo, et al., 2018; Mehta, Jensen, & Quinn, 2016; Burnett-Hartman, Mehta, & Zheng, 2016). Improvements in screening and accessibility to early detection services can lead to reductions in CRC incidence and mortality rates (ACS, 2019; Araghi et al., 2019; Wittich et al., 2019).

Age has been associated with sporadic CRC for individuals 40 years of age, and the incidence increase significantly from 45 to 50 years of age (Mehta, Jensen, & Quinn, 2016). Age-specific CRC incidence rates increase with each succeeding decade after 50 years of age (Macrae, 2019; Jeon et al., 2018). Rising CRC incidence among younger adults 20 to 39 years of age have also been reported (Macrae, 2019), although the absolute incidence in this age group remains much lower than for adults aged 50 or older (Siegel et al., 2017; Tawadros et al., 2015). Data from the SEER database suggest a steady increase in CRC incidence for individuals below 50 years of age at a rate of 2% per year from 1992 through 2013 (SEER Stat, 2016); and decreasing rate in age groups over 50 years (Meester, Mannalithara, Lansdorp-Vogelaar, & Ladabaum, 2019; Siegel, Miller, & Jemal, 2019). This may be attributable to increase CRC screening among individuals over 50 years of age (Atkin et al., 2017).

Although screening for CRC aid physician to identify and remove precursors to CRC (ACS, 2019); social inequalities in CRC outcomes remain remarkably evident (Wittich et al., 2019; Cronin et al., 2018; Burnett-Hartman, Mehta, & Zheng, 2016; Wilder & Wilson, 2016; Verma, Sarfaty, Brooks, & Wender, 2015; Liss & Baker, 2014). Also, the distribution of economic resources, and knowledge about CRC screening uptake are unevenly distributed along the social cleavages of age, gender, race, health insurance coverage and access to healthcare professionals (Wittich et al., 2019; Golboni, Nadrian & Najafi, 2017; Burnett-Hartman, Mehta, & Zheng, 2016; Wilder & Wilson, 2016; Williams et al., 2016; Fernandez et al., 2015).

Risk Factors of Colorectal Cancer

Although epidemiological findings suggest that some risk factors are more related to colon than to rectal cancer (Wei, Giovanni & Wu, 2004; Presciuttini, & Strigini, 1996), for the purpose of this dissertation, both colon and rectal cancer will be considered as the same entity. Risk factors for CRC include, mutations in inherited genes such as the *APC*, *KRAS*, and *p53* (Yu, & Hemminki, 2019; Jeon, 2018; Li et al., 2018; Zhu et al., 2017);

and chromosomal instability which includes the CIN phenotype found in over 80% of CRC, the CIMP+ phenotype found in 15 to 20% of CRC; and the MSI+ phenotype found in 12 to 20% of CRC (Jeon et al., 2018; Folprecht, 2014).

Other risk factors include, personal and family history of CRC and adenomas (Simon, 2016); history of inflammatory bowel disease (Jeon et al., 2018; NCI, 2015); and environmental, sedentary and other lifestyle and modifiable risk factors such as diet high in flavonoid, and red meat intake (Chen et al, 2018); physical inactivity, obesity, excessive alcohol intake, and cigarette smoking (Chang et al., 2018; He, & Sun, 2016; Hua et al., 2016). However, the prevalence of modifiable risk factors varies widely by age, race/ethnicity (Wittich et al., 2019; Fernandez et al., 2015); and by health insurance access (Wyatt, Pernenkil & Akinyemiju 2017). Early detection through CRC screening, identification and removal of colorectal polyps have played a crucial role in reducing the CRC-related incidence and mortality rates across groups (Sauer, Siegel, Jemal, & Fedewa, 2019; Matsuda, Ono, Kakugawa, Matsumoto, & Saito, 2015). Therefore, the impact of some high-risk factors to CRC could be minimized through screening.

Colorectal Cancer Screening

The fact that it takes multiple years for normal cells in the colonic mucosa to grow and become cancerous, provides a great opportunity for successful CRC screening programs (ACS, 2019). Modeling studies have suggested that improvements in CRC screening will save lives (Zauber, 2015), and that the disease could be nonexistent in the US if screening becomes commonplace (Maxon, 2018; Simonson, 2018; Simon, 2016). The USPSTF is the national policy group that provides guidelines for CRC screening for average risk adults, starting at age 50 years and continuing until 75 years (USPSTF, 2019). The current USPSTF guidelines (Appendix A) include CRC screening recommendations for both stool-based and endoscopic methods for all screen eligible adults aged 50–75 years of age. However, the guidelines may vary slightly within states (Rex et al., 2017; Lin, Piper, & Perdue, 2016). For example, in California, screening is recommended for everyone to begin at age 50 years (Levin et al., 2018); while in Maryland screening is recommended for average risk individuals 45–75 years of age (Watkins et al., 2018).

The epidemiology of race and age-related differences in CRC screening had been evaluated in a population-based retrospective cohort study of asymptomatic average risk African Americans and Latinos (Williams et al., 2016). Results showed improvements in CRC screening rates with rates for blacks who had received screening guidelines increasing from 6.5% in 2000 to 30.6% in 2008 (Williams et al., 2016). However, in a cross-sectional study, Hispanics in rural areas were less likely to be screened for CRC and more likely to present with late stage disease than other race or ethnic groups (Wittich et al., 2019). Studies have shown that consideration of sociodemographic and economic factors (Rogers et al., 2017; Fernandez et al., 2015); and combinations of different screening options are viable to investigate CRC screening uptake (Rosenberg, 2019; Wittich et al., 2019; Li, 2018). To increase CRC screening use and to achieve the optimal screening goal across all groups, health care providers should therefore emphasize all available information for each test method to the patient during the decision-making process to choose appropriate CRC screening modality needed to accomplish individual goals (Golboni, Nadrian & Najafi, 2017).

Effectiveness of Colorectal Cancer Screening

The preventive effects, benefits and harms of various CRC screening modalities in average-risk populations have been assessed in randomized controlled trials, and observational studies (Doubeni, 2019; Doubeni et al., 2018). In terms of performance, findings from recent studies suggest that CRC detection rates using the fecal occult blood test (FOBT) every 2 years for five consecutive screening rounds were similar to a single screening round by any of the endoscopic techniques (Koskenvuo et al., 2019; Emilsson, Holme, & Bretthauer, 2017; Sali, Mascalchi, & Falchini, 2015). In their randomized population based study to investigate the effectiveness of CRC screening, Koskenvuo et al. (2019) found that overall survival rate was higher among those in the screening arm than those in the control arm; Suggesting that biennial FOBT screening is effective in improving CRC outcomes in men, but not in women (Koskenvuo et al., 2019).

Stool-based tests are important approaches for CRC screening programs due to its cost-effectiveness and non-invasiveness (Li & Yuan, 2019; Cross et al., 2019; Senore et al., 2019). By using FOBT, high-risk individuals can be selected from the general population, therefore reduce the demand for colonoscopies (Li & Yuan, 2019). Overall, there is evidence that regardless of the screening modality used, both endoscopic and stool-based techniques provide enough reliability in detecting cancer early, and in reducing the risk when current established guidelines are followed (Cardoso et al., 2019; Li & Yuan, 2019; Doubeni et al., 2019; Salas et al., 2014). The benefits of participating in any screening program outweigh the harms associated with any of the recommended screening test method (Cardoso et al., 2019; Meester et al., 2018; Bibbins-Domingo, Grossman, & Curry, 2016; Bibbins-Domingo et al., 2016; Meester et al., 2015). The focus should therefore be on improving various CRC screening strategies and the efficiency of the modalities used.

Colorectal Cancer Screening in the United States

There is no standard national cancer control plan (Rex et al., 2017). Instead, states develop and implement specific cancer plans for its residents, based on federal recommendations, state policies and programs, and recommendations of other authoritative sources such as the ACS, who are consulted during the development of state cancer plans (Fowler et al., 2015; Villanueva, Gugel, & Dwyer, 2013). Elements that determine the Maryland cancer control plan depends on multiple factors, including state priorities, political climate, stakeholder involvement and partnership (Fowler et al., 2015). Due to the relative low incidence of CRC in women compared to men, some researchers have suggested that CRC screening for men should begin five years earlier than for women, and that women may start screening at age 50–55 years and men at 45-50 years of age depending on their risk levels (Arana-Arri et al., 2017; Brenner & Werner, 2017).

Others have argued that despite the difference in incidence rates, guidelines for CRC screening programs should start at age 50 years for both men and women of average risk (Doubeni et al., 2019; Li, 2018). However, Brenner & Werner (2017) pointed out that regardless of the age at which initial screening is recommended for any public health program, the essential factors to consider are the individuals’ risk level, the sensitivity and specificity of the test, the capacity of the specific target population and availability of colonoscopy. Although there are improvements in CRC screening trends in the past 10 years (MMWR, 2016), there is evidence of racial/ethnic disparities in screening uptake across groups (Sauer, Siegel, Jemal, & Fedewa, 2019; Wilder & Wilson, 2016; Liss & Baker, 2014; Tammana & Laiyemo, 2014). Hispanics and Asian Americans are known to have low (<50%) CRC screening rates (Jih et al., 2018; Jung et al., 2018); compared to 54.3% for American Indian/Alaska Natives, 61.8% for blacks, and 65.4% for whites (Rosenberg, 2019). Therefore, States need to review their cancer control plans to determine where the focus should be to improve CRC screening use across all groups.

Cancer in Maryland

Despite recent decline in CRC incidence and mortality rates in Maryland (Brun & Kanarek, 2018; Dwyer et al., 2015), the cancer burden for Maryland remains large when measured by human suffering, loss of life, loss of quality of life, and expenditures for medical care (Ahmad et al., 2018). More than 27,000 Marylanders are diagnosed with invasive cancer each year, and many family members, and friends support patients through their cancer treatment journeys (MDH, 2016-2020 Cancer Report). According to the MDH, if current trends in incidence and mortality rates continue, cancer will soon become the leading cause of death in Maryland (Brun & Kanarek, 2018). Although several prevention-related recommendations are covered under the Affordable Care Act (ACA) introduced in 2012 (Fox & Shaw, 2015), the Maryland Comprehensive Cancer

Control Plan (MCCCP) provides prevention strategies which sometimes do not match federal evidence-based screening recommendations (Fowler et al., 2015).

The Maryland Centers for Cancer Control and Prevention developed a comprehensive cancer control strategy managed under the Maryland Comprehensive Cancer Control Plan (MCCCP). The first Maryland cancer control plan was written in 1991 by contributors from hospitals, the academia, nongovernment organizations and volunteers; and has been updated every five years since then (Fowler et al., 2015). The MCCCP involves communities and partners working together to maximize the impact of cancer through coordinated efforts to reduce the risk, detect cancers early, improve treatment and enhance survivorship (MDH, 2016-2020 cancer report). The most recent MCCCP is the updated 2016-2020 cancer report which is a coordinated effort of staff from the MDH, and 83 public and private stakeholders across the state (Ahmad et al., 2018). The goal of the MCCCP is to encourage collaboration among all stakeholders and coordinate activities of the Maryland Cancer Collaborative (MCC), and the Maryland Patient Navigation Network (MPNN) (MDH, 2016-2020 cancer report). Both the MCC and the MPNN are statewide coalition of individuals and organizations who volunteer to navigate patients through the Maryland cancer continuum, promote initiatives and implement priorities set by the MCCCP (MDH, 2016-2020 Cancer Report). A 2014 study to examine the cancer prevention treatment demonstration (CPTD) screening trial in Maryland revealed that patient navigation was an effective strategy to increase CRC screening among older blacks in Baltimore City (Horne et al., 2015).

In its efforts to continue a steady progress towards low cancer incidence with zero disparities (Brun & Kanarek, 2018), the MCC recently met in Annapolis, Maryland for the 2018 MCC annual meeting, with a main agenda to set priority projects and strategies on cancer prevention goals for 2019–2021 and a focus to increase CRC screening uptake across all groups (Platz, 2018). The MCCCP is a useful resource for cancer statistics needed by professionals and organizations throughout the state to help guide their cancer control activities and by researchers conducting studies on cancer control topics in Maryland (Ahmad et al., 2018). According to the MDH, healthcare access and cancer disparities are two areas that offer opportunities and challenges for patients, public health professionals, and healthcare providers across the cancer continuum; hence are emphasized in the 2019–2021 MCCCP (MDH, 2019). This study will provide evidence-based data to inform future priorities for the MCCCP.

Colorectal Cancer in Maryland

CRC is classified as one of seven high burden cancers for Maryland including breast, cervical, colorectal, lung, oral, prostate, and skin cancer (Ahmad et al., 2018; Brun & Kanarek, 2018), and accounts for 9.0% of cancer deaths in Maryland (MDH, 2016-2020 cancer report). The Maryland Cigarette Restitution Fund Prevention, Education, Screening, and Treatment program (CRF PEST) has targeted the seven high burden cancers for public health programs (Smith et al., 2019; Richardson et al., 2015). Between 2010-2014, Maryland was the 27th highest in CRC mortality rate among all states in the US and the District of Columbia (MDH, 2017 cancer report). Data from the Maryland Cancer Registry (MCR) shows that 2,477 new cases and 955 deaths from CRC were reported in Maryland in 2014 (MCR, 2015). The 2014 age-adjusted CRC incidence rate for Maryland was 37.3 per 100,000 (35.8-38.8, 95% CI); and the mortality rate was 14.4 per 100,000 (13.5-15.4, 95% CI); statistically higher than the national CRC mortality rate of 14.1 per 100,000 (14.0-14.2, 95% CI) for the same period (SEER Stat, 2015). Statistically significant ($p < 0.05$) differences in CRC diagnosis exist between age, sex, and race groups in Maryland (MDH, 2017 cancer report). Between 2008-2012, more blacks (22.4%) in Maryland were diagnosed with CRC, than whites (19.5%). Among those diagnosed at distant stages, black males (25.5%), white males (22.5%); and black females (20.4%), white females (17.0%) (MDH, 2017 cancer report).

The 2012 Maryland BRFSS data for screen eligible adults, shows that only 65.2% males and 70.2% females have received at least one surveillance CRC screening by any of the recommended modality (Brun & Kanarek, 2018). The percentage of adults, 50 years and older, who were up-to-date with CRC screening increased from 64% in 2002 to 70% in 2012 (Platz, 2018; MDH, 2017). However, data from the Baltimore City Health Department Office of Epidemiologic Services, shows that despite increases in CRC screening rates, up-to-date screening are not uniform across the State, as differences within gender, race/ethnicity, and access to health care services persist across all 24 counties in Maryland (MDH, 2017 cancer report). In 2016, 69.2% white, 68.3% blacks and 53.6% Asians in Maryland were up-to-date with screening (Brun & Kanarek, 2018).

Cross-sectional studies have identified factors such as gender, and race as reasons for not adhering to CRC screening in Maryland (Dwyer et al., 2015; Villanueva, Gugel, & Dwyer, 2013). Socioeconomic factors such as low-income, and health insurance, were identified as factors that affect CRC screening among African American men and women 50 years and older in Maryland (Palmer, Chhabra & McKinney, 2011). According to the Maryland Center for Cancer Surveillance and Control, between 2002 to 2012 the proportion of adults who reported never being screened for CRC was consistently higher among the uninsured, compared to the insured (MDH, 2017 cancer report). The focus of statewide public health efforts to address the CRC problem is to reduce disease outcomes through screening and early detection (Brun & Kanarek, 2018; Richardson et al., 2015). During the 2018 MCC annual meeting Dr. Elizabeth Platz pointed, efforts to reduce CRC incidence through screening are essential to meet the State's target goals (Platz, 2018).

Colorectal Cancer Control and Prevention Strategies in Maryland

Improvements in CRC screening programs remains an important pillar of work by the MDH, as it strives to bridge the sex and race gaps in CRC screening, and increase the percentage of screen eligible adults who are up to date with screening schedule (Watkins et al., 2018). The current public health effort by the state is to increase the number of adults ages 45 to 75 years who have had a FOBT in the past 1-3 years, a sigmoidoscopy in the past 5 years and a colonoscopy in the past 10 years (MDH, 2016-2020 cancer report). Based on the 2018 guidelines, the FOBT combined with fecal immunochemical test (FIT) is the recommended stool-based modality for CRC screening programs in Maryland, that serve as a screening test for any of the endoscopic tests (Watkins et al., 2018). For those enrolled in the Maryland CRF CPEST program, a positive stool test is directly recommended for colonoscopy, and for a negative test, a colonoscopy or sigmoidoscopy is encouraged at the next annual FOBT/FIT or during follow-up calls

(Ahmad et al., 2018; Watkins et al., 2018). The goal of a colonoscopy is to remove all identified polyps whether sessile or pedunculated, biopsied and sent for pathologic examination (Watkins, et al., 2018). Under the CRF CPEST program, all cancer diagnoses are immediately followed with treatment funded by the program (Watkins et al., 2018).

In Maryland, the public health purpose of CRC screening is to ensure enough bowel preparation to visualize polyps >5mm through adequate colonoscopy; and that polyps found during sigmoidoscopy are not removed but referred for colonoscopy for complete excision or biopsy depending on the size of the lesion (MDH, 2017). The good news for Marylanders is that new prevention programs as well as promising practices to reduce cancer disparities in the state are ongoing (Ahmad et al., 2018; Watkins et al., 2018). Some epidemiologists have recently evaluated the 30 years' progress in the implementation of cancer control and prevention programs in Maryland (Brun & Kanarek, 2018), and provided useful CRC statistics used in designing this dissertation.

Maryland's Contexts of the Colorectal Cancer Screening Problem

The guidelines for "Minimal Clinical Elements for Colorectal Cancer Detection and Diagnosis" was generated by the advisory board of the Maryland CRF PEST, to serve as CRC screening guidelines for diagnostic services in the CRF CPEST program (Watkins et al., 2018). The updated 2018 guidelines, included elements to promote CRC screening for Marylanders who are either uninsured or underinsured, aged 50-75 years, and enrolled in the CRF CPEST program. Under this guideline, in-office FIT or FOBT are not recommended, each positive FIT or FOBT must be followed with a colonoscopy.

Any other procedures or follow-up can be done only after a discussion between the participant and provider (Watkins et al., 2018). See appendix B for details.

Literature Review Related to Study Variables

Key variables in this study include education level completed, household income level, health insurance coverage, access to health care professional (independent variables), age, sex, race/ethnicity (covariates) and CRC screening use (dependent variable). These variables are of interest because, studies have shown statistically significant relationships between them and CRC screening across groups in the United States (Doubeni, 2019; Rosenberg, 2019; Doubeni, Corley, & Quinn, 2018; Burnett-Hartman, Mehta, & Zheng, 2016; Williams et al., 2016). Findings from this study will help to improve understanding of CRC screening use in Maryland and demonstrate the effect of sociodemographic factors on CRC screening rates in the State.

How Other Researchers Have Approached the Problem of low CRC Screening

Although there is a paucity of data on the predictors of CRC screening across various groups in Maryland; researchers have investigated predictors of CRC screening use in population-based retrospective and cross-sectional studies using both primary and secondary data (Abuadas et al., 2018; Helander, Heinävaara, Sarkeala, & Malila, 2018; Jih et al., 2018; Almadi et al., 2015). Publicly available data from reliable databases such as the National Health Interview Survey (NHIS), National Health and Nutrition Examination Survey (NHANES), and the CDC BRFSS, have been used to investigate risk factors (Cardoso et al., 2019; Sauer, Siegel, Jemal, & Fedewa, 2019); as well as barriers and trends in CRC screening utilization across demographic and socioeconomic characteristics in the US (Ran et al., 2019; Vanthomme, & Gadeyne, 2019; DeMoor, et al., 2018; Miranda et al., 2017; Kang & Son, 2017; Seibert, Hanchate, Berz, & Schroy, 2017; Lin, McKinley, Sripipatana, & Makaroff, 2017).

Secondary data from the 2014 Health Center Patient Survey was used to investigate the relationship between age, sex, race/ethnicity, geography, preferred language, household income, insurance, employment status and patient-provider communication on CRC screening among patients aged 45–75 years in the U.S. (Lin, McKinley, Sripipatana, & Makaroff, 2017). Results from multiple logistic regression analyses showed that patients 65–70 years of age had higher odds (aOR, 2.32; 95% CI, 1.37–3.94) of receiving CRC screening compared to those of the younger age group. Those who were insured were, 2.5 times more likely to receive CRC screening compared to the uninsured who were 67% less likely (aOR, 0.33; 95% CI, 0.18–0.61) to receive CRC screening (Lin, McKinley, Sripipatana, & Makaroff, 2017).

A population-based study was used to identify barriers to CRC by examining the prevalence of CRC screening adherence among obese adults 50–75 years of age, using the 2010 data from the NHIS. Results of the multiple logistic regression analysis showed that obese class III men (BMI $\geq$40), were 65 % less likely (aOR = 0.35, 95% CI = 0.17, 0.75, $p = 0.04$) to adhere to screening guidelines compared to non-obese class men (Seibert, Hanchate, Berz, & Schroy, 2017). A retrospective cohort study using the 2000–2015 data from the Kaiser Permanente North California members in a community-based CRC screening program, showed that implementation of a structured CRC screening program using stool-based test and colonoscopy significantly ($p < 0.01$) increased CRC screening uptake, from 38.9% in 2000 to 82.7% in 2015 (Levin, Corley & Jensen, 2018). Implementation of organized CRC screening outreach programs have been associated with rapid increase in screening participation (Cardoso et al., 2019; Doubeni, 2019; Levin et al., 2018) and decrease in CRC incidence and mortality rates (Li & Yuan, 2019; Pellat, Deyra, Coriat, & Chaussade, 2018).

Evidence-based approaches, such as patient navigation, have also been used for promoting CRC screening at population levels (Hunleth, Steinmetz, McQueen, & James, 2016; Enard, Nevarez, & Hernandez, 2015; Gordon & Green, 2015; Verma, Sarfaty, Brooks, & Wender, 2015; Fernandez et al., 2015). However, disparities in CRC screening rates across age, sex, and race/ethnic groups persist (Burnett-Hartman, Mehta, & Zheng, 2016; DeSantis et al., 2016; Wilder & Wilson, 2016). As evident in the literature, a strength in research on CRC screening use is the use of quantitative approaches that employ multiple logistic regression models to analyze data across groups (Cardoso et al., 2019; Levin, Corley & Jensen, 2018; Seibert, Hanchate, Berz, & Schroy, 2017; Lin, McKinley, Sripipatana, & Makaroff, 2017).

The weakness in population-based and cross-sectional designs on CRC screening is that most of the studies are broad, using national data (Lin, McKinley, Sripipatana, & Makaroff, 2017; Seibert, Hanchate, Berz, & Schroy, 2017; Verma, Sarfaty, Brooks, & Wender, 2015). Little information is available on cross-sectional studies on CRC screening use across groups in Maryland. However, previous researchers have found a strong association between physician recommendation for CRC screening and adherence to screening guidelines across some groups in Maryland (Palmer et al., 2011; Gilbert &

Kanarek, 2005). To meet the state CRC screening target of ≥80%, smaller, culturally sensitive and tailored studies on predictors of CRC screening use such as is the premise of this dissertation are necessary.

Age and Colorectal Cancer Screening Use

There is overwhelming evidence from the literature that for people aged 45 years or older, screening by any of the recommended modalities can detect CRC early and improve treatment if diagnosed (Doubeni et al., 2019; Zauber et al., 2018). Yet CRC screening uptake remain low among this age group (De Moor et al., 2018; Kang & Son, 2017). According to Molina-Barceló et al., (2018) men are more likely to participate in CRC screening only if they are 60 years of age or older. De Moor et al., (2018) used the 2008–2015 NHIS data to examine CRC screening rates among individuals 50–75 years of age with health insurance coverage. After stratifying the age variable into two subgroups (50–64 years and 65–75 years), results from multiple logistic regression analysis showed that adults aged 50–64 had a higher (73.4%) use of CRC screening by any modality compared to adults aged 65–75 years with lower (71.7%) use (De Moor et al, 2018).

To support this finding, Kang & Son, (2017) used secondary data from a 2012 Community Health Survey to conduct a cross-sectional study to examine the relationship between age, sex, and CRC screening participation. Results from the multiple logistic regression analysis showed that younger age was associated to CRC screening in both men and women. Pooled analysis of randomized trials to determine the effectiveness of screening in CRC screening program showed that screening reduced CRC incidence in women <60 years of age (RR 0.71; 95% CI 0.59–0.84), but not significantly (0.90; 95%

CI 0.80–1.02) in those ≥60 years old (Holme et al., 2017). Increase in public health effort is needed to promote CRC screening among the younger age group in the U.S. (Maxwell, Hannon, & Escoffery 2014).

Sex and Colorectal Cancer Screening Use

Screening by any of the recommended modalities can detect CRC early (USPSTF, 2018), yet sex differences in CRC screening uptake exist with men having lower CRC screening rates compared to women (Brenner & Chen, 2018; Molina-Barceló et al., 2018; Sava, Dolan, May, & Vargas, 2018; Kang & Son 2017; Mehta, Jensen & Quinn, 2016; Symonds et al., 2016). In a cross-sectional study using multiple logistic regression analysis to examine the factors that influence CRC screening, Molina-Barceló et al., (2018) found a statistically significant ($p < 0.05$) relationship between sex and CRC screening participation. Results showed that women were more likely (OR:1.52; 95% CI: 1.06–2.19) to participate in screening compared to men. However, men were more likely to participate in screening if they live with a partner (OR: 6.26; 95% CI: 1.82–21.49) or have family responsibilities (OR: 2.53; 95% CI: 1.39–4.63) (Molina-Barceló et al., 2018). Contrary to these findings, Almadi et al., (2015) found that, neither gender, income, marital status, nor knowledge about CRC were associated with participation in screening. However, understanding that colonoscopy is a screening test was associated with a strong desire (OR:1.55, 95% CI; 1.04–2.29) to undergo screening (Almadi et al., 2015).

Furthermore, to determine the highest CRC screening rates in sex and age groups Sava, Dolan, May, & Vargas (2018), found that CRC screening participation was higher in women (35.81%) aged 50–59 years than in men (25.91%) of same age group.

Although there is limited current literature on sex specific differences in CRC screening use, the influence of traditional gender roles where women have greater self-care compared to men who have a poorer perception of vulnerability could explain the gender differences in CRC screening participation (Molina-Barceló et al., 2018; Mehta, Jensen & Quinn, 2016). Moreover, available literature shows that higher rates of positive CRC screening test for men may be associated with lower CRC screening uptake (Sava, Dolan, May, & Vargas, 2018; Symonds et al., 2016). Therefore, gender-specific interventions are needed to encourage CRC screening use for both sexes (Kang & Son, 2017).

Race/Ethnicity and Colorectal Cancer Screening Use

Despite increases in CRC screening rates among adults 50–75 years of age, significant racial disparities remain across groups (Bernardo et al., 2018; Meester et al., 2018; Moreno, Fibus, Krupinski, Kim, & Pickhardt, 2018; Seibert, Hanchate, Berz, & Schroy, 2017; Gonzales, Qeadan, & Mishra, 2017; Burnett-Hartman, Mehta, & Zheng, 2016; Wilder & Wilson, 2016; Liang, Mayer, &Wakefield, 2016; Liss & Baker, 2014). The relationship between race/ethnicity and CRC screening in the US, had been investigated in population based studies that revealed Hispanics lag Whites, Blacks, and other racial groups in being up-to-date with CRC screening (Burnett-Hartman, Mehta, & Zheng, 2016; Khajuria, 2016; Mehta Jensen & Quinn, 2016). Data from the Morbidity and Mortality Weekly Report (MMWR, 2016), showed that during the 2000–2015 period, CRC screening rates were higher among non-Hispanic white (65.6%), relative to non-Hispanic black (60.3%), non-Hispanic Asian (52.1%), and Hispanic (47.4%).

Using the 2010 data from the CDC BRFSS database, results from multiple regression analysis showed that CRC screening rates were highest among whites (62.0%) compared to, blacks (59.0%), Native Hawaiian/Pacific Islander (54.6%); English-speaking Hispanics (52.5%), American Indians/Alaska Natives (49.5%), Asians (47.2%), and exceptionally low for Hispanic-Spanish groups with 30.6% (Liss & Baker 2014). Also, Liss & Baker (2014) demonstrated that racial/ethnic disparities persisted even after adjusting for SES and access to health care professional; Hispanic-Spanish (RR:0.76, 95% CI: 0.69–0.83); Hispanic-English (RR:0.94, 95%CI: 0.91–0.98); and American Indian/Alaska Native (RR:0.91, 95%CI: 0.85–0.97). In support of these findings a retrospective cohort study using the 2004–2013 data of the KPNC community-based integrated healthcare system was conducted to examine the association between race/ethnicity and CRC screening and timely follow-up after intervention program (Mehta, Jensen, & Quinn, 2016). Results of the multiple logistic regression analysis showed that, although screening rates increased across all groups after the intervention program, rates remained lower in minority race groups compared to whites both before and after implementation of CRC screening program; whites (rate ratio:1.04, 99 % CI: 1.02–1.05) and blacks (RR = 0.97, 99% CI: 0.96–0.97).

Although an estimated 61% of the U.S. population have shown the inclination to screen for CRC (Mason, 2018; Ransohoff, & Sox, 2016), compared to other race/ethnic groups 65% of Vietnamese Americans aged 50 years and older have never taken a CRC screening test (Heiniger, Sherman, Shaw, & Costa, 2015; Ghai et al., 2015). Data from the National Center for Health Statistic (NCHS) showed that between 2003 to 2013, CRC screening rates increased from 41% to 60% for Whites, 35% to 58% for Blacks, 27% to 50% for Asians, but increased the least for Hispanics from 27% to 41% (NCHS, 2017). Given that some racial/ethnic groups are less likely to get screened (Khajuria, 2016), and more likely to present with late stage CRC (Gonzales, Qeadan, & Mishra, 2017; ACS, 2017); It is therefore no secret that the racial/ethnic differences in CRC screening rates and their association with CRC diagnosis has been a challenge to CRC prevention programs across many healthcare systems in the United States (Burnett-Hartman, Mehta, & Zheng, 2016). Enhanced, multilevel efforts and multi-component culturally tailored programs are important strategies to address CRC screening differences among at risk race groups such as Hispanics, Blacks and Asians (Wittich et al., 2019; Khajuria, 2016; Fernandez et al., 2015; Enard, Nevarez, & Hernandez, 2015; Gordon & Green, 2015; Hunleth, Steinmetz, McQueen, & James, 2016); who often lack the economic resources such as health insurance that is needed for most screening programs (Sauer, Siegel, Jemal, & Fedewa, 2019).

Education Level and Colorectal Cancer Screening Use

Extensive studies had been conducted to show that CRC screening rates among adults age 50-75 is linked to education level and education is a strong predictor to CRC screening participation. Researchers have studied the relationship between education level and CRC screening use by examining highest level of education completed on the ability to read, judge, make informed decision (Lee, Natipagon-Shah, Sangsanoi-Terkchareon, Warda, & Lee, 2019; Woudstra, Smets, Verdam, & Fransen, 2019; Woudstra et al., 2018; Rodriguez, & Smith, 2016; Wee, McCarthy, 2005 & Phillips,

2005) and the effect of health literacy on the ability to understand and apply CRC screening information for personal relevance (Ojinnaka et al., 2015). Results from a multivariable logistic regression analysis to investigate the factors that influence CRC screening uptake among Thais in the United States aged 50–75 years, showed that in addition to other sociodemographic factors, significant predictors of screening adherence include having at least some college education (OR 3.74, 95% CI 1.23–11.37), compared to those no college education (Lee et al., 2019).

To examine the association between education level and CRC screening among US veterans age 50–75 years using the 2012 BRFSS data, results from multiple logistic regression analyses showed that while adjusting for sex, income, race/ethnicity, health insurance coverage, having a primary care provider, employment status, and delay in care due to medical cost, the probability to obtained CRC screening increases as education level increases ($p < .05$); individuals with less than high school (73%), high school graduates (77%), some college (84%) and college degree or more (87%) compared to those with lower education levels (Rodriguez, & Smith, 2016). To support these findings, by adjusting for age, sex, healthcare access, and region of the country, Wee, McCarthy, & Phillips, (2005) found that respondents at lower education levels were less likely to undergo CRC screening by FOBT (OR: 0.7 [95% CI: 0.6–0.9]) and colonoscopy (OR: 0.8 [95% CI: 0.7–0.9]) compared to those at higher education levels. According to Woudstra, Smets, Verdam, & Fransen, (2019) individuals at lower educational levels have more difficulty understanding health information and making informed decisions about CRC screening. However, people with less education are more likely to participate in CRC screening at the initiative of a health care professional or a screening programme (Willems, & Bracke, 2018).

Income Level and Colorectal Cancer Screening Use

There is overwhelming evidence from retrospective, prospective and cross-sectional studies that income level highly correlates with CRC screening use; with higher income associated with increased odds of up-to-date CRC screening in both retrospective and prospective studies (Sharma et al., 2019; Simkin, Ogilvie, Hanley, & Elliott, 2019; Honein-AbouHaidar et al., 2016; Satsangi & DeGroff, 2016; Singh et al., 2015; Pruitt et al., 2014; Wheeler et al., 2014). Previous researchers have examined the association between income and CRC screening, by investigating the effect of cost of screening on compliance and adherence to USPSTF recommended guidelines in both community and population based studies (Cross et al., 2019; Honein-AbouHaidar et al., 2016; Ojinnaka et al., 2015; Davis, & Ballreich, 2014; Pornet et al., 2014; Klabunde et al., 2013). The association between income level and CRC screening has also been investigated in the context of other aspects related to socio-economic deprivation, social determinants of health, rurality, and universal access (Hunleth, Steinmetz, McQueen, & James, 2016; Calo et al., 2015; Singh et al., 2015; Shariff-Marco et al., 2013).

To estimate the prevalence of up-to-date CRC screening among adults aged 50-74 years across income strata by urbanization, Simkin, Ogilvie, Hanley, & Elliott, (2019) used the 2013/2014 data from the Canadian Community Health Survey and found that up-to-date CRC screening rates ranged from 47.0% for the lowest income group to 54.0% for the highest income group. Results from the multiple logistic regression analysis revealed high income quintile (OR = 1.49, 95% CI 1.17–1.89) and middle income quintile (OR = 1.42, 95% CI: 1.02–1.99) were more likely to be up-to-date CRC screening compared to the lowest income quintile (Simkin, Ogilvie, Hanley, & Elliott, 2019). Low-income and rural populations are less likely to report up-to-date CRC screening than high-income and urban counterparts, respectively (Simkin, Ogilvie, Hanley, & Elliott, 2019). It is essential to understand and address inequities in CRC screening use, particularly among low-income populations.

In the 2015 CDC funded CRC Control Program (CRCCP), researchers analyzed clinic data using ordinary least square regression analysis to estimate CRC screening rates across income levels, and found that those who lived in low income counties were negatively associated with lower (43%) CRC screening rates compared to high income counties (Satsangi & DeGroff, 2016). Given the disparities in CRC screening rates by income levels, there is need to examine up-to-date CRC screening use across income levels in Maryland. The design and implementation of CRC screening programs in Maryland should be underpinned by evaluation of the current CRC screening program to help identify vulnerable populations and inform screening priorities across groups.

Health Insurance Coverage and Colorectal Cancer Screening Use

Health insurance coverage has been linked to limited use of preventive health services such as CRC screening programs (Wyatt, Pernenkil & Akinyemiju 2017; Zhao, Okoro, Li, & Town, 2017; Wools, Dapper, & de Leeuw, 2016). Although the ACA has expanded access to health insurance for people who were previously uninsured, and cost-sharing for most preventive health care plans with USPSTF grade “A” or “B” has been eliminated in the Medicare program (Blumenthal & Collins, 2014); many eligible adults are not screening according to USPSTF recommendations (White et al., 2017). The literature revealed that individuals without health insurance coverage of any type are less likely to receive CRC screening (Miranda et al., 2017; Zhao, Okoro, Li, & Town, 2017); and more likely to present with advanced stages of disease (Amini, Jones, & Yeh, 2016).

In using data from the CDC BRFSS to examine CRC screening participation among U.S. adults by health insurance status, Zhao, Okoro, Li, & Town, (2017) found that the underinsured (3%) and never insured (47%) women, as well as the underinsured (6%) and never insured (52%) men were less likely to receive CRC screening. However, women and men ≥50 years of age with private plans were less likely to receive CRC screening, and men with public insurance were more likely to receive CRC screening (Zhao, Okoro, Li, & Town, 2017). The odds of CRC screening were slightly higher (OR: 1.05, 95% CI: 1.03–1.08) during high resource availability period post-recession/ACA of 2010-2012; and lower (OR: 0.73, 95% CI: 0.72–0.75) during the low resource availability period of the 2007–2009 recession (Wyatt, Pernenkil & Akinyemiju, 2017).

Contrary to this finding, De Moor et al., (2018) used the 2008–2015 data from the NHIS and demonstrated that, compared to other health insurance plans like TRICARE individuals aged 50–75 years with traditional employer-sponsored insurance were 62.2% more likely to be screened those with traditional private purchase plans (50.9%), and the uninsured (24.8%). However, screening increased from 51.6% in 2008 to 58.3% in 2010; then plateaued from 2010 to 2013 but increased again from 58.3% to 61.3% in 2015 during high resource available period (De Moor et al., 2018). It is essential to point that

CRC screening rates increased from 2013, after the 2012 ACA, when over 40 million more Americans gained health insurance coverage (Sommers, Gunja, & Finegold, 2015) and have steadily progressed since the ACA (Zhao, Okoro, Li, & Town, 2017; Wherry, & Miller, 2016). These findings suggest that more public health efforts are needed to close the gaps in insurance plans so as to increase the use of preventive healthcare services among the insured and the uninsured in the U.S (Zhao, Okoro, Li, & Town, 2017). It is likely that health insurance coverage and support from healthcare professionals will contribute to improvements in CRC screening use in Maryland, as health insurance remains a primary focus of CRC screening programs in Maryland (MDH, 2017).

Access to Healthcare Professional and Colorectal Cancer Screening Use

There is evidence from the literature that access to a health care professional is a strong predictor of CRC screening use. Previous researchers have suggested that access to a healthcare professional provides an opportunity for individuals to make informed decision to participate in CRC screening programs, regardless of educational attainment, poverty, level of urbanization, and other factors that may influence the use of preventive health care services (Figueroa et al., 2017; Kirkegaard et al., 2016) and increase the likelihood to participate in CRC screening programs (Willems, & Bracke, 2018). The relationship between access to healthcare professional and CRC screening use have been investigated in the realms of the number of health care specialists as a preventive approach for cancer (Sharma et al., 2019; Simkin, Ogilvie, Hanley, & Elliott, 2019; DeGroff et al., 2018; Jackson, Goel, Kho, & Keswani, 2016); and the role of physician counseling in increasing CRC screening uptake (Willems, & Bracke, 2018; Satsangi & DeGroff, 2016; Wee, McCarthy, & Phillips, 2005).

To identify factors that contribute to variations in CRC screening rates among patients who visit four medical centers in Chicago, results from the multiple logistic regression analysis showed that patients who had regular checkups with health care professionals in the previous two years were 16 times more likely (OR 16.01, 95% CI: 3.75, 68.75) to have obtained CRC screening for the first time compared to those who did not visit the clinic regularly (Jackson, Goel, Kho, & Keswani, 2016). Moreover, in their cross-sectional study to examine the role of primary care clinic to increase CRC screening rates in medically underserved areas, Sharma et al., (2019) found that those with access to at least one health care professional had up to 16.4% higher CRC screening rates compared to those who did not visit the primary care clinic. To support these findings, Wee, McCarthy, & Phillips, (2005) found that among those who did not undergo CRC screening in low SES areas, 92% were not counseled by their physician.

Some researchers have suggested that, a strategy to increase CRC screening rates and reduce SES inequity is by systematic patient counseling about CRC screening through visit to a health care professional (DeGroff et al., 2018; Satsangi, & DeGroff, 2016). Therefore, it is essential for public health professionals to design and implement combinations of CRC screening programs that are underpinned by access to a health care professional, cost, and capacity of specific community need. This study went further to quantitatively examine if there is any association between access to one or more than one health care professional and fully meeting the USPSTF CRC screening recommendation within the recommended time interval among adults 50–75 years in Maryland.

Literature Review Related to the Research Design and Methodology

Based on the literature gathered so far, it is no secret that removal of precancerous lesions as well as early detection of CRC through screening reduces CRC-related incidence and mortality in men and women (Sauer, Siegel, Jemal, & Fedewa, 2019). This dissertation utilized a quantitative design using secondary data from the CDC BRFSS to determine associations between the independent variables (age, sex, race/ethnicity, health insurance coverage, access to health care professional) and the dependent variable (CRC screening use). The BRFSS is a rich resource for a wide variety of research questions on CRC screening use. Using data from the BRFSS would allow me to collect and analyze a large volume of data within a relatively short time (Lakerveld et al., 2017).

The influence of the identified independent variables on CRC screening participation and adherence to screening programs were also discussed in this chapter. Data for this study were analyzed using multiple logistic regression approach because the model allowed for the estimation of the predictive relationship between the predictors and the dichotomous dependent variable, and useful to identify outliers control of potential confounding factors (Rogers et al., 2017; McDonald, 2014). Prior studies that only measure initiation of CRC screening, without follow-up of positive results, may have overestimated CRC screening participation, and missed potential differences in CRC screening completion rates across groups (Cross et al., 2019; Wilder & Wilson, 2016; Wools, Dapper, & de Leeuw, 2016). The underlying hypothesis of this study is that the association between the predictor variables and CRC screening use differs across groups depending on demographic characteristics and resource availability. Thus, findings from this study are a useful guide for the MCC to design, targeted screening programs within a variety of community settings in Maryland.

Summary

Epidemiologic studies to evaluate the age to start and stop CRC screening, and the differences in screening rates based on presumed level of benefit were reviewed. Researchers have demonstrated that it is essential for adult men and women aged 50–75 years to comply with USPTSF CRC screening recommendation (Cardoso et al., 2019; Meester et al., 2018); because screening can prevent the disease through detection and removal of precancerous polyps (Jeon et al., 2018). Adherence to recommended guidelines play a significant role in reducing CRC outcomes among groups (Jeon et al., 2019). The reasons for low CRC screening rates are multifactorial, including sociodemographic and socioeconomic factors that include age, sex, race/ethnicity, education level, income level, health insurance coverage, and access to health care professional (Simkin, Ogilvie, Hanley, & Elliott, 2019; DeGroff et al., 2018; De Moor et al, 2018; Woudstra et al., 2018; Rogers et al., 2017; Jackson, Goel, Kho, & Keswani, 2016). CRC is one of seven high burden cancers for Maryland hence a focus on CRC screening programs in the last ten years in the State (MDH, 2018).

In embracing the overall literature, CRC screening use is higher among women than men of the same age and race group (Chen, Hoffmeister, & Brenner, 2019; Brenner & Chen, 2018; Molina-Barceló et al., 2018; Sava, Dolan, May, & Vargas, 2018; Arana-

Arri et al., 2017). Also, CRC screening rates are higher among whites than in any other race/ethnic groups (Mehta, Jensen, & Quinn, 2016; Liss & Baker, 2014). Access to a health care professional is influential to improving CRC screening up take among groups (Willems, & Bracke, 2018; Satsangi & DeGroff, 2016). Surveillance screening should not be limited to those with health insurance coverage, but provided to all individuals in the community regardless of income level or resource availability (Cross et al., 2019). This study fills a gap in understanding the documented issues around low CRC screening rates in Maryland (MDH 2016-2020 cancer report) and elucidate where the focus should be to increase CRC screening use among various groups. Given the benefits of CRC screening, targeted screening programs would produce better prognosis from early diagnosis, and consequently reduce CRC mortality rate (Dubé, 2018).

Conclusions

The evidence around sociodemographic and socioeconomic inequalities in CRC outcomes remains remarkable (Cross et al., 2019). Some researchers have suggested that regardless of associations, more targeted and culturally tailored screening programs at both the national and state levels may improve CRC screening and early diagnosis in both men and women (Dubé, 2018; Stock, Hoffmeister, & Brenner, 2018; White et al., 2018). Using a comprehensive culturally sensitive and system-wide approach can be effective for long-term CRC screening programs in Maryland. Increase in CRC screening rates are essential to improve overall population health for the state. To increase rates across all groups in the Maryland population CRC screening can be extended to both the insured and the uninsured.

Chapter 3: Research Method

Introduction

The purpose of this study was to improve understanding of CRC screening uptake in Maryland by identifying factors that predict CRC screening use in the state. Previous researchers found strong associations between sociodemographic factors, socioeconomic factors, and CRC screening uptake in both small and large scale communities (Cross et al., 2019; Simkin, Ogilvie, Hanley, & Elliott, 2019; De Moor et al., 2018; DeGroff et al., 2018; Molina-Barceló et al., 2018; Rogers et al., 2017; Zhao, Okoro, Li, & Town, 2017). Data for this study were obtained from the CDC BRFSS database. In this chapter, I provide a detailed description of the research design and method, data access and collection procedures, instrumentation and operationalization, threats to validity, and ethical procedures for data collection.

Research Design and Rationale

This study utilized a quantitative, cross-sectional, descriptive design to analyze secondary data collected from the BRFSS database. Quantitative designs are used to count features and to examine statistically significant relationships between quantifiable groups (Creswell & Creswell, 2018; Rudestam & Newton, 2015). Cross-sectional designs are observational in nature and are assumed to have high reliability (McCusker & Gunaydin, 2015) and higher methodological quality (Yang & Yu, 2018). Cross-sectional designs are used to describe characteristics in a population, make inferences about relationship between variables, and to gather preliminary information to support further research (Creswell, 2014). The independent variables used in this study were age, sex, race/ethnicity, education level, household income, health insurance coverage, and access to healthcare professional. Age, sex, and race/ethnicity were also used as covariates in the statistical analysis. The outcome variable was CRC Screening Use (CRCSU). These variables were important for this Maryland-based study because previous studies have shown statistically significant ($p < 0.001$) relationships between them and CRC screening participation and adherence to surveillance CRC screening guidelines (Cardoso et al., 2019; Macrae, 2019; O'Leary et al., 2019).

A cross-sectional design was appropriate for this study to determine the factors that predict CRCSU, because the BRFSS stores quantitative data with survey questions on demographic and socioeconomic variables (Maryland BRFSS, 2018) that are specific to the research topic and the outcome variable of this study. The overall strategy chosen to logically integrate the different components of this study and to practically describe the research problem, included the utilization of two RQs and several analyses that were necessary to correctly address the RQs. The RQ and hypotheses that drive this study were as follows:

1. Research Question 1 (RQ1): Is there any association between socioeconomic status measured by education level, household income, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity?

   Null Hypothesis 1 (H_{01}): There is no statistically significant association between socioeconomic status measured by education level, household income, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

Alternative Hypothesis 1 (H_{a1}): There is a statistically significant association between socioeconomic status measured by education level, household income, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

The research design for this study provided a streamlined approach to answer RQ1 with the focus to determine the relationship between the five independent variables (age, sex, race/ethnicity, education level, household income) and the dependent variable, CRCSU, and whether the covariates (age, sex, race/ethnicity) have a confounding effect on the outcome or not. To answer RQ1, the categorical predictor variables were manipulated by creating subgroups and coding of the variables for simplicity in the analysis. Since there are more than one independent variable and a single nominal dichotomous outcome variable, multiple logistic regression analysis was used to assess associations between the predictor variables and the outcome variable, and to test the hypothesis whether the odds ratio (OR) is statistically significant at 95% confidence interval (CI) or not.

2. Research Question (RQ2) – Is there any association between access to preventive health care service measured by health insurance coverage, access to health care professional, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity?

Null Hypothesis 2 (H_{02}): There is no statistically significant association between access to preventive health care service measured by health insurance coverage, access to health care professional, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

Alternative Hypothesis 2 (H_{a2}): There is a statistically significant association between access to preventive health care service measured by health insurance coverage, access to health care professional, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

For RQ2, there are two predictor variables (health insurance coverage, access to health care professional), three covariates (age, sex, and race/ethnicity) and one dichotomous outcome variable (CRCSU). The research design of this study corresponds to RQ2 in that, multiple logistic regression was applied to understand the functional relationship between the identified predictor variables and CRCSU and to determine if the covariate affect the probability of the outcome to change or not. The research design also connects to RQ2 in that, analyses were performed to test the hypothesis whether the OR is statistically significant at 95% CI or not.

The use of accessible secondary data was suitable for this study because it helps to maximize the output of data collection efforts by eliminating the issue of time and resource constraints, safeguards anonymity, and reduces cost that are consistent with primary data collection and qualitative designs (Wickson-Griffiths et al., 2014). The design choice for this dissertation is consistent with current epidemiological research designs as the most popular approach to enhance the overall efficiency of the health research enterprise (Betge et al., 2017). The cross-sectional design is unique for this study because the main concern of the dependent variable relates to peoples' behaviors which cannot be correctly conducted even in a well-controlled experimental design (McDonald, 2014). The quantitative design choice will also help to advance public health knowledge in the discipline on CRC screening behaviors by utilizing the large data available in the BRFSS database; necessary to inform the best strategic approach for designing and implementing CRC screening programs in Maryland.

Methodology

This study utilized a quantitative methodology using secondary data from the BRFSS database. Quantitative methodologies are useful to determine differences, relationships and patterns between groups and to emphasize objective and precise measurements of data collected from polls, questionnaires, and surveys (Rudestam & Newton, 2015). The quantitative methodology allowed me to seamlessly perform manipulations of the data using statistical techniques. Multiple logistic regression is the best fitting and most relevant approach for this study because it produces a model that shows how the predictor variables affect the probability of the outcome variable, and covariates can be tested using the model. The rest of this chapter include details of how I implemented my design and specific procedures used to upload my data, manage the dataset and analyze the data to address the research problem.

Target Population

CRC is rare in children and adults less than 45 years of age, and common among adults 45 years of age and older (Bibbins-Domingo et al., 2016). Based on the United States Preventive Service Task Force (USPSTF) guidelines on CRC screening for average-risk individuals; the target population for this study is males and females aged 50–75 years, resident in Maryland and respondents of the BRFSS survey of 2014, 2016 and 2018, the most recent available CRC screening data of Maryland. This population is suitable for my research because evidence from the literature shows that the selected variables are associated to the likelihood to adhere to CRC screening schedule (Liang & Dominitz, 2019; O'Leary et al., 2019); with minority groups highly disadvantaged to be compliant with routine CRC screening programs (Cross et al., 2019; Bernardo et al., 2018). Based on the BRFSS survey questionnaire, the target population included both males and females, ages 50–75. To compensate for missing data, incomplete questionnaires, and any potential sampling bias, the target population size for this study was 6641 respondents of the BRFSS survey of 2014, 2016, and 2018.

Sampling and Sampling Procedures

Sample Size

The sample size for this study was calculated using the design-based input mode of G*Power statistical power analysis software. The G*Power software is preferred because it is a flexible stand-alone tool to assess a variety of popular statistical tests used in social and behavioral research (Faul, Erdfelder, Lang, & Buchner, 2007). G*Power allowed me to choose the preferred effect size, alpha, and power.

Effect Size and Power Analysis

The power of a statistical test determines the viability of the null hypothesis (H_0) and is used to calculate the probability of detecting an effect such that by using the test, the H_0 will be rightly rejected if the alternative hypothesis (H_a) is true (Mudge, Baker, Edge, & Houlahan, 2012). According to Ellis (2010), the effect size can be small, medium or large depending on what is being investigated. Large effect size with a significant *p*-value indicates a strong relationship between the measured variables; while a small effect size shows that even with a significant *p*-value the relationship between the measured variables may not be significant (Ellis, 2010). A medium effect size provides an average but consistent effect to identify and illustrate any association between variables in the sample under study (Mudge, Baker, Edge, & Houlahan, 2012).

In epidemiological studies, the level of statistical significance (alpha) is the level of error allowed for the test to reject a true hypothesis (Frankfort-Nachmias, & Nachmias, 2015). The alpha (α) value (*p*-value) which ranges from 0 to 1 plays a key role in determining the point to reject or accept a H_0 (Frankfort-Nachmias, & Nachmias, 2015). Traditionally a *p*-value >.05 means the H_0 is accepted and the result is statistically not significant; and a *p*-value <.05 means the H_0 is rejected and the result is statistically significant (Frankfort-Nachmias, & Nachmias, 2015).

High power tests minimize type II errors in the results; but require a larger sample size (Ellis, 2010). Consistent with the power level used by most researchers, I used 80% power level to determine sample size in this study, because it reduces the probability of type II error and gives me enough leverage to attain an appropriate sample size for the scope of this study. Using an adequate sample size improves confidence in applying the result to the general population (Amawi, Ashby, & Tiwari, 2017).

To calculate an adequate sample size for this study, linear multiple regression with respect to the F test and the A priori power analysis in G*Power was used. The G*Power inputs were set at medium effect size of 0.15, α err prob of 0.05, and power (1-β err prob) of 0.80 with 7 predictors. Using these tests statistics, G*Power calculated a sample size of 103 needed to achieve 80% power level. A post-hoc power analysis was conducted and the G*Power output showed that, knowing my effect size, α, and sample size, I achieved 100% power at 3126 participants. In this study, I used a sample size of 3134 to justify empirical validity of the results from my analysis. This large sample size is significant because it represents data from all 24 counties in Maryland, and accounts for any potential bias, or any other limitations in data collection.

Procedures for Data Collection

In this study secondary data from the BRFSS was used for statistical analysis.

Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System

The CDC BRFSS was established in 1984 with 15 states as the premier system of health-related telephone surveys, that collect data from U.S. residents on health-related risk behaviors, chronic conditions, and use of preventive services (CDC, 2014). Currently, the BRFSS collects data from more than 400,000 adult interviews each year from all 50 states, the District of Columbia and three U.S. territories; making it the largest ongoing health survey system in the world (CDC, 2017). By collecting and storing behavioral risk data across state and local levels, the BRFSS has become a robust tool used by public health professionals to target and build health promotion activities (CDC, 2014). Currently, there is a wide demand and sponsorship of the BRFSS survey for states, other CDC centers and US federal agencies (CDC, 2017).

Maryland Behavioral Risk Factor Surveillance System

The Maryland BRFSS was established and made available in 1995 with a typical overall annual sample size of 13,000 non-institutionalized Maryland residents aged 18 years and older (Maryland Department of Health and Mental Hygiene MDH, 2019). Under the CDC sponsorship and guidance, the MDH conducts statewide BRFSS surveys each year on many topics including the use of preventive services, and elements that affect chronic diseases (MDH, 2019). The Maryland BRFSS telephone-based disease surveillance program is designed to collect annual data, maintain, manage and store extensive state-specific data to estimate the behaviors, and conditions on many health-related risk factors such as nutritional habits, tobacco use, cancer screening behaviors and survivorship that may have public health consequences in Maryland (MDH, 2019).

Data from the Maryland BRFSS is typically used by the MDH for public health programs, local health departments, universities, and research organizations to assess needs, plan and evaluate programs, apply for funding, and to inform state public health policy (MDH, 2017). All Maryland BRFSS data from 1995 to present are publicly available on the Maryland BRFSS website and the Maryland IBIS website (MDH, 2019). Estimates from the Maryland BRFSS are weighted by State population and includes county level data tables as well as industry and occupation health indicators for the state

(Smith et al., 2019). Examples of results that have been disseminated using data from the Maryland BRFSS include findings from the 2016 six nationally-recognized disability status questions on disability and chronic health conditions among Maryland adults (Maryland BRFSS, 2018). The results revealed that 21.6% of Maryland adults have one or more disability ranging from cognitive disability (8.8%), mobility disability (11.4%), vision disability (3.1%), hearing disability (4.1%), self-care disability (2.6%), and 5.7% with an independent living disability (Maryland BRFSS, 2018). The 2018 BRFSS briefs also revealed findings on prediabetes (volume 1); hypertension and cognitive decline among older adults in the State (volume 2).

A benefit of using the BRFSS database for this study is that the data are readily available for research use, and the BRFSS analysis tool has options to download data in a format that is compatible with the IBM Statistical Package for the Social Science (SPSS) software used for analyses in this study. More also, the BRFSS tool allowed me to seamlessly generate simple descriptive statistics such as frequencies and cross-tabulation which are appropriate for my quantitative methodology. The BRFSS is the best source of data for this study because it is based on large sample sizes of statewide survey that are representative of the Maryland population (Maryland BRFSS, 2018).

Procedure for Data Access and Collection Process

Data used for this study is publicly available. Permission to access the dataset and approval to conduct this study was granted by the Walden University’s Institutional Review Board (IRB) with approval number 02-25-20-0678352. After receiving IRB approval, data was extracted following Walden IRB guidelines. Since the data were readily available, there are no specific collection methods; except that datasets were uploaded from the database, saved on my computer and reloaded into SPSS for analysis. An advantage of using secondary data is that it is easily accessible and requires less time to gather data, thereby expediting the data collection phase and strengthen the research project (Boyd et al., 2015).

Instrumentation and Operationalization of Constructs

Instrument & Materials

I used the 2014-2018 datasets from the CDC BRFSS database for this study. The BRFSS survey questions do not distinguish between a diagnostic or a screening test for CRC. However, the BRFSS surveys questions related to CRC screening use are asked in ways such as (1) Have you had one or more of the USPSTF recommended CRC tests within the recommended time interval? (2) If “Yes,” “When was your last test?” (CDC, 2014). BRFSS survey questions about access to a health care professional, are usually asked like, “Do you have one person you think of as your personal doctor or health care provider?” If “No”, Is there more than one or is there no person who you think of as your personal doctor or health care provider? (CDC, 2018). The BRFSS provide invaluable health information at national, state and local levels that are comparable to those of other survey instruments (Nelson, Powell-Griner, Town, & Kovar, 2003).

There is evidence that supports BRFSS validity with high survey response rates compared to estimates from other national health survey instruments such as the National Health Interview Survey (NHIS) and the National Health and Nutrition Examination Survey (NHANES) on multiple topics of health risk behavior (Zhang et al., 2014;

Pierannunzi, Hu, & Balluz 2013). According to Pierannunzi, Hu, & Balluz (2013) limitations of the BRFSS compared to the NHANES and the NHIS instruments could be due to differences in the mode of data collection. However, the BRFSS is a reliable and highly reputable source of data for many health surveys and provides anonymous CRC screening data by age, sex, race/ethnicity, education level completed, household income, health insurance coverage, and access to a health care professional (MDH, 2018); which are necessary to estimate associations in this study. To maximize the output of data collection and to enhance the overall efficiency of this research, I assessed more variables than those strictly needed to verify my hypotheses. Considering the reliability of BRFSS data, and mindful of the fact that an objective of this study is to utilize secondary data, no new instrument, device, or tool was developed for this study.

Validity and Reliability of Behavioral Risk Factor Surveillance System Data

Researchers have examined the reliability and validity of the instrument used in BRFSS measurements and the system's capability to provide valid national estimates and multiple assessments across states. Consistent across many studies, the validity and reliability of the BRFSS survey compared to the NHIS and the NHANES reveals high participation rates and similar estimates for several outcome measures including cancer screening, coronary heart disease, and stroke (Leung et al., 2015; Towle, Tolliver, Bui, Warner, & van Dyke, 2015; Silva, 2014; Pierannunzi, Hu, & Balluz, 2013); obesity, smoking, hypertension, diabetes, and lack of health insurance coverage as barriers to medical care (Moore et al., 2015; Zhang et al., 2015; Skopec, Musco, & Sommers, 2014; Pierannunzi, Town, Garvin, Shaw, & Balluz, 2012). For example, the validity and reliability of BRFSS survey instrument was tested by using the 2008–2015 data from the NHIS, NHANES and BRFSS databases, to examine CRC screening measurements on individuals aged 50–75 years with health insurance coverage, and results showed a higher (88.4%) survey respond rate for the BRFSS compared to the NHIS and NHANES survey instruments (De Moor et al., 2018). By using the BRFSS survey instrument to evaluate the test-retest reliability and validity of stool-based and endoscopic CRC screening tests over 2-week, 3-month, and 6-month intervals, Vernon et al., (2008) found that at the end of the validation survey, the test-retest reliability assessment showed high participation rates across all three survey modes; face-to-face and telephone (99%), and mail (98%).

The CDC's Division of Cancer Prevention and Control has analyzed BRFSS data for several publications in the Morbidity and Mortality Weekly Report (MMWR) and report age-adjusted estimates for specific cancers by age groups (CDC, 2014). Evidence-based findings from epidemiological researches, show that BRFSS data are collected using new methods of weighting, and multiple modes of data collection that include, mail, cell and landline telephone, face-to-face survey and by mailing follow-up surveys (CDC, 2014, Qayad et al., 2013). The validity and reliability of BRFSS survey suggest that the instrument can classify groups of adults into levels recommended and defined by Healthy People 2010 (Yore et al., 2007). It is reassuring from the literature that there is consistency and similarity between the BRFSS, NHANES and the NHIS estimates of key health indicators, as defined by Healthy People 2020 (CDC, 2014). This study provides empirical support for the proposition that the reliability and validity of self-reported survey instrument such as the BRFSS is a reliable source of data (MDH BRFSS, 2018).

Study Operational Variables

In epidemiological quantitative research design, operationalization is the process of precisely defining the variables used into measurable factors (Allen, 2017). I used six independent and one dependent variable for the main analysis in this study, and two of the predictor variables as potential covariates. All variables were collected from the BRFSS public data files of 2014, 2016, and 2018. No variable was calculated. The independent variables and covariates were assessed based on the needs of this study and their importance as potential predictors of CRCSU in Maryland.

Independent Variables

Education level completed. Corresponds to the highest level of education completed by the respondent. assessed as an indicator of socioeconomic status, and measured as a categorical variable and coded as 1 = did not complete high school, 2 = completed high school, 3 = some college or technical school, 4 = college graduate.

Household income. Corresponds to individuals' total annual household income from all sources in dollar amounts. Also assessed as an indicator of socioeconomic status; measured as a categorical variable and recoded as: 1 = \$0–<\$35,000 (low-income), 2 = \$35,000–<\$75,000 (middle-income), and 3 = \$75,000 or more (high-income).

Health insurance coverage. Corresponds to the primary source of a person's health care coverage. Assessed as a succor to using preventive health care services; measured as a categorical variable and coded as: 0 = other health insurance plan, 1 = private plan, 2 = public plan.

Access to healthcare professional. Corresponds to the BRFSS survey question of whether a respondent has one, or more than one person considered of as his personal doctor or health care provider. Assessed as a source to using preventive health care service; measured as a categorical variable, recoded as 0 = no health care professional, 1 = one health care professional; 2 = more than one health care professional.

Dependent Variable: Colorectal cancer screening use.

This variable corresponds to the BRFSS survey question of whether respondents have fully met the USPSTF recommendation by receiving one or more of the CRC screening test within the recommended time interval or not. This variable was measured as a dichotomous variable and recoded as coded as: 0 = did not fully meet the USPSTF recommendation; 1 = fully meet the USPSTF CRC screening recommendation.

Covariates

Age. The categorical age variable corresponds to an individual’s age, with values ranging from 50–75 years based on the USPSTF CRC guidelines for average-risk individuals. The age variable was stratified to three subgroups; 50–59, 60–69, and 70–75.

Sex. Sex as a biological variable is based on the BRFSS definition of male and female; measured as a categorical dichotomous variable; M = male; F = female.

Race/ethnicity. Corresponds to an individual’s race or ethnicity; measured as a nominal categorical variable and coded as; 1 = white, 2 = black, 3 = Asian, 4 = Hispanic, 5 = other. The race/ethnicity values of multiracial, Native Hawaiian, and American Indian, were recoded as “Other,” because there was not enough of these race groups to warrant a regression.

Data Analysis Plan

Statistical Analysis Plan

The data analysis plan for this study on the relationship between age, sex, race, education level, income, health insurance coverage, access to health care professional, and CRC screening use (CRCSU) in Maryland includes, the BRFSS data dictionary which helped me to understand the data items, variable types, categories, permissible values and level of measurement used in the analysis to address the research questions and hypotheses (Statistics Solution, 2019). The dataset, the statistical tests, and the software used for analysis are also included in this data analysis plan. I did not create the dataset, all variables that I used to answer my research questions were collected from the BRFSS database. The data analysis plan for this study identifies with Kamin's (2010) five steps procedure for analyzing inferential statistics.

1. The null (H_0) and alternative (H_a) hypotheses statements.
2. The test to determine the proper statistical test.
3. The decision rule, degrees of freedom (*df*) and the region of rejection.
4. The statistical results based on the calculated test statistic.
5. Interpretation of the results using the *p*-value. Details of steps 4 and 5 are discussed in chapter 4.

All data manipulation and statistical analyses were conducted using SPSS version 25 software. Data from the BRFSS was uploaded by survey years 2014, 2016, and 2018, and reloaded into SPSS. The dataset files were merged into one dataset file in SPSS and used for all analyses to answer my research questions. Researchers have pointed that including missing data in the data analysis can reduce the statistical power, produce biased estimates of parameters, reduce the representativeness of the sample, and may complicate the analysis, leading to invalid conclusions from the study (DeCrane et al., 2013; Kang, 2013). Since this study assumed that the causes of missing data are not controlled by the dependent variable (missing data at random), cases with missing observations from the dataset file were excluded from my analysis. Descriptive statistics including frequency distribution of each distinct variable and category were conducted to show the characteristics of the study population (Marshall, & Jonker, 2010). Results from the descriptive analysis clearly indicated how missing data were handled.

Graphical representation of the data was examined for normality and skewness; although emphasis was not placed on the distribution and shape of the data, because the multiple logistic regression model used is a generalized model that is distribution-free (McDonald, 2014). Based on the categorical variables used, the research questions and hypotheses, the nonparametric Pearson chi-square test of independence was used to check the appropriateness of the model (Kamin, 2010) and to test the assumption that the multiple logistic regression model fits the data, by comparing the observed cases with the expected ones. The Pearson chi-square test was conducted with the assumption that all observed frequencies are equal in proportion; and the “expected” counts were calculated under the assumption that the null hypothesis (H_0) is true. The Pearson chi-square test generated the chi square value, the degrees of freedom (*df*), and the statistical significance measured by the *p*-value. The alpha (α) level showed how extreme the result of the test for significance must be to reject or retain the H_0 (Taylor, 2017). Hypothesis testing was two-sided with an alpha of .05, and a 95% CI for statistical comparisons across groups.

For inferential statistics, multiple logistic regression analyses were performed to determine the associations, test statistical significance, and to identify the variables that predict the likelihood for individuals 50–75 years to fully meet the USPSTF CRC screening recommendation or not. Multiple logistic regression analysis is appropriate for this cross-sectional design, because there are multiple predictor variables and a single dichotomous nominal outcome variable (McDonald, 2014). The SPSS calculated Exp(B) values in the logistic regression model represents the OR used to determine the likelihood to fully meet the CRC screening recommendation. The Wald statistics was used to determine whether the beta (β) for any of the predictor variable in the model is significantly different from zero or not (Field, 2013).

The decision rule for all analyses was that, where the test statistic was in the region of rejection, the H_0 was rejected; indicating a type I error (Kamin, 2010). The *df* was assessed based on k - l, where k is the number of participants (Kamin, 2010). Hypothesis testing was two-sided and statistical significance determined by α level of 0.05. A 95% CI was used for statistical comparisons across groups. Where the $p = .000$, I interpreted as $p < .05$ and rejected the H_0 that there is no statistically significant association between the independent and the dependent variable. Likewise, where $p > .05$ indicating non-significance, I accepted the H_0, implying that the prediction does not differ significantly and if any difference exists, it was probably due to chance.

Analytical Techniques to Answer Research Questions

The research questions (RQ) and hypotheses (H_{01} and H_{a1}) used for analysis were:

1. RQ1. Is there any association between socioeconomic status measured by education level, household income, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity?

   H_{01}. There is no statistically significant association between socioeconomic status measured by education level, household income, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

   H_{a1}. There is a statistically significant association between socioeconomic status measured by education level, household income, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

The variables to be analyzed to answer RQ1 are:

Age. Age is a predictor variable collected as a categorical variable measured in years ranging from 50–75 years. To control for the wide age difference between 50 and 75 years, the age variable was stratified into three subgroups for men and women, and recoded as: 1 = 50–59 years, 2 = 60–69 years, and 3 = 70–75 years. Frequency distribution was conducted to see if there was a small or wide dispersion in the measurement of age groups, and to determine the smallest and largest number and percentage of cases in each age group to be used for analysis. The Pearson chi-square test of independence was conducted to examine if there is a statistically significant relationship between age and CRCSU. Since the dependent variable is dichotomous, binary logistic regression analysis was performed to test for association and to determine the odds of age to predict CRCSU when all the variables are in the model. The Wald statistics from the logistic regression model was used to determine whether the β for any of the predictor variables in the model was significantly different from zero or not. The "Decision Rule" for this analysis was that, if the test statistic is in the region of rejection, the H_0 was rejected. Where $p < .05$ the null hypothesis (H_0) was rejected and the alternative (H_a) retained. The degrees of freedom (*df*) was assessed based on k - l, where k is the number of participants (Kamin, 2010). Hypothesis testing was two-sided and statistical significance was determined by α of .05. A 95% CI was used for statistical comparisons across groups.

Sex. Sex is a predictor variable measured as a dichotomous variable (male/female). The frequency distribution for sex was performed to assess and exclude missing data, and to determine the number and percentage of samples to be used for analysis. Sex values such as don't know/not sure or refused were removed from the analysis. The Pearson chi-square test of independence was performed to test the statistic and to check the appropriateness of the model used to examine if there is a statistically significant relationship between sex and CRCSU under the assumption that the H_0 is true. A binary logistic regression analysis was performed to assess the association between sex and CRCSU when all the variables are in the model. The OR value in the logistic regression model was used to determine the change in the odds of CRCSU based on a change in sex. For this analysis, where $p < .05$ the H_0 was rejected and the H_a accepted; where $p > .05$ the H_0 retained and the H_a forgone. The df was assessed based on k - l, where k is the number of participants (Kamin, 2010). Hypothesis testing was two-sided and statistical significance was determined by α level of .05, at 95% CI.

Race/ethnicity. Race/ethnicity is a predictor variable measured as a nominal categorical variable and stratified into five subgroups to account for a discrete comparison between the groups. I recoded the race/ethnicity variable as: 1 = white, 2 = black, 3 = Asian, 4 = Hispanic, 5 = other. The frequency distribution was performed to assess and exclude missing data, and to determine the number and percentage of cases to be used for analysis. Race/ethnicity values of don’t know/not sure or refused were removed from the analysis. Values of multiracial, native Hawaiian, and American Indian, were recoded as “Other,” because there was not enough of each of these race groups to warrant a regression. Stratified random sampling approach was used to ensure an equal probability of selecting cases from all race/ethnicity groups.

The Pearson chi-square test of independence was performed to test the statistic and to check the appropriateness of the model used in the logistic regression. A binary logistic regression analysis was conducted to test for associations between race/ethnicity and CRCSU, and to determine the odds of race/ethnicity to predict CRCSU when all the variables are in the model. The OR values in the logistic regression model was used to determine the likelihood to fully meet the CRC screening recommendation based on race group. The Wald statistics was used to determine whether the β of any of the race/ethnicity subgroup was significantly different from zero or not. The decision rule here is that, if the test is in the region of rejection, the H_0 was rejected. Where $p > .05$ the H_0 that there is a statistically significant association between race and CRCSU was retained and the H_a forgone. Likewise, where $p = .000$, I interpreted as $p < .05$ and rejected the H_0 and the H_a retained. The *df* was assessed based on *k* - l, where k is the number of participants (Kamin, 2010). Hypothesis testing was two-sided at 95% CI.

Education level completed. Education level is a predictor variable measured as a categorical variable and recoded as: 1 = did not complete high school, 2 = completed high school, 3 = some college or technical school, 4 = college graduate. Frequency distribution for the education level variable was obtained to get the sum of responses for each subgroup to be used in the analysis. The Pearson chi-square test of independence was performed to test the statistic and to check the appropriateness of the model used to examine association between education level completed and CRCSU under the assumption that the H_0 is true.

A binary logistic regression analysis was conducted to test the association, and to determine the odds of education level to predict CRCSU. The OR values from the logistic regression model was used to determine the likelihood to fully meet the CRC screening recommendation based on the level of education completed. The Wald statistics showed whether education level made a significant contribution to the model or not. The decision rule here is that, where $p < .05$ the H_0 that there is no statistically significant association between education level completed and CRCSU was rejected. Likewise, where $p = .000$, I interpreted as $p < .05$ and rejected the H_0 as well. If the test statistic is not in the region of rejection, the H_0 will be accepted. The *df* will be assessed based on *k* - l, where k is the number of participants (Kamin, 2010). Hypothesis testing will be two-sided and statistical significance will be determined by α level of 0.05 at 95% CI.

Household income. Household income is a predictor variable measured as a categorical variable and stratified into three subgroups, coded as: 1 = \$0-<\$35,000 (low-income), 2 = \$35,000-<\$75,000 (middle-income), and 3 = \$75,000 or more (high-income). Frequency distribution was performed to determine the number and percentage of samples for each income group to be used for analysis. The Pearson chi-square test of independence was performed to test the statistic and to check the appropriateness of the model under the assumption that the H_0 is true. A binary logistic regression analysis was conducted to test for associations and to determine the odds of income level to predict CRCSU. Additionally, age group, sex, and race/ethnicity variables were used as covariates to test for effect modification in this model. The OR values from the logistic regression model was used to determine the likelihood to fully meet the CRC screening recommendation based on income level. The Wald statistics was used to determine whether any income level model made a significant contribution to the model or not. The decision rule here is that, where $p > .05$ the H_0 was accepted and the H_a forgone. Likewise, where $p = .000$, I interpreted as $p < .05$ and rejected the H_0 that there is no statistically significant association between income level and CRCSU. The *df* was assessed based on k - l, where k is the number of participants (Kamin, 2010). Hypothesis testing was two-sided at 95% CI.

CRC screening use (CRCSU). CRCSU is the outcome variable measured as a categorical dichotomous variable coded as 0 = did not fully meet the USPSTF CRC screening recommendation, and 1 = fully meet the USPSTF CRC screening recommendation. A single outcome variable was used in this study to answer the RQs. For all variables, the Pearson chi-square test of independence was used to test the hypotheses, and to determine the chi-square value, degrees of freedom for both the row and the column variables, and the *p*-values at 95% CI. A relationship exists between the variables when the H_0 is rejected and the H_a is accepted (Statistics Solutions, 2019). Since both the predictor and the outcome variables in this study are categorical, the non-parametric Pearson chi-square test of independence was appropriate to test the statistics, and the "expected" counts calculated under the assumption that the H_0 was true. Findings from this study can be used for suggestions about which predictor variables have a major effect on CRC screening rates in Maryland.

2. RQ2. Is there any association between access to preventive health care service measured by health insurance coverage, access to health care professional, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity?

   H_{02}. There is no statistically significant association between access to preventive health care service measured by health insurance coverage, access to health care professional, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

   H_{a2}. There is a statistically significant association between access to preventive health care service measured by health insurance coverage, access to health care professional, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

Health insurance coverage. Health insurance coverage is a predictor variable collected and measured as a categorical variable, and recoded as: 0 = other health insurance plan, 1 = private health insurance plan, 2 = public health insurance plan. The “other health insurance plan” subgroup was used as the reference category for comparison relative to private purchased plan and public health insurance plan. Health insurance plans of TRICARE, Tribal Health Services or health insurance from some other source were grouped as “Other plan” because there was not enough of each of these groups to warrant a regression. More also, individuals with health insurance plans such as TRICARE and Tribal Health Services are less likely to participate in surveillance CRC screening programs (DeMoor et al., 2018). Frequency distribution was performed to determine the number and percentage of samples to be used for analysis.

The Pearson chi-square test of independence was performed to test the statistic under the assumption that the H_0 is true. A binary logistic regression analysis was performed to determine if there is a statistically significant relationship between health insurance coverage and CRCSU. The OR was used to determine the likelihood to fully meet the CRC screening recommendation based on health insurance plan. The Wald statistics was used to determine whether the health insurance coverage variable made a significant contribution to the model by assessing the β value. The decision rule here was that, where $p = .000$, I interpreted as $p < .05$ and rejected the H_0 that there is no statistically significant association between health insurance coverage and CRCSU. Likewise, where $p > .05$ the H_0 was accepted and the H_a rejected. The *df* was assessed based on k - l, where k is the number of participants (Kamin, 2010). Hypothesis testing will be two-sided and statistical significance was determined by α level of 0.05. A 95% CI was used for statistical comparisons across groups.

Access to healthcare professional. Access to healthcare professional is a predictor variable collected and measured as a categorical variable, and recoded as 0 = no health care professional, 1 = access to one health care professional; 2 = more than one health care professional. Frequency distribution was performed to determine the number and percentage of samples to be used for the analysis. The Pearson chi-square test of independence was performed to test the statistic and to check the appropriateness of the model used to examine if there is a statistically significant relationship between access to healthcare professional and CRCSU under the assumption that the H_0 is true.

A binary logistic regression analysis was performed to determine if there is a statistically significant relationship between access to healthcare professional and CRCSU. Additionally, age group, sex, and race/ethnicity variables were used as covariates to test for effect modification in this model. The OR was used to determine the likelihood to fully meet the CRC screening recommendation based on the number of healthcare professional that an individual has access to. The Wald statistics was used to determine whether access to healthcare professional made a significant contribution to the model. The decision rule here was that, where $p = .000$, I interpreted as $p < .05$ and rejected the H_0 that there is no statistically significant association between access to healthcare professional and CRCSU. Likewise, where the $p > .05$ the H_0 was retained and the H_a forgone. The df was assessed based on k - l, where k is the number of participants. Hypothesis testing was two-sided and statistical significance was determined by α level of .05 at 95% CI for statistical comparisons across groups.

For both RQs, statistical analysis included a descriptive analysis of the variables, the chi-square test of independence to test the appropriateness of the models and multiple logistic regression analyses to determine associations. Additionally, age group, sex, race/ethnicity variables were used as covariates to test for confounding effects on the OR between the independent and the dependent variable. Except for sample size calculation that was done using the G*Power software, all statistical analyses were conducted using IBM SPSS version 25, following steps outlined by Merlo, Wagner, Austin, Subramanian, & Leckie, (2018). According to Field (2013), the result of the Wald statistics in logistic regression indicates whether the predictor variable makes a significant contribution to the outcome occurring or not.

An OR greater than one indicates that the odds of the outcome occurring increases as the predictor variable changes; while an OR value less than one signifies that the odds of the outcome occurring decreases as the predictor increases or changes (Field, 2013). The results of these analyses are reported as OR for simplicity. Conclusions are based on the OR because failing to reject the H_0 under the constraints of committing a Type I or Type II error, is a better decision than simply accepting the H_0 (Kamin, 2010). Results of the analyses for this study are presented in chapter 4. Also, an objective assessment, and cautious interpretation of the results are presented in chapter 5.

Rationale for Using Specific Statistics

The goal of this study is to assess the predictive relationship between multiple categorical variables and a dichotomous outcome variable. The five-step data analysis plan stands as a unified entity that will allow me to follow a procedure for all the statistical tests to be used in this study. Descriptive statistics helped me to assess if there are trends within different groups and CRCSU or if perhaps age, or race/ethnicity are predictors for Marylanders to participate in CRC screening programs. Multiple logistic regression technique used for the inferential statistics is appropriate because it is used to assess the relationship between multiple predictors and an outcome variable (Betge et al., 2017); and to determine if the characteristics of the variables differ by a statistically significant margin (McDonald, 2014). The model has been used in multiple scientific and epidemiological research that examined demographic and socioeconomic factors affecting the use of preventive health behaviors such as CRC screening uptake, across several small- and large-scale populations (Cardoso et al., 2019; Doubeni et al., 2019). Also, by using multiple logistic regression analysis, I was able to control for imbalanced characteristics identified in the descriptive analysis, and identify outliers (Weedmark, 2018). Hence the research problem and findings from these analyses stand as a distinctive unit of thought and effort.

Threats to Validity

In epidemiological studies validity refers to accuracy and the absence of bias in the research (Szklo, & Nieto, 2014). A threat to the validity is anything that causes a shift from an accurate result (Szklo, & Nieto, 2014). The validity of the inferences made from a study therefore, depends on the accuracy of the research method and procedures (Alexander, Lopes, Ricchetti-Masterson, & Yeatts, 2016). To maximize the validity of a study, threats to external, internal and construct validity must be minimized as much as possible (Frankfort-Nachmias et al., 2015). If threats to validity are not given proper consideration, they can either underestimate or overestimate the true effect or association between variables. The following are potential threats to validity in this study.

Threats to External Validity

External validity is the degree to which the results from a study can be generalized to other groups not studied (Boyd et al., 2015). A potential threat to external validity from this study is that of recall bias (Cutts, Izurieta, & Rhoda, 2013; Taylor et al., 2013). Respondents to the BRFSS survey could have provided answers based on their ability to recall past events and do not recall if they had ever received CRC screening. Secondly, respondents are mostly those in CRC surveillance screening programs; hence those who are not in the surveillance program, and may have received CRC screening for other reasons may not be accounted for in this study, which limits the generalization of the results to the entire Maryland population.

However, to minimize potential threats to external validity and improve the strength of the results, I used a research method that precludes minimal exclusion criteria, using data from a more natural setting as the original data is from surveys conducted specifically for the Maryland population. Also, potential threats to external validity where minimized by using a large sample size, medium effect size, and a 95% CI for the sample size calculation (Sullivan, & Feinn, 2012). Social desirability bias was minimized by using the most recent data from the validated BRFSS database. Hence this is a pragmatic research with high external validity.

Threats to Internal Validity

Internal validity is the extent to which the study outcome is explained by the effects of a predictor variable on the outcome variable and not by any manipulation of the predictor variable or any other factor (Cuncic, 2019; Mcleod, 2013). Threats to internal validity affect the reliability of the study results, which may include instrumentation bias, statistical errors and differential selection (Frankfort-Nachmias et al., 2015). According to Creswell, (2014), an experimental study is the only way to control for threats to internal validity. Hence a potential threat to internal validity in this study is due to limitations from the use of secondary data and a non-experimental design. To minimize potential threats to internal validity I used the most appropriate descriptive statistics (frequency distribution), and inferential statistics (multiple logistic regression) to estimate parameters and determine associations.

Threats to construct validity is the ability of a test to measure what it was meant to measure (Frankfort-Nachmias et al., 2015; McLeod, 2013). In this study, threats to construct validity were minimized by using the Pearson chi-square test of independence, which has shown valid and reliable results to a test statistic (Frankfort-Nachmias et al., 2015). A valid study is one whose results are based on the most appropriate research design and methodology that produces results that are close to the truth (Knottnerus, & Tugwell, 2014). This research is considered a valid study because an extensive literature review was carried out to ensure the degree to which bias was prevented in other studies, and the degree to which the most appropriate study design and statistical tests were implemented (Althubaiti, 2016; Pannuucci & Wilkins, 2010).

Ethical Procedures

Ethical challenges with epidemiological studies include issues of data access, privacy, confidentiality, informed consent, reporting of research results and findings, commercialization, benefit-sharing, and the possibility of discrimination (Chanda-Kapata et al., 2015; van der Heide, Uiters, Schuit, Rademakers, & Fransen (2015). Considering that the secondary data used for this study is freely available on the BRFSS database, no concern or issues with privacy is expected because respondents must have signed consent documents as to the use of their data for future research (Ehrenstein et al., 2017). Hence permission for further use is implied (Chanda-Kapata et al., 2015). Since no new instrument or survey question was developed for this study, I expect to have only limited to no ethical concerns in conducting this research.

Potential Risk to and Protection of Participants

Since this study employed secondary data, there is no risk to participants' involvement and relatively fewer risks for Institutional Review Board (IRB) concerns (Walden University, n.d.). However, appropriate ethical procedures and standards were upheld throughout the conduct of the study. All efforts were made to protect the rights of respondents by using Walden's quantitative checklist and strictly following Walden University's IRB guidelines. Walden's IRB approval was obtained before data collection. It is understood that data from the BRFSS survey are protected and respondents are guaranteed that their personal information is kept confidential (MDH BRFSS, n.d.).

However, ethical issues related to participants' confidentiality and anonymity of data were upheld by protecting and storing the uploaded data electronically to maintain data integrity. Only me as the primary researcher and potentially my committee chair has access to the data. More about data coding is discussed in chapter 4.

Transparency and ethical judgment was followed at all stages of the research process; from data collection to analysis; and a careful interpretation of the results, being mindful of any potential contractual obligations between the data owners and myself. The results of this study may be disclosed to the MDH. For this dissertation, ethical integrity began with understanding the research process and working closely with Walden IRB for guidelines on ethical issues surrounding secondary data collection on CRC research. However, no data were collected, viewed or analyzed without IRB approval for me to do so. The original data will be destroyed after I successfully defend my research following guidelines from the Walden's Center for Research Quality.

Summary

In this chapter, I described the research design (cross-sectional descriptive) and methodology used to determine predictors of CRC screening use in Maryland. I also described the procedures used to determine the sample size within a quantitative methodology, from a secondary dataset file. Reliability and validity of BRFSS survey instrument was also discussed in this chapter. Self-reporting bias and social desirability bias was minimized by using the most recent data from the validated BRFSS database (MDH, 2018). The independent, dependent, covariate variables, and their levels of measurements were provided. I also provided information on how data were cleaned and manipulated for analyses as well as the descriptive and inferential statistics used to determine the associations between the predictor variables, and the outcome variable. I explained how the Pearson chi-square test of independence was used as a test statistic, with medium effect size of .15, alpha (α) 0.05, power (1-β) of 0.80 at 95% CI. The data analysis plan was described in the methodology section. I also described the potential threats to external and internal validity, and how they were minimized in this chapter. Finally, I provided information on the steps that I followed to adhere to ethical concerns, by ensuring that I received Walden IRB approval before data abstraction and analysis.

Chapter 4 covers a detailed description of the steps taken to perform all statistical analyses and an outline of the results as relates to my research questions and hypotheses. I also provide a cautious interpretation of my results and how my findings are representative of the general population. Chapter 4 also includes information of how my findings add knowledge and provide insight to public health practice as relates to CRC screening programs. An explanation of how data was stored throughout the study and destroyed at the end of the study is provided in Chapter 4.

Chapter 4: Results

Introduction

The purpose of this study was to improve understanding of colorectal cancer (CRC) screening by utilizing a quantitative cross-sectional study to examine factors that predict CRC screening use (CRCSU) among adults, age 50–75 years, in Maryland. To conduct this study, I used secondary data from the CDC BRFSS database to assess the association between age, sex, race/ethnicity, education level, household income, health insurance plan, access to health care professional, and CRC screening use. In this study, CRCSU represents, fully meeting the USPSTF guidelines, measured as receiving one or more of the recommended CRC tests within the recommended time interval.

I extracted and merged Maryland BRFSS data of 2014, 2016, and 2018 into one dataset file to answer two RQs. The Pearson chi-square test of independence was used to test the statistical association and multiple logistic regression was used to determine associations between the independent and the dependent variables. In this chapter, I provide the results obtained from the analyses and display them in tables. I begin this chapter by repeating the RQs that I explored in this study.

Research Questions and Hypotheses

Research Question 1: Is there any association between socioeconomic status measured by education level, household income, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity?

H_{01}: There is no statistically significant association between socioeconomic status measured by education level, household income, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

H_{a1}: There is a statistically significant association between socioeconomic status measured by education level, household income, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

Research Question 2: Is there any association between access to preventive health care service measured by health insurance coverage, access to health care professional, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity?

H_{02}: There is no statistically significant association between access to preventive health care service measured by health insurance coverage, access to health care professional, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

H_{a2}: There is a statistically significant association between access to preventive health care service measured by health insurance coverage, access to health care professional, and colorectal cancer screening use among adults age 50–75 years in Maryland, after adjusting the effects of age, sex, and race/ethnicity.

Data Collection

Publicly available secondary data of 2014, 2016, and 2018 were used to conduct this study. I accessed the data repository through the CDC BRFSS website. I followed the data collection plan as outlined in Chapter 3 with minor deviation; because I pulled the Maryland data through the CDC BRFSS instead of the Maryland BRFSS website. Walden University's Institutional Review Board (IRB) was duly informed about this discrepancy before data collection. The IRB approval number for this study was 02-25-20-0678352. Following the IRB guidelines allowed me to be in compliance with Walden University's research requirements. The data repository provided access to a ZIP file that included 336 different variables with 48,588 cases. I downloaded the files that included data from all states in the U.S., saved the files on my computer and then uploaded into SPSS. In SPSS, I split the file to include only Maryland data and then merged all three data sets (2014, 2016, 2018) into one dataset file.

Discrepancies in Data Collection

Originally, the independent variables to be used were to include health care professional recommendation for screening, screening test methods—Fecal Occult Blood Test (FOBT), sigmoidoscopy and colonoscopy. However, after collecting and reviewing the data, the health care professional recommendation variable was not available, and the assumptions of collinearity were not met for the screening test methods variable; therefore, not reported in my analyses. Nonetheless, I replaced these variables with three new variables; education level, household income, and access to health care professional, to match the data collection procedure discussed in chapter three. The data were limited to respondents, age 50-75 years, due to lack of CRC screening data of individuals below 50 years of age. The current national guideline is for CRC screening to begin at 50 years of age for average risk individuals (USPSTF, 2018).

The above discrepancies which were due to lack of available data, led me to modify my original RQs as presented above. The intent of this study to examine association between socioeconomic status (SES), access to preventive health care, and CRC screening use remained the same despite these changes. The new independent variables for this study are age, sex, race, education level, income level, health insurance coverage, access to health care professional; and dependent variable is CRCSU. To support the use of education level and income to determine association between SES and CRCSU, the literature reveals that there is a statistically significant ($p < .05$) and positive relationship between education level, income, and completion of CRC screening (Zhao, Okoro, Li, & Town, 2017). Likewise, DeGroff et al., (2018) found an association between access to health care professionals, and increase in CRC screening uptake.

Data Analysis

Data Cleaning

This study assumed that missing data were not due to the outcome variable, but missing at random. All variables were collected as categorical variables. No variable was calculated. I excluded variables not needed for my analysis, and utilized data of 6641 respondents with eight different variables. I excluded 2601 cases with values of either, don’t know/not sure, refused, or missing. Simple random sampling technique was used to select cases. The application of stratified random sampling to select the data makes the sample a good representation of the study population and provided a strong external validity and credibility to my results. The dataset files included the data dictionary, and code book, which I used to recode the variables, input the values and labels in SPSS.

Data Coding

I created three new subcategories for “age” based on age grouping from the BRFSS codebook, and recoded as 1 = 50–59 years, 2 = 60–69 years, and 3 = 70–75 years. Sex was coded as 1 = male, and 2 = female. Race and ethnicity were used as one entity in this study. Race/ethnicity was recoded as, 1 = white, 2 = black, 3 = Asian, 4 = Hispanic, 5 = other. The race/ethnicity values of multiracial, native Hawaiian, and American Indian, were recoded as “other,” because there was not enough of each of these race groups to warrant a regression. Education was collected as, elementary school, some high school, high school graduate, some college or technical school, and college graduate. I recoded education level as: 1 = no or some high school, 2 = high school, 3 = some college or technical school, 4 = college graduate. Household income was collected as, <$10,000; $10,000-< $15,000; $15,000-<$20,000; $20,000-<$25,000; $25,000-<$35,000; $35,000-<$50,000; $50,000-<$75,000; $75,000 or more. I recoded household income as: 1 = $0-<$35,000 (low-income), 2 = $35,000-<$75,000 (middle-income), and 3 = $75,000 or more (high-income). Health insurance coverage was collected as, a plan purchased through an employer or a union; medicare; medicaid; tribal health services; TRICARE; some other service; and No coverage. I recoded health insurance coverage as: 0 = other health insurance plan, 1 = private plan, 2 = public plan. Access to health care professional was coded as 0 = no health care professional, 1 = access to one health care professional; 2 = more than one health care professional.

Furthermore, the question of whether respondents have fully met the USPSTF CRC screening test recommendation within the recommended time interval in the code book, represents the dependent variable (CRCSU). CRCSU was collected as a dichotomous variable and coded as: 0 = did not receive one or more of the CRC test within recommended time interval, and 1 = received one or more of the CRC test within the recommended time interval. I limited the covariates to age, sex and race/ethnicity, because other variables like history of CRC, and marital status were not captured in the datasets and hence not considered in the analysis. After IRB approval, the timeframe to begin and complete the data collection process was approximately three weeks.

Descriptive and Demographic Characteristics of the Sample

The demographic characteristics of this study includes a sample size of 3134 cases of males and females age 50–75 years from five race/ethnicity groups, who responded to the 2014, 2016, and 2018, BRFSS survey. The frequency distribution for the set of categorical variables (age, sex, race, education, income, health insurance coverage, health care professional, CRCSU) showed 100% (*n* = 3134) valid cases and no missing data. There were slightly more cases in the 60–69 years' group (*n* = 1347, 43.0%) compared to the 50–59 years' group (*n* = 1148, 36.6%), and the 70–75 years' group (*n* = 639, 20.4%). There were slightly more females (*n* = 1,966, 62.7%) than males (*n* = 1,168, 37.3%). The frequency distribution of race variable, showed that there were more whites (*n* = 2328, 74.3%) than any other race group; blacks (*n* = 612, 19.5%), Asians (*n* = 58, 1.9%), Hispanics (*n* = 43, 1.4%), other (*n* = 93, 3.0%).

The frequency distribution for the four education levels shows that most respondents were college graduates (*n* = 1388, 44.3%), followed by high school (*n* = 861, 27.5%), then some college (*n* = 745, 23.8%), and no high school group (*n* = 140, 4.5%). Results of the income variable showed that most respondents were in the high-income group (*n* = 1,318, 42.1%), followed by middle-income (*n* = 915, 29.2%), and the least number of cases was from the low-income group (*n* = 901, 28.7%). Descriptive of the health insurance coverage variable showed that all respondents in the sample had at least one type of health insurance plan. There was none without health insurance coverage. Those with private plan had the highest number of cases (*n* = 2196, 70.1%), followed by public plan (*n* = 811, 25.9%), and other health insurance plan (*n* = 127, 4.1%). For the health care professional variable, those with access to only one health care professional were seven times (*n* = 2608, 83.2%), those with access to more than one health care professional (*n* = 358, 11.4%), and the smallest number of cases was the no health care professional group (*n* = 168, 5.4%). The descriptive statistics of the dependent variable (CRCSU) further showed that out of the 3134 cases, most of the respondents have received one or more of the recommended CRC test (*n* = 2387, 76.2%), and those who have not (*n* = 747, 23.8%). Result of the frequency distribution of all variables is displayed in Table 1.

Table 1

Frequency Distribution of Demographic and Sample Characteristics

Variable	Frequency	Percent
Age Group		
50 - 59 years	1148	36.6
60 - 69 years	1347	43.0
70 -75 years	639	20.4
Sex		
Male	1168	37.3
Female	1966	62.7
Race/Ethnicity		
White, Non-Hispanic	2328	74.3
Black, Non-Hispanic	612	19.5
Asian, Non-Hispanic	58	1.9
Hispanic	43	1.4
Other	93	3.0
Education Level		
No or Some High School	140	4.5
High School Graduate	861	27.5
Some College	745	23.8
College Graduate	1388	44.3
Household Income		
Low-Income	901	28.7
Middle-Income	915	29.2
High-Income	1318	42.1
Health Insurance Coverage		
Private plan	2196	70.1
Public plan	811	25.9
Other plan	127	4.1
Health Care Professional		
One health care professional	2608	83.2
More than one health care professional	358	11.4
No health care professional	168	5.4
CRC Screening Use		
Yes	2387	76.2
No	747	23.8

Results of Statistical Analysis

Through this study I examined the association between seven independent variables: age, sex, race, education, income, health insurance coverage, health care professional, and one dichotomous dependent variable: CRCSU. I performed the non-parametric Pearson chi-square test of independence to test the statistics, and multiple logistic regression inferential statistics to determine association between the predictors and the outcome variable. I also employed the Hosmer-Lemeshow (H-L) goodness of fit test to compare the observed cases to the number predicted by the regression model. The SPSS calculated Exp(B) which is the odds ratio (OR) was used to describe the probability of associations and to reflect the effect size. The beta (β) value which represents the change in odds of an outcome as a result of a unit change in the predictor variable; and the Wald statistics which indicates whether the β for a predictor variable is significantly different from zero or not (Field, 2013), were essential in reporting the results.

Prior to conducting the inferential statistics, the assumptions of multiple logistic regression analysis (large sample size, multicollinearity and outliers) were tested and met. To test for threat of multicollinearity, a Pearson correlation and linear regression analyses were conducted for all predictor variables. Results of the correlation analysis showed that none of the variables had tolerance value <.1; or Variance Inflation Factor (VIF) >10. Therefore, this assumption was met. For all analyses, a 95% confidence interval (CI) was used for statistical comparison. Hypothesis testing was two-sided at an alpha level of .05. Table 2 shows results of the cross-tabulation and Pearson chi-square test; and tables 3-9 show results of the binary logistic regression analysis by RQs.

Table 2

Cross tabulation: Chi-Square Test between the Independent and the Dependent Variables

Number of Cases, *N* = 3134	Fully meet CRC screening recommendation (CRCSU)		*P* – Value
	Yes	No	
Age Group			**.000**
50 - 59 years	762 (66.4%)	386 (33.6%)	
60 - 69 years	1083 (80.4%)	264 (19.6%)	
70 -75 years	542 (84.8%)	97 (15.2%)	
Sex			**.640**
Male	895 (76.6%)	273 (23.4%)	
Female	1492 (75.9%)	474 (24.1%)	
Race-Ethnicity			**.015**
White, Non-Hispanic	1754 (75.3%)	574 (24.7%)	
Black, Non-Hispanic	492 (80.4%)	120 (19.6%)	
Asian, Non-Hispanic	42 (72.4%)	16 (13.8%)	
Hispanic	36 (83.7%)	7 (16.3%)	
Other Race/Ethnicity	63 (67.7%)	30 (32.3)	
Education Level			**.000**
No or some High School	87 (62.1%)	53 (37.9%)	
High School Graduate	606 (70.4%)	255 (29.6%)	
Some College	577 (77.4%)	168 (22.6%)	
College Graduate	1117 (80.5%)	271 (19.5%)	
Household Income Level			**.006**
Low-Income	655 (72.7%)	246 (27.3%)	
Middle-Income	696 (76.1%)	219 (23.9%)	
High-Income	1036 (78.6%)	282 (21.4%)	
Health Insurance Coverage			**.000**
Private Plan	1635 (74.5%)	561 (25.5%)	
Public Plan	648 (79.9%)	163 (20.1%)	
Other Plan	104 (81.9%)	23 (18.1%)	
No Health Insurance	0 (0.0%)	0 (0.0%)	
Health Care Professional			**.002**
One Health care professional	2019 (77.4%)	589 (22.6%)	
More than one health care professional	281 (78.5%)	77 (21.5%)	
No health care professional	87 (51.8%)	81 (48.2%)	

Research Question 1: Socioeconomic Status and Colorectal Cancer Screening Use

To answer RQ1, I conducted the Pearson chi-square test of independence to test the null hypothesis and determine model fitness; and a binary logistic regression to assess whether SES measured by education level and household income is associated with CRCSU, after adjusting the effects of age, sex, and race/ethnicity. For the binary logistic regression, the omnibus test of model coefficients was significant (chi-square = 44.627, *df* = 5, *p* = .000); the model summary showed the Nagelkerke R^2 = .021. The H-L test (chi-square = 3.704, df = 7, *p* = .813) showed that the prediction did not differ significantly from the observed cases in the contingency table, implying that at the model's estimates fit the data are well fitted at an acceptable level. The classification table showed that the specificity of the model with respect to those who responded "Yes" to CRCSU was 100% with an overall classification accuracy of 76.2%.

Education level. Results of the cross-tabulation and the Pearson Chi-square between education and CRCSU (Table 2) showed that most respondents who have fully met the CRC screening test recommendation are college graduate 1117 (80.5%), and the least are No high school graduate 87 (62.1%); high school graduate 606 (70.2%) and some college 577 (77.4%). Among those who did not fully meet the CRC screening recommendation, college graduate 271 (19.5%) had the least percentage and No high school 53 (37.9%) had the largest percentage. The chi-square = 45.900, *df* = 3, *p* = .000, showed a significant association between education level and CRCSU. Based on the preliminary results, I reject the null hypothesis that there is no statistically significant association between education level and CRCSU.

For the binary logistic regression (Table 3), the OR for No high school graduate was used as the reference category for comparing groups relative to the high school through college graduate groups, because it is expected that those with no high school are less likely to fully meet the CRC screening test recommendation (Rodriguez, & Smith, 2016). The Wald statistics (34.755) and significance (*p* = .000), showed that education level makes a significant contribution to the model. The results showed that compared to the no high school graduate group, high school graduate were 1.4 times more likely (OR = 1.424; 95% CI: .978, 2.074); some college were 2 times more likely (OR = 2.040; 95% CI: 1.379, 3.017), and college graduate were 2.4 times more likely (OR = 2.420; 95% CI: 1.644, 3.562) to CRCSU; showing increase in odds from the high school graduate level.

Nevertheless, the difference across groups was, non-significant for high school graduate (β = .354, S.E. = .192, Wald = 3.403, *p* = .065); and significant for some college (β = .713, S.E. = .200, Wald = 12.753, *p* = .000) and college graduate groups (β = .884, S.E. = .197, Wald = 20.070, *p* = .000). The OR for all education levels were >1, and the β were positive, indicating that increasing education level is associated with increasing odds of CRCSU. Therefore, I reject the null hypothesis that there is no statistically significant association between education level and CRCSU, and conclude that education level completed is significantly associated to CRCSU in Maryland.

Table 3

Binary Logistic Regression for Education, Income, and Colorectal Cancer Screening Use

Variables	B	S. E.	Wald	df	Sig.	Exp(B)	95% CI. for EXP(B)	
							Lower	Upper
Education Level			34.755	3	.000			
No High Sch. Grad (BL)						1.00		
High School Grad.	.354	.192	3.403	1	.065	1.42	.978	2.074
Some College	.713	.200	12.753	1	.000	2.040	1.379	3.017
College Graduate	.884	.197	20.070	1	.000	2.420	1.644	3.562
Income Level			.360	2	.835			
Low Income (Baseline)						1.00		
Middle Income	.051	.111	.212	1	.645	1.052	.847	1.308
High Income	.064	.111	.327	1	.568	1.066	.857	1.326

a. Variable(s) entered on Step 1: Education Level, Income Level.

Household income level. Results of the cross-tabulation between income and CRCSU showed that among respondents who answered “Yes” to fully meeting the CRC screening recommendation, high-income 1036 (78.6%), middle-income 696 (76.1%) and low-income 655 (72.7%) had the smallest number of cases. Among those who responded “No”, low-income 246 (27.3%) had the most percentage of cases followed by middle-income 219 (23.9%) and high-income 282 (21.4%). The Pearson chi-square test (chi-square = 10.293, *df* = 2, *p* = .006), showed a statistically significant association between income and CRCSU. Therefore, I reject the null hypothesis in favor of the alternative.

For the binary logistic regression, the OR for low-income was used as the reference category for comparing groups relative to middle and high income, because low income has been associated with lowest CRC screening rates (Simkin, Ogilvie, Hanley, & Elliott, 2019). Results showed that compared to the low income group, middle income was 1 time as likely (OR = 1.052; 95% CI: .847, 1.308) to fully meet the CRC screening test recommendation. Similarly, the high income was 1 time as likely (OR = 1.066; 95% CI: .857, 1.326) to fully meet the CRC screening test recommendation compared to the low income group. Nonetheless, the difference is positive and non-significant; middle income (β = .051, S.E. = .111, Wald = .212, p = .645), and high income (β = .064, S.E. = .111, Wald = .327, p = .568). Since, the OR is slightly greater than the null hypothesis OR of 1.0, and the β for all income levels were positive, this indicated that there is a slightly increasing probability that increase in income level is associated with increasing odds of CRCSU. Based on these results, I retain the null hypothesis; and conclude that the association between income level and CRCSU is statistically non-significant.

Age. In the next analysis, the age variable was added to the multiple logistic regression (Table 4); and the results showed that age made a significant contribution to the model (Wald = 113.289, p = .000). The model summary (chi-square = 161.843, df = 7, p = .000); the Nagelkerke R^2 (.076) and the H-L test (chi-square = 15.160, df = 8, p = .056) indicated a well fitted model. Using the 50–59 years' age group as a reference category, those in the 60–69 years' group were 2.2 times more likely (OR: 2.202; 95% CI: 1.827, 2.653); and those in the 70–75 years' group were 3.3 times more likely (OR=3.332; 95% CI: 2.576, 4.309) to fully meet the CRC screening recommendation. Nevertheless, the difference in both age groups are positive and significant; 60–69 years' (β = .789, S.E. = .095, Wald = 68.837, p = .000), and 70–75 years' (β = 1.203, S.E. = .131, Wald = 84.094, p = .000). Based on these results, I reject the null hypothesis that there is no statistically significant association between age and CRCSU, and conclude that age is a positive and significant predictor of CRCSU in Maryland.

Furthermore, by adding age to the model, the OR for high school increased from (OR: 1.424; 95% CI: .978, 2.074; p = .065) to (OR: 1.503, 95% CI: 1.020, 2.214, p = .039); some college from (OR: 2.040; 95% CI: 1.379, 3.017, p = .000) to (OR: 2.179, 95% CI: 1.456, 3.262; p = .000); and college graduate increased from (OR: 2.420; 95% CI: 1.644, 3.562; p = .000) to (OR: 2.558, 95% CI: 1.716, 3.812, p = .000). Similarly, the OR for middle income level increased from (OR: 1.052; 95% CI: .847, 1.308, p = .645) to (OR: 1.105, 95% CI: .885, 1.380, p = .379); high income increased from (OR: 1.066; 95% CI: .857, 1.326, p = .568) to (OR: 1.326, 95% CI: 1.057, 1.665, p = .015). Based on these results, I reject the null hypothesis and conclude that age is a statistically significant ($p < .05$) and confounding factor on the association between education level, household income level, and CRCSU in Maryland.

Table 4

Binary Regression for Education, Income, Age, and Colorectal Cancer Screening Use

Variables	B	S. E.	Wald	df	Sig.	Exp(B)	95% CI. for EXP(B)	
							Lower	Upper
Education Level			35.106	3	.000			
No HS. Grad. (BL)						1.00		
High School Grad.	.407	.198	4.246	1	.039	1.503	1.020	2.214
Some College	.779	.206	14.323	1	.000	2.179	1.456	3.262
College Graduate	.939	.204	21.281	1	.000	2.558	1.716	3.812
Income Level			6.184	2	.045			
Low Income (BL)						1.00		
Middle Income	.100	.113	.773	1	.379	1.105	.885	1.380
High Income	.282	.116	5.928	1	.015	1.326	1.057	1.665
Age Group			113.289	2	.000			
50-59 years (BL)						1.00		
60-69 years	.789	.095	68.837	1	.000	2.202	1.827	2.653
70-75 years	1.203	.131	84.094	1	.000	3.332	2.576	4.309

a. Variable(s) entered on Step 1: Education Level, Income Level, Age.

Sex. When sex variable was added to the model (Table 5), the Wald statistics (.000), and significance (p = .999) showed that sex made a non-significant contribution to the model. The model summary (chi-square = 44.627. *df* = 6, p = .000), the Nagelkerke R^2 (.021); and the H-L test (chi-square = 5.276, *df* = 8, p = .728) indicated a well fitted model. Using male as the reference category, females were no more nor less likely (OR: 1.000; 95% CI: .841, 1.190) to fully meet the CRC screening test recommendation compared to males. Since the OR = 1, this indicates no difference in the probability of CRCSU from female to male. Based on this result, I accept the null hypothesis that there is no statistically significant association between sex and CRCSU, and conclude that sex is not a predictor to CRCSU in Maryland.

Furthermore, by adding sex to the model, the OR for all education levels (high school graduate, some college, college graduate) and income categories (middle-income, high-income) as well as values for the β, the Wald statistics and the levels of significance across all categories remained the same. Sex had no confounding effect on the OR. Therefore, sex is not a confounder on the association between education level, household income, and CRCSU.

Table 5

Binary Regression for Education, Income, Sex, and Colorectal Cancer Screening Use

Variables	B	S. E.	Wald	df	Sig.	Exp(B)	95% CI. for EXP(B)	
							Lower	Upper
Education Level			34.753	3	.000			
No HSch. Grad. (BL)						1.00		
High School Grad.	.354	.192	3.401	1	.065	1.424	.978	2.074
Some College	.713	.200	12.735	1	.000	2.040	1.379	3.017
College Graduate	.884	.197	20.070	1	.000	2.420	1.644	3.562
Income Level			.356	2	.837			
Low Income (BL)						1.00		
Middle Income	.051	.111	.211	1	.646	1.052	.847	1.308
High Income	.064	.112	.323	1	.570	1.066	.856	1.327
Females	.000	.089	.000	1	.999	1.000	.841	1.190

a. Variable(s) entered on Step 1: Education Level, Income Level, Sex.

Race/ethnicity. When the race/ethnicity was added to the model (Table 6), the results showed that race/ethnicity made a significant contribution to the model (Wald =15.504, p = .004). The model summary (chi-square = 60.575. df = 9, p = .000); the Nagelkerke R^2 (.029); and the H-L test (chi-square = 7.113, df = 6, p =.310) indicated a well fitted model. In this model, White was used as the reference category for comparing groups relative to all other race groups, because White is the largest racial group in the sample. Compared to whites, blacks were 1.4 times as likely (OR: 1.430; 95% CI: 1.143, 1.789), Asians were 25% less likely (OR: .754; 95% CI: .418, 1.359); Hispanics were 1.7 times as likely (OR=1.681; 95% CI: 737, 3.834); and “other” race was 29% less likely (OR: .709; 95% CI: .452, 1.111) to fully meet the CRC screening test recommendation. Nonetheless, the difference is positive, blacks (β = .358, S.E. = .114, Wald = 9.802, p = .002); Asians (β = .283, S.E. = .301, Wald = .883, p = .347); Hispanics (β = .519, S.E. = .421, Wald = 1.522, p = .217); and “other” (β = .344, S.E. = .229, Wald = 2.249, p =

.134). Based on these results, I accept the null hypothesis that there is no statistically significant association between race/ethnicity and CRCSU; and conclude that the likelihood to CRCSU depends on the race/ethnic group.

Moreover, by adding race/ethnicity to the model, high school graduate increased from (OR: 1.424; 95% CI: .978, 2.074, *p* = .065) to (OR: 1.462, 95% CI: 1.002, 2.133, *p* = .049); some college from (OR: 2.040; 95% CI: 1.379, 3.017, *p* = .000) to (OR: 2.068, 95% CI: 1.396, 3.064, *p* = .000); and college graduate from (OR: 2.420; 95% CI: 1.644, 3.562; *p* = .000) to (OR: 2.530, 95% CI: 1.716, 3.732, *p* = .000). Similarly, by adding race/ethnicity to the model, the OR for middle income increased from (OR: 1.052; 95% CI: .847, 1.308, *p* = .645) to (OR: 1.070, 95% CI: .860, 1.331, *p* = .546); and high income increased from (OR: 1.066; 95% CI: .857, 1.326, *p* = .568) to (OR: 1.086, 95% CI: .872, 1.352, *p* = .462). Race/ethnicity is a confounder on the association between education level, income level and CRCSU in Maryland.

Table 6

Binary Regression for Education, Income, Race, and Colorectal Cancer Screening Use

Variables	B	S. E.	Wald	df	Sig.	Exp(B)	95% CI. for EXP(B)	
							Lower	Upper
Education Level			36.782	3	.000			
No High Sch. Grad. (BL)						1.00		
High School Grad.	.380	.193	3.880	1	.049	1.462	1.002	2.133
Some College	.727	.201	13.132	1	.000	2.068	1.396	3.064
College Graduate	.928	.198	21.924	1	.000	2.530	1.716	3.732
Income Level			.601	2	.740			
Low Income (Baseline)						1.00		
Middle Income	.067	.111	.365	1	.546	1.070	.860	1.331
High Income	.082	.112	.541	1	.462	1.086	.872	1.352
Race-Ethnicity			15.504	4	.004			
White, Non-Hispanic (BL)						1.00		
Black, Non-Hispanic	.358	.114	9.802	1	.002	1.430	1.143	1.789
Asian, Non-Hispanic	.283	.301	.883	1	.347	.754	.418	1.359
Hispanic	.519	.421	1.522	1	.217	1.681	.737	3.834
Other Race/Ethnicity	.344	.229	2.249	1	.134	.709	.452	1.111

a. Variable(s) entered on Step 1: Education Level, Income Level, Race-Ethnicity.

Research Question 2: Preventive Health Care Service and CRC Screening Use

To answer RQ2, I conducted the Pearson chi-square test to determine model fitness; and binary logistic regression to assess whether access to preventive healthcare service measured by health insurance coverage and access to health care professional is associated to CRCSU, after adjusting for the effects of age, sex, and race/ethnicity. Results of the binary logistic regression (Table 7), showed that the prediction did not differ significantly from the observed cases in the contingency table. The omnibus test of model coefficients (chi-square =31.253, $df = 4$, $p = .000$); the Nagelkerke R^2 (.015); and the H-L test (chi-square =3.805, $df = 2$, $p = .149$) indicated a good fit model. The classification table shows that the specificity of the model with respect to those who responded “Yes” to CRCSU was 100% with an overall classification accuracy of 76.2%.

Health insurance coverage. Results of the cross-tabulation between health insurance coverage and CRCSU showed that most respondents who answered “Yes” to CRCSU had private plans 1635 (74.5%), followed by public plan 648 (79.9%) and “other” health insurance plan 104 (81.9%). Among those who answered “No,” private plan 561 (25.5%), public plan 163 (20.1%) and “other” plan 23 (18.1%) had the smallest percentage. Results of Pearson chi-square (chi-square = 12.072, *df* = 2, *p* = .002), showed a statistically significant association between health insurance coverage and CRCSU. Based on this result, I reject the null hypothesis that there is no statistically significant association between health insurance coverage and CRCSU.

For the binary logistic regression, the OR for “other” health insurance plan was used as the reference category for comparing groups relative to private and public plans, because individuals with health insurance plans such as TRICARE are less likely to participate in surveillance CRC screening programs (DeMoor et al., 2018). The result showed that health insurance coverage made a significant contribution to the model (Wald =19.905, *p* = .000). Compared to “other” plan, those with private plan were 1.3 times as likely (OR: 1.309; 95% CI: .872, 1.967) to CRCSU. Similarly, those with public plan were 14% less likely (OR: .868; 95% CI:.569, 1.324) to CRCSU. Nonetheless the difference for both plans is positive and non-significant, private plan (*β* = .269, S.E. = .208, Wald = 1.685, *p* = .194), and public plan (*β* =.142, S.E. = .215, Wald = .433, *p* = .511). Based on these results I accept the null hypothesis that there is no statistically significant association between health insurance coverage and CRCSU; and conclude that, the likelihood to fully meet the CRC screening test recommendation in Maryland depends on the health insurance plan.

Table 7

Binary Logistic Regression of Health Insurance Coverage, Access to Health Care Professional, and Colorectal Cancer Screening Use

Variables	B	S. E.	Wald	df	Sig.	Exp(B)	95% CI. for EXP(B)	
							Lower	Upper
Health Insurance Cov.			19.905	2	.000			
Other Plan (Baseline)						1.00		
Private Plan	.269	.208	1.685	1	.194	1.309	.872	1.967
Public Plan	.142	.215	.433	1	.511	.868	.569	1.324
Health Care Professional			12.375	2	.002			
No Health Care Prof. (BL)						1.00		
One Health Care Prof.	.590	.169	12.189	1	.000	1.803	1.295	2.511
More than One Hlth C. Prof.	.488	.204	5.708	1	.017	1.628	1.092	2.429

a. Variable(s) entered on step 1: Health Insurance Coverage, Health Care Professional.

Access to health care professional. Results of the cross-tabulation between health care professional and CRCSU showed that among those who answered “Yes” to CRCSU, most respondents had access to only one health care professional (*n* = 2019, 77.4%); more than one health care professional (*n* = 281, 78.5%), and no health care professional (*n* = 87, 51.8%). The highest percentage for those who answered “No” to CRCSU was the no health care professional group (*n* = 81, 48.2%), followed by one health care professional (*n* = 589, 22.6%) and more than one health care professional (*n* = 77, 21.5%). The Pearson chi-square test (chi-square = 58.316, *df* = 2, *p* = .000), indicated a statistically significant association between access to health care professional and CRCSU. Based on these results, I reject the null hypothesis that there is no statistically significant association between access to health care professional and CRCSU.

For the binary logistic regression, the OR for no health care professional was used as the reference category for comparing groups relative to only one health care professional and more than one health care professional, because those without access to a health care professional are less likely to screen for CRC (DeGroff et al., 2018). The results showed that access to health care professional made a significant contribution to the model (Wald =12.375, p = .002). Those with access to only one health care professional were 1.8 times as likely (OR: 1.808; 95% CI: 1.295, 2.511) to CRCSU compared to those without access to a health care professional. Similarly, those with access to More than one health care professional were 1.6 times as likely (OR: 1.628; 95% CI: 1.092, 2.429) to CRCSU. Nevertheless, the difference across all groups is positive and significant; Only one health care professional (β = .590, S.E. = .169, Wald = 12.189, p = .000), and More than one health care professional (β = .488, S.E. = .204, Wald = 5.708, p = .017). Based on these results, I reject the null hypothesis that there is no statistically significant association between access to health care professional and CRCSU; and conclude that access to health care professional is significantly ($p < .05$) associated to CRCSU in Maryland.

After adding the age variable to the model (Table 8), the OR for private health insurance plan increased from (OR: 1.309; 95% CI: .872, 1.967, p = .194) to (OR: 1.467, 95% CI: .967, 2.225, p = .072); and public plan from (OR = .868; 95% CI: .569, 1.324, p = .511) to (OR: .971, 95% CI: .630, 1.496, p = .895). This result indicated that age had a non-significant, effect on the association between health insurance coverage and CRCSU.

Similarly, the OR for those with access to Only one health care professional changed from (OR: 1.808; 95% CI: 1.295, 2.511, *p* = .000) to (OR: 2.031, 95% CI: 1.445, 2.855, *p* = .000); and More than one health care professional changed from (OR: 1.628; 95% CI: 1.092, 2.429, *p* = .017) to (OR: 2.123, 95% CI: 1.406, 3.207, *p* = .000). Age mediated the effect on the association between access to health care professional and CRCSU by increasing the OR. Age is a confounder on the association between health insurance coverage, access to health care professional, and CRCSU in Maryland.

Table 8

Binary Logistic Regression of Health Insurance Coverage, Health Care Professional, Age, and Colorectal Cancer Screening Use

Variable	B	S. E.	Wald	df	Sig.	Exp(B)	95% CI. for EXP(B)	
							Lower	Upper
Health Insurance Coverage			20.254	2	.000			
Other Plan (Baseline)						1.00		
Private Plan	.383	.213	3.248	1	.072	1.467	.967	2.225
Public Plan	.029	.221	.018	1	.895	.971	.630	1.496
Health Care Professional			17.137	2	.000			
No Hlth Care Prof. (BL)						1.00		
Only One Hlth Care Prof.	.709	.174	16.652	1	.000	2.031	1.445	2.855
More than One HC. Prof.	.753	.210	12.818	1	.000	2.123	1.406	3.207
Age Group			101.477	2	.000			
50-59 years (Baseline)						1.00		
60-69 years	.737	.094	61.346	1	.000	2.089	1.737	2.511
70-75 years	1.112	.129	74.204	1	.000	3.040	2.360	3.915

a. Variable(s) entered on Step 1: Health Insurance Coverage, Health Care Prof., Age Group.

Furthermore, when race/ethnicity variable was added to the model, (Table 9) the results showed that, race/ethnicity had a confounding effect on the association between health insurance coverage and CRCSU. The OR for private plan changed from (OR:

1.309; 95% CI: .872, 1.967, *p* = .194) to (OR: .625, 95% CI: .391, .999, *p* = .049); indicating that people with private plans are less likely to have CRCSU. Moreover, public plan changed from (OR: .868; 95% CI:.569, 1.324, *p* = .511) to (OR: .873, 95% CI: .535, 1.426, *p* = .589). Similarly, the OR for access to Only one health care professional changed from (OR: 1.808; 95% CI: 1.295, 2.511, *p* = .000) to (OR: 1.460, 95% CI: 1.036, 2.057, *p* = .031); and access to More than one health care professional changed from (OR: 1.628; 95% CI: 1.092, 2.429, *p* = .017) to (OR: .473, 95% CI: .253, .888, *p* = .020). Based on these results, race/ethnicity is a confounder on the association between health insurance coverage, access to health care professional and CRCSU in Maryland.

Table 9

Binary Logistic Regression of Health Insurance Coverage, Health Care Professional, Race, and Colorectal Cancer Screening Use

Variable	B	S. E.	Wald	df	Sig.	Exp(B)	95% CI. for EXP(B)	
							Lower	Upper
Health Insurance Cov.			13.519	2	.001			
Other Plan (Baseline)						1.00		
Private Plan	.470	.239	3.863	1	.049	.625	.391	.999
Public Plan	.135	.250	.292	1	.589	.873	.535	1.426
Health Care Professional			54.913	2	.000			
No Hlth Care Prof. (BL)						1.00		
Only One Hlth Care Prof.	1.186	.163	53.155	1	.000	3.273	2.380	4.502
More than One HC Prof.	1.269	.202	39.247	1	.000	3.556	2.391	5.288
Race-Ethnicity			12.999	4	.011			
White, Non-Hisp. (BL)						1.00		
Black, Non-Hispanic	.304	.114	7.100	1	.008	1.355	1.084	1.694
Asian, Non-Hispanic	.171	.300	.325	1	.568	.843	.468	1.517
Hispanics	.530	.421	1.585	1	.208	1.699	.745	3.876
Other Race/Ethnicity	.404	.230	3.074	1	.080	.668	.425	1.049

a. Variable(s) entered on Step 1: Health Insurance Coverage, Health Care Prof., Race-Ethnicity.

Summary

In this chapter, I reported the results of the statistical analyses used to assess the association between age, sex, race, education level, household income level, health insurance coverage, access to health care professional, and CRC screening use. I further explained the effect of covariates age, sex, race/ethnicity on the association between SES, access to preventive health care service, and CRC screening use. The results of the Pearson Chi-square test of independence and multiple logistic regression analyses showed that age, race/ethnicity, education level, income level, health insurance coverage, and access to health care professional, were associated with whether an individual 50–75 years of age in Maryland would fully meet the USPSTF CRC screening test recommendation at the recommended time interval or not. No association was observed between sex and CRC screening use.

Furthermore, when the covariate variables were added to the regression models, the results showed that age, and race/ethnicity had a confounding effect on the association between SES, access to preventive healthcare service, and CRC screening use, and sex did not. These results support the hypotheses that age, race, education level, and access to healthcare professional are significantly ($p < .05$) associated to CRSU. In chapter 5, I provided an interpretation of the results and the study findings in lieu of existing literature. I also provided information on the significance of the findings, recommendations for future research, implications for positive social change and conclusion of the study.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

This quantitative, cross-sectional study was conducted to examine the association between the independent variables (age, sex, race, education, income, health insurance coverage, access to health care professional), and the dependent variable (CRCSU) in Maryland, using secondary data of 2014-2018, extracted from the CDC BRFSS data repository. I merged and analyzed data of 3134 respondents, 50–75 years of age. I then used the Pearson chi-square test of independence to test the statistic and multiple logistic regression to determine the associations and explain the relationships between the predictors and the outcome variable.

This study was justified because, despite evidence from the literature on the role of screening in reducing CRC incidence and mortality (Sauer, Siegel, Jemal, & Fedewa, 2019), CRC screening rates remain low in Maryland (MDH, 2016-2020 cancer report) and even? lower in some age, race and socioeconomic groups that have limited resources to participate in CRC screening programs (Platz, 2018). Key findings revealed statistically significant associations ($p < .05$) between socioeconomic status (SES), access to preventive health care service, and CRCSU; age and race/ethnicity were confounders on the associations. However, non-significant association was observed with some measured variables (sex, income level, health insurance coverage). This chapter includes a detailed interpretation of the findings, limitations of the study, recommendations for future research, positive social change implications, and my conclusion.

Interpretation of the Findings

This study fills a gap in research on factors that predict whether an individual will fully meet the USPSTF CRC screening test recommendation within the recommended time interval (CRCSU) in the state of Maryland. Findings from this research were based on the following research questions:

Research Question 1: Socioeconomic Status and Colorectal Cancer Screening Use

My first finding is that SES, as measured by education level and household income, is significantly ($p < .05$) associated with CRCSU among adults 50–75 years of age in Maryland; hence, it is a predictor for fully meeting the CRC screening test recommendation. For the education category, those in the high school graduate group were 1.4 times more likely to fully meet the CRC screening test recommendation (p =.065) compared to those who did not graduate from high school; some college group was 2 times more likely (p =.000) and college graduate group was 2.4 times more likely (p =.000). As education level increases so is the likelihood of fully meeting the CRC screening test recommendation in Maryland. This finding is consistent with the literature, which shows that a person living in a county in the U.S. where many residents have lower education level is less likely to get tested for CRC (Weir, Li, Henley, & Joseph, 2017).

Furthermore, Siegel, Desantis, & Jemal, (2014) found that the rate of appropriate CRC screening for people with less than 11 years of education (43.9%) was lower than the rate for individuals with college education (69.2%). Other researchers have found that education level is a strong predictor (p <.05) to the utilization of CRC screening services in the U.S. (DeMoor et al., 2018; Miranda et al., 2017; Wools, Dapper, & de Leeuw, 2016). However, contradictory to these findings, Almadi et al., (2015) found that neither gender, education level, nor marital status, were associated with the willingness to undergo CRC screening in a large-scale population-based cross-sectional study. The inability of education level to predict CRCSU in some population suggest the need to explore other factors that may be barriers to CRC screening uptake among those at lower education level. Similarly, results from this study revealed that income level is a positive but non-significant ($p > .05$) predictor of CRCSU among adults 50–70 years of age in Maryland. Relative to the low-income category, the odds of CRCSU among the middle-income group (OR: 1.052; 95% CI: .847, 1.308, $p = .645$) and high-income (OR: 1.066; 95% CI: .857, 1.326, $p = .568$). This finding suggest that some segments of the Maryland population may be experiencing barriers that limits their ability to participate in the free, and low-cost CRC screening programs provided by the state (Maryland Cancer Report, 2017; Palmer, Chhabra & Mckinney, 2011). Therefore, the effect of income level on CRC screening should be examined relative to other variables that may have a substantial influence on CRC screening use.

Findings from these analyses are consistent with other research findings that lowest CRC screening rates are seen among those with lower levels of education or lower income (Miranda et al., 2017; Honein-AbouHaidar et al., 2016). Some researchers have also found that those from minority populations and those of low SES have lower rates of CRC screening (Doubeni, 2019; Doubeni et al., 2012; Fiscella et al., 2011). Since factors related to socioeconomic disadvantage tend to occur in the same persons (Miranda et al., 2017), improvement in strategies to promote screening uptake, and to enhance existing screening programs can help the state of Maryland achieve, sustain and surpass its ≥80% CRC screening goal for all screen eligible individuals regardless of SES. There is a need to adopt strategies that account for all education and income levels to increase CRC screening in every segment of the Maryland population.

A second model of the regression analysis was performed to ascertain the effects of age, sex and race/ethnicity on the likelihood to fully meet the CRC screening test recommendation. The results from this analysis revealed that there is a statistically significant ($p < .05$) association between age, race/ethnicity, and CRSCU. Also, age and race had statistically significant ($p < .05$) confounding effects on the association between education level, income level, and CRCSU by increasing the OR at each level. For example, before adjusting for age, the OR for the high school graduate group, compared to lowest educated group was (OR: 1.424, $p = .065$), and after adding age to the model, the OR (OR: 1.503, $p = .039$) increased slightly. Similarly, before adjusting for age, people with some college education (OR: 2.040, $p = .000$); and after adjusting for age, the OR increased (OR: 2.179, $p = .000$). For college graduate, the OR increased from (OR: 2.420, $p = .000$) to (OR:2.558, $p = .000$) after adjusting for age.

However, sex was not associated and did not mediate the effect on the OR between education, income, and CRCSU. This is contrary to findings from previous research that 65.5% of women and 62.4% of men adhered to CRC screening in a large community-based research (Kang & Son, 2017). In the same vein, Sava, Dolan, May, & Vargas (2018) found that CRC screening participation rate was higher in women (44.0%) aged 50-59 years than in men (25.91 %) of same age group. Statistically ($p < .001$) higher

CRC detection rate and advanced adenoma in men have been attributed to lower CRC screening rates in men compared to women (Arana-Arri et al., 2017). Another study revealed higher odds of CRC screening participation in males (OR = 1.63, 95% CI: 1.36, 1.96), compared to females (Molina-Barceló et al., 2018). Some researchers have suggested that, reasons for the sex differences in CRC screening participation is because women have greater self-care and a higher perception of vulnerability to disease compared to men (Mehta et al., 2016; Symonds et al., 2016). Differences between studies on the association between sex and CRC screening signify the need to better understand the effect of sex on CRC screening participation within groups. According to the MDH (2019), it is essential for public health professionals to know the behavioral risk factors within groups to inform the design and implementation of CRC screening programs.

Similarly, this study demonstrated that race/ethnicity is a significant ($p < .05$) contributor to the likelihood to fully meet the screening recommendation; and a confounder on the association between education level, household income, and CRCSU by increasing the OR. Compared to Whites, the probability for CRCSU was significantly lowest among Asians (OR = .754; 95% CI: .418, 1.359), relative to Blacks (OR: 1.430; 95% CI: 1.143, 1.789), and Hispanics (OR = 1.681; 95% CI: 737, 3.834). This is consistent with previous finding that, Asians in Maryland have the lowest (53.6%) CRC screening rate compared to any other race groups (Platz, 2018). Furthermore, evidence from previous research revealed that self-reported CRC screening rates are highest among whites (62.0%), relative to blacks (59.0%), Hispanics (52.5%), and Asians (47.2%), and remain high even after adjusting for SES and access to health care (Liss &

Baker, 2014). More also, Whites are more likely to participate and complete CRC screening programs compared to any other race group (Mehta et al., 2016).

However, finding from this analysis is contradictory to previous research that participation, adherence, and completion of CRC screening programs is increasingly driven by age, sex, race (Wilder & Wilson, 2016; Hurtado et al., 2015). Based on these findings, there is a need to pay more attention to improve CRC screening among Asians in Maryland. Therefore, multi-component and culturally tailored CRC screening programs are important strategies for addressing CRC screening differences among at risk age, sex and race groups.

Research Question 2: Preventive Health Care Service and Colorectal Cancer Screening Use

My second relevant finding from this research is that access to preventive health care service measured by health insurance plan and access to health care professional can predict whether an individual 50–75 years of age in Maryland will fully meet the USPSTF CRC screening recommendation or not. Results from this analysis further reveal that, age and race are confounders on the association between health insurance coverage, access to a health care professional and CRCSU. Compared to those with “other” health insurance plan, those with private plan were 1.3 times more likely to have CRCSU (OR: 1.309; 95% CI: .872, 1.967); and those with public plan were 14% less likely (OR: .868; 95% CI:.569, 1.324) to fully meet the CRC screening test recommendation. The frequency distribution for the health insurance variable showed that out of the 3134 cases analyzed, all (100%) had at least one form of health insurance plan either through, an employer or family based purchased private plan, Medicare or Medicaid public plan, or some other health insurance plan (TRICARE, Alaska Native, Indian Health or Tribal Health Services). Since every subject in this study had some type of health insurance, I do not know the effect of having no health insurance on CRCSU in Maryland. When comparing the differences in CRCSU among people with different types of health insurance, there was no significant difference across groups ($p > .05$). I therefore judge that there is no association between health insurance type and CRCSU in Maryland.

This finding is consistent with findings that individuals with traditional employer-sponsored insurance were 62.2% more likely, and those with traditional private purchase plans were 50.9% more likely to be screened for CRC compared to those with other health plans like TRICARE (De Moor et al., 2018). Moreover, it had been suggested that type of health insurance coverage is associated with receipt of preventive health services in the US (Sabatino, White, & Thompson, 2015). Although changes to health insurance laws like the Affordable Care Act, have expanded access to health insurance options for many people in the US (Blumenthal & Collins, 2014), cost-sharing for adults with Medicaid continues to vary by state. Notably, the absence of cost-sharing for most health insurance plans, was suggested as the reason why many eligible adults are not screening according to USPSTF recommendations (White et al., 2017). Findings from this analysis demonstrate that segments of the Maryland population are screening within the recommended time intervals. However, CRC screening use remain lower for some groups that experience persistent barriers to healthcare access, such as those without access to a health care professional (Richardson, King, Dwyer, Parekh, & Lewis, 2015).

Another finding from this analysis is that access to health care professional is a significant (*p* < .05) predictor to CRCSU. The frequency distribution for the health care professional variable showed that out of the 3134 cases, 2608 (83.2%) had access to one health care professional, 358 (11.4%) had access to more than one health care professional and 168 (5.4%) were without access to a health care professional. Result from the Pearson chi-square test showed that among those with access to only one health care professional, there was a statistically significant (*p* = .000) difference between those who respondent "Yes" 2019 (77.4%) versus those said "No" 589 (22.6%) to CRCSU. Of the 168 without access to a health care professional, 87 (51.8%) responded "Yes" to CRCSU and 81 (48.2%) responded "No." Also, when compared to those who do not have access to a health care professional, those with access to only one health care professional were 1.8 times more likely (OR=1.808; 95% CI: 1.295, 2.511, *p* = .000); and those with access to more than one health care professional were 1.6 times more likely (OR: 1.628; 95% CI: 1.092, 2.429, *p* = .017) to CRCSU. This result supports findings from Yang & Hwang, (2016) that access to a health care professional as a health care resource is a predictor to utilization of preventive health services. Sabatino, White, & Thompson, (2015) found that there is limited cancer screenings among adults who lack access to preventive health care services; implying that there is relatively high CRCSU among those who visit at least one health care professional compared to not having access to any health care professional.

Furthermore, findings from these analyses persisted even after controlling for some demographic variables. Age, and race/ethnicity confounded the relationship between the predictors and the outcome variable (CRCSU); but the odds ratios for CRCSU remained the same even after adjusting for sex. This finding is consistent to previous research finding that age (DeMoor et al, 2018; Symonds et al., 2016) and race (Burnett-Hartman, Mehta, & Zheng, 2016; Mehta et al., 2016) are confounding factors to CRC screening participation. However, it is contrary to previous research that sociodemographic factors such as sex is a confounder to the association between preventive health care services and adherence to CRC screening program (Sava, Dolan, May, & Vargas, 2018; Kang & Son 2017). Factors such as age, sex, and race/ethnicity are essential measures to assess CRC screening behaviors in large scale populations (Brenner & Chen, 2018; Molina-Barceló et al., 2018).

Other studies have revealed that respondents in the low-income groups tend to have low-paying jobs, which may have an effect on their use of preventive health care services regardless of their sex (Meester et al., 2018; Yang & Hwang, 2016; Almadi et al., 2015). The influence of health insurance coverage, and access to health care professional on CRCSU should be explained relative to other factors that may affect CRC screening use. For example, physician recommendation for screening and other social determinants of health have been associated to CRC screening use in community-based populations (Bernardo et al., 2018; Jih et al., 2018; Lin, McKinley, Sripipatana, & Makaroff, 2017; Mehta et al., 2016; Palmer et al., 2011; Gilbert & Kanarek, 2005). These findings suggest that more efforts to reduce lapses in insurance coverage and encourage individuals to visit a doctor for preventive purposes are needed to encourage compliance with national guidelines for CRC screening.

The latest initiative from the 2019 National Colorectal Cancer Roundtable (NCCRT) was to enhance strategies to achieve ≥80% CRC screening rates in every community (NCCRT, 2019). Findings from this study add knowledge to the public health discipline in that both health insurance coverage and access to a healthcare professional are linked to preventive health care use. Therefore, to increase CRC screening adherence in communities, public health officials need to promote initiatives necessary to increase access to health care resources in minority communities (Wilder & Wilson, 2016). According to Liang & Dominitz, (2019) the availability of multiple CRC screening test options offers opportunities to both patients and physicians to choose the best screening test for each patient.

Findings from this study, are consistent to findings from systematic reviews and trend analysis that, there is a wide gap in CRC screening utilization between individuals at different education levels, income levels, and access to a health care professional (Cardoso et al., 2019; Doubeni et al., 2019; Sauer, Siegel, Jemal, & Fedewa, 2019; Jih et al., 2018; Levin et al., 2018). Considering that my data was a random sample from a large population, the multiple logistic regression technique provided some clues as to the direction of the relationship between the independent and the dependent variables. Based on the decision rule for my research questions, the null hypothesis was rejected for some measures and accepted on others. Since I cannot draw an absolute conclusion from this study alone, I can only state that there is insufficient evidence to reject the null hypothesis that there is no statistically significant difference in the association between SES, access to preventive healthcare service, and CRCSU even after controlling for age, sex and race/ethnicity.

This research makes a unique contribution to two theoretical and conceptual frameworks, Health Belief Model (HBM) and Fundamental Cause Theory (FCT), that I selected to guide this study. The HBM is structured to develop an understanding of people’s willingness to engage in prevention programs to control disease (Glanz, Rimer, & Viswanath, 2015); while the FCT is structured around the effect of socioeconomic resources such as money, knowledge, and power to individuals taking actions towards preventive behaviors to improve health and reduce disease mortality (Link & Phelan, 1995). By applying the concept of cues to action, results obtained from this study support the HBM model, by effectively incorporating education level and access to healthcare professional as avenues for taking action towards CRC screening.

The FCT is supported in this study by effectively incorporating the types of health insurance plan, and income level as resources necessary to take action towards preventive health behaviors such as CRC screening. Through this study, I expanded the use of the HBM and the FCT to CRC screening use, and advanced the application of these frameworks to different age, sex and race/ethnicity groups. One could argue that as long as the HBM concept of cues to action is concerned, both the HBM and the FCT compensate for the gaps in each other and therefore cannot be used without each other. This study further contributes to the application of the HBM and the FCT in CRC screening by providing insights into the complexity involved in CRC screening behaviors in other geographic areas with similar demographic distribution like Maryland. At the least, given the lack of sufficient research on the predictors of CRC screening use in Maryland, this study provides a crucial background upon which future studies on this topic can be based on.

Limitations of the Study

Despite its contribution stated above, there are limitations to this study that need to be discussed. Firstly, using secondary data from self-reported survey may be susceptible to recall bias. Most of the BRFSS survey questions depended on the ability of respondents to recall when a CRC screening was done and what test was used. Although there is evidence of high reliability and validity of BRFSS data, there is the possibility that some respondents might under-report or over-report responses. Inaccurate responses to survey questions, may be a significant limitation to accurate data analysis (Ponto, 2015). There is a potential for selection and information bias as, more information may have been pulled from some counties in Maryland than others.

Secondly, the original dataset included many cases with missing data which I basically removed from the analysis; hence limiting the results from generalization to the entire Maryland population of over 6 million people (U.S. Census, 2018). However, using stratified random sampling technique in selecting cases was helpful to minimize the problem of missing data in the analytic stage of this research. Hence the reliability of the results was similar to that of the full version of the BRFSS dataset. Also, there was a limitation in the balance of the samples in some categories. For example, the frequency distribution shows that there are almost twice as many respondents in the college graduate subgroup compared to some college group; and respondents in the White race/ethnicity group were over three times those in the black and other race groups.

Thirdly, although the use of a cross-sectional design was appropriate for this study; it is limited in its ability to conclude causal inferences for the study variables. Moreover, all six concepts of the HBM were not incorporated in this study, which could limit its ability to describe the impact of knowledge, susceptibility, severity and barriers of CRC screening. Lastly, it was difficult to ascertain whether observed differences in results were confounded by other variables such as marital status that were not measured in the analysis.

Recommendations

The strength of this cross-sectional study is grounded in the use of multiple logistic regression technique which is an excellent model to estimate associations simultaneously with the effects of group-level predictors on the outcome (Merlo et al., 2018). Multiple logistic regression analyses used in this study corrected for the effects of data collection at different age, sex, and race/ethnicity categories. This study is beneficial because it reveals the relationship between demographic, SES, access to preventive health care service and CRC screening use; and exposes the need to develop targeted CRC screening programs for specific subgroups.

A power of this study is that it uses secondary data from a reliable and recognized database, that stores CRC data from all states in the US. By using datasets from the BRFSS, there is a high probability that my results are reliable and valid. More also data from the CDC BRFSS are freely available hence eliminates time and cost constrains usually associated with primary data collection (Althubaiti, 2016). Another strength is that most of the literature was pulled from recent articles published less than five years. The studies reviewed included research findings of both primary and secondary datasets from a wide geographic area. Although findings from this study showed statistically significant associations between the predictors and the outcome variable, this study was limited to the state of Maryland.

A recommendation for future research is that another quantitative study can be conducted to examine the barriers implicated in low CRC screening use among specific subgroups in Maryland. This study pointed to the role of demographic characteristics to fully meet the CRC screening test recommendation. Future research could include a focus on balancing the frequency distribution of all demographic variables. A randomized study will allow for a more generalized result that could be applied to a larger population in the United States. It is essential for future researchers to conduct prospective studies with larger sample sizes to examine the intra-relation within specific predictor variables across all SES levels. For example, future researchers can examine if there is a difference in CRC screening use restricted to race/ethnic groups at the same education level. A prospective study could focus on evaluating CRC screening programs in specific groups, and estimate the effect of low CRC screening rates in minority populations.

There is a chance that low CRC screening rates in minority population may have a negative health and economic impact in a community; however, more studies are needed to ascertain that theory. Given existing literature and findings from this study, there are other potential predictors of CRC screening use that are not applicable to Maryland in particular. Future studies could, therefore, include longitudinal investigations that provide more than a snapshot of predictors of CRC screening use in Maryland. Such longitudinal studies, could include a cluster of predictor variables and tracking of survey respondents from 50 years to when they are 75 years or older to see if their CRC screening behaviors change with age and time.

Social Change Implications

Findings from this study revealed that the predictors of CRC screening use among adults aged 50–75 years are multifactorial. This information is of interest to public health professionals, governmental and non-governmental organizations, physicians, individuals and volunteers who work to reduce the cancer burden of the communities in which they serve. In their 2019 annual conference, the NCCRT pointed out that despite efforts to promote and increase CRC screening rates across groups "not everyone is benefiting equally as some racial/ethnic groups, many rural and low income communities still experience lower CRC screening rates" (NCCRT, 2019). To increase CRC screening rates to 80% and higher, the NCCRT can use findings from this study to understand which predictors have a significant effect on CRC screening adherence.

This study helps to narrow the gap in knowledge by improving understanding of the effects of age, sex, and race/ethnicity on CRC screening use and the complex nature of factors that predict CRC screening across groups. This study could be excellent in advancing epidemiological knowledge as it provides a useful framework for problems that have a multifactorial structure. Public health practitioners in Maryland, can design programs that target specific groups as an effort to help increase CRC screening use and reduce CRC incidence in the State. CRC causes over $15 billion of the US health care costs per year, with the potential to increase if CRC prevalence is not controlled (Bibbins-Domingo et al., 2016). The policy implications from this study are that, there is an urgent need for public health administrators and policymakers who lead the development and approve the implementation of programs at state and federal levels to prioritize initiatives that focus on eliminating inequity in CRC screening across all communities.

Key stakeholders for CRC screening initiatives may include public health professionals who will design CRC screening programs; public health agencies at all levels that will fund the programs; community leaders who will help health care workers to advocate for screening by encouraging dynamic behavioral and lifestyle changes that correspond to CRC screening guidelines; physicians who will educate and recommend screening when patients visit the clinics; individuals who must adhere to screening guidelines; and health insurance companies that will advocate for CRC screening to reduce cost of treatment if the disease if diagnosed. The NCCRT ≥80% screening goal can be met if all stakeholders collaborate to the success of various public health initiatives towards CRC screening use. For example, public health professionals can work with volunteer organizations to donate free CRC screening kits, and educational materials to low SES communities.

Conclusion

Colorectal cancer is one of the most common cancer diagnosed in both men and women, and a good candidate for screening programs (Levin et al., 2018). Given the multiple benefits of CRC screening and better prognosis associated with early diagnosis, more efforts to increase screening rates are essential strategy to improve Maryland population health. Findings from this study suggest that predictors of CRC screening may not be homogeneous in all populations. The results showed that CRC screening use among minority groups that experience persistent barriers to preventive healthcare services, remain lower than expected. Higher odds ratios of CRCSU was observed among those with higher education and income levels compared to those at the lower levels of education and income, or no access to healthcare professionals.

Although race and SES are associated factors, they both reflect distinct processes of stratification where either race or SES is likely to be a proxy for exposures that affect health outcomes (Williams, Priest, & Anderson, 2016). Hence, SES cannot fully explain the reasons for CRC screening differences across age and race groups (Siegel, Desantis & Jemal, 2014). Maryland is a state with significant health care resources, hence a targeted program that can ensure access to health care resources such as specific health insurance coverage for minority groups can potentially help to increase CRC screening uptake in the state. As of 2019, Maryland is yet to meet its ≥80% CRC screening goal. Based on the resolution from the 2019 NCCRT conference, members agreed to continue on their mission to achieve at least 80% screening rates in every community, by defining the target population for screening, surveillance intervals, and potential risk strategies.

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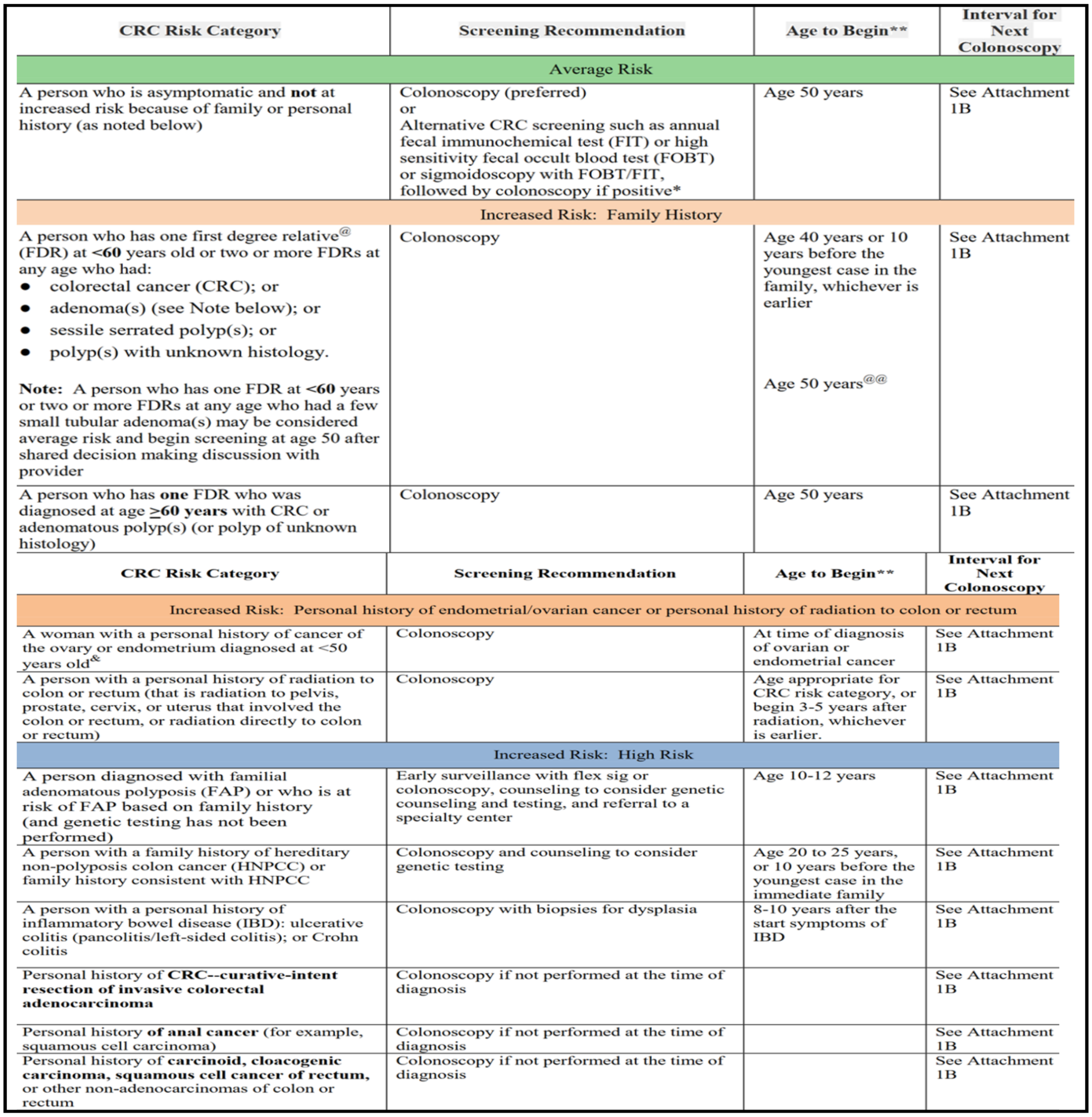
Appendix A: USPSTF CRC Screening Guideline for Average-risk Individuals

Screening method	Frequency	Efficacy	Main issues for informed decisions
Colonoscopy	Every 10 years	Reduction in mortality in a prospective cohort study	Most sensitive. Can detect precancerous lesions. Requires full bowel preparation and possibly sedation.
Sigmoidoscopy	Every 5 years	Reduction in mortality in RCTs	Only distal colon is examined. Can detect precancerous lesions. Requires limited bowel preparation.
FOBT	Every year	Reduction in mortality in RCTs	Performed at home but should be repeated annually. Limited ability in detecting precancerous lesions. Follow-up colonoscopy is needed if result is positive.
FIT	Every year	Higher sensitivity and specificity in detecting CRC than FOBT, but RCTs is lacking	Performed at home but should be repeated annually. Limited ability in detecting precancerous lesions. Follow-up colonoscopy is needed if result is positive.

Note. From “Recent advances in colorectal cancer screening”, by Li D., 2018, *Journal of Chronic Diseases and Translational Medicine, 4(3), 139–147.* Published online 2018 Sep 17. doi: 10.1016/j.cdtm.2018.08.004

Appendix B: Maryland Department of Health, Medical Advisory Committee Guidelines for Colorectal Cancer Screening Revised Version May 2018



CRC Risk Category	**Screening Recommendation**	**Age to Begin****	**Interval for Next Colonoscopy**
Average Risk			
A person who is asymptomatic and **not** at increased risk because of family or personal history (as noted below)	Colonoscopy (preferred) or Alternative CRC screening such as annual fecal immunochemical test (FIT) or high sensitivity fecal occult blood test (FOBT) or sigmoidoscopy with FOBT/FIT, followed by colonoscopy if positive*	Age 50 years	See Attachment 1B
Increased Risk: Family History			
A person who has one first degree relative[@] (FDR) at **<60** years old or two or more FDRs at any age who had: • colorectal cancer (CRC); or • adenoma(s) (see Note below); or • sessile serrated polyp(s); or • polyp(s) with unknown histology. **Note:** A person who has one FDR at **<60** years or two or more FDRs at any age who had a few small tubular adenoma(s) may be considered average risk and begin screening at age 50 after shared decision making discussion with provider	Colonoscopy	Age 40 years or 10 years before the youngest case in the family, whichever is earlier Age 50 years[@@]	See Attachment 1B
A person who has **one** FDR who was diagnosed at age **≥60 years** with CRC or adenomatous polyp(s) (or polyp of unknown histology)	Colonoscopy	Age 50 years	See Attachment 1B
Increased Risk: Personal history of endometrial/ovarian cancer or personal history of radiation to colon or rectum			
A woman with a personal history of cancer of the ovary or endometrium diagnosed at <50 years old[&]	Colonoscopy	At time of diagnosis of ovarian or endometrial cancer	See Attachment 1B
A person with a personal history of radiation to colon or rectum (that is radiation to pelvis, prostate, cervix, or uterus that involved the colon or rectum, or radiation directly to colon or rectum)	Colonoscopy	Age appropriate for CRC risk category, or begin 3-5 years after radiation, whichever is earlier.	See Attachment 1B
Increased Risk: High Risk			
A person diagnosed with familial adenomatous polyposis (FAP) or who is at risk of FAP based on family history (and genetic testing has not been performed)	Early surveillance with flex sig or colonoscopy, counseling to consider genetic counseling and testing, and referral to a specialty center	Age 10-12 years	See Attachment 1B
A person with a family history of hereditary non-polyposis colon cancer (HNPCC) or family history consistent with HNPCC	Colonoscopy and counseling to consider genetic testing	Age 20 to 25 years, or 10 years before the youngest case in the immediate family	See Attachment 1B
A person with a personal history of inflammatory bowel disease (IBD): ulcerative colitis (pancolitis/left-sided colitis); or Crohn colitis	Colonoscopy with biopsies for dysplasia	8-10 years after the start symptoms of IBD	See Attachment 1B
Personal history of **CRC--curative-intent resection of invasive colorectal adenocarcinoma**	Colonoscopy if not performed at the time of diagnosis		See Attachment 1B
Personal history **of anal cancer** (for example, squamous cell carcinoma)	Colonoscopy if not performed at the time of diagnosis		See Attachment 1B
Personal history of **carcinoid, cloacogenic carcinoma, squamous cell cancer of rectum,** or other non-adenocarcinomas of colon or rectum	Colonoscopy if not performed at the time of diagnosis		See Attachment 1B