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# Evaluation and Comparison of Theoretical Models' Abilities to Explain and Predict Colorectal Cancer Screening Behaviors

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# Evaluation and Comparison of Theoretical Models' Abilities to Explain and Predict Colorectal Cancer Screening Behaviors

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

by

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Abstract

EVALUATION AND COMPARISON OF THEORETICAL MODELS' ABILITIES TO EXPLAIN AND PREDICT COLORECTAL CANCER SCREENING BEHAVIORS

By Anthony Molisani, Ph.D., M.P.H.

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BACKGROUND: Colorectal cancer (CRC) is the fourth most common and second most deadly cancer in the United States. However, it is highly preventable and treatable if detected at the precancerous or local stage of development. There exists multiple screening methods each with varying sensitivity, required effort, and recommended frequency of use. Complete adherence to screening guidelines by the recommended, at-risk population would halve the current mortality rate. Unfortunately, screening adherence remains the lowest of all screened cancers with a median state screening adherence rate of about 65%. To understand what individual-level factors influence an individual's decision to be screened, health behavior theory is used. However, few studies have evaluated the performance of entire behavioral theories in their ability to explain CRC screening intentions and behaviors.

METHOD: Health Belief Model, Theory of Reasoned Action, Theory of Planned Behavior, and Attribution Theory were evaluated within the context of colorectal cancer screening using an online national sample (N=403) of at-risk individuals age 50 and older. Confirmatory factor analyses were performed for each evaluated construct of the theory. Structural equation models were created using the estimated constructs for each theory. Each theory was evaluated for the following screening use: colonoscopy, sigmoidoscopy, fecal occult blood test (FOBT), and general screening use. Fit statistics were estimated for each model. Models with acceptable fit were examined for significant pathways within the model as well as consistency of the model with the behavioral theory.

RESULTS: All models displayed adequate fit statistics. While not all pathways were significant in each model, no estimate was the inverse in directionality to that hypothesized. This provides support that each theory lends some explanatory power and none of the theories evaluated detract from understanding CRC screening intentions and behaviors. Comparison of the models illustrates advantages to each theory and suggests potential integration of theories.

CONCLUSION: The constructs of the Health Belief Model, Theory of Planned Behavior, and Attribution Theory all provide adequate explanations of individual-level CRC screening behavior influences. Although, further review and refinement of the theories is warranted and recommended.

# Introduction

Colorectal cancer is diagnosed in over 140,000 and kills over 50,000 Americans annually. These rates make it the fourth most common and second most deadly cancer in America (American Cancer Society, 2013; National Cancer Institute, 2014). Yet, colorectal cancer is a preventable and treatable disease – especially when diagnosed as a precancerous polyp or at a localized stage (American Cancer Society, 2014; Bretthauer, 2011). The American Cancer Society (2013) estimates that if all recommended were routinely screened, the mortality rate associated with colorectal cancer would decrease by half – 25,000 lives per year. However, screening rates remain the lowest among preventable cancers (Centers for Disease Control and Prevention, 2014; Jones, Vernon, & Woolf, 2010). To understand what individual-level factors affect a person's decision to be screened, behavioral science turns to commonly applied health behavior theories. This study attempts to evaluate the use of these theories in explaining and predicting colorectal cancer screening behavioral intentions and behaviors. Individual-level, colorectal cancer related constructs are modeled consistent with frequently used health behavior theories. The models are then tested to determine how well each theory performs in its ability to explain screening intentions and behavior while also providing insight into what individual-level factors most influence colorectal cancer screening in an at-risk population sample.

# Background

## Colorectal Cancer

Colorectal cancer encompasses multiple types of cancer that grow within the colon or rectum. It is typically a slow growing cancer that may take several years to develop (American Cancer Society, 2013). The vast majority of colorectal cancers originate from the cells that form the glands which lubricate the colon and rectum. Other colorectal cancers start from specialized cells within the digestive tract, immune system cells, or blood vessels located within the colon and rectum. However, these cancers make up less than 5% of colorectal cancers and will not be further addressed. Prior to the growth of cancer cells, benign, non-cancerous growths of these glandular cells, known as adenomatous polyps, will begin to develop on the inner lining of the digestive tract. These pre-cancerous cells may continue to grow to the point where they will eventually fail to exhibit contact inhibition. Contact inhibition means the cancer cells will continue to grow as they reach other cells. The cells can then grow into and through the wall of the colon or rectum and metastasize through the associated blood and lymph vessels (American Cancer Society, 2013).

**Staging of Colon and Rectum Cancers.** Assessing the progression of cancer at the time of diagnosis is critical for proper treatment and provides the greatest chance of successful outcomes. In the United States, there are three staging systems most commonly used: the

American Joint Committee on Cancer TNM System, Summary Staging, and Extent of Disease Coding (Edge & Compton, 2010). Each system classifies the cancer case based on tumor growth and the extent that the cancer has spread from its point of origin.

The TNM system is the most widely used system among clinicians and uses a stage grouping mechanism based on the developments of the primary tumor (T), regional lymph nodes involvement (N), and distant metastases (M). The TNM system is currently in its seventh edition as of January 1, 2010 (Edge & Compton, 2010). For colorectal cancer, T indicates how far the tumor has grown into the wall of the intestine and nearby tissue. N defines the number of lymph nodes to which the cancer has spread. M indicates whether or not the cancer has metastasized (American Cancer Society, 2013). Each letter is attributed a number to describe the extent of the cancer's progression for each category. The primary tumor can range from 0, in situ (is), 1 to 4. Regional lymph nodes can range from 0 to 3. Distant metastasis can range from 0 to 1 (National Cancer Institute, 2006). For example, colon cancer that has spread to the outermost layer of the colon but not through it, is found in or near 1 to 3 nearby lymph nodes, but has not spread beyond the local region would be considered T3 N1 M0.

Summary staging is considered to be the simplest method of cancer staging (Edge & Compton, 2010). It is a basic system that can be applied to all solid tumor cancers. However, the categories are broad enough to include a wide variety of cases in each category. As such, these categories group cancers that have developed and progressed differently yet have equally dispersed throughout the body. The first category of summary staging is "In Situ," meaning that the cancerous cells have not penetrated into the cells of the surrounding tissue. "Localized" stage indicates that the tumor has spread into the surrounding tissues but has not spread beyond the organ of origin. The "Regional" stage classifies cancer that has spread beyond the organ of origin

by direct extension and/or through the lymph system to other nearby tissue. Finally, "Distant" staging indicates that the cancer has spread to areas of the body away from the primary tumor. The Extent of Disease Coding expands upon these classifications by providing a range of two-digit codes for each stage (Table 1). The range associated with each stage allows for recording of the progression of cancer within each summary stage. As the depth of invasion increases for a given stage, the extension code increases (National Cancer Institute, 2009).

*Table 1. Comparison of Summary Staging and Extent of Disease Codes for Colon Cancer as Classified by the Surveillance, Epidemiology and End Results (SEER) Program (National Cancer Institute, 2009)*

| Summary Stage | Description of Tumor Extent | Codes |
|---|---|---|
| In Situ | Noninvasive tumor | 0 |
| | Polyp, noninvasive | 5 |
| Localized | Localized tumor in colon | 10-30 |
| Regional | Tumor invasive through bowel wall or adjacent structures | 40-66 |
| Distant | Tumor with distant involvement | 70-85 |
| | Unknown extension | 99 |

Another common method of grouping stages for cancer progression is through a Roman numeral number system ranging from 0 to IV similar to summary staging. The National Cancer Institute's staging of colorectal cancer is observed in Table 2. In contrast, the American Cancer Society provides an integration of the TNM classification and stage groupings. Stage 0 encompasses only the Tis N0 M0 classification as this represents cancer cells only found in situ. Stage I encompasses T1-2 with N0 and M0 meaning that the tumor has grown but remains within the colon or rectum. Stage II includes T3-4 with N0 and M0 indicating that the tumor has grown into and through the outermost layers of the intestine but has not yet begun to spread. Stage III can be classified as T(>0) N(>0) M0 indicating that the tumor has grown at least into surrounding cells and has been found in some nearby lymph nodes, but it has not metastasized. Stage IV represents T(>0) N(>0) M1 indicating that the cancer has spread to distant organs or

sets lymph nodes as well (American Cancer Society, 2013). Subcategories of classifications and stages are also used to further specify cancer growth and spread.

*Table 2. Stages of Colorectal Cancer (National Cancer Institute, 2006)*

| Colorectal Cancer Stages | |
|---|---|
| Stage 0 | The cancer is found only in the innermost lining of the colon or rectum. Carcinoma in situ is another name for Stage 0 colorectal cancer. |
| Stage I | The tumor has grown into the inner wall of the colon or rectum. The tumor has not grown through the wall. |
| Stage II | The tumor extends more deeply into or through the wall of the colon or rectum. It may have invaded nearby tissue, but cancer cells have not spread to the lymph nodes. |
| Stage III | The cancer has spread to nearby lymph nodes, but not to other parts of the body. |
| Stage IV | The cancer has spread to other parts of the body, such as the liver or lungs. |

**Colorectal cancer rates and trends.** The National Cancer Institute estimates that 5% of men and women will be diagnosed with colorectal cancer at some point during their lifetime (National Cancer Institute, 2006). Colorectal cancer accounts for approximately 9% of all new cancer cases as well as 9% of all cancer deaths in the United States. Over 140,000 new incidences of colorectal cancer – 100,000 colon and 40,000 rectum cancers – were estimated to have occurred in 2013. This incidence rate – 45.0 per 100,000 men and women per year – makes colorectal cancer the fourth most common cancer after prostate, breast, and lung cancer (American Cancer Society, 2013; National Cancer Institute, 2014). Similarly, Surveillance, Epidemiology, and End Results (SEER) Program data estimates that 50,000 deaths annually can attributed to colorectal cancer. This equates to an age-adjusted death rate of 16.4 per 100,000

men and women per year, making it the second most deadly cancer after lung cancer (National Cancer Institute, 2014).

Overall, combined – i.e. all races, males, and females – long-term incidence rates have been declining for colorectal cancer since 1975 (Edwards et al., 2010). During this time span, the incidence of new cases has decreased from a high of 66.3 per 100,000 in 1985 to a low of 40.6 per 100,000 in the most recently presented year, 2010 (National Cancer Institute, 2014). While short-term (i.e. within the last observed decade) incidence rates have been decreasing, especially for individuals older than 65 years, short-term incidence rates have actually increased annually for individuals younger than 50 years, especially among black individuals (Edwards et al., 2010). From 2000 to 2009, incidence significantly decreased by 3% per year among men. Stratified by race and ethnicity, significant decreases of 3%, 2%, and 2% per year have been observed among white, black, and Hispanic men, respectively (Centers for Disease Control and Prevention, 2014). Among woman, incidence has also significantly decreased by 3%. Similarly, decreases of 3%, 2%, and 2% per year were observed among white, black, and Hispanic women, respectively (Centers for Disease Control and Prevention, 2014). In both sexes, whites have seen the greatest decrease while blacks have seen the slowest decline of incidence rates.

The median age at diagnosis for colorectal cancer is 69 years with almost half (48%) of new cases occurring between the ages of 65 and 84 years. Incidence is more prevalent among males than females (52.2 vs 39.3 per 100,000, respectively). Stratified by sex, the incidence rates per 100,000 white, black, Asian American and Hispanic individuals are 50.9, 62.5, 40.8 and 47.3 among men and 38.6, 46.7, 31.0 and 32.6 among women, respectively (American Cancer Society, 2014). In both sexes, blacks have the highest current incidence rates while Asian Americans have the lowest rates.

Annual mortality rates have seen a similar decline in the same time period (Edwards et al., 2010). According to SEER 9 statistics, the age-adjusted number of deaths per 100,000 have declined from 28.1 in 1975 to 15.5 in 2010 (National Cancer Institute, 2014). More recently, the 2000 to 2009 trend in mortality among men has decreased significantly by 3% per year. Stratified by race and ethnicity, mortality decreased significantly by 3%, 2%, and 2% per year among white, black, and Hispanic men, respectively. Rates among women also significantly decreased by 3% per year. Mortality rates for women by race and ethnicity also decreased significantly by 3%, 3%, and 2% among whites, blacks, and Hispanics, respectively (Centers for Disease Control and Prevention, 2014). In both sexes, improvements in mortality rates are highest among whites and lowest among Hispanics.

Current mortality statistics indicate that colorectal cancer deaths are highest among those aged 75-84 (28%) while the median age at death attributed to colorectal cancer is 74 years. Disparities are also present in death rates by sex, race, and ethnicity. Similar to incidence, the number of deaths per 100,000 is higher in males (19.6) than females (13.9). Additionally, the number of deaths is highest among black males compared to white, Asian American, and Hispanic males – 28.7 vs 19.2, 13.1 and 16.1 per 100,000, respectively – as well as among black females compared to white, Asian American, and Hispanic females – 19.0 vs 13.6, 9.7 and 10.2 per 100,000, respectively (American Cancer Society, 2014). Differences in mortality rates also vary significantly by state. While the overall national rate has declined from 23.7 per 100,000 in 1990 to 17.6 per 100,000 in 2007, state disparities ranging from 21.0 deaths per 100,000 in West Virginia to 12.8 deaths per 100,000 in Utah are observed (Naishadham, Lansdorp-Vogelaar, Siegel, Cokkinides, & Jemal, 2011).

Overall 5-year relative survival rates have significantly improved since 1975 (Edwards et al., 2010). The age-adjusted survival rate for individuals of all races and sexes was less than half (49%) in 1975. As of the most recent data (2009), this rate has increased to 65% (American Cancer Society, 2014). While this illustrates an improvement in survival, rates differ considerably by stage. Distant stage 5-year survival is only 13% while regional and localized stages are as high as 70% and 90%, respectively (American Cancer Society, 2014). This clearly illustrates a substantial benefit from identifying colorectal cancer at earlier stages, especially the localized stage. However, only 40% of cases are identified at this localized stage (National Cancer Institute, 2014).

**Screening Methods, Guidelines, and Rates**

Colorectal cancer screening reduces mortality through early detection and curative intervention at the precancerous and localized stages where survival is highest (Janz, Wren, Schottenfeld, & Guire, 2003). Screening can be considered both a prevention and early detection tool based upon the malignancy status of the polyps at the time of testing (Bretthauer, 2011). The American Cancer Society estimates that the death rate associated with colorectal cancer would decrease by half – 25,000 lives per year – if all adults 50 years and older were routinely screened (American Cancer Society, 2013).

**Types of colorectal cancer screening.** Multiple colorectal cancer screening methods exist including fecal occult blood testing (FOBT), sigmoidoscopy, and colonoscopy (Steinwachs et al., 2010a). The various screening options differ by the amount of effort required by the patient, associated costs, and recommended frequencies (Steinwachs et al., 2010b).

***Fecal occult blood testing.*** Fecal occult blood testing (FOBT) detects trace amounts of blood that is released by the damaged vessels of larger colorectal polyps or cancers (Bretthauer,

2011). FOBT has been the most widely used screening method for the general population (Steinwachs et al., 2010a). The test is performed with a kit that the patient uses at home. The process typically involves taking stool or feces samples from one to three consecutive bowel movements based on the kit and then returning the kit for lab testing (American Cancer Society, 2013). There are two types of FOBT tests typically employed. The first, gFOBT, is a guac-based test that detects human blood in the feces. The second, FIT or iFOBT, is an immunochemical-based test that detects antibodies in the feces specific to human blood (Blanco et al., 2015). As a take-home test, FOBT is typically considered simple, inexpensive, and noninvasive to perform (Bretthauer, 2011). However, FOBT sensitivity for detecting cancer can vary widely based on the manufacturer of the test – between 30% and 80% – and may miss tumors that bleed little or not at all (Bretthauer, 2011; Burt et al., 2010).

***Sigmoidoscopy.*** Sigmoidoscopy, or flexible sigmoidoscopy, uses a sigmoidoscope approximately 60 cm long following a distal colorectum cleansing (Bretthauer, 2011). The ten to twenty minute procedure has relatively high sensitivity, and it does not require sedation or extensive preparation. If abnormalities are detected by the scope, a colonoscopic polypectomy is performed to remove and biopsy any identified polyps or abnormalities (Burt et al., 2010). Bretthauer (2011) reports the results of three randomized control trials evaluating the effectiveness of flexible sigmoidoscopy. The results of the most comprehensive and recent trial suggest a 33% incidence and 43% mortality reduction in people who received sigmoidoscopy screenings. However, the greatest limitation of sigmoidoscopy is that it only examines the rectum and lower half of the colon, potentially missing abnormalities outside those areas (Burt et al., 2010).

***Colonoscopy.*** Colonoscopy has become the most prevalent method of colorectal cancer screening since 2001 (Steinwachs et al., 2010a). Colonoscopy is used both as a primary screening method as well as a follow-up procedure to positive FOBT and sigmoidoscopy tests (Bretthauer, 2011). A colonoscopy is performed using a scope capable of examining the rectum and entire length of the colon (American Cancer Society, 2013). The efficacy of colonoscopy has not been evaluated with randomized controlled trials (Bretthauer, 2011; Burt et al., 2010). However, Burt et al. (2010) present multiple case-control and cohort studies that suggest colonoscopy may result in an estimated 50% reduction in colorectal cancer incidence. Colonoscopy does require a high level of preparation prior to the procedure since the colon and rectum must be empty and clean at the time of the test. In addition sedation is administered, adding risk associated with sedation and requiring more hospital support than either FOBT or sigmoidoscopy. Similar to the sigmoidoscopy, removal and biopsy of polyps are performed during the procedure (American Cancer Society, 2013).

### Colorectal Screening Recommendations and Guidelines

The generally recommended guidelines provided by the United States Preventive Services Task Force (USPSTF) state that all adults ages 50 until 75 years should be screened for colorectal cancer using FOBT, sigmoidoscopy, or colonoscopy. This recommendation is applicable to adults of all ethnic and racial groups with the exceptions of individuals with specific inherited syndromes, inflammatory bowel disease, and those with one or more first-degree relatives who developed colorectal cancer at a younger age. The following screening tests are equally recommended: annual FOBT; sigmoidoscopy every five years with FOBT every three years; or colonoscopy every ten years (U.S. Preventive Services Task Force, 2014).

Similarly, the American Cancer Society (ACS) recommends annual FOBT; sigmoidoscopy every five years; or colonoscopy every ten years. However, ACS guidelines recommend that all people at average risk begin screening at age 50 and continue to be screened even after age 75. ACS guidelines acknowledge specific groups of individuals with increased or high risk of developing colorectal cancer who should be screened prior to age 50 and more frequently than average risk individuals. These groups include: individuals with a history of colorectal cancer or adenomatous polyps; a history of inflammatory bowel disease; a family history of colorectal cancer or polyps; or a known family history of a hereditary colorectal cancer syndrome (American Cancer Society, 2013).

**Screening Rates**

While certain factors as those mentioned may place individuals at a higher risk of developing colorectal cancer, at least 80% of all cases occur in average-risk (≥ 50 years) individuals (Bretthauer, 2011). With the multiple methods of testing, the stark differences in survival based on stage, and the broad average-risk factor, one would imagine that colorectal screening would be common and routine for all individuals. However, screening rates have been reported as low as 20% for those 50 years or older in the late 1980s and 90s (Holden et al., 2010; Steinwachs et al., 2010a; Vernon, Bettencourt, Coan, & Hawley, 2011). While this rate has increased over the past thirty years – partially attributed to advancements in Medicare coverage of testing – self-reported screening rates have only risen to around 50 to 60% as of 2008 (Holden et al., 2010; Steinwachs et al., 2010a; Vernon et al., 2011). As of 2010, rates for adults 50 to 75 years old who are up-to-date with recommended colorectal cancer screenings range from 54 to 75% across the United States, with half of states achieving screening rates less than 64%

(Centers for Disease Control and Prevention, 2014). These rates remain lower than other screened cancers including breast and cervical cancer (Jones et al., 2010).

It is the primary goal of the National Colorectal Cancer Roundtable and the American Cancer Society to raise the national screening rate to 80% by 2018 (National Colorectal Cancer Roundtable, 2015; Simon, 2015). A study by Meester et al. (2015) modeled the impact "80% by 2018" would have on CRC related morbidity and mortality in the United States. According to their predictive models, improving screening rates by 2018 from the current approximately 60% to 80% adherence would create a substantial decrease in both incidence and mortality by 2030. The models were based on comparing stable screening rates of 60% and 80% through 2030 and taking into account the aging US population. Though the incidence of CRC would initially increase due to detection of those previously unscreened, incidence would ultimately decrease about 30% which would equate to 43,000 averted cases of CRC annually and 277,000 averted cases over the course of the evaluated time (Meester et al 2015). Similarly, Meester et al (2015) estimate 21,000 fewer deaths annually and 203,000 fewer deaths cumulatively attributed to CRC by achieving an 80% screening rate. While the ultimate goal would be total screening adherence by at-risk individuals, these results demonstrate the substantial influence of improving CRC screening rates even by one-third of the current adherence rate.

**Screening Behaviors and Cues to Action**

Several individual and interpersonal characteristics and behaviors may influence the decision to undergo colorectal cancer screening. Regarding sociodemographics, three of the strongest predictors of screening include higher income and education level as well as health insurance status (Holden et al., 2010; Steinwachs et al., 2010a, 2010b). Older patients, i.e. age 60 to 75 years, were also more likely to be screened than those 59 years and younger. When

statistical models were controlled for income, education, and age, differences in rates of screening based on other sociodemographic variables such as race and ethnicity were not significant (Steinwachs et al., 2010a).

Individual patient factors that are associated with screening behaviors are centered on patient perceptions of screening procedures and subsequent treatment. Specifically, patients' knowledge and beliefs about screening tests are associated with screening outcomes. Patients with inadequate knowledge about the test, high anxiety about the test and potential outcomes, anticipation of pain, and feelings of embarrassment or vulnerability reduced the likelihood of being screened (McLachlan, Clements, & Austoker, 2012; Steinwachs et al., 2010a).

Perceptions of risk also play a significant role in a patient's decision to be screened. Steinwachs et al. (2010a) report that the belief that a healthy person does not need to be tested is associated with not being screened. Similarly, knowledge of a family history of cancer or knowing someone else diagnosed with cancer was positively associated with screening (McLachlan et al., 2012). Interestingly, up-to-date screening behavior rates were observed in a parabolic association with individual risk. Felsen, Piasecki, Ferrante, Ohman-Strickland, and Crabtree (2011) observed greater odds of being up-to-date with screening for high-risk individuals (i.e. those with Crohn's disease and/or ulcerative colitis, history of polyps, and/or personal/family history of CRC) compared to regular-risk (OR: 3.14; 95% CI 1.85 – 5.32). However, increased-risk individuals (i.e. those with diabetes, obesity, and/or former or current smoking status) actually have lower odds of screening compared to regular-risk individuals (OR: 0.68; 95% CI 0.42 – 1.08).

Ultimately, the strongest predictor of screening is discussion and recommendation of screening by a physician (Brawarsky, Brooks, Mucci, & Wood, 2004; Felsen et al., 2011;

McLachlan et al., 2012; Siminoff, Rogers, Thomson, Dumenci, & Harris-Haywood, 2011; Steinwachs et al., 2010a). Brawarsky et al. (2004) conclude that individual decisions to be screened are strongly influenced by physician recommendation and that screening is highly unlikely without such recommendation. Such endorsement plays a critical role to screening adherence and is the only well-established physician-related factor thus observed (McLachlan et al., 2012; Steinwachs et al., 2010a). However, it is also important to note that poorly discussed recommendations could also have adverse effects on the decision to screen. Jones et al. (2010) found physician discussions of multiple screening options were associated with greater confusion which, in turn, was associated with nonadherence to screening. Additionally, poor communication between patients and physicians, including failure to recognize symptoms as being associated with colorectal cancer, may lead to significant diagnostic delays (Siminoff et al., 2011).

**Conceptual Framework**

The conceptual framework applied in this study illustrates how two distinct types of individual-level values, i.e. behavioral value and outcome value, drive an individual's decision to adhere to cancer screening recommendations (Figure 1). Behavioral values describe the beliefs an individual has pertaining to the necessity and characteristic of the behavior. This can include whether or not the individual believes that he or she is at risk for the associated condition, perceptions of how others value the behavior, the positive and negative characteristics of the behavior, and the ability of the behavior to do what it is intended to do. Regarding colorectal cancer screening, behavioral beliefs refer to the idea that an individual must believe that he or she could develop colorectal cancer and that screening has value and can detect the cancer.

Outcome value, the second type within the conceptual model, refers to whether or not an individual believes that she can subsequently manipulate the outcome of the behavior. Within the framework, the perceived ability to manipulate the outcome is determined by the perceived cause of the outcome. The implication of this belief is that an individual who does not perceive an ability to manipulate the outcome may not choose to undergo a procedure to assess her current condition (Taylor & May, 1996). Regarding colorectal cancer, the framework suggests that an individual would get screened if she believes that she has the ability to influence her condition after her current status is known.

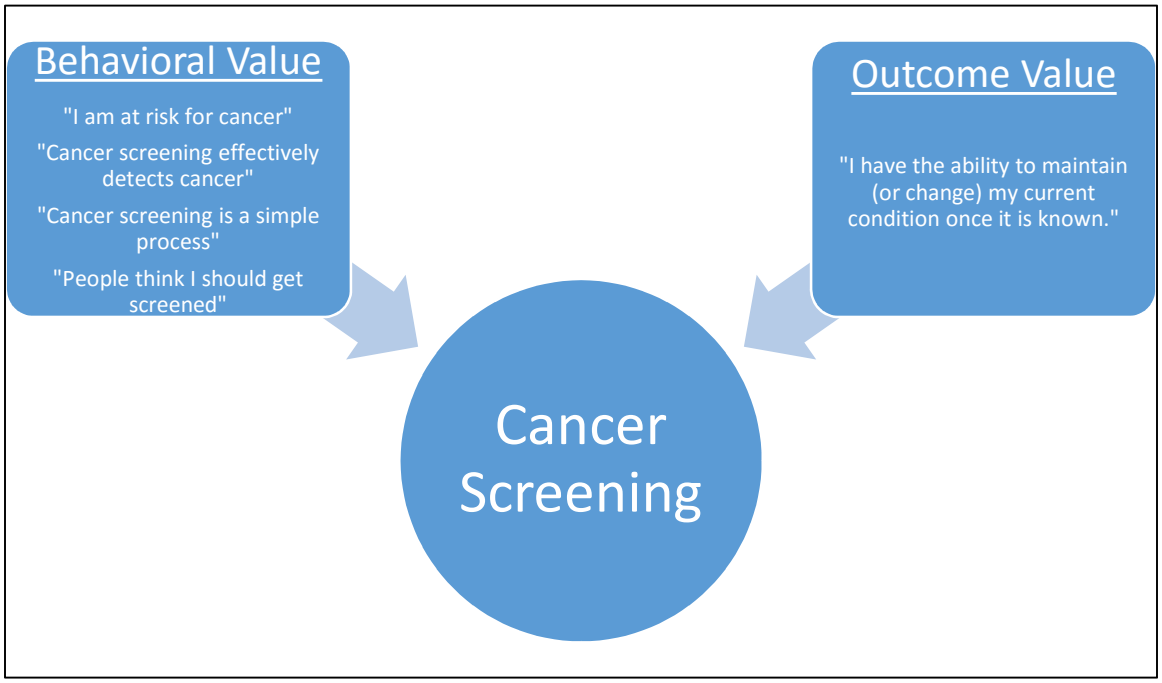


*Figure 1. Conceptual Framework for Colorectal Cancer Screening with Examples of Each Value Type*

**Behavioral Theory**

The use of behavioral theory is instrumental in explaining health-related behaviors across multiple health domains, including colorectal cancer screening. Additionally, theory is employed in the development of public health campaigns and interventions to improve health behaviors (e.g., the decision to stay up to date on colorectal cancer screenings). Behavioral theories –

predominantly individual-level behavioral theories – are commonly the starting point for interventions intended to elicit health-related behavior change (Kiviniemi, Bennett, Zaiter, & Marshall, 2011; Rothman, 2004).

Kerlinger (1986) defines a theory as "a set of interrelated constructs (concepts), definitions, and propositions that present a systematic view of phenomena by specifying relations among variables, with the purpose of explaining and predicting phenomena" (p. 9). Theories and models are used to explain how constructs interact with each other in an attempt to predict behavioral outcomes (Glanz, Rimer, & Viswanath, 2008). Since these constructs and interactions guide the creation of behavioral change intervention design and implementation, public health practitioners rely on the quality of a theory (Rothman, 2004). Along with its ability to explain and predict a phenomena, a theory is commonly evaluated based on its consistency, parsimony, plausibility, and usefulness (Burdine & McLeroy, 1992; McGuire, 1983).

A wide array of behavioral theories exist in an attempt to understand health-related behaviors. There is very little consensus regarding which theory is superior in explaining a given health-related behavior. Noar and Zimmerman (2005) report multiple meta-analyses that each provide support for different behavioral theories. Similarly, issues arise due to the similar concepts associated with the constructs of various theories. The difference in terminology to refer to similar, if not common, ideas creates disjoint and redundancy within the literature. A recent review by Davis, Campbell, Hildon, Hobbs, and Michie (2014) identified the use of 82 behavior and behavior change theories. However, of the 82 theories identified, 70 of these theories (85.4%) were used fewer than 6 times in the literature with most only being applied 1 or 2 times each (Davis et al, 2014). Ultimately, the proliferation of a theory's use depends not only on its utility but also on its popularity and ease of understanding (Noar & Zimmerman, 2005).

Commonly used behavioral theories often go unchallenged, with failures of the models' explanatory power attributed to extraneous variables such as the study sample or measurement tools (Head & Noar, 2013). As a result, behavioral theorists have been calling for greater theory testing and comparison (Head & Noar, 2013; Noar & Zimmerman, 2005; Rothman, 2004). However, a review of theory use and comparison literature illustrates that while a substantial proportion of health-related behavioral explanation and change literature (45%) referenced the use of theory to some degree, most focus only on specific constructs from the referenced theory rather than employing the whole theory. Even fewer studies used multiple theories, with only 0.4% of the total citations analyzed comparing the utility of multiple theories (Noar & Zimmerman, 2005).

As stated, predominant theories emerge as the most frequently used for a variety of empirical and popular reasons. Certain theories have been applied across a range of topics both within and outside the realm of health behavior. While any number of theories could be included for analysis and comparison, choices have to be made to maintain feasibility of the study scope and minimize subject burden. As such, the following inclusion criteria were used in this study to determine the evaluated theories:

- The theory is relevant to at least one of the constructs of the conceptual framework
- The theory is relevant and used within the context of CRC
- The theory is an individual-level theory and does not include direct environmental or cultural influences
- The theory pertains to internal constructs such as attitudes, beliefs, and values rather than external stimuli such as social marketing or role modeling

- The theory is cross-sectional in nature and does not rely heavily on temporal concepts (e.g. Stages of Change Model)

Regarding behavioral beliefs, the Health Belief Model, the Theory of Reasoned Action, and the Theory of Planned Behavior are the most widely used theories relevant to the subject matter (Kiviniemi et al., 2011). Each theory is commonly used to explain why an individual will execute a specific behavior as well as how that individual may justify his or her rationale for the behavior. Additionally, components of Attribution Theory (Weiner, 2010) have been repeatedly used to explain how the cause an individual attributes to a condition affects his or her outcome value of associated behaviors. These four theories are evaluated in this study and are described in detail in the following sections.

**Health Belief Model.** The Health Belief Model (Rosenstock, 1966) has been one of the most widely used behavioral theories since its introduction over 50 years ago (Orji, Vassileva, & Mandryk, 2012). Originally, the Health Belief Model (HBM) was conceptualized to explain preventive health behavior. In this sense, "health behavior" is a specific term used to demarcate activity by a person who perceived him or herself to be currently healthy "for the purpose of preventing disease or detecting disease in an asymptomatic stage" (Rosenstock, 1974a, p. 354). Since its initial application, the HBM has been extended to evaluate public health behaviors beyond prevention to responses to symptoms and diagnoses as well as medical adherence (Champion & Skinner, 2008).

The fundamental model includes four core constructs of perception that are integrated to predict health behavior: perceived benefits, perceived barriers, perceived susceptibility, and perceived severity. Rosenstock (1974b) provides an overview and detailed explanation of these original constructs:

> "in order for an individual to take action to avoid a disease he would need to believe (1) that he was personally susceptible to it, ( 2 ) that the occurrence of the disease would have at least moderate severity on some component of his life, and (3) that taking a particular action would in fact be beneficial by reducing his susceptibility to the condition or, if the disease occurred, by reducing its severity, and that it would not entail overcoming important psychological barriers such as cost, convenience, pain, embarrassment" (p. 330).

Figure 2 illustrates the most common conceptualization of the Health Belief Model. As described in the following section, the model suggests that behavior is directly influenced by perceived threat and the net difference of benefits minus barriers. Additionally, perceived threat is moderated or activated by exogenous cues to action. Finally, the model also depicts how sociodemographic variables can influence an individual's perceptions of the four major constructs.

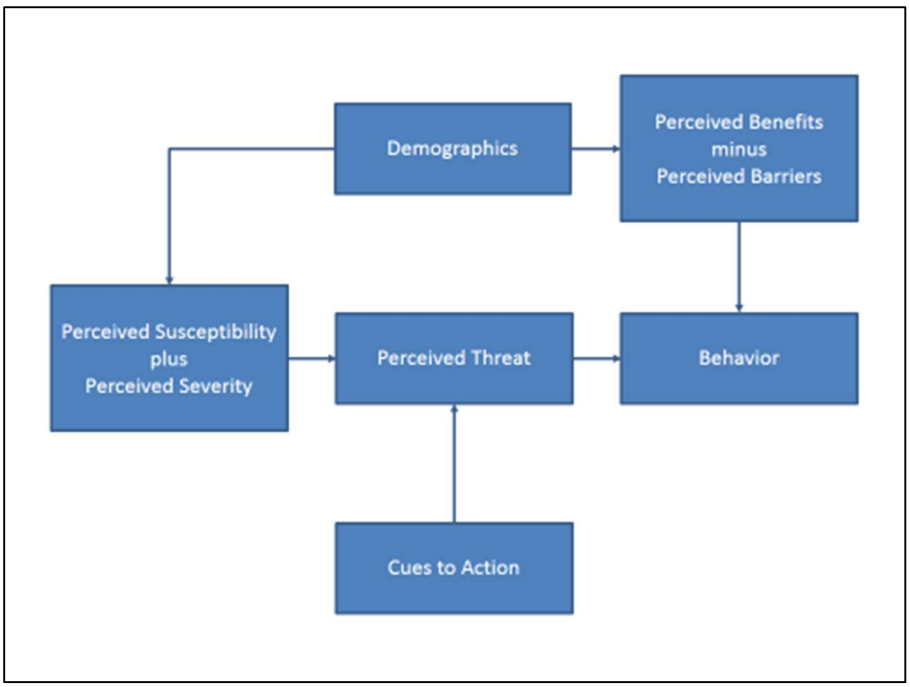


*Figure 2. Conceptual Model of Health Belief Model (Rosenstock, 1974b)*

***Perceived Susceptibility.*** The first construct, perceived susceptibility, refers to an individual's subjective risk of contracting a condition (Rosenstock, 1974b). In order for an individual to subscribe to a specific behavior, he or she needs to believe that it is likely, or at least possible, that the condition the behavior is intended to prevent or treat can occur (Champion & Skinner, 2008). For example, a parent must believe that there is a chance that his or her child could contract measles in order for that parent to execute the behavior of vaccinating the child against measles.

***Perceived Severity.*** Related to susceptibility, the construct of perceived severity also relates to the risk involved with the condition. Perceived severity is about the seriousness of contracting and/or leaving a condition untreated (Champion & Skinner, 2008). Rosenstock (1974b) states that the degree of seriousness can be measured by both the health burden associated with the disease as well as the emotional or social consequences associated with the condition (e.g. the stigma of being diagnosed with a sexually transmitted infection (STI)). If an

individual does not perceive that the condition would have a large impact on his or her life, that individual is far less likely to engage in preventive behavior (Carpenter, 2010).

***Perceived Threat.*** Taken together, the combination of perceived severity and perceived susceptibility create an individual's perceived threat associated with a given condition (Champion & Skinner, 2008). Both a higher perception of severity and susceptibility are necessary for one to take action. An individual must believe that he or she has a practical chance of contracting a condition and that the condition would cause substantial harm. Relating to previous examples, if a parent does not believe it is likely that his or her child could contract measles (i.e. low susceptibility), vaccination is unlikely even if the parent believes that if contracted, the seriousness of measles is high (i.e. high severity). Similarly, if a sexually active individual believes that it is very likely that he or she could contract syphilis (i.e. high susceptibility) but also believes that contracting syphilis would create only a minor inconvenience cured by a course of penicillin (i.e. low severity), it may be the case that this individual would not perceive a strong need to use STI-preventative measures.

***Perceived Benefits.*** While perceived threat and its components concentrate more on the individual's perceptions of the condition, the remaining constructs emphasize the individual's perceptions of the preventative behavior (Champion & Skinner, 2008). Therefore, the construct of perceived benefits corresponds to an individual's beliefs about the availability and effectiveness of the health behavior (Rosenstock, 1974b). Above all, an individual must believe that engaging in the behavior will likely prevent the negative outcome and reduce the threat of the condition (Carpenter, 2010; Champion & Skinner, 2008). Additionally, perceived benefits can relate to any health or non-health related perceptions associated with the behavior that would make engaging in the behavior desirable to the individual (Champion & Skinner, 2008).

Examples of these include the perceptions that healthy foods make you feel better, reducing or stopping smoking saves money, or that sexual partners think highly of people that engage in safe-sex behaviors.

***Perceived Barriers.*** Opposed to perceived benefits, the final core construct of the HBM relates to the perceived barriers associated with the health behavior. This includes the beliefs about the behavior that would deter an individual from taking part in the action. Similar to the perceived benefits of the behavior, the perceived barriers extend beyond health-related contexts to tangible and psychological barriers as well (Champion & Skinner, 2008). For example, Rosenstock (1974b) cites potential barriers as behaviors that are inconvenient, expensive, unpleasant, painful, or upsetting. An analogous equation to perceived threat is observed for perceived benefits and barriers as well. Though not necessarily conscious, the HBM posits that an individual will conduct a cost-benefit analysis of the benefits and barriers of a given behavior. Only if the sum of benefits outweighs the sum of barriers will the behavior be implemented (Champion & Skinner, 2008).

These four core constructs combine to create the primary model of what influences and predicts individual behavior. The model attempts to explain the valuation process of both (a) the condition in question and (b) the associated preventive behaviors. Specifically, a sense of perceived threat (i.e. severity and susceptibility) provides the reason to combat the condition, while the perceived benefits and barriers of the necessary behaviors to combat the condition provide the "preferred path of action" (Rosenstock, 1974b, p. 332). Both pathways – a strong sense of threat from the condition and a net sum benefit of the behavior – are necessary to elicit the behavior.

***Cues to Action.*** While the HBM is for all intents and purposes an individual-level behavioral theory, a commonly exogenous variable, "cues to action," is also included in some forms of the model as a modifying factor to perceived threat. Cues to action relate to factors that instigate the perceived threat and serve as a catalyst for the behavior response (Rosenstock, 1974b). These cues can present in various forms from a public health awareness campaign to an internal cue such as the presentation of a negative health symptom (Carpenter, 2010). Cues to action can be relatively ubiquitous and vary between individuals making them difficult to conceptualize and evaluate. As Champion and Skinner (2008) state, "a cue can be as fleeting as a sneeze or the barely conscious perception of a poster" (p. 49). Despite its potential importance, the construct of cues to action is rarely included in HBM theoretical testing and meta-analyses (Carpenter, 2010; Kiviniemi et al., 2011) and is not included in the evaluated model of HBM in this study.

***Self-efficacy.*** Self-efficacy has been proposed to be included as a separate construct in later iterations of the HBM as a result of the model being applied to maintained behavioral change such as chronic disease management (Rosenstock, Strecher, & Becker, 1988). The addition of self-efficacy in the HBM posits that in addition to high perceived threat and perceived benefits outnumbering perceived barriers, individuals must also believe that they are able to overcome any potential barriers to engage in the behavior (Champion & Skinner, 2008). Behavioral theorists question the validity of model testing the HBM when new variables are included in the model. Additionally, since there is no definitive model of the HBM that includes a self-efficacy pathway, the argument has been presented that inclusion of these variables creates a new theory all together (Carpenter, 2010). Based on this rationale, self-efficacy is often

excluded from HBM studies not related to behavioral maintenance. As such, self-efficacy is not included in the main HBM model of this study but was measured for use in future analyses.

The HBM has maintained its status as one of the most widely recognized theories in behavioral health primarily due to its utility in developing health interventions focused around preventing and detecting diseases (Carpenter, 2010; Rimer & Glanz, 2005). It has continued to demonstrate its ability to explain and predict a variety of health related behaviors (Carpenter, 2010). Additionally, HBM is a cognitive based model meaning that it is rooted in mental processes and value-expectancy (Champion & Skinner, 2008). As such, constructs of the HBM are easily targeted with information-based messages common to health-related programming and campaigns (Carpenter, 2010). Given its widespread use in program and policy development, continued evaluation of its explanatory power and validity is warranted.

**Theory of Reasoned Action.** Like the HBM, the Theory of Reasoned Action (TRA) (Ajzen, Heilbroner, Fishbein, & Thurow, 1980; Fishbein & Ajzen, 1975) is also widely used and is the fundamental theory associated with the Reasoned Action Approach (RAA) family of behavioral theories (Head & Noar, 2013). The primary tenant of the TRA is that "behavioral intentions, which are the immediate antecedents to behavior, are a function of salient information or beliefs about the likelihood that performing a particular behavior will lead to a specific outcome" (Madden, Ellen, & Ajzen, 1992, p. 3). Within the TRA, there are two primary categories of beliefs that influence behavioral intention: attitudes toward the behavior and subjective norms.

***Attitude toward the behavior.*** An individual's attitude toward a specific behavior defines what a person believes about the specific behavioral outcome itself and not the condition associated with the behavior (Poss, 2001). For example, if the behavior in question is

mammography, the attitudes relevant to the model are attitudes specific to the mammography screening process and not necessarily the individual's attitude towards breast cancer. Attitudes are measured as an individual's beliefs associated with the behavior weighted by the outcome evaluation of each belief (Fishbein & Ajzen, 1975).

*Behavioral Beliefs.* Behavioral beliefs are defined as the underlying influence on an individual's attitude toward performing the behavior (Madden et al., 1992). This includes beliefs about both the attributes and outcomes of performing the behavior (Montano & Kasprzyk, 2008). In other words, behavioral beliefs can encompass attributes such as whether or not an individual believes that a given procedure is painful as well as outcome beliefs such as exercise will expedite recovery time from surgery. Behavioral beliefs are measured by the strength of the belief of the individual (Ajzen, 2002)

*Outcome Evaluation.* The second dimension of an individual's attitudes toward a behavior is his or her outcome evaluation. Outcome evaluation relates to the individual's specific valuation of each behavioral belief (Vallerand, Deshaies, Cuerrier, Pelletier, & Mongeau, 1992). In line with the examples of behavioral beliefs, related outcome evaluations would be to what degree pain during a procedure matters to the individual. Similarly, outcome evaluation would rate the individual's valuation of how good or bad expediting recovery from a surgery is to the individual (Ajzen, 2002). Most studies employ a multiplicative equation to assess attitude from the sum of behavioral beliefs and outcome evaluations where:

$$A = \Sigma b_i e_i \quad (1)$$

and $A$ represents attitude toward behavior, $b_i$ represents behavioral belief $i$, and $e_i$ represents the outcome evaluation for individual belief, $i$ (Vallerand et al., 1992). While this weighting of behavioral beliefs by outcome evaluation is the accepted formula (Ajzen, 2002; Montano &

Kasprzyk, 2008), little has been done to study the independent roles of these constructs as determinants of attitude (Vallerand et al., 1992).

***Subjective Norms.*** The second major construct associated with beliefs as part of the TRA is subjective norms. Subjective norms are the individual's perceptions of what individuals or group that are important to the individual think the individual should do in regard to the behavior in question (Vallerand et al., 1992). Subjective norms, like attitudes toward the behavior, are a product of individual normative beliefs weighted by the individual's motivation to comply with each belief (Albarracin, Johnson, Fishbein, & Muellerleile, 2001).

*Normative Beliefs.* Normative beliefs, similar to injunctive norms, are specific beliefs associated with a person or group important to the individual pertaining to what the individual believes that entity would want him or her to do regarding the behavior. It is assessed based on whether each group approves or disapproves of the behavior (Montano & Kasprzyk, 2008). Examples of groups relevant to normative beliefs are significant others, family, authority figures, or people similar to the individual in pertinent characteristics.

*Motivation to Comply.* Normative beliefs are each weighted by a motivation to comply with the perceived expectations of the specific person or group (Linke, Robinson, & Pekmezi, 2014). Most motivation to comply is conceptualized by the strength of agreement an individual has with the statement that the individual wants to do what the referent group thinks he or she should do (Ajzen, 2002). The formulation of subjective norms is the sum of normative beliefs weighted by motivation to comply with each belief where:

$$SN = \Sigma n_i m_i \quad (2)$$

and *SN* represents subjective norm, $n_i$ represents normative belief *i,* and $m_i$ represents the motivation to comply with normative belief, *i* (Vallerand et al., 1992). For example, the influence of an individual's doctor on screening would be the product of the individual's

perception of if he or she thinks the doctor wants him or her to perform the behavior and to what extent the individual cares about meeting the expectations of the doctor (Montano & Kasprzyk, 2008).

Figure 3 presents a conceptual model of the TRA and the pathways of the described constructs on behavioral intention and, ultimately, behavior. The primary model is relatively straightforward as the theory suggests that attitudes and norms have a direct influence on intention and that behavioral intention is the strongest predictor of behavior (Madden et al., 1992). The accepted statistical models associated with the TRA also depict full mediation of the influence of attitudes and subjective norms on behavior through intention (Hankins, French, & Horne, 2000). According to Fishbein and Ajzen (1975), all other variables external to the model affect behavior only insomuch as they influence relevant attitudes and subjective norms. In addition to the main constructs depicted in the figure, Fishbein and Ajzen (1975) also posit that the effect of behavioral intention on behavior can be modified by three conditions: "(a) the degree to which the measure of intention and the behavioral criterion correspond with respect to their levels of specificity, (b) the stability of intentions between time of measurement and performance of the behavior, and (c) the degree to which carrying out the intention is under the volitional control of the individual" (Madden et al., 1992, p. 4).

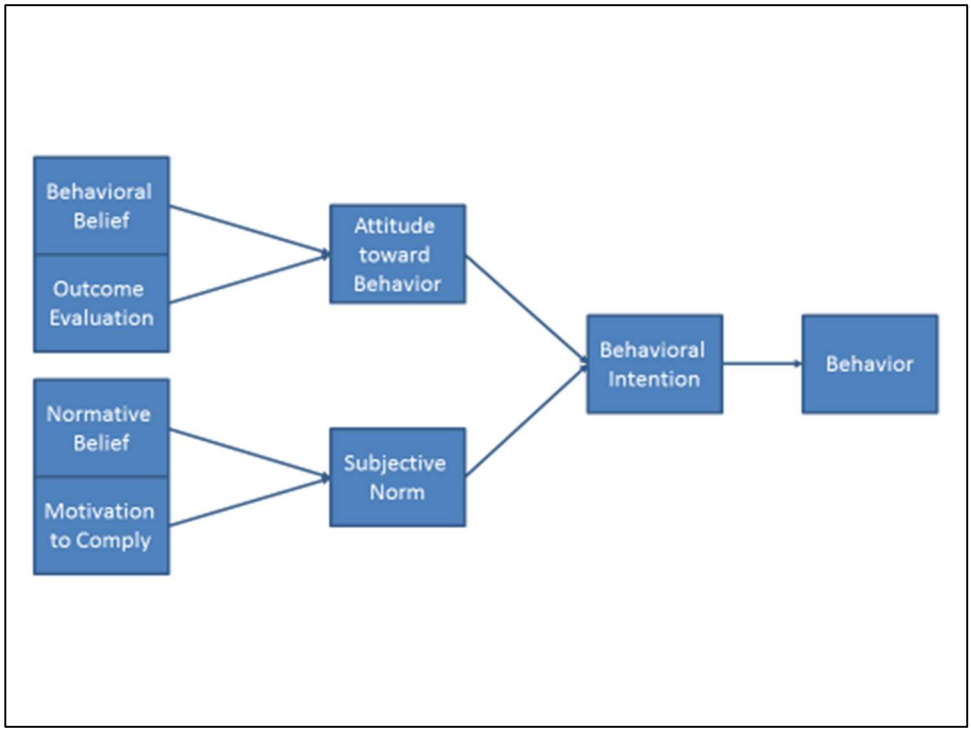


*Figure 3. Conceptual Model of the Theory of Reasoned Action (Madden et al., 1992)*

**Theory of Planned Behavior.** A major limitation of the TRA, as referenced in the conditions of the model, is that the theory assumes that the behavior in question is under the volitional control of the individual. That is, it is predominantly – if not entirely – up to the individual whether or not to engage in the specified behavior (Linke et al., 2014; Madden et al., 1992; Montano & Kasprzyk, 2008; Vallerand et al., 1992). In response to this limitation, Ajzen (1991) introduced a new construct into the model, perceived behavioral control, and renamed the proposed theory "Theory of Planned Behavior (TPB)." Much like the HBM, the TPB is one of the most widely used and tested behavioral health theories (McEachan, Conner, Taylor, & Lawton, 2011). As seen in Figure 4, the original four constructs of TRA are retained. In addition, perceived behavioral control is introduced as having a direct effect on behavioral intention. Additionally, perceived behavioral control is the only construct to be depicted to have a direct

effect on behavior itself both conceptually and when statistically evaluated (Hankins et al., 2000).

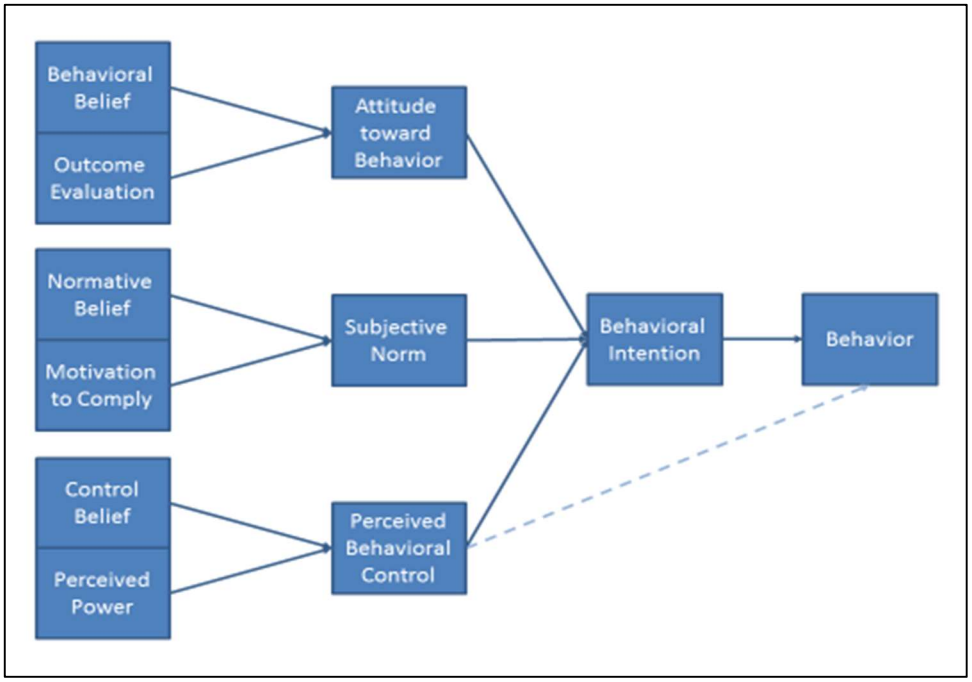


*Figure 4. Conceptual Model of the Theory of Planned Behavior (Ajzen, 1991)*

***Perceived Behavioral Control.*** The construct of perceived behavioral control relates to the individual's "perception of the ease or difficulty of performing the behavior of interest" (Ajzen, 1991, p. 183). Ajzen (1991) asserts that perceived behavioral control differs from other constructs of control beliefs. Specifically, the construct does not refer to the individual's actual control over execution of the behavior, but rather the impact of the individual's perception of control. Additionally, Ajzen (1991) distinguishes perceived behavioral control as independent from other control beliefs such as Rotter's (1966) locus of control discussed in detail later. Simply, the constructs differ such that while locus of control centers on the source of control, perceived behavioral control emphasizes capability to perform the behavior (Ajzen, 1991). As with the other belief constructs of the TRA and TPB, perceived behavioral control can be conceptualized as control beliefs weighted by the perceived power of each belief.

*Control Beliefs.* Control beliefs are a set of beliefs that reflect "the presence or absence of requisite resources and opportunities [to execute the behavior]" (Ajzen, 1991, p. 196). Ajzen (1991) asserts that the more resources and fewer impediments that an individual anticipates, the more that individual will perceive to have control over the behavior. The value of the construct of control beliefs is based on the perceived likelihood or expectation of a factor that facilitates or constrains the behavior (Montano & Kasprzyk, 2008). Measures of control beliefs are based on the frequency of occurrence of factors that impact engagement of the behavior (McEachan et al., 2011).

*Perceived Power.* The "perceived effect of each condition in making behavioral performance difficult or easy" defines perceived power (Montano & Kasprzyk, 2008, p. 75). While control beliefs are assessed based on the perceived likelihood of the facilitator or barrier, perceived power is assessed based on the agreement by the individual regarding to what extent the facilitator or barrier would enable or restrict the behavior, respectively (Ajzen, 2002). Typical of RAA models, the construct of perceived power is used to multiplicatively weight the impact of each specific control belief where:

$$PBC = \Sigma c_i p_i \tag{3}$$

and *PBC* represents perceived behavioral control, $c_i$ represents control belief $i$, and $p_i$ represents the perceived power of control belief, $i$ (Ajzen, 1991).

The RAA theories emphasize the rational, cognitive process linking individual beliefs with behaviors. A large body of evidence has demonstrated their use to explain significant amounts of variability in behavior and develop interventions focused on RAA construct manipulation (Montano & Kasprzyk, 2008). However, while the RAA theories lend themselves to testing through explicit, well-defined pathways and construct calculation (Montano &

Kasprzyk, 2008), few experimental tests of TRA/TPB have been conducted (Sniehotta, Presseau, & Araújo-Soares, 2014).

**Attribution Theory.** Attribution Theory is a collective term defined as a "set of theories [that] attempts to describe and explain the mental and communicative processes involved in everyday explanations…of individual and social events" (Manusov & Spitzberg, 2008, p. 37). Heider (1958) first established attribution theory, arguing that people are "naïve scientists" such that individuals want to make sense of the world around them in a consistent and logical manner. Therefore, people create causal theories in order to satisfy what is described as the most elemental human question of "Why?" (Heider, 1958). The constructs of various attribution theories have since expanded from the simple, qualitative question "why?" to include various causal pathways and dimensions. Such dimensions include: locus, stability, controllability, intentionality, complexity, and motivation (Weiner, 1985). Fundamental to all variations of attribution theories, people are concerned with the origin of the cause attributed to the outcome or event and whether the origin of the cause is found in the person or situation (Gerrig & Zimbardo, 2007). This personal versus situational causality belief has since been demarcated using the constructs of locus of control established by Rotter (1966).

Rotter (1966) defines locus of control as "the degree to which the individual perceives that the reward [from an event] follows from, or is contingent upon, his own behavior or attributes versus the degree to which he feels the reward is controlled by forces outside of himself and may occur independently of his own actions" (p. 1). When an individual perceives that forces beyond his or her control are the cause of an outcome – e.g. luck, fate, others, etc. – this is referred to as an external control belief. When an individual believes that the outcome of an event is reliant upon his or her own behaviors and attributes, this is referred to as an internal control belief.

Commonly, research involving locus of control have dichotomously classified individuals into internal or external beliefs. However, Rotter (1975) suggests that perceived internal/external control occurs on a unidimensional continuum. Therefore, individuals fall along a spectrum related to the amount of control that one feels he or she possesses. Later hypotheses by Wallston and Wallston (1981) suggest the use of a multidimensional locus of control whereas an individual may possess high to low levels of beliefs relating to the influence of three continuums including: internal control, powerful others, and chance. Regardless, both the unidimensional and multidimensional models of locus of control suggest the possibility of varying degrees of internality/externality rather than the possession of one belief or another.

Weiner (1985), in his attempt to create a more complete and unified Attribution Theory, reviewed the previous attribution research to identify perceived causes of success and failure. In his review, Weiner (1985) first identifies three dimensions as the underlying structure of perceived causality. The first dimension of attribution, as previously mentioned, is that of an internal-external factor (locus of control) as established by Heider (1958). Weiner (1985) originally established a second dimension of "controllability" related specifically to the degree of volitional control of the cause. However, this dimension was later deemed not to be independent of locus of control and was removed from the dimensions of Weiner's Attribution Theory (Weiner, 2010). Weiner (1971) also introduced a third dimension to Heider's theory which is "stability." Stability is defined as whether a causal factor remains relatively constant or is more variable and fluctuates (Weiner, 1985).

Figure 5 depicts how the two dimensions of locus of control and stability combine to explain how individuals perceive to what an outcome is attributed. Locus of control satisfies the question of the individual perceiving the degree to which the outcome is attributed to internal or

external factors. Stability satisfies the question of the individual perceiving the degree to which a cause is perceived as constant and enduring (stable) or immediate and varying (unstable). Given that both the construct of locus of control and stability are defined as continuums, each dimension is represented along an axis. Together, these two dimensions create four quadrants that represent the predominant perceived attribution by which an individual's attribution theory can be measured through Cartesian coordinates – i.e. (x,y) plot – corresponding to their locus of control and stability. The conceptualization of attribution theory as two continuous dimensions rather than discrete categories has yet to be evaluated to the knowledge of the author.

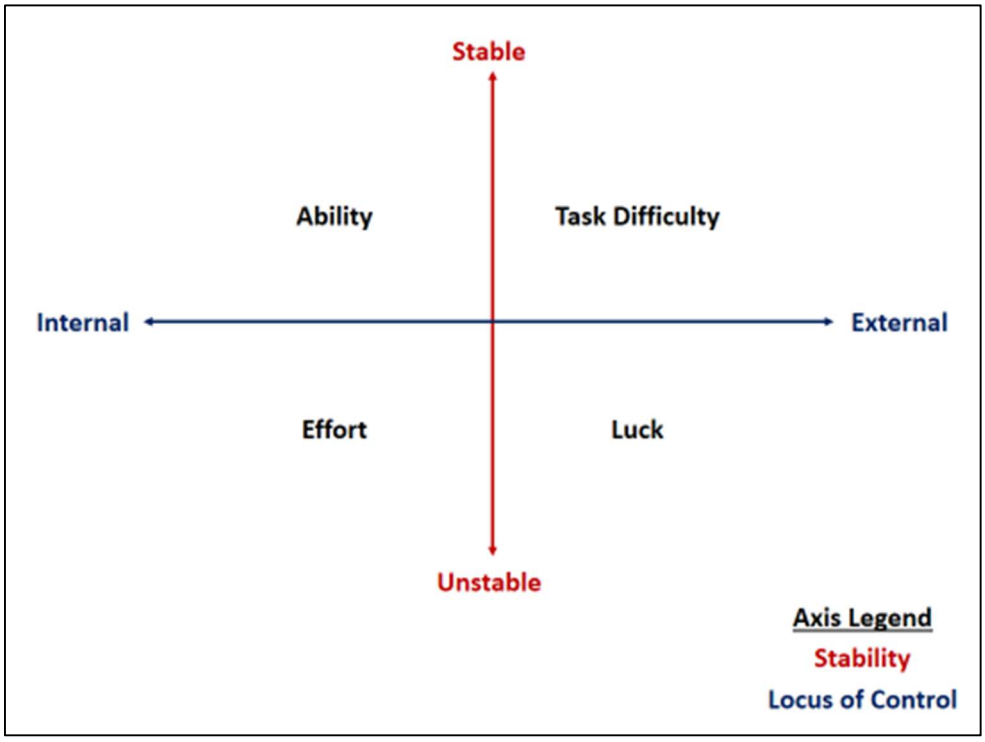


*Figure 5. Dimensions of Attribution Theory by perceived Locus of Control and Causal Stability*

## Theory Application in Colorectal Cancer Screening

**Behavioral Value.** Kiviniemi et al (2011) conducted a literature review of individual-level health behavior theories and colorectal cancer screening behaviors including the HBM, TRA, and TPB as well as the Transtheoretical Model. The review sought to identify articles

containing keywords associated with both individual theory constructs and colorectal cancer screening through November 2008. The search resulted in 81 articles primarily addressing constructs associated with the HBM (Kiviniemi et al., 2011).

Of all the articles evaluated, only thirteen studies tested all constructs of an entire theory – all of which were testing the four original constructs of the health belief model (Kiviniemi et al., 2011). The remaining articles only evaluated select constructs from a given theory. The constructs of perceived benefits, barriers, and susceptibility of the HBM have been most studied. The constructs of perceived severity of the HBM, perceived behavioral control of the TPB, and normative beliefs of the TRA and TPB have been studied to a lesser extent. The major construct of attitudes as it relates to TRA/TPB was only evaluated in one of the reviewed articles. Kiviniemi et al (2011) point out that the constructs are often measured differently from how the theories define or conceptualize the constructs. This creates an additional issue for determining how well a theory – or even individual constructs within the theory – can explain and/or predict colorectal cancer screening behaviors.

The review suggests that the majority of articles supported the construct validity of the theories as they relate to colorectal cancer screening behaviors and behavioral intentions. That is, all of the studies that report significant associations between theoretical constructs and colorectal cancer screening indicated a positive relationship between constructs and screening with the exception of increased perceived barrier inversely affecting screening. The remaining studies that did not illustrate associations concurrent with the theories predominantly displayed no relationship and "virtually never the case that the relation reported was the opposite of the one predicted by the model" (Kiviniemi et al., 2011, p. 1026).

An independent PubMed literature search by this author in August 2015 including the described theories and colorectal cancer screening keywords [i.e. (("health belief model" OR "theory of reasoned action" OR "theory of planned behavior" OR "attribution") AND ("colorectal" OR "fecal" OR "colonoscopy" OR "sigmoidoscopy" OR "colon" OR "rectum" OR "rectal"))] was conducted. The use of Boolean Logic (e.g. AND/OR statements) allowed for the search to produce all results that contained at least one of the desired theories and at least one of the desired colorectal terms. Separate searches with specific terms confirmed the accuracy of the search string. The search returned 119 articles. Of those articles, only fourteen were deemed relevant to behavioral theory use with colorectal cancer screening and not already reviewed as part of Kiviniemi et al. (2011).

***Health Belief Model.*** Compared with the reviewed articles of Kiviniemi et al. (2011), the search found one relevant article related to the HBM (Bunn, Bosompra, Ashikaga, Flynn, & Worden, 2002) within the same date range. Bunn et al. (2002) is consistent with the predominant findings of Kiviniemi et al (2011). Their findings suggest that perceived susceptibility and benefits are both positively associated with genetic screening for colorectal cancer while perceived barriers are negatively associated. Of the remaining fourteen articles published after the review by Kiviniemi et al (2011), nine also focused on constructs of the HBM (Almadi et al., 2015; Bae, Park, & Lim, 2014; Cyr, Dunnagan, & Haynes, 2010; Hilmi, Hartono, & Goh, 2010; Hughes, Watanabe-Galloway, Schnell, & Soliman, 2015; Javadzade et al., 2012; Javadzade et al., 2014; Koc & Esin, 2014; Sohler, Jerant, & Franks, 2015).

The updated articles are also mainly consistent with previous research involving colorectal cancer screening and the HBM. In every study, perceived barriers were inversely associated with screening (Almadi et al., 2015; Bae et al., 2014; Cyr et al., 2010; Hilmi et al.,

2010; Hughes et al., 2015; Javadzade et al., 2012; Javadzade et al., 2014; Koc & Esin, 2014; Sohler et al., 2015). Perceived susceptibility was shown to have a positive association with adherence to screening for five of the nine studies (Almadi et al., 2015; Bae et al., 2014; Cyr et al., 2010; Hilmi et al., 2010; Hughes et al., 2015) while two other studies found no significant association when evaluated (Javadzade et al., 2012; Koc & Esin, 2014). Perceived benefits was not significant for one study (Bae et al., 2014) but displayed the anticipated positive association for the remaining five in which it was evaluated (Cyr et al., 2010; Hilmi et al., 2010; Hughes et al., 2015; Javadzade et al., 2012; Koc & Esin, 2014). In fact, Cyr et al. (2010) report perceived benefits as explaining the greatest amount of variance associated with genetic screening of colorectal cancer.

Interestingly, perceived severity displayed mixed results regarding its association with screening. Consistent with past studies, Javadzade et al. (2012) reported a higher rating of perceived severity among those receiving FOBT testing than those that did not complete an FOBT in the last year. Both Koc and Esin (2014) and Hilmi et al. (2010) did not report any significant associations between perceived severity and screening. However, in a study of 237 South Korean adults over 50 years old, Bae et al. (2014) reports perceived severity as having a negative association with adherence to FOBT screening (AOR: 0.582) even when controlling for sociodemographic factors (AOR: 0.522). The authors recognize the counterintuitive nature of this relationship. They propose the observed association may be a result of culture norms such that the fear associated with a positive diagnosis of a severe condition may elicit avoidant coping strategies (Bae et al., 2014). However, the potential inverse relationship should not be discounted due to differences in cultural norms as a study of 393 rural and urban residents of Nebraska also

observed a negative association between the likelihood of sigmoidoscopy use and perceived severity (Hughes et al, 2015).

***Theory of Reasoned Action/Theory of Planned Behavior.*** Two additional articles have tested the associations between colorectal cancer screening and the constructs of the TPB, which also includes the constructs of TRA (Baghianimoghadam et al., 2012; Sieverding, Matterne, & Ciccarello, 2010). Sieverding et al. (2010) surveyed 2,426 German men regarding their behaviors and behavioral intentions to be screened for cancers including colorectal via FOBT and prostate as well as their attitudes, subjective norms, and perceived behavioral control related to any screening. While the study does not stratify based on type of cancer screening, the results do show a significant positive correlation between all of the constructs of TPB and behavioral intention to be screened. Further, these relationships remained while controlling for interactions with descriptive norms as well as past cancer screening behavior (Sieverding et al., 2010).

Similarly, Baghianimoghadam et al. (2012) surveyed 99 first degree relatives of colorectal cancer patients in Iran. The study involved an education session on colorectal cancer screening behavior intended on manipulating the TPB constructs. Irrespective of sociodemographics including education, mean scores of participants' attitudes, subjective norms, and perceived behavioral control relative to favorable beliefs towards colorectal cancer screening all significantly improved after an education seminar. This indicates a successful manipulation of TPB constructs not dependent on exogenous variables. Concurrently, behavioral intention to be screened also improved significantly (Baghianimoghadam et al., 2012). While the results are correlational only, Baghianimoghadam et al. (2012) assert that improvement in constructs of the TPB positively influence colorectal cancer screening behavioral intention.

**Outcome Value.** The second pathway of the conceptual framework – outcome value – has been a neglected area of study regarding colorectal cancer screening. Although, it is reasonable to suggest that whether or not an individual believes he or she can affect their cancer diagnosis may influence his or her intentions to screen for cancer in the first place.

***Attribution Theory.*** Attribution Theory can be used to evaluate an individual's perception of the control and permanence of cancer, making it a useful theory for outcome value assessment. However, the association between colorectal cancer screening and Attribution Theory has not been sufficiently evaluated in the past. Just two articles specific to colorectal cancer screening were identified that assess the influence of constructs of attribution theory (Gili, Roca, Ferrer, Obrador, & Cabeza, 2006; Jun & Oh, 2013). None of the studies evaluate the complete model as defined by Weiner (2010). Rather, the studies evaluate individual concepts within Attribution Theory similar to what has been observed with evaluations of other behavioral theories.

Gili et al. (2006) evaluated the psychosocial factors associated with adherence to colorectal cancer screening of 90 siblings of colorectal cancer patients (mean age = 61.1±9). Among the factors evaluated were multidimensional locus of control and other measures of internality/externality related to the participant's coping strategies. While only analysis of group comparisons and not correlational analysis was performed between factors and screening behavior, significant differences were observed between those screened and not screened regarding attribution theory factors. Primarily, only the locus of control dimension of "powerful others" was significantly different between groups. Those that were not screened had a greater belief that influential people such as doctors influence one's health. No differences were observed between internal and chance locus of control scales. It is also worth noting that those

that were screened reported a higher frequency of blaming oneself as a coping strategy (Gili et al., 2006). This may indicated that those who are more likely to attribute cancer to personal factors are more likely to adhere to screening.

Another concept consistent with the model of Attribution Theory, fatalism, was evaluated by Jun and Oh (2013). Briefly, fatalism can be conceptualized as the belief that outcomes are destined by nature or considered an accepted part of God's Will (Jun & Oh, 2013). These causal attributions are consistent with the external and stable dimensions of Weiner's Attribution Theory model. Jun and Oh (2013) evaluated fatalism as a causal attribution of colorectal cancer in Asian, Hispanic, and White Americans using 2005 Health Information National Trends Survey (HINTS) data. For the majority of responses Asian and Hispanic Americans were significantly more likely to report fatalistic beliefs compared to White Americans, which is consistent with the groups' cultural beliefs (Jun & Oh, 2013). It was also illustrated that significantly fewer Asian and Hispanic Americans had undergone colon cancer screening within the recommended guidelines compared to Whites: 39.7% and 41.5% vs. 55.0%, respectively. Consequently, when controlling for fatalistic beliefs, the adjusted odds ratios of screening adherence for Asian compared to White Americans dramatically changes from 0.533 to 2.036. The adjusted odds ratios of screening adherence for Hispanic compared to White Americans changes from 1.153 to 0.9, respectively (Jun & Oh, 2013). While the directionality of the two observations differs, the substantial difference in odds ratios once controlling for fatalism indicates an important association between causal attribution of colorectal cancer – specifically external and stable belief – and screening adherence.

**Summary.** The review of previous literature demonstrates the utility of the discussed behavioral theories with explaining and predicting colorectal cancer screening behaviors to a

relatively high degree of consistency. This consistency along with public health practitioner familiarity with these theories gives reason for why these theories are often cited as the foundations for behavioral intervention (Kiviniemi et al., 2011).

However, as previously mentioned, there are a very limited number of studies that have tested entire behavioral theory models especially in the realm of colorectal cancer screening. A review of National Cancer Institute's funded R01 proposals from 1998 to 2010 observed virtually all proposals mentioning a behavioral theory, yet no proposal using all constructs of the mentioned theory and all proposals' conceptual models combining constructs from multiple theories (Kobrin et al., 2015). As the authors concluded, "plans to use theory are often superficial and are not structured to enable rigorous testing of the theoretical principles guiding the intervention research" (Kobrin et al., 2015, p. 9).

While scarce, rigorous testing of entire theoretical models rather than a fragmented selection of constructs from theories is essential to evaluating the efficacy of the theory. Interactions and simultaneous influences of individual constructs must be taken into account to truly assess the explanatory and predictive power of the theory. This is not possible when essential constructs are missing or misconstrued. Additionally, to the current knowledge of the author, no studies have compared the predictive and explanatory power of these behavioral theory models within the realm of colorectal cancer screening.

# Methods

## Overview

The purpose of the study is twofold. First, this study evaluates the discussed behavioral theories' abilities to explain an individual's colorectal cancer screening intentions and behaviors. Second, this study evaluates which of the discussed behavioral theories is most consistent with its respective data.

The constructs of each theory were assessed through a series of measures previously validated or adapted from previously validated measures. Each theory was evaluated based on the conceptual pathways connecting constructs found within the literature previously reviewed. Each theory's ability to explain colorectal cancer screening intentions and behaviors was assessed individually as well as subjectively compared to assess which of the discussed theories is most consistent with its data and best explains CRC screening intention and behavior within the study sample.

## Theory Testing

As previously discussed, very few studies attempt to empirically evaluate entire behavioral theories let alone compare entire theories as suggested by Noar and Zimmerman (2005). Their review of the literature to find studies that empirically compare behavioral theories identified only nineteen studies. The predominant method used to analyze and compare theories

is multiple regression (Ajzen, 1991; Carpenter, 2010; Kobrin et al., 2015; Noar & Zimmerman, 2005; Richards & Johnson, 2014). This method identifies the behavioral intention or behavior as the dependent variable, B. Each construct within the model is identified as an independent, predictor variable, C. The theory is evaluated such that for i constructs in the theory:

$$B = a + \beta_1 C_1 + \cdots + \beta_i C_i$$

The regression equation estimates the change in the behavior influenced by each construct through its corresponding standardized regression coefficient, β, and variance of the behavior explained by each construct through its corresponding partial $R^2$. The equation also estimates the total variance in the behavior explained by the model, $R^2$. Theory comparison is then accomplished through the comparison and difference in total variance, $R^2$, observed between the competing theories (Bish, Sutton, & Golombok, 2000).

A visual representation of a linear regression model for a theory consisting of four constructs is observed in Figure 6. While linear regression models will predict the influence that constructs within a theory have on the variance of a dependent behavior or outcome, such analytical techniques fail to account for the conceptual structures of behavioral theories. As seen in the model, all constructs can only be estimated to have a direct effect on the behavior or interaction effect (e.g. $C_1$ x $C_2$) on the behavior at a magnitude equal to the construct's regression coefficient, β. The model cannot evaluate the theoretical processes (e.g. $C_1$ affecting $C_2$ affecting B) nor simultaneously evaluate multiple path equations within a model.

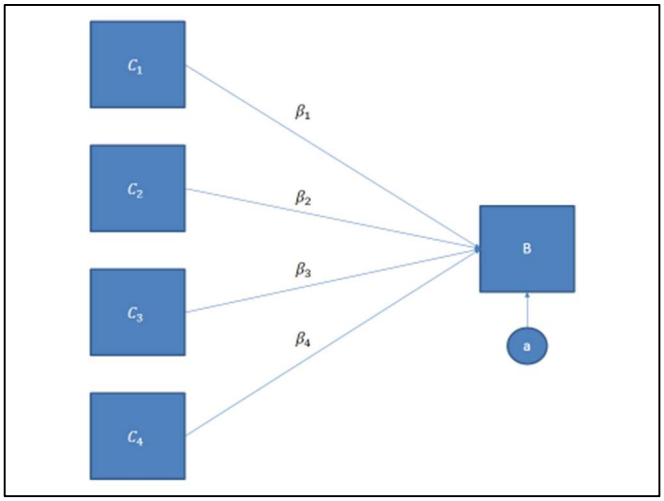


*Figure 6. Illustrative example of a linear regression model of a 4-construct theory*

A comparison of the behavioral theory conceptual models (Figures 2-4) and the linear regression model (Figure 6) clearly illustrates the greater complexity found in the theoretical models not represented in the regression model. The behavioral theories represented involve mediating variables, indirect influence pathways, and correlated, latent constructs. To account for these complexities within behavioral theory models, an increasingly popular analytical method to employ is structural equation modeling (SEM) (Babin & Svensson, 2012; Grewal, Cote, & Baumgartner, 2004; Savalei & Bentler, 2010).

Support for SEM analysis of HBM, TRA, and TPB has already been established through previous research (Carmack & Lewis-Moss, 2009; Gerend & Shepherd, 2012; Glanz et al., 2008; Heirman & Walrave, 2012; Murphy, Vernon, Diamond, & Tiro, 2013, 2014; Plotnikoff, Lubans, Penfold, & Courneya, 2014; Roncancio, Ward, & Fernandez, 2013; Roncancio et al., 2015; Vallerand et al., 1992). SEM combines several multivariate analytical techniques in order to evaluate all of the relationships between independent and dependent constructs through simultaneous, multiple equation estimations (Babin & Svensson, 2012). As such, the analysis can estimate both the direct and indirect effects of constructs without the need to "piecemeal" parameter estimates through separate analyses (Vallerand et al., 1992; Vidrine, Amick, Gritz, & Arduino, 2005). This ability of SEM analysis to simultaneously analyze multiple pathways allows the retention of the behavioral theory's conceptual framework.

The use of SEM also allows for the estimation of latent constructs through indicator variables (Vidrine et al., 2005). Latent constructs are variables that cannot be directly and literally observed (Mulaik, 2009). Since the construct cannot be directly observed, measurement of the construct is achieved through estimation by multiple, observed variables. For example, a person's level of depression cannot be directly observed. However, what can be observed are

reported behaviors and/or feelings that are signs of depression. Multiple survey items all associated with signs of depression would be administered that, when combined, attempt to measure the extent of an individual's depression.

The multiple indicator variables take random error and measurement-specific variance into account when estimating the latent variable (Anderson & Gerbing, 1988). Regression or correlational analyses of theory are limited to observed (manifest) variables and cannot realize latent variables (Vallerand et al., 1992). However, latent variables are prevalent in behavioral theories (Steenkamp & Baumgartner, 2000). As such, SEM allows one to accurately analyze theoretical constructs. Figure 7 illustrates the same four construct theory from Figure 6 conceptualized as an SEM model. The SEM model is able to retain the structure of the theory's conceptual model and analyze the theoretical variables as unobservable, latent variables.

All of the constructs, $C_{1\text{-}4}$ are still predictor variables each measured by a set of indicator variables. In this example, each latent construct, C, is also measured by three observed, indicator variables. However, the SEM model now allows for interactions and causal pathways between the constructs. For Figure 7, $C_1$ and $C_3$ are correlated; $C_2$ is a mediator of the relationship between $C_1$ and $C_3$ and the behavior, B; and $C_4$ has a direct effect on behavior, B.

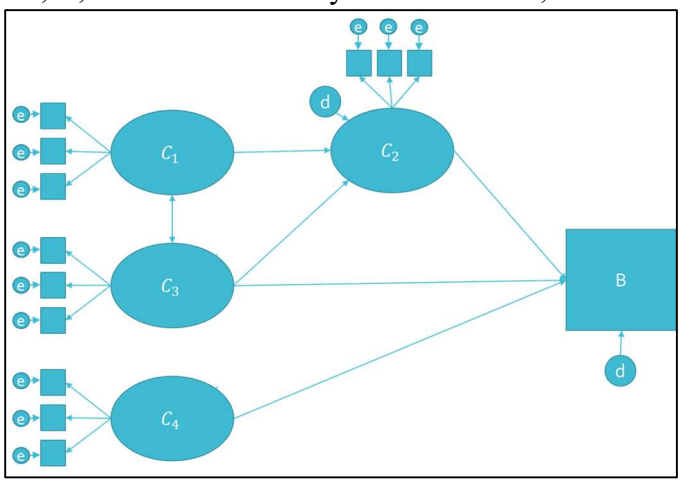


*Figure 7. Structural Equation Model of a 4-construct theory.*

A common concern with SEM analysis is the process of reconstructing the model until a good statistical fit is obtained. In the process of manipulating the model to fit data, it is possible that key relationships between constructs may be omitted or other erroneous relationships may

be included (Babin & Svensson, 2012). SEM is best applied as a confirmatory statistical methodology and should avoid model reconstruction. The goal of SEM is to support or reject a preexisting model. This is particularly appropriate for theory testing. Model reconstruction is not applicable when testing existing theory. The conceptual framework of a behavioral theory is already well established based on past development and research. As previously mentioned, reconstruction of a theory's conceptual model would not be an evaluation of the original theory and would be, in essence, creating a new theory. The reconstruction would also result in a retrospective explanation of observed data rather than a test of the proposed model. Since the concern of model reconstruction is not applicable when evaluating an existing theory, SEM is ideal for truly testing a theory and its posited construct relationships. (Anderson & Gerbing, 1988; Babin & Svensson, 2012; Rizzo & Kintner, 2013; Steenkamp & Baumgartner, 2000).

## Study Design

**Participant Criteria.** Eligibility to participate in the proposed study was based upon the American Cancer Society (ACS) screening guidelines for average risk individuals. Individuals were eligible to participate in the study if they were 50 years old or older at the time of survey administration; are a United States citizen; and can fluently read and understand English. As previously mentioned, the ACS suggests that all people at average risk begin screening at age 50 and continue to be screened even after age 75. Since the recommended guidelines are based on and intended for the US population, the study sample should be representative of this audience and, therefore, was restricted to US residents. Finally, only participants who can read and understand English were included as the measurement materials were only available in English.

**Survey Administration.** The study sample was recruited through the web-based survey provider SurveyMonkey.com ("SurveyMonkey"). SurveyMonkey maintains a pool of SurveyMonkey Contribute panelist members. Members opt-in to SurveyMonkey Contribute by voluntarily signing up for free through solicitation after completion of a SurveyMonkey survey. Panelists are typically incentivized to complete surveys by SurveyMonkey through two mechanisms. First, SurveyMonkey donates to a charity of the member's choice for each completed survey. Also, members are entered into a sweepstakes for a chance to win $100 per survey.

Members fill out an initial profile survey to determine the demographics of the participant. These data are used by SurveyMonkey to select which panelists are solicited to complete a survey relevant to the desired population. SurveyMonkey employs an invite algorithm based on the given inclusion criteria and desired sample size to compute the number of people invited to take the survey. Based on the time needed to complete the project, invitations are emailed to the relevant participant pool over a period of several days. The email notification sent to invitees is standard to SurveyMonkey and cannot be altered.

The primary limitations to the use of the SurveyMonkey Contribute population pool are consistent with most online-based survey implementation: all respondents have internet access and have actively signed up to take surveys. As such, the population skews towards older individuals with higher income and education levels. However, SurveyMonkey maintains that their audience is reflective of the US population with over 30 million unique respondents completing surveys per month. SurveyMonkey Audience asserts that projects are balanced to avoid major skews in demographics and are representative of the population being sampled.

Additionally, since the eligibility requirement includes being over the age of 50, the skew of an older population is a non-issue.

In addition to providing the study sample, SurveyMonkey was also responsible for the administration of the survey instrument and data collection. The survey instrument was constructed within the SurveyMonkey online program, including an initial informational consent page preceding the instrument questions. Once an individual accepted the invitation from SurveyMonkey Audience, s/he was directed to the survey. There, the participant chose to proceed to the questions after reviewing the introduction page. By continuing, the participant completed the measures described below. Response data were collected and maintained on the SurveyMonkey.com server. No personal data of the participants was ever recorded that was not explicitly solicited within the survey instrument. Since no identifiable information was obtained, the study was deemed exempt from the Virginia Commonwealth University IRB.

Data and simple descriptive statistics were reviewed in real time online as surveys were completed by participants. SurveyMonkey considers a survey complete when a participant who qualifies to take the survey answers all relevant questions and gets to the end of the survey. SurveyMonkey claims that they provide fully completed surveys for each participant response; all responses are of high quality; and that there will be no missing at random data. The typical time to complete administration varies by the available participants and complexity of the project. Based on the response rate of the invited pool members, the final sample collected may exceed the subscribed sample size. Once the desired sample size was achieved and the data was reviewed for quality, the final data set was available for export for use with statistical analysis software.

## Variables and Measures

Indicator variables related to the constructs of each theory, along with observed participant demographic and behavioral information, were assessed through previously validated measures or adapted versions of previously validated measures. As such, the survey instrument (Appendix A) includes the following variables and measures for each construct:

**Theory of Reasoned Action/Theory of Planned Behavior.** The items associated with TRA/TPB are separated into three sections: Attitudes, Subjective Norms, and Perceived Behavioral Control (TPB only). The format, scaling, and wording of the items and measures are consistent with the recommended construction of a TPB survey described by Ajzen (2002). All items are measured on a 7-point Likert scale. The three sections are comprised of 5 to 8 pairs of questions. Each pair of items relates to a specific attitude, influential group, or perceived behavioral control. The first item of each pair measures the agreement to the behavioral, normative, or control belief. The second item measures the corresponding outcome expectation, motivation to comply, or perceived power of the first item. The final measure of each item set is the product of the first item value weighted by the second item value.

The majority of item content is derived from previously established measures of beliefs towards colorectal cancer screening methods. Specifically, attitudinal beliefs are derived from Jones, Magnusson, Dumenci, and Vernon (2011a) and Jones, Magnusson, Dumenci, and Vernon (2011b). Analysis of the measures confirmed good fit of a hierarchical four-factor barrier models with three subscales for each screening modality, i.e. colonoscopy, sigmoidoscopy, and FOBT adherence. Subscale reliability ranged from 0.84-0.95 (Jones et al., 2011a, 2011b). For the measurement of the TRA/TPB construct of Attitudes, items were derived from the attitudinal barriers subscales.

Similarly, the item content for Subjective Norms and Perceived Behavioral Control is adapted from McQueen, Tiro, and Vernon (2008), who developed a correlated four-factor model of perceived pros, cons, social influences, and self-efficacy associated with colorectal cancer screening. Factor loadings for social influence items ranged from .31-.64 with a Cronbach's alpha of 0.65. Measure of self-efficacy demonstrated strong factor loadings of .57-.86 with a Cronbach's alpha of 0.91. The content of these items were adapted to fit the model of Ajzen's (2002) measure of TPB subjective norms and perceived behavioral control, respectively.

**Attribution Theory.** As described in the previous theory section, causal attribution is conceptualized as a bidimensional construct of locus of control and causal stability. As such, the constructs of locus of control and stability are independently measured as follows:

***Locus of Control.*** Locus of control is measured using the Multidimensional Health Locus of Control – Form C (MHLC-C) Scale (Wallston, Stein, & Smith, 1994). The MHLC-C is an 18-item measure with a 6-point Likert scale ranging from 1 ("strongly disagree") to 6 ("strongly agree"). The measure comprises a four-subscale model assessing the extent that an individual attributes control to each of the following: internality (6 items), chance (6 items), doctors (3 items), and powerful others (3 items). The Form C was developed with the ability to be adapted to assess condition-specific locus of control. The MHLC-C has demonstrated acceptable internal reliability with internality and chance $\alpha > 0.80$ and doctors and powerful others $\alpha > 0.70$ (Wallston et al., 1994). The items were reworded to relate to colorectal cancer as recommended by Wallston (2007). Since Attribution Theory relies upon the internal locus of control dimension, only the internality sub-scale is referenced for the remainder of this study. Results of the other subscales implemented will be used in secondary analyses.

***Stability.*** Causal stability is measured from an adapted form of the Dweck (2000) Theories of Intelligence Scale. The original measure is an eight-item self-report form with a 6-point scale with a range of 1 ("strongly disagree") to 6 ("strongly agree"). A higher score represents a more incremental belief orientation. The scale has been demonstrated to be reliable with a range of $\alpha = 0.94 – 0.98$ and not correlated with other scales of self-perceptions or cognitive abilities (Dweck, Chiu, & Hong, 1995). The original Theories of Intelligence Scale was designed to assess to what extent an individual perceives intelligence as a fixed or malleable trait (i.e. can one become smart or is s/he born smart?). Previous adaptions of the scale pertaining to health-related domains, specifically, weight management (Burnette, 2010) assessed whether an individual's weight is perceived as substantially malleable and were observed to have a good internal reliability of $\alpha = 0.82$. The scale is adapted in the same manner as Burnette (2010) by substituting the terms related to intelligence with those related to colorectal cancer.

**Health Belief Model.** The constructs of the HBM are measured using the adapted Champion Health Belief Model Scale (CHBMS) in Jacobs (2002). The CHBMS was developed with the intent of assessing the HBM as it relates to breast cancer. Cronbach's alpha for the used subscales (i.e. susceptibility, seriousness, benefits, barriers, and self-efficacy) range from .61-.78. Test-retest correlations also ranged from .47 to .86 (Champion, 1984). Jacobs (2002) adapted the measure to address colorectal instead of breast cancer. The adapted measure was assessed by multiple experts, including Champion, for content validity Jacobs (2002). The final measure used is a 29-item instrument (Susceptibility - 5 items, Seriousness – 7 items, Benefits – 6 items, Barriers – 6 items, and Self-efficacy – 5 items) with a 5-point Likert scale from 1 ("strongly disagree") to 5 ("strongly agree").

**Colorectal Cancer Screening Behavioral Intention.** Colorectal cancer screening behavioral intention items were also developed based on the recommendation by Ajzen (2002). Items are based on a 7-point Likert scale determining how likely an individual intends on being screened for colorectal cancer from 1 ("very unlikely") to 7 ("very likely"). Screening is assessed globally as well as specifically for each screening modality within the modality's recommend timeframe of adherence. A final question also assesses which modality the participant would be most likely to perform.

**Previous Colorectal Cancer Screening Behavior.** Previous colorectal cancer screening behavior is assessed for each modality based on Jones, Mongin, Lazovich, Church, and Yeazel (2008). Each question asks participants to recall if they have performed each modality. If the participant confirms having done the screening, participants also indicate when the screening was done on an ordinal time scale relative to the modality and recommended guidelines.

**Participant Characteristics.** Participant characteristics are assessed using sociodemographic and cancer health history related items from Siminoff et al. (2011). The 12 items assess participant: overall health, previous polyp and cancer diagnosis, age, sex, race, ethnicity, education, employment, marital status, and yearly income.

## Analysis

Data analysis was performed using SPSS22.0 and Mplus7.3. Preliminary descriptive and bivariate analysis of all variables and measures was conducted. The initial examination of data assessed the extent to which the variables included in the model met the scaling and statistical assumptions required by each of the proposed analyses. Solutions to non-normality included dropping extreme cases, correcting extreme cases through data transformations, or using an asymptotically-free estimator, if applicable.

**Behavioral Theory Model Testing.** The analysis of each behavioral theory was accomplished through the two-step structural equation modeling approach for theory testing introduced by Anderson and Gerbing (1988). The first step of the approach involved confirmatory factor analysis (CFA) of the measurement models to examine the reliability of the instrument to measure the intended latent variables. The second step of the approach was to test the pathways of each proposed theory and its ability to predict colorectal cancer screening behavioral intention and behavior for each screening modality.

Estimators for the models depended on the corresponding outcome variables. For binary and ordinal outcome variables, an asymptotically distribution-free estimator such as diagonally weighted least squares (DWLS) was used. Normally distributed continuous outcome variables were estimated with maximum likelihood (ML). For non-normally distributed continuous outcome variables, a restricted maximum likelihood (MLR) estimator was used instead. Likert-scale variables with five or more values was evaluated as a continuous variable (Schmitt, 2011).

For all models, model fit is based on the following indices: *p*-value associated with $\chi^2$ test of model fit, root-mean-square-error of approximation (RMSEA), comparative fit index (CFI), and the Tucker-Lewis index (TLI). A non-significant $\chi^2$ *p*-value indicates good fit. Assessment of fit goodness with the remaining indices is subjective without specific cut-off values demarcating fit. Lower RMSEA values indicate better fit of the model with general guidelines of .10, .08, .05, and .00 representing fair, adequate, close, and exact fit, respectively. CFI and TLI values approaching 1.00 indicate better model fit with values greater than .90 generally accepted as good fit (Hu & Bentler, 1995, 1999; Murphy et al., 2014; Plotnikoff et al., 2014).

***Confirmatory Factor Analysis of Latent Constructs.*** The purpose of the first step of the analysis was to evaluate the relationship of the observed survey items used to the specific

constructs of the theory that the items are intended to measure. To do this, a confirmatory factor analysis was performed for each latent variable measured through observed manifest variables. Similar to the justification previously discussed, a confirmatory rather than exploratory approach is taken because the instruments have already been designed to measure previously hypothesized constructs.

Factor loadings, λ, are estimated for each item regressed on the latent construct such that the general equation for all models is:

$$Y_i = \lambda_{ik} F_k + e_i, \; i = 1,2, \dots, j \tag{4}$$

where $Y_i$ is the $i^{th}$ observed item of item set, j, measuring construct k, $F_k$ represents the latent construct k, $\lambda_{ik}$ represents the factor loading for item i on construct k, and $e_i$ is the unique variance for item i.

As suggested by Anderson and Gerbing (1988), each factor was evaluated independently from all other measured factors using CFA. In order to ensure the best model fit and estimation of the latent models from the measures, modifications to the construct models were made when appropriate. Recommendation for modifications was based upon review of response data, reevaluation of items, and the use of modification indices suggested by Mplus output. Modifications implemented included removal of items based on poor factor loadings, correlation of error terms of similar items, and creation of sub-factors when results of the initial CFA clearly indicated the need of more than one factor within the model.

The factor loadings, λ, for each item "represents the amount of difference in the item score that corresponds to a unit difference in the [factor]" (McDonald, 1999, p. 78). The resulting λ item values for each factor were evaluated for appropriateness of measuring the given factor. This was based on a factor loading value greater than λ=0.40. Items with factor loadings less

than 0.4 are typically not considered a salient or effective indicator of the factor. This is partly because the square of a standardized factor loading represents how much of the item variance is explained by the factor variance. Additionally, the product of two items with small factor loadings would result in a low item correlation. In either case, an item with a factor loading less than 0.4 would result in a $\lambda^2$ or item-correlation less than 0.16, a negligible amount (Costello & Osborne, 2005; McDonald, 1999). Therefore, items with a value of $\lambda<0.40$ were considered for removal from the model unless further justification could be made for its retention.

Similarly, the number of items per factor is critical to the reliability of the measure and amount of the factor explained by it. As computed by coefficient alpha, a larger number of items will improve the reliability of the measure, i.e. the amount of measure variance due to the factor variance (Crocker & Algina, 2008). However, the return on improvement of the reliability coefficient decreases as the number of items grows. Also, a more parsimonious and concise measure is easier to administer, and less of a burden on the participant to complete. Therefore, a minimum number of optimal indicators can best provide a reliable representation of the factor (Little, Lindenberger, & Nesselroade, 1999). Typically, the recommended minimum number of indicators needed in order to achieve this optimization is within the range of three to five items (Costello & Osborne, 2005; Guilford, 1952; Raubenheimer, 2004; Velicer & Fava, 1998). Additionally, a one-factor model (such as those being evaluated) is not over-identified until a minimum of four indicators are present (Raubenheimer, 2004). With three indicators, the model will be just-identified until constraining one factor loading to 1.

Therefore, it was desired that no fewer than four items be retained for each factor measured. The bare minimum of three items was retained only if the fourth item has very poor characteristics and its removal from the model had a substantial positive effect to the efficacy of

the measure. Finally, the models were evaluated for good fit based on the previously mentioned criteria as well as significant item correlations within factors and the reliability measures of Cronbach's alpha and McDonald's omega.

The following models (Figures 8 – 16) are those initially estimated for each construct used in the primary analyses of this study. Numbers correspond to items of the survey instrument or the manipulation of the survey instrument items (e.g. $1 = 1a \times 1b$).

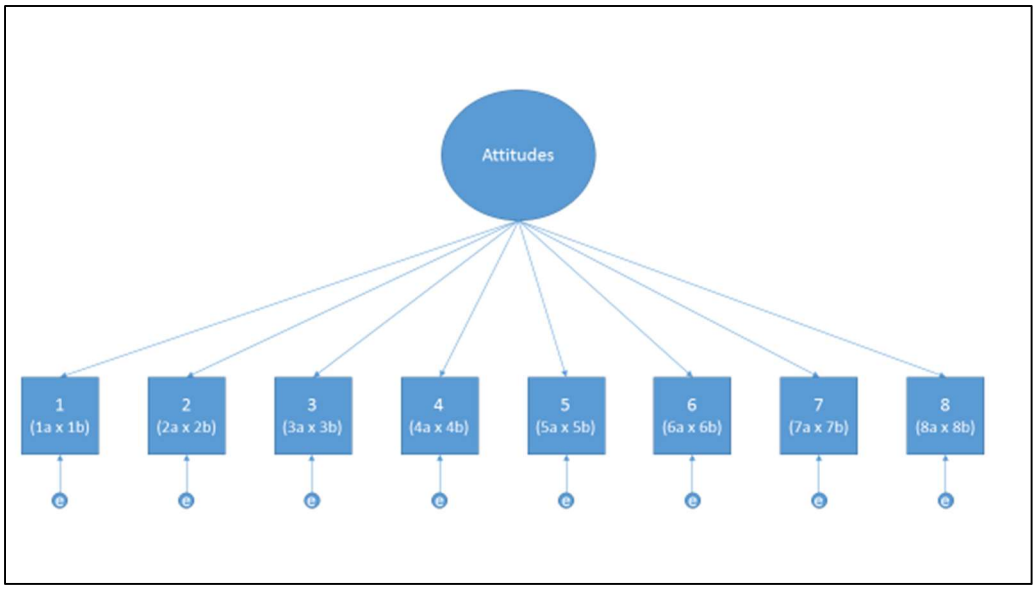


*Figure 8. Attitudes TRA/TPB construct.*

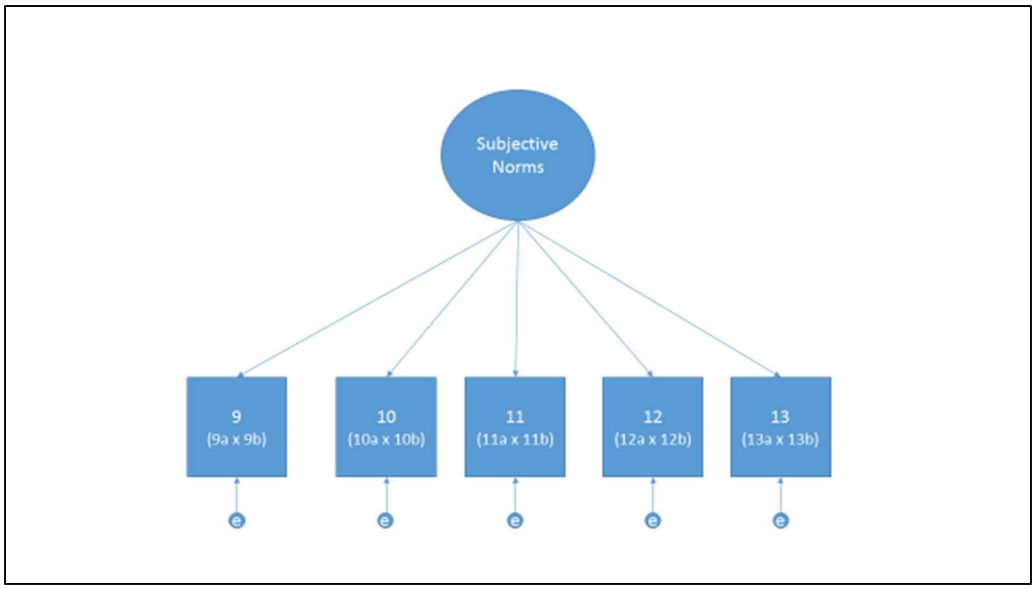


*Figure 9. Subjective norms TRA/TPB construct.*

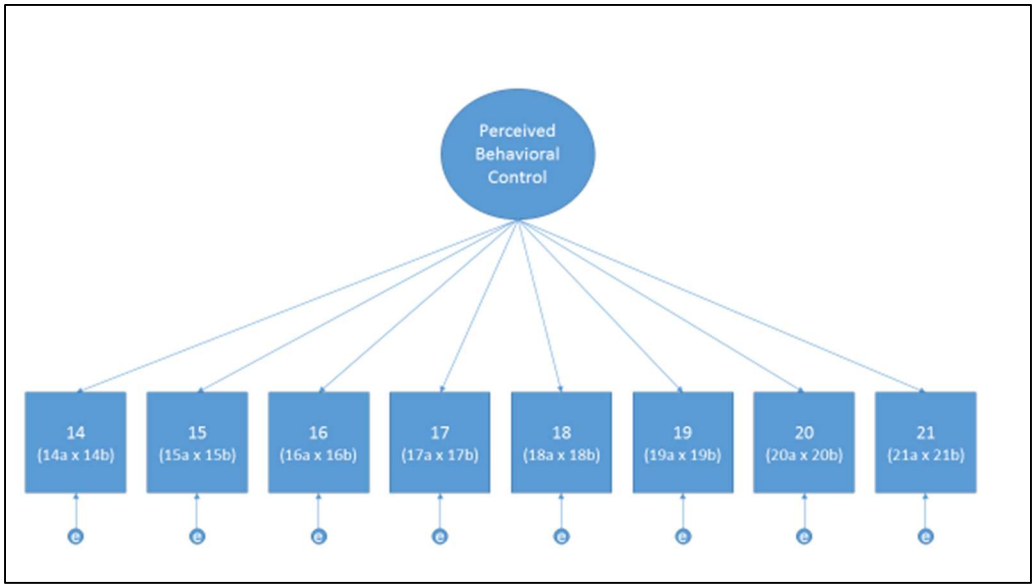


*Figure 10. Perceived behavioral control TPB construct.*

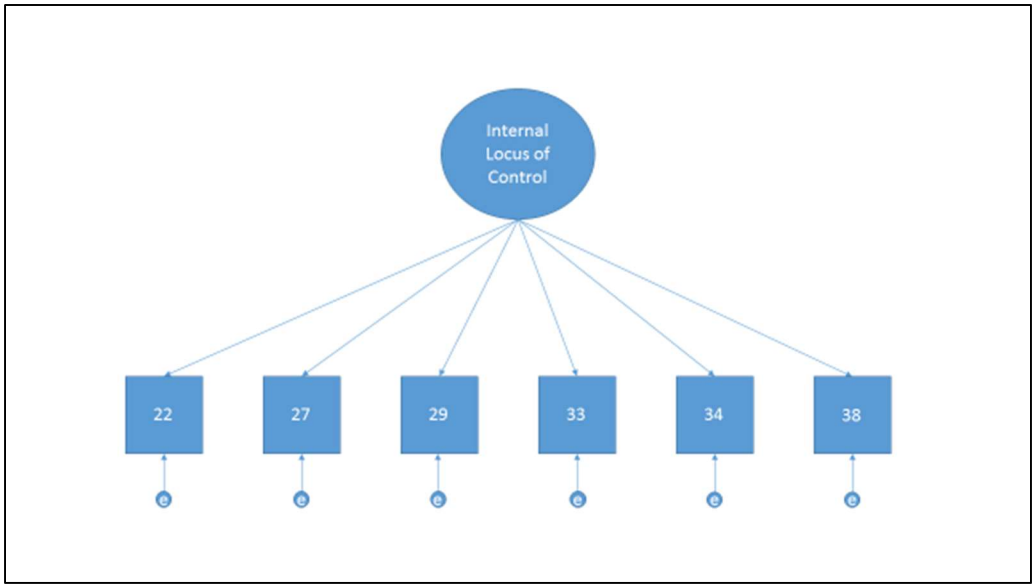


*Figure 11. Internal locus of control AT construct.*

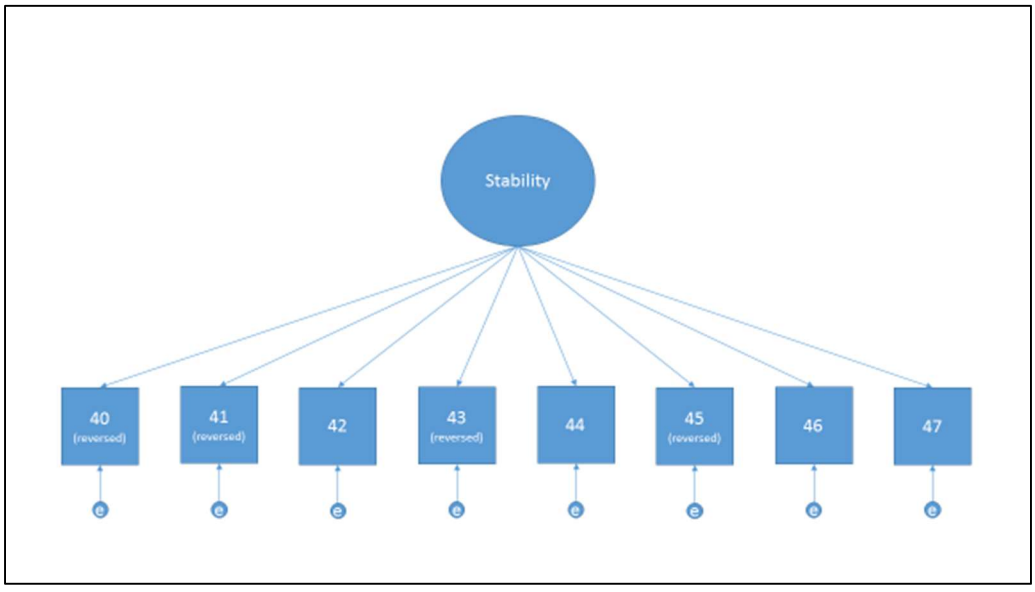


*Figure 12. Stability AT construct.*

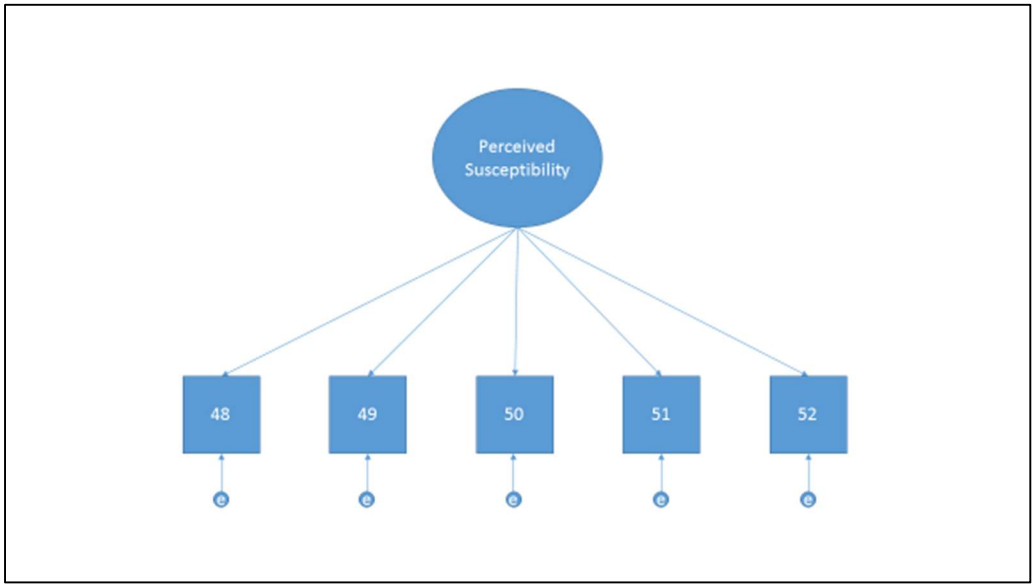


*Figure 13. Perceived susceptibility HBM construct.*

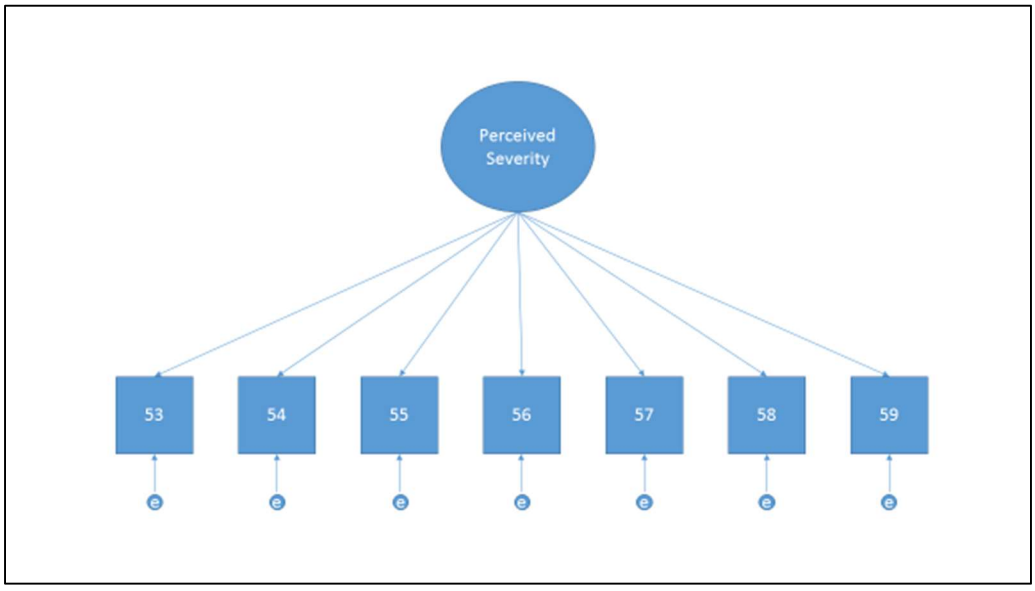


*Figure 14. Perceived severity HBM construct.*

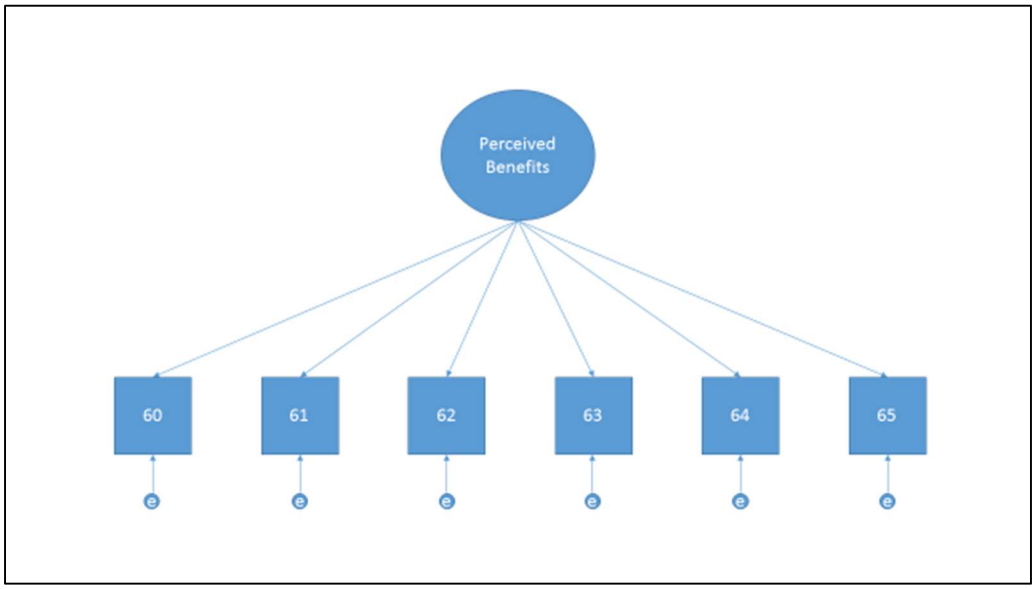


*Figure 16. Perceived benefits HBM construct.*

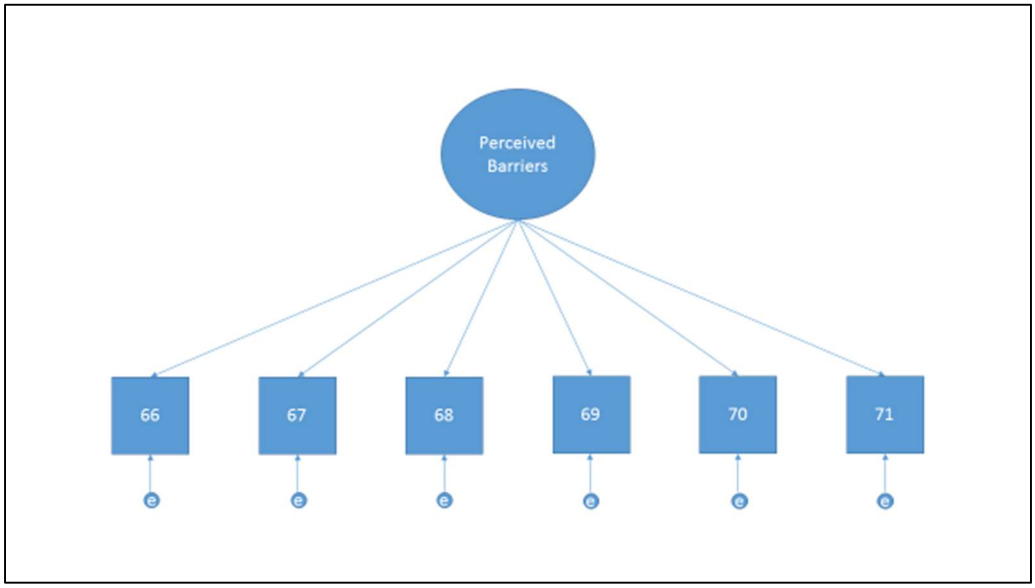


*Figure 15. Perceived barriers HBM construct.*

***Theoretical Model Analysis.*** Once the individual factor analyses were completed, the appropriate factors were modeled for each behavioral theory. The following models (Figures 17 – 19) are those initially estimated for each behavioral theory used in the primary analyses of this study based on the proposed latent constructs illustrated in Figures 8 - 16. Any modification of the latent construct models will translate to these models as well. The models represent the statistical versions of the conceptual models of each theory (Figures 2 – 5) based on previous analyses of the theories as well as interpretation of the theory by the author. The models include all manifest variables (observed items), latent variables (theoretical constructs), and dependent outcome variables (behavioral outcomes). The general model of each theory is depicted in Figures 17 – 19 with no specific reference to the intentions or behaviors evaluated in the study. However, each behavioral theory was modeled for four self-reported behavioral outcomes: colonoscopy screening, sigmoidoscopy screening, FOBT screening, and general colorectal cancer screening.

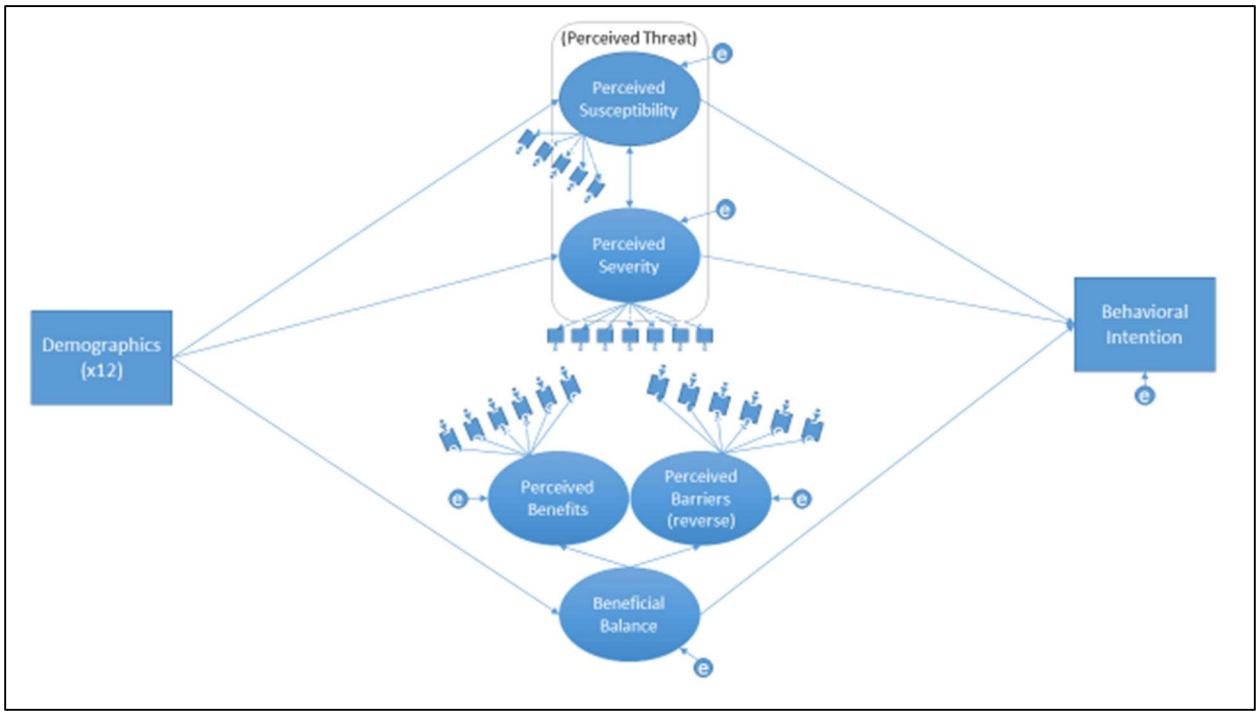


*Figure 17. Health Belief Model structural equation model.*

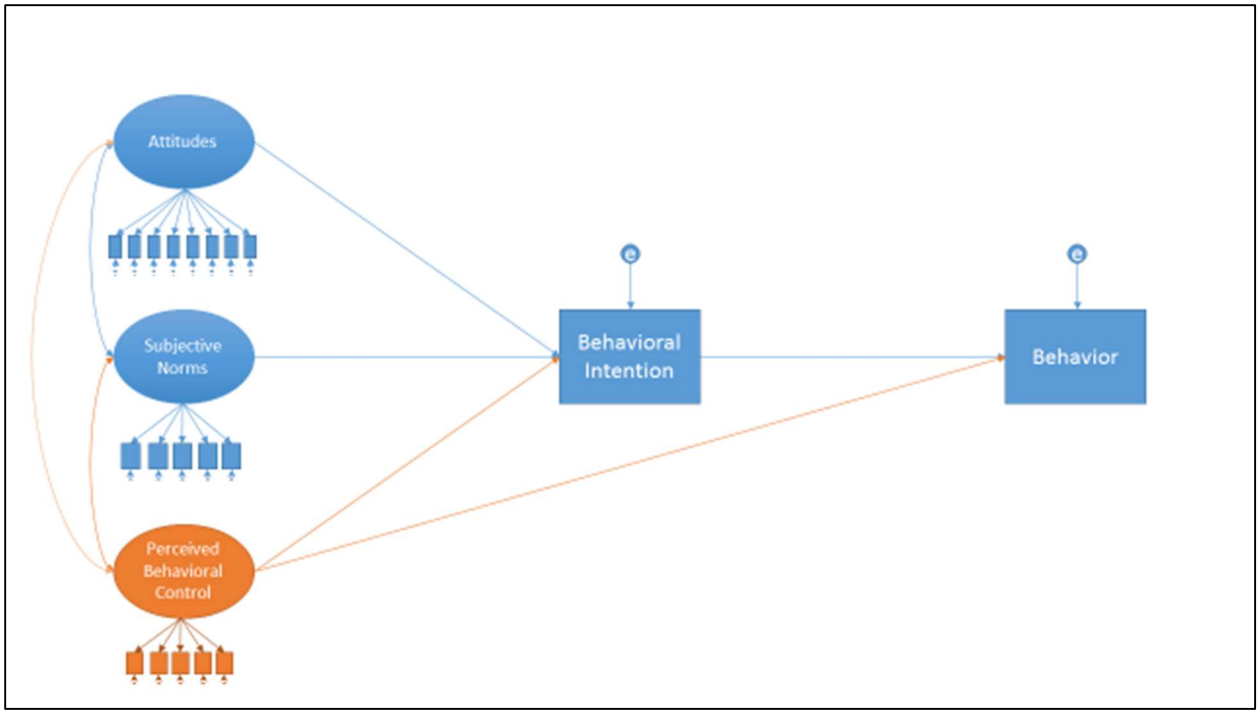


*Figure 18. Theory of Reasoned Action (blue) and Theory of Planned Behavior (blue + orange) structural equation model.*

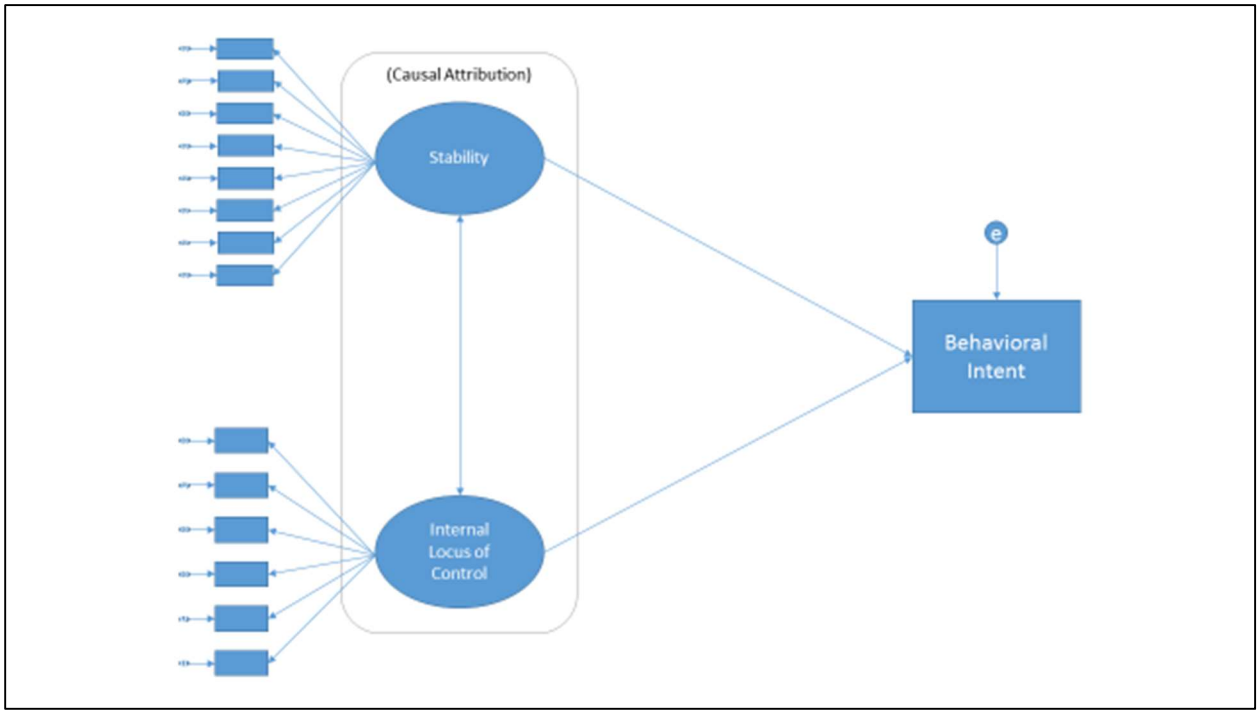


*Figure 19. Attribution Theory structural equation model.*

The model pathways were constrained to the pathways hypothesized by each theory and discussed in the previous sections. It is important to note that all of the second order latent variables within each theory are comprised of two first order latent variables. This creates a major constraint to identification of good fit for each model as these constructs create issues of local under-identification. In order to avoid this local under-identification while preserving the previously hypothesized structure of the theories, the factor loadings of the second order latent variable on each first order latent variable was restrained to 1. Doing so implies within the models that both first order latent variables equally contribute to and explain the second order variable.

Models were not restructured for fit because doing so would not be evaluating the constructs and pathways of the original theory. Though, models of the HBM were completed using a two-step approach to eliminate unnecessary sociodemographic variables. If a sociodemographic variable did not have a significant influence on any construct, it was removed from the second iteration of the model. This process could have been repeated until all sociodemographic variables displayed significant influences or were completely removed from the models. However, it was decided to employ only one round of sociodemographic evaluation in an effort to reduce over-manipulation of the model.

Each model was evaluated based on the following criteria:

- The overall model displayed good fit statistics as previously defined.
- The pathways of the model had significant ($p < .05$) effect sizes.
- The directionality of the significant pathway effects (i.e. positive or negative) was consistent with the hypothesized influences of the theory's constructs.

**Theoretical Model Comparison.** Significant theoretical models were subjectively compared to determine which theory best explains colorectal cancer screening behaviors. Theories were compared based on each theory's performance across modalities: colonoscopy, sigmoidoscopy, FOBT, and general colorectal cancer screening. Because each theory contains different variables from the other theories, models do not have the same variance/covariance matrices. As such, the theoretical models cannot be statistically compared against each other. Rather, the competing theories were compared based on how well each theory was consistent with its respective data within the observed sample.

Comparison of the theories was first evaluated by each model's fit statistics. Any non-significant model determined by poor fit criteria was eliminated from theory comparison since these models are not consistent with the data. Significant models were compared by contrasting the models' performance of the previously described evaluation criteria. The most favorable models were determined based on which model is most congruent with its hypothesized theory. It is important to note that such comparison is not falsifying less favorable models; comparison identifies which model is most consistent with the data and best contributed to explaining CRC screening intentions and behavior.

**Sample Size and Power Consideration**

Monte Carlo power analysis (Muthén & Muthén, 2002) with 1,000 replications was used to test the power of detecting statistically significant path coefficients, specific indirect effects, and total effects for the model presented in Figure 20. Type-I error rate was set 0.05. Standardized parameter estimates were used for effect sizes. In the population, the standardized factor loadings ranges were .836 - .848, .852 - .929, .490 - .826, .562 - .856, and .519 - .828 for factors 1 thru 6, respectively. Standardized path coefficients ranged from .119 to .533. Results

indicated that, with N = 400, the minimum power to detect a significant factor loading was 84.7%, path coefficient 84.7%, specific indirect effect 82.9%, and total effect 99.6%. Overall, the sample size of N = 400 is sufficiently large to detect statistically significant effects ($p < 0.05$) with power > 80%.

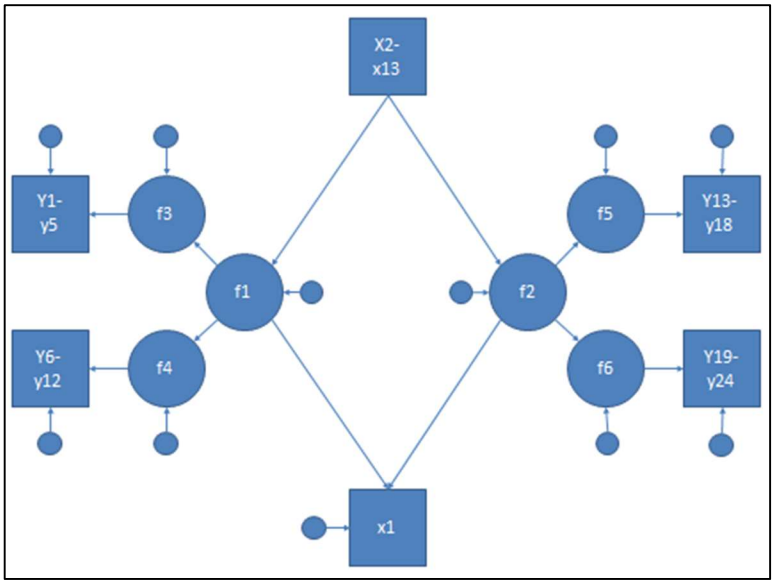


*Figure 20. SEM model of HBM for Power Analysis*

Similar analyses were performed for models representing TPB (Figure 21) and AT (Figure 22) for N=400 and Type-I error rate of 0.05. For TPB, the standardized factor loading ranges were .718-.780, .688-.860, .785-.902, .493-.769, .491-.746, .561-.773, .443-.674, .483-.798, and .456-.786 for factors 1 through 9, respectively. Standardized path coefficients ranged from .123 to .552. The minimum power to detect a significant factor loading was >99.9%, path coefficient 98.4%, specific indirect effect 98.4%, and total effect 98.4%. Regarding AT, the standardized factor loading ranges were .629-.710, .440-.742, and .419-.693 for factors 1 through 3, respectively. The standardized path coefficients was .346. The minimum power to detect a significant factor loading was >99.9% and path coefficient >99.9%.

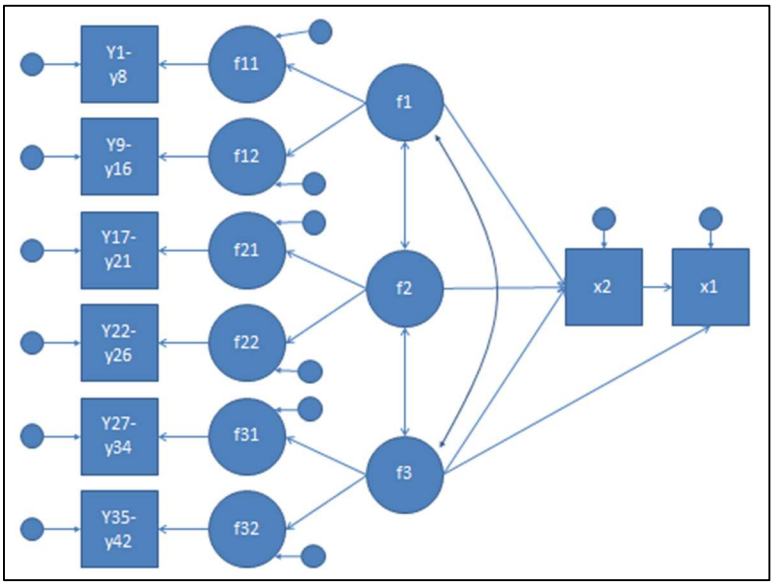


*Figure 21. SEM model of TPB for Power Analysis.*

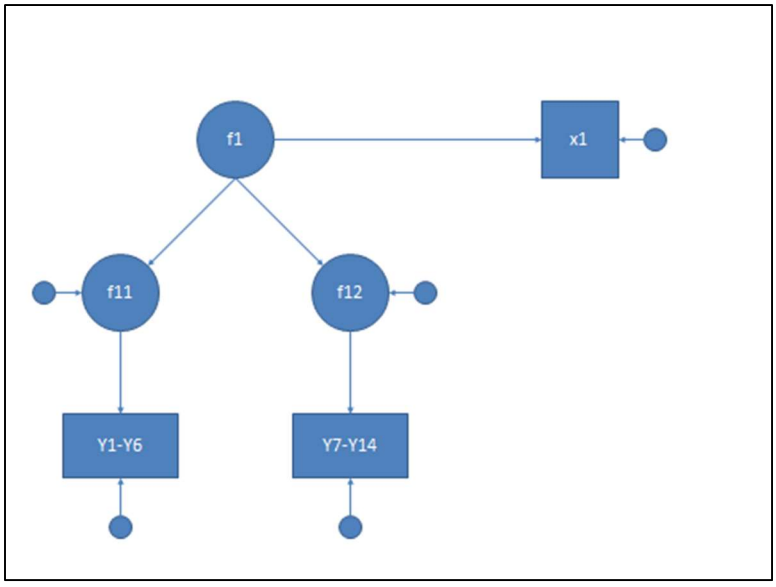


*Figure 22. SEM model of AT for Power Analysis.*

**Methodological Considerations**

The design of the study is not without constraints. As previously discussed, one of the primary constraints of the study methods is the representativeness of the study sample. Given that the sample was recruited and the survey instrument was administered online, the representativeness of the population is limited to individuals with access to the internet and willingness to participate in online surveys in addition to the parameters of colorectal cancer screening recommendations. However, as previously noted, the online population sampled is sufficiently large and encompasses a diverse population. Additionally, since SurveyMonkey only provided complete data, access to participants with incomplete data was unavailable for subsequent analysis. As such, only a complete case analysis was performed with the available data.

Also, the adapted measures used in the study have not all been extensively analyzed for reliability and validity after the necessary adaptations were performed. However, the measures were subject to cognitive interviewing to assess the quality of the items. The cognitive interview process was conducted as described by Fowler (2013). Additionally, the independent CFAs performed assessed the reliability of adapted measures in the study sample. Furthermore, since the instrument was only administered at one time point, only past behavior and current behavioral intentions were assessed. Follow-up assessment of future screening behaviors and their association with current behavioral intentions are beyond the scope of this study.

Finally, because the models do not contain the same variables, direct statistical comparison is impossible. As such, no claims can be made that any one theory is falsified based on the performance of another theory. However, the proposed study was able to examine which theory is most consistent in explaining colorectal cancer screening behaviors and intentions.

Since not all theories will be equally consistent with their respective data, a subjective comparison as to which is most consistent can be utilized.

**Meeting Study Goals**

After study approval from the committee was obtained, all necessary application and forms were submitted to the Virginia Commonwealth University IRB. Once IRB exemption was obtained, the recruitment procedures promptly began. This included the cognitive interviewing of behavioral health specialists and individuals meeting the colorectal cancer screening recommended guidelines, uploading of the final instrument to SurveyMonkey, and execution of the survey deployment on SurveyMonkey. In the event of data goals not met with the first round of recruitment, a subsequent appeal to the SurveyMonkey population would be initiated to obtain the remaining number of responses necessary to meet the necessary number of participants determined by the power analysis. Once all data was collected, analysis promptly began.

# Results

Data collection was completed over the course of the month of October, 2014. An initial participant solicitation elicited 440 responses. Of the 440 responses, 403 participants completed the survey. Upon review of the completed responses, 12 participants did not meet the eligibility requirement of being older than fifty years as determined by the "date of birth" question of the sociodemographics section of the survey. As such, these participants were excluded, bringing the total number of usable responses from the initial collection to 391. Being below the calculated sample size necessary from the Monte Carlo power analysis, a second round of participant solicitation was performed in which 12 more complete, eligible participants were elicited. Therefore, a total sample of 403 participants had complete cases for analysis.

## Descriptive Statistics

**Sociodemographics.** The sociodemographic characteristics of the study sample are reported in Table 3. The mean age of the sample as calculated by date of birth was 63.6 years (standard deviation (SD): 7.78 years). The study sample was essentially balanced ($p = .08$) regarding sex with 219 (54.3%) female participants and 184 (45.7%) male participants. The majority of participants identified as White or Caucasian (88.6%), non-Hispanic or Latino origin (96.8%), and Married/Cohabitated (57.6%). A plurality of the sample reported being retired

(46.4%), having attended some college but did not obtain a degree (27.0%), and reported an annual household income of $10,000-19,000 (15.4%).

**Health Status.** The health status of the sample is reported in Table 4. Most respondents (41.2%) considered themselves in "good" health while 33.0% reported "very good" and 15.4% reported "fair" health. Only a relatively small percentage of the study ample considered themselves on either extreme of the response categories as being in "excellent" (6.9%) or "poor" (3.5%) health. Slightly less than half of the study sample (48.4%) was "Average Risk," 31.8% were "Increased Risk,"

*Table 3. Sociodemographics.*

| | Count (%) |
|---|---|
| Age, years - Mean (Std Dev) | 63.6 (7.78) |
| Sex | |
| Female | 219 (54.3%) |
| Race | |
| White or Caucasian | 357 (88.6%) |
| Black or African American | 31 (7.7%) |
| Other | 15 (3.7%) |
| Hispanic or Latino origin | |
| Yes | 13 (3.2%) |
| Highest level of education completed | |
| Less than high school or some high school | 10 (2.5%) |
| High school graduate or Graduate Equivalent Degree (GED) | 89 (22.1%) |
| Some college, but no degree | 109 (27.0%) |
| Associate degree | 65 (16.1%) |
| Bachelor's degree | 69 (17.1%) |
| Some postgraduate work | 16 (4.0%) |
| Master's degree | 40 (9.9%) |
| Doctoral degree | 5 (1.2%) |
| Employment status | |
| Employed full-time | 90 (22.3%) |
| Employed part-time | 33 (8.2%) |
| Unemployed | 29 (7.2%) |
| Retired | 187 (46.4%) |
| Homemaker | 25 (6.2%) |
| Disability | 39 (9.7%) |
| Marital status | |
| Never married | 40 (9.9%) |
| Married/Cohabit | 232 (57.6%) |
| Divorced/Separated | 92 (22.8%) |
| Widowed | 39 (9.7%) |
| Household's total yearly income (n=402) | |
| Under $10,000 | 22 (5.5%) |
| $10,000-19,999 | 62 (15.4%) |
| $20,000-29,999 | 57 (14.2%) |
| $30,000-39,999 | 50 (12.4%) |
| $40,000-49,999 | 42 (10.4%) |
| $50,000-59,999 | 40 (10.0%) |
| $60,000-69,999 | 31 (7.7%) |
| $70,000-79,999 | 25 (6.2%) |
| $80,000-89,999 | 16 (4.0%) |
| $90,000-99,999 | 17 (4.2%) |
| $100,000 + | 40 (10.0%) |

and 19.9% were "High Risk" for colorectal cancer. Within the sample surveyed, 25.8% had been told by a healthcare professional that they have had polyps in their colon or rectum. Additionally, 13.2% of participants had been diagnosed with a type of cancer other than colorectal cancer, and two participants (0.5%) had been diagnosed with colorectal cancer by a healthcare professional.

*Table 4. Study sample health status.*

| | | Count (%) |
|---|---|---|
| Self-reported overall health | | |
| | Excellent | 28 (6.9%) |
| | Very good | 133 (33.0%) |
| | Good | 166 (41.2%) |
| | Fair | 62 (15.4%) |
| | Poor | 14 (3.5%) |
| Risk Status | | |
| | Average Risk | 195 (48.4%) |
| | Increased Risk | 128 (31.8%) |
| | High Risk | 80 (19.9%) |
| Ever had polyps in your colon or rectum | | |
| | Yes | 104 (25.8%) |
| Ever diagnosed with any other type of cancer | | |
| | Yes | 53 (13.2%) |
| Ever diagnosed with colorectal cancer | | |
| | Yes | 2 (0.5%) |

**Previous Colorectal Cancer Screening Behavior.** Past behavior was recorded with respect to general screening adherence, previous FOBT/FIT screening use, previous sigmoidoscopy screening use, and previous colonoscopy screening use.

***General adherence.*** The adherence rate of the study sample for colorectal cancer screening by any modality (FOBT/FIT, sigmoidoscopy, or colonoscopy) within ACS time guidelines was observed to be 64.0% (Table 5). Ninety-four participants (23.3%) reported never being screened by any of the modalities. Seventeen participants (4.2%) were recently screened – i.e. FOBT/FIT between one and five years and/or sigmoidoscopy between five and ten years – but fall outside of the recommended time guidelines. Of the remaining 8.4% of the sample, 7.4% reported ever being screened but longer than 5 years ago for FOBT/FIT and 10 years for

sigmoidoscopy/colonoscopy. One percent reported not knowing if they've ever been screened by any of the modalities.

*Table 5. General CRC screening adherence.*

| Adherence: | Count (%) |
|---|---|
| Adherent | 258 (64.0%) |
| Recently Screened | 17 (4.2%) |
| Ever Screened | 30 (7.4%) |
| Never Screened | 94 (23.3%) |
| Don't Know | 4 (1.0%) |

***FOBT/FIT.*** The responses of past behavior regarding gFOBT and FIT/iFOBT were combined to represent general FOBT screening behavior (Table 6). Two hundred twenty-four participants (55.6%) reported ever completing an FOBT test. Of them, 69 participants (17.1%) reported completing an FOBT test within the last year, i.e. within the recommended screening timeframe. Twenty participants (5.0%) did not recall whether or not they had completed any form of FOBT testing in their lifetimes.

***Sigmoidoscopy.*** Sigmoidoscopy was the least used of the three recorded modalities (Table 6). The vast majority, 71.2% of participants, reported never completing a sigmoidoscopy in their lifetimes. Only 85 participants reported completing a sigmoidoscopy, with only 32 participants (8.0%) completing a sigmoidoscopy within the recommended timeframe of within the past five years. However, of the three modalities, sigmoidoscopy also had the highest rate of individuals not recalling if they have ever completed a sigmoidoscopy screening (7.7%).

***Colonoscopy.*** Two hundred thirty-nine participants (59.3%) reported completing a colonoscopy within their lifetime (Table 6). Of them, 229 participants (56.8%) completed a colonoscopy within the recommended timeframe of within the past ten years. As such,

colonoscopy has the highest adherence rate of the three modalities. Only 7 participants (1.7%) were unable to report whether or not they have completed a colonoscopy in their lifetimes.

*Table 6. Previous CRC screening behavior by modality.*

| Have you ever had: | Count (%) |
|---|---|
| FIT/iFOBT/gFOBT | |
| Yes, 1 year ago or less | 69 (17.1%) |
| Yes. more than 1 but not more than 2 years ago | 53 (13.2%) |
| Yes, more than 2 but not more than 5 years ago | 36 (8.9%) |
| Yes, more than 5 years ago | 66 (16.4%) |
| No, have never had one done | 159 (39.5%) |
| Don't know if I have | 20 (5.0%) |
| Sigmoidoscopy | |
| Yes, 1 year ago or less | 12 (3.0%) |
| Yes. more than 1 but not more than 5 years ago | 20 (5.0%) |
| Yes, more than 5 but not more than 10 years ago | 16 (4.0%) |
| Yes, more than 10 years ago | 37 (9.2%) |
| No, have never had one done | 287 (71.2%) |
| Don't know if I have | 31 (7.7%) |
| Colonoscopy | |
| Yes, 1 year ago or less | 73 (18.1%) |
| Yes. more than 1 but not more than 5 years ago | 114 (28.3%) |
| Yes, more than 5 but not more than 10 years ago | 42 (10.4%) |
| Yes, more than 10 years ago | 10 (2.5%) |
| No, have never had one done | 157 (39.0%) |
| Don't know if I have | 7 (1.7%) |

**Colorectal Cancer Screening Behavioral Intentions.** Four colorectal cancer screening intentions were measured using 7-point Likert scales, anchored by the choices "Very Unlikely" and "Very Likely," asking participants how likely they are to get screened for colorectal cancer in general and for each modality. All intention question responses ranged the entire scale. None of the response distributions of the four questions substantially departed from normality (West,

Finch, Curran, & Hoyle, 1995) with absolute values of skewness ranging from 0.002 to 0.837 and kurtosis ranging from 0.420 to 0.985. Descriptives for each question are reported in Table 7.

*Table 7. CRC screening behavioral intentions.*

| | Very Unlikely Count (%) | Unlikely Count (%) | Somewhat Unlikely Count (%) | Neutral Count (%) | Somewhat Likely Count (%) | Likely Count (%) | Very Likely Count (%) |
|---|---|---|---|---|---|---|---|
| **General Screening Intention** | | | | | | | |
| "I intend on getting screened for colorectal cancer" | 28 (6.9%) | 20 (5.0%) | 24 (6.0%) | 64 (15.9%) | 44 (10.9%) | 70 (17.4%) | 153 (38.0%) |
| **Specific Screening Adherence Intention** | | | | | | | |
| FIT/iFOBT/gFOBT in the next year | 71 (17.6%) | 37 (9.2%) | 38 (9.4%) | 118 (29.3%) | 47 (11.7%) | 38 (9.4%) | 54 (13.4%) |
| Sigmoidoscopy in the next 5 years | 100 (24.8%) | 48 (11.9%) | 28 (6.9%) | 124 (30.8%) | 33 (8.2%) | 29 (7.2%) | 41 (10.2%) |
| Colonoscopy in the next 10 years | 43 (10.7%) | 27 (6.7%) | 22 (5.5%) | 64 (15.9%) | 35 (8.7%) | 44 (10.9%) | 168 (41.7%) |

***Screening intention 1: General intention.*** The mean response to the statement "I intend on getting screened for colorectal cancer" was 5.2 (SD: 1.90; Range 1 to 7), which would equate to an average response between being somewhat likely and likely to be screened. Of the four questions, the mean response to general intention was the highest. Being "very likely" to intend to be screened in general was the most common response reported (38.0%).

***Screening intention 2: FOBT/FIT.*** The mean intention of completing an FOBT/FIT within the next year was 3.9 (SD: 1.94; Range 1 to 7), indicating a relatively neutral average response. As such, the plurality of the sample (29.3%) reported being "neutral" in their intentions.

***Screening intention 3: Sigmoidoscopy.*** Similar to FOBT/FIT, the mean response to the intention of completing a sigmoidoscopy within the next five years was 3.5 (SD: 1.95; Range 1 to 7). Of the four questions, intention for sigmoidoscopy was the least likely, with the largest proportion of "very unlikely" responses (24.8%) out of the four questions. However, the plurality of the study sample, similar to FOBT/FIT, was "neutral" in their intentions (30.8%).

***Screening intention 4: Colonoscopy.*** Intentions to be screened using colonoscopy within the next ten years were more favorable than FOBT/FIT and sigmoidoscopy intentions. The mean response was 5.0 (SD: 2.12; Range 1 to 7), which would equate to an average response of "somewhat likely" to intend to screen using colonoscopy. Similar to general intention, the plurality of the study sample (41.7%) indicated intentions of being "very likely" to use colonoscopy in the next ten years.

**Colorectal Cancer Screening Modality Preference.** Screening preference is depicted in Figure 23. When asked which of the three modalities the participant would be most likely to complete, the majority of the study sample chose colonoscopy (65.3%). The remaining participants overwhelming preferred FOBT/FIT to sigmoidoscopy: 31.8% vs 3.0%, respectively.

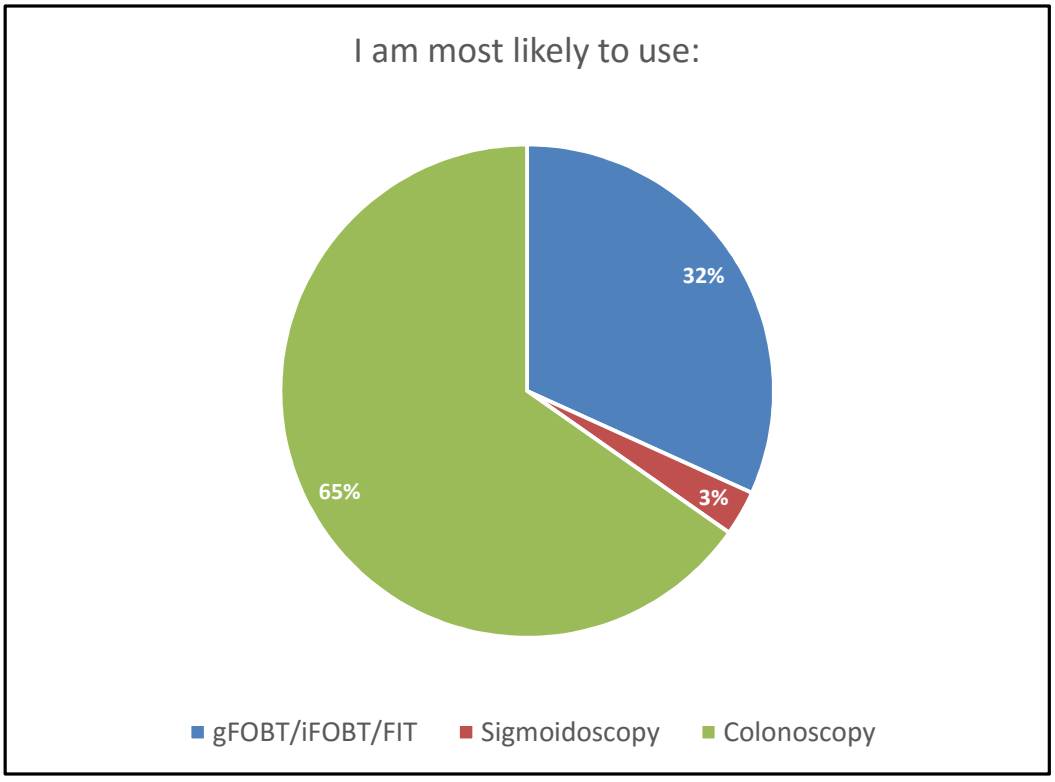


*Figure 23. Screening preference.*

## Confirmatory Factor Analyses

Evaluation of the theoretical models was conducted using the two-step process introduced by Anderson and Gerbing (1988). This section presents the results of reliability analyses and confirmatory factor analysis (CFA) for each latent construct used by at least one of the theories reviewed.

**Health Belief Model.** The constructs of the Health Belief Model evaluated within this analysis include: Perceived Benefits, Perceived Barriers, Perceived Susceptibility, and Perceived Severity.

***Perceived benefits.*** Items representing the Health Belief Model construct of perceived benefits included questions 60 through 65 of the survey. Bivariate correlations of Benefits items ranged from rho ($\rho$) = 0.512 to 0.758. Also, internal reliability of the 6-item measure was good with Cronbach's $\alpha = 0.908$ and McDonald's $\omega = 0.957$. Initial CFA resulted in fit statistics of $\chi^2_{df=9} = 148.867$, $p < 0.001$; RMSEA = 0.196; CFI = 0.913; and TLI = 0.855. Standardized factor loadings ranged from $\lambda = 0.745$ to 0.855.

Upon evaluation of the items and modification indices, the residuals of questions 60 and 61 as well as 63 and 64 were correlated within the subsequent model. Items 60 and 61 both refer to the emotional benefits of screening. Similarly, items 63 and 64 both refer to the screening benefits of decreasing the chance of negative events resulting from CRC. The resulting model (Figure 24) resulted in improved fit statistics of $\chi^2_{df=7} = 16.898$, $p = 0.018$; RMSEA = 0.059; CFI = 0.994; and TLI = 0.987. Standardized factor loadings ranged from $\lambda = 0.704$ to 0.878.

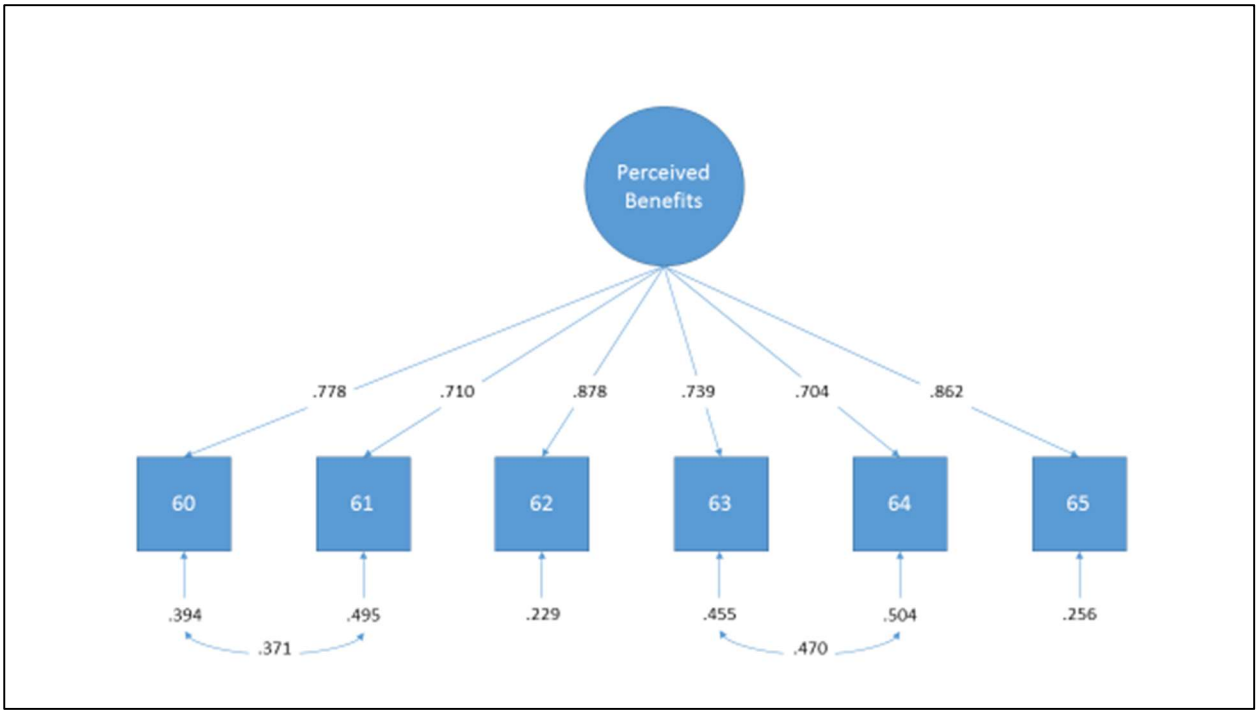


*Figure 24. Perceived benefits CFA.*

***Perceived barriers.*** The original CFA for the perceived barriers construct included questions 66 through 71 of the survey instrument. Questions were reverse coded such that lower scores indicate a greater degree of perceived barriers. All items within the model displayed significant correlations with one another ranging from $\rho = 0.345$ to 0.633. Fit statistics for the model included the following: $\chi^2_{df=9} = 60.647$, $p < 0.001$; RMSEA = 0.119; CFI = 0.937; and TLI = 0.895. Standardized factor loading estimates for the items ranged from 0.418 to 0.819.

To improve fit, question 67 – "having regular checkups to detect colon cancer will make me worry about colon cancer" – was removed from the model due to its lower factor loading ($\lambda = 0.418$) compared to the remaining items ($\lambda$ range: 0.595 – 0.895). The resulting 5-item model (Figure 25) resulted in substantially improved fit statistics of $\chi^2_{df=5} = 15.215$, $p = 0.010$; RMSEA = 0.071; CFI = 0.986; and TLI = 0.971. Additionally, the five items displayed good internal

reliability with Cronbach's α = 0.824 and McDonald's ω = 0.902. Standardized factor loadings ranged from 0.572 to 0.820.

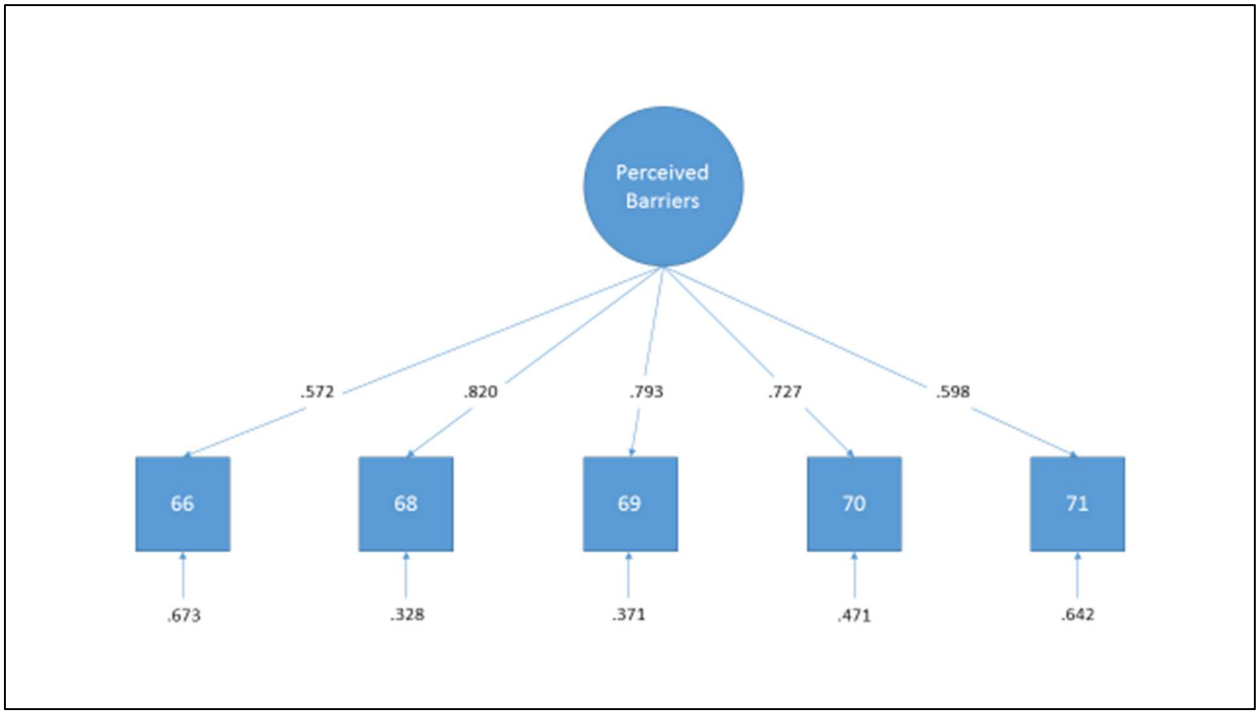


*Figure 25. Perceived barriers CFA.*

***Perceived susceptibility.*** Items representing manifest variables for perceived susceptibility include questions 48 through 52 of the survey instrument. All bivariate correlations between items were significant, ranging from ρ = 0.688 to 0.890. Additionally, Cronbach's α = 0.948 and McDonald's ω = 0.987, suggesting very good internal reliability. CFA of the construct (Figure 26) displayed reasonable fit of $\chi^2_{df=5} = 48.760$, $p < 0.001$; RMSEA = 0.147; CFI = 0.978; and TLI = 0.957. Standardized factor loadings ranging from λ = 0.834 to 0.942. Considering the reasonable fit and high factor loadings, no subsequent modifications were made to the model.

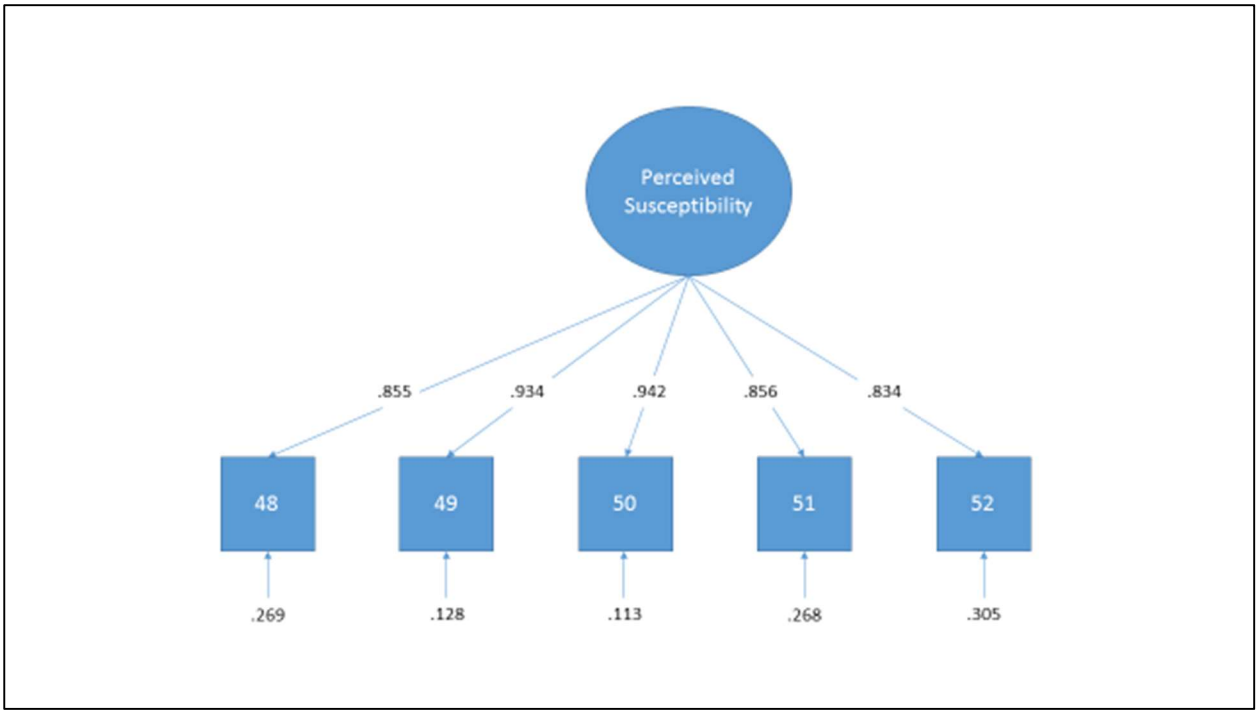


*Figure 26. Perceived susceptibility CFA.*

***Perceived severity.*** The original item set for perceived severity included questions 53 through 59. The initial CFA produced fit statistics of $\chi^2_{df=14} = 174.524$, $p < 0.001$; RMSEA = 0.169; CFI = 0.827; and TLI = 0.740. Standardized factor loading estimates for the items ranged from 0.379 to 0.833. Upon review of the model, it was concluded that question 57 would be eliminated from the model given its low factor loading of $\lambda < 0.4$ as well as its lack of construct validity with the rest of the items, i.e. the only item of the set pertaining to relationships with others.

The resulting item set (questions 53 through 56, 58, and 59) model displayed slightly modified fit statistics of $\chi^2_{df=9} = 127.795$, $p < 0.001$; RMSEA = 0.181; CFI = 0.857; and TLI = 0.762. There was also a noticeable contrast in standardized factor loadings with questions 53 through 55 ranging from $\lambda = 0.729$ to 0.831 and questions 56, 58, and 59 ranging from $\lambda = 0.393$ to 0.530. This contrast suggested a possible two-factor model.

Upon analysis of the model, it was determined that questions 53 through 55 represented immediate perceived severity while questions 56, 58, and 59 represented long-term perceived severity. As such a 2nd-order model with correlated factors was constructed (Figure 27) representing severity manifested as two factors of immediate and long-term severity. Significant item correlations ranged from $\rho = 0.565$ to 0.707 for immediate severity as well as $\rho = 0.208$ to 0.449 for long-term severity. Reliability statistics of Cronbach's $\alpha = 0.836$ and McDonald's $\omega = 0.917$ were observed for immediate severity and Cronbach's $\alpha = 0.687$ and McDonald's $\omega = 0.822$ for long-term severity. This final model displayed much improved fit statistics of $\chi^2_{df=8} = 28.506$, $p < 0.001$; RMSEA = 0.080; CFI = 0.975; and TLI = 0.954. Standardized factor loadings ranged from $\lambda = 0.722$ to 0.858 for immediate severity and $\lambda = 0.513$ to 0.728 for long-term severity.

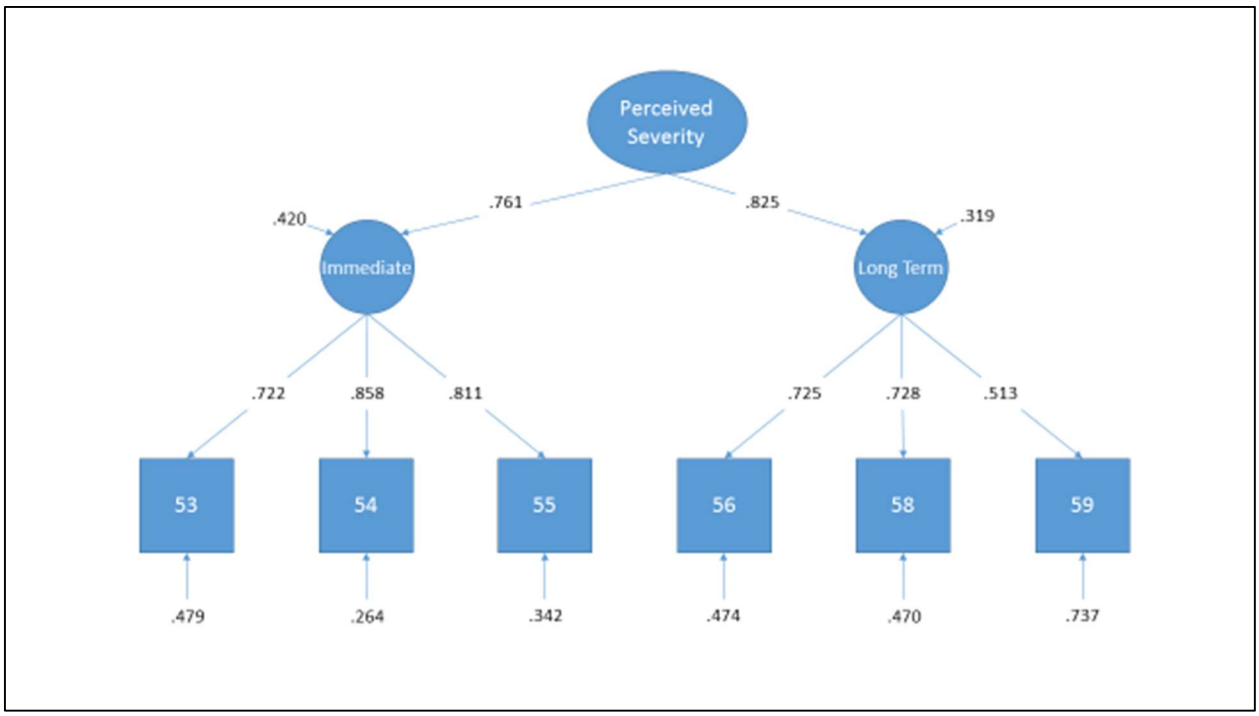


*Figure 27. Perceived severity CFA.*

**Theory of Reasoned Action.** The Theory of Reasoned Action includes the constructs of attitudes and subjective norms. Attitudes are delineated as an individual's behavioral belief weighted by an outcome evaluation of the belief. Similarly, subjective norms are delineated as normative beliefs weighted by one's motivation to comply (Ajzen, 1991). Given the integral relationship between the two halves of each construct, the manifest variables for each construct were computed by multiplying each belief question with its corresponding valuation question (e.g. item 1 = question 1a × question 1b).

***Attitudes.*** Manifest variables for attitude originally included items 1 through 8. Internal reliability for the item set was fair with Cronbach's $\alpha = 0.664$. Additionally, items 1 through 6 displayed all significant bivariate correlations ranging from $\rho = 0.242$ to 0.586. However, only 5 of 13 (38.5%) bivariate correlations associated with items 7 and 8 were significant. CFA of the model displayed poor fit statistics overall with $\chi^2_{df=20} = 316.878$, $p < 0.001$; RMSEA = 0.192; CFI = 0.620; and TLI = 0.468. Standardized factor loadings for items 1 through 6 ranged from $\lambda = 0.425$ to 0.754 while $\lambda = 0.027$ and -0.036 for items 7 and 8, respectively. This all provided strong evidence for items 7 and 8 to be dropped from the item set.

Given the modified manifest variable set of items 1 through 6, internal reliability improved to Cronbach's $\alpha = 0.753$. The associated CFA provided the following improved fit statistics: $\chi^2_{df=9} = 86.228$, $p < 0.001$; RMSEA = 0.146; CFI = 0.863; and TLI = 0.771. Standardized factor loadings ranged from $\lambda = 0.426$ to 0.752. Review of modification indices along with reevaluation of the items suggested correlations with items 1 and 2 (i.e. items related to worry and fear) as well as items 3 and 6 (i.e. items related to work and preparation involved with screening).

The final model (Figure 28) displayed substantially improved fit statistics from the previous model of $\chi^2_{df=7} = 29.595$, $p < 0.001$; RMSEA = 0.089; CFI = 0.960; and TLI = 0.914. Standardized factor loadings ranged from $\lambda = 0.358$ to 0.828 and McDonald's $\omega = 0.794$. Because item 1 has an observed factor loading of $\lambda = 0.358$, the item was considered for removal. However, its question content and relationship with item 2 warranted its retention. Additionally, exploration of the model without item 1 showed no substantial improvement to the model's fit.

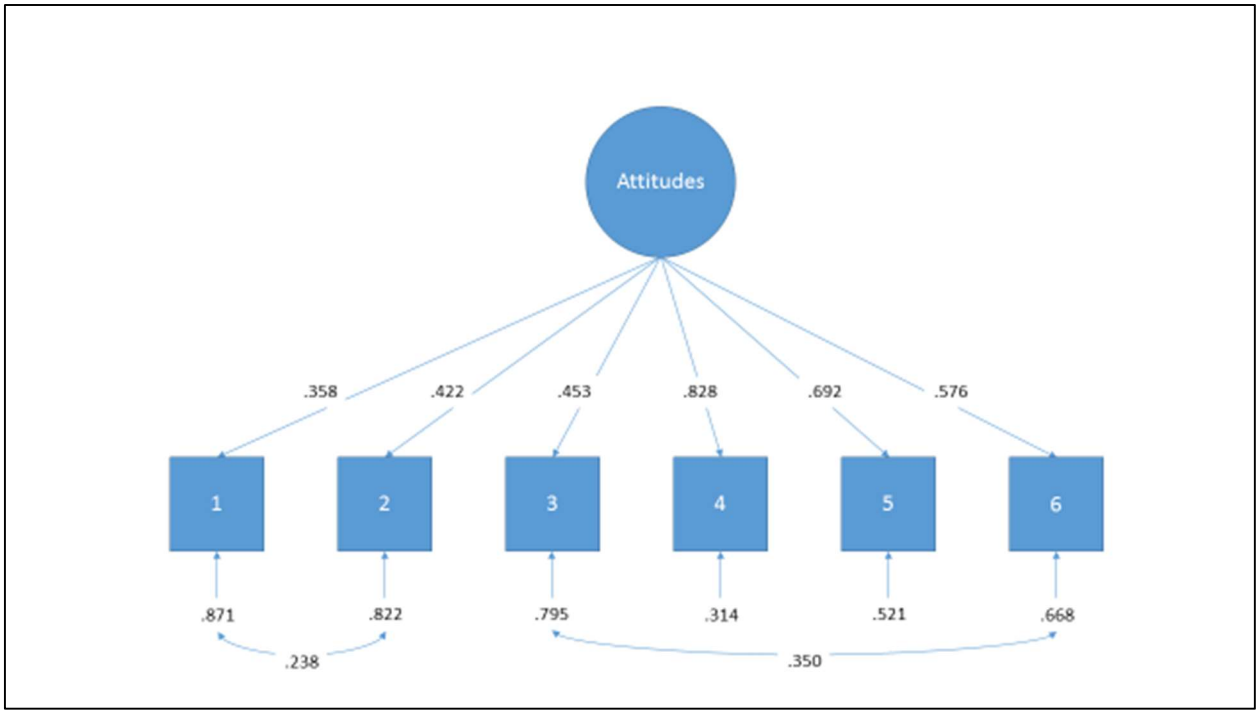


*Figure 28. Attitudes CFA.*

***Subjective norms.*** Subjective norms was assessed using items 9 through 13. All items were significantly correlated with each other with a range of $\rho = 0.478$ to 0.785. The item set also displayed good internal reliability with Cronbach's $\alpha = 0.892$. CFA of the item set returned fit statistics including $\chi^2_{df=5} = 71.476$, $p < 0.001$; RMSEA = 0.182; CFI = 0.939; and TLI = 0.879, and standardized factor loadings ranging from $\lambda = 0.693$ to 0.919.

Item review along with modification indices suggested a correlation between items 11 and 12 which relate to the subjective norms of "friends" and "people like me." The final model for subjective norms (Figure 29) displayed improved fit compared to the previous model: $\chi^2_{df=4} = 18.777$, $p < 0.001$; RMSEA = 0.096; CFI = 0.987; and TLI = 0.966. Standardized factor loadings ranging from $\lambda = 0.646$ to 0.946 and McDonald's $\omega = 0.945$.

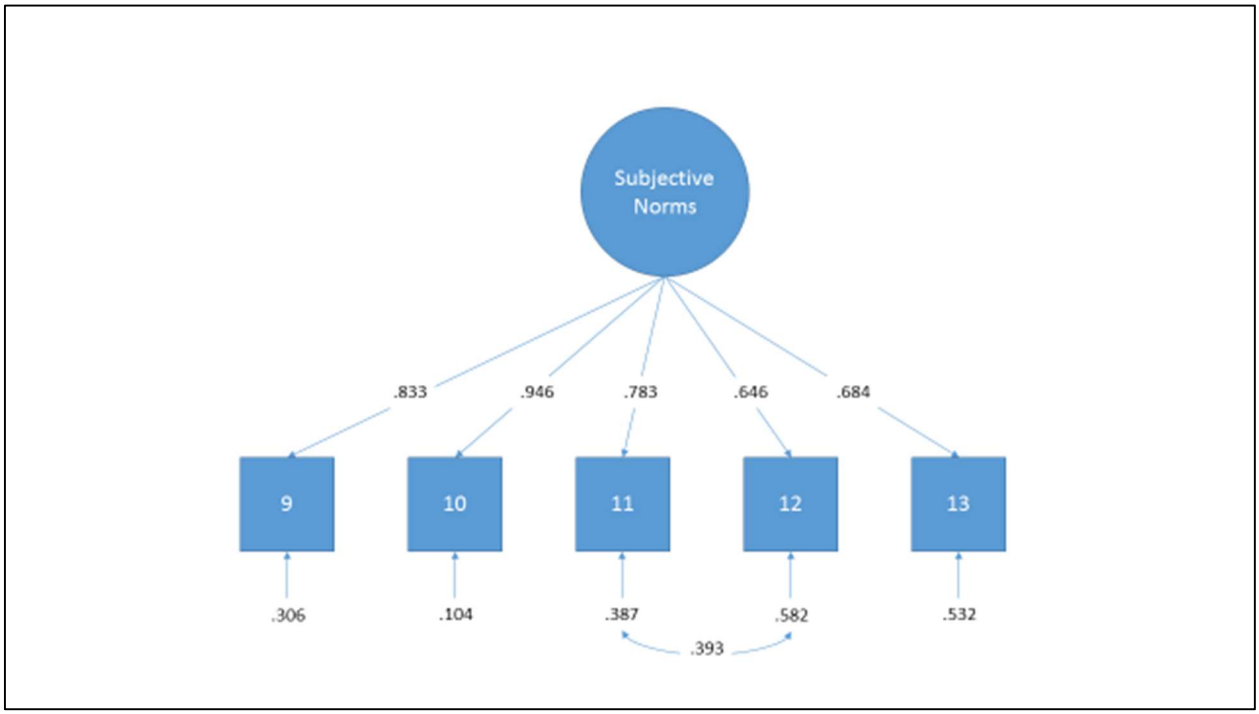


*Figure 29. Subjective norms CFA.*

**Theory of Planned Behavior.** In addition to the construct of the Theory of Reasoned Action, the Theory of Planned Behavior includes perceived behavioral control. Similar to the constructs of attitudes and subjective norms, the items for analysis of perceived behavioral control were constructed by multiplying each control belief question with its corresponding perceived power (i.e. weighted valuation) question.

***Perceived behavioral control.*** Items 14 through 21 of the survey instrument were included as manifest variables of perceived behavioral control. All items were significantly

correlated (range: $\rho = 0.426$ to 0.868) and the item set displayed very good internal reliability (Cronbach's $\alpha = 0.950$). CFA of perceived behavioral control (Figure 30) displayed reasonable fit of $\chi^2_{df=20} = 157.770$, $p < 0.001$; RMSEA = 0.131; CFI = 0.959; and TLI = 0.943. Standardized factor loadings ranging from $\lambda = 0.651$ to 0.927 and McDonald's $\omega = 0.982$. Considering the reasonable fit, factor loadings, and high reliability, no modifications were made to the model.

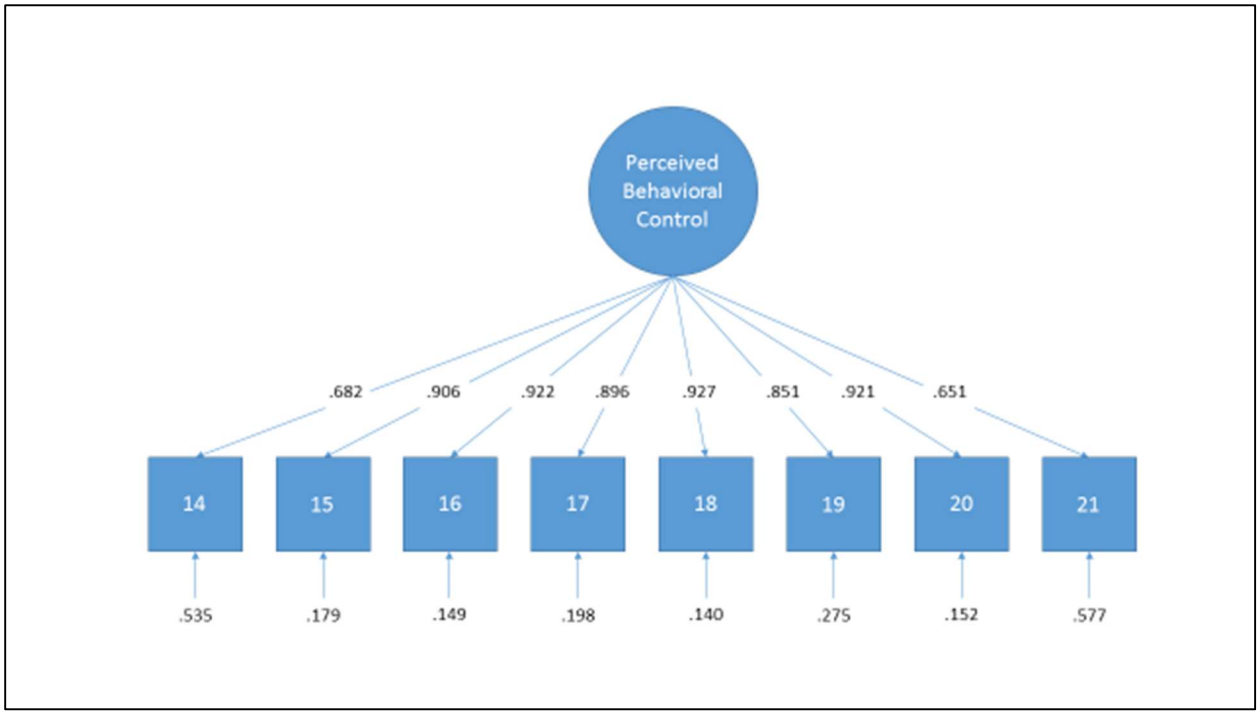


*Figure 30. Perceived behavioral control CFA.*

**Attribution Theory.** Attribution, as previously described and depicted in Figure 5, is conceptualized as the intersection of an individual's belief in the stability (or malleability) of a condition and internal (or external) locus of control regarding the condition.

***Stability.*** Stability was measured using questions 40 through 47 of the survey instrument. Questions 40, 41, 43, and 45 are reverse coded so that higher item scores are associated with a greater agreement to malleability across all questions. Significant bivariate correlations across all items ranged from $\rho = 0.155$ to 0.733. Internal reliability of the item set was observed to be Cronbach's $\alpha = 0.856$. CFA of stability resulted in the following model fit information: $\chi^2_{df=20} = 706.262$, $p < 0.001$; RMSEA = 0.292; CFI = 0.642; and TLI = 0.499. Standardized factor loadings ranged from $\lambda = 0.299$ to 0.877. However, there was a clear dichotomy between stable-worded questions (i.e. questions 40, 41, 43 and 45) and malleable-worded question (i.e. questions 42, 44, 46, and 47) with factor loading ranges of $\lambda = 0.299$ to 0.488 and $\lambda = 0.738$ to 0.877, respectively.

The dichotomy indicated that a 2nd-order model of stability consisting of correlated "stable belief" and "malleable belief" factors was appropriate. Factor analysis of this two-factor model (Figure 31) displayed substantially improved model fit of $\chi^2_{df=19} = 121.39$, $p < 0.001$; RMSEA = 0.116; CFI = 0.947; and TLI = 0.921. Additionally, standardized factor loadings for stable belief ranged from $\lambda = 0.581$ to 0.843 with reliability measures of Cronbach's $\alpha = 0.848$ and McDonald's $\omega = 0.927$. Standardized factor loadings for malleable belief ranged from $\lambda = 0.730$ to 0.900 with reliability measures of Cronbach's $\alpha = 0.903$ and McDonald's $\omega = 0.965$.

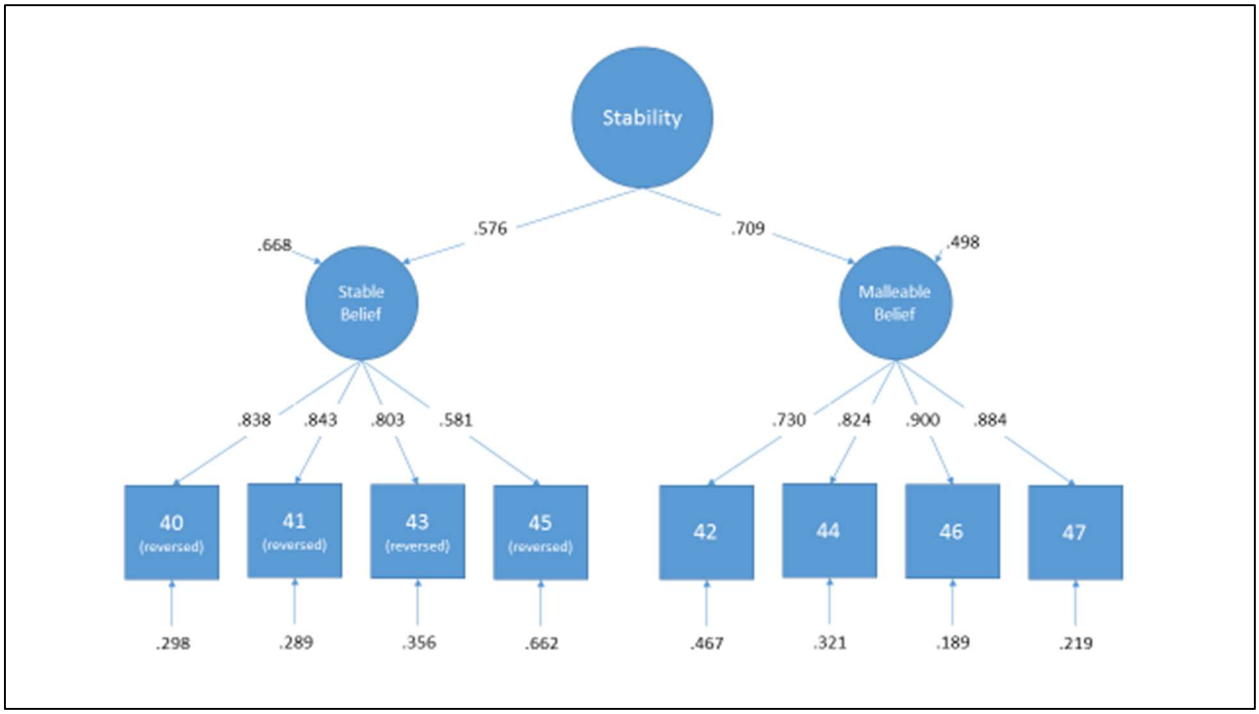


*Figure 31. Stability CFA.*

***Internal locus of control.*** Internal locus of control is measured by questions 22, 27, 29, 33, 34, and 38 of the survey instrument. All items were significantly correlated (range: $\rho = 0.258$ to 0.528) and the item set displayed good internal reliability: Cronbach's $\alpha = 0.801$ and McDonald's $\omega = 0.861$. Initial CFA resulted in fit statistics of $\chi^2_{df=9} = 74.937$, $p < 0.001$; RMSEA = 0.135; CFI = 0.901; and TLI = 0.835, and standardized factor loadings of $\lambda = 0.561$ to 0.679.

Evaluation of modification indices suggested a correlation of questions 22 and 27. The resulting model (Figure 32) produced a substantially better model fit of $\chi^2_{df=8} = 35.104$, $p < 0.001$; RMSEA = 0.092; CFI = 0.959; and TLI = 0.924. Standardized factor loadings ranged from $\lambda = 0.485$ to 0.706.

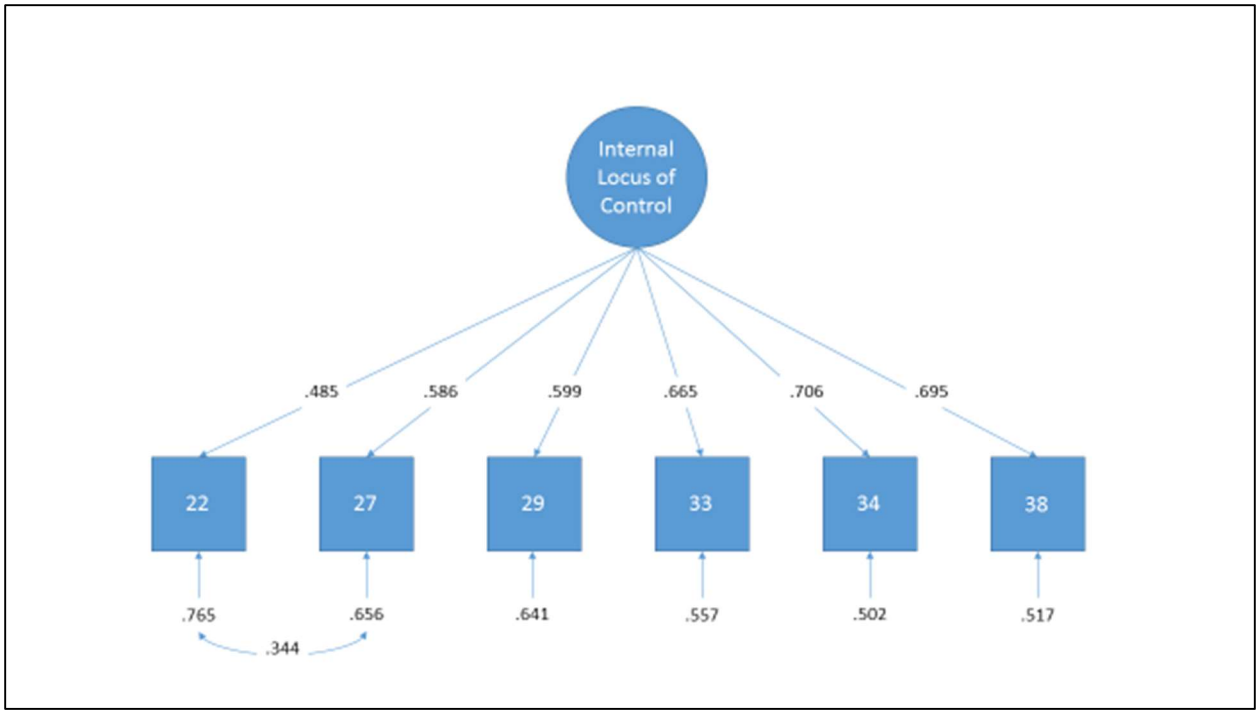


*Figure 32. Internal locus of control CFA.*

**Theoretical Structural Equation Models**

Upon completion of the analyses of individual constructs, structural equation models for each theory were constructed for each screening modality as well as colorectal cancer screening in general. All final models for both steps of the Anderson and Gerbing (1988) process are summarized in Tables 8 and 9.

*Table 8. Confirmatory factor analyses models information.*

| Theory | Construct | # of items | Response Format | Measurement Model | Model Modification |
|---|---|---|---|---|---|
| Health Belief Model | Perceived Benefits | 6 | 5-point Likert items | One-Factor Model | Correlated Residuals (60,61); (63,64) |
| | Perceived Barries | 5 | 5-point Likert items | One-Factor Model | Dropped 67 |
| | Perceived Susceptibility | 5 | 5-point Likert items | One-Factor Model | N/A |
| | Perceived Severity | 6 | 5-point Likert items | 2nd Order Model | Dropped 57; Split items into two factors (53-55) & (56,58-59) |
| | (Immediate) | (3) | | | |
| | (Long Term) | (3) | | | |
| Theory of Reasoned Action | Attitudes | 6 | Product of two 7-point Likert items | One-Factor Model | Dropped 7 & 8; Correlated Residuals (1,2); (3,6) |
| | Subjective Norms | 5 | Product of two 7-point Likert items | One-Factor Model | Correlated Residuals (11,12) |
| Theory of Planned Behavior | Perceived Behavioral Control | 8 | Product of two 7-point Likert items | One-Factor Model | N/A |
| Attribution Theory | Stability | 8 | 6-point Likert items | 2nd Order Model | Split items into two factors (40-41, 43, 45) & (42, 44, 46-47) |
| | (Stable) | (4) | | | |
| | (Malleable) | (4) | | | |
| | Internal Locus of Control | 6 | 6-point Likert items | One-Factor Model | Correlated Residuals (22, 27) |

*Table 8 cont.*

| Theory | Construct | Chi-Square (df) | p< | RMSEA | CFI | TLI | Cronbach Alpha | McDonald Omega | Variable (Standardized FL) |
|---|---|---|---|---|---|---|---|---|---|
| Health Belief Model | Perceived Benefits | 16.898 (7) | 0.018 | 0.059 | 0.994 | 0.987 | 0.908 | 0.957 | 60(.778); 61(.710); 62(.878); 63(.739); 64(.704); 65(.862) |
| | Perceived Barries | 15.215 (5) | 0.010 | 0.071 | 0.986 | 0.971 | 0.824 | 0.902 | 66(.572); 68(.820); 69(.793); 70(.727); 71(.598) |
| | Perceived Susceptibility | 48.76 (5) | 0.001 | 0.147 | 0.978 | 0.957 | 0.948 | 0.987 | 48(.855); 49(.934); 50(.942); 51(.856); 52(.834) |
| | Perceived Severity | 28.506 (8) | 0.001 | 0.080 | 0.975 | 0.954 | | | Immediate(.761); Long Term(.825) |
| | (Immediate) | | | | | | 0.836 | 0.917 | 53(.722); 54(.858); 55(.811); |
| | (Long Term) | | | | | | 0.687 | 0.822 | 56(.725); 58(.728); 59(.513); |
| Theory of Reasoned Action | Attitudes | 29.595 (7) | 0.001 | 0.089 | 0.960 | 0.914 | 0.753 | 0.794 | 1(.358); 2(.422); 3(.453); 4(.828); 5(.692); 6(.576) |
| | Subjective Norms | 18.777 (4) | 0.001 | 0.096 | 0.987 | 0.966 | 0.892 | 0.945 | 9(.833); 10(.946); 11(.783); 12(.646); 13(.684) |
| Theory of Planned Behavior | Perceived Behavioral Control | 157.77 (20) | 0.001 | 0.131 | 0.959 | 0.943 | 0.950 | 0.982 | 14(.682); 15(.906); 16(.922); 17(.896); 18(.927); 19(.851); 20(.921); 21(.651) |
| Attribution Theory | Stability | 121.39 (19) | 0.001 | 0.116 | 0.947 | 0.921 | | | Stable(.576); Malleable(.709) |
| | (Stable) | | | | | | 0.848 | 0.927 | 40(.838); 41(.843); 43(.803); 45(.581); |
| | (Malleable) | | | | | | 0.903 | 0.965 | 42(.730); 44(.824); 46(.900); 47(.884); |
| | Internal Locus of Control | 35.104 (8) | 0.001 | 0.092 | 0.959 | 0.924 | 0.801 | 0.861 | 22(.485); 27(.586); 29(.599); 33(.665); 34(.706); 38(.695) |

*Table 9. Structural equation models information.*

| Theory | Screening Modality | Chi-Square (df) | p< | RMSEA | CFI | TLI | Screening Intention $R^2$ | Past Behavior $R^2$ |
|---|---|---|---|---|---|---|---|---|
| HBM | General | 971.587 (343) | 0.001 | 0.068 | 0.897 | 0.882 | 0.818 | |
| | Colonoscopy | 999.978 (383) | 0.001 | 0.063 | 0.898 | 0.883 | 0.723 | |
| | Sigmoidoscopy | 1050.293 (383) | 0.001 | 0.066 | 0.888 | 0.872 | 0.120 | |
| | FOBT/FIT | 976.992 (343) | 0.001 | 0.068 | 0.893 | 0.878 | 0.171 | |
| Theory of Reasoned Action | General | 233.159 (60) | 0.001 | 0.085 | 0.915 | 0.890 | 0.326 | 0.219 |
| | Colonoscopy | 240.612 (60) | 0.001 | 0.086 | 0.910 | 0.883 | 0.270 | 0.202 |
| | Sigmoidoscopy | 153.209 (60) | 0.001 | 0.062 | 0.948 | 0.932 | 0.115 | N.S. |
| | FOBT/FIT | 153.646 (60) | 0.001 | 0.062 | 0.949 | 0.933 | 0.121 | 0.127 |
| Theory of Planned Behavior | General | 652.332 (180) | 0.001 | 0.081 | 0.918 | 0.905 | 0.463 | 0.232 |
| | Colonoscopy | 646.365 (180) | 0.001 | 0.080 | 0.919 | 0.905 | 0.381 | 0.215 |
| | Sigmoidoscopy | 606.273 (180) | 0.001 | 0.077 | 0.922 | 0.909 | 0.120 | 0.042 |
| | FOBT/FIT | 621.535 (180) | 0.001 | 0.078 | 0.920 | 0.907 | 0.136 | 0.132 |
| Attribution Theory | General | 362.243 (86) | 0.001 | 0.089 | 0.903 | 0.882 | 0.118 | |
| | Colonoscopy | 347.497 (86) | 0.001 | 0.087 | 0.908 | 0.887 | 0.122 | |
| | Sigmoidoscopy | 326.354 (86) | 0.001 | 0.083 | 0.915 | 0.896 | 0.138 | |
| | FOBT/FIT | 339.385 (86) | 0.001 | 0.086 | 0.910 | 0.890 | 0.077 | |

**Health Belief Model.** The models associated with Health Belief Model include constructs of perceived benefits, barriers, severity, and susceptibility; sociodemographics; and behavioral intentions. The intersection of perceived severity and susceptibility represent the perceived threat of colorectal cancer. Perceived threat of colorectal cancer and the beneficial balance of perceived benefits and barriers to screening explain behavioral intention.

The Health Belief Model also includes the influence of sociodemographics on perceived benefits, barriers, severity, and susceptibility. To determine which sociodemographics to include

in each model, a primary model including all sociodemographics assessed through the instrument were included. Sociodemographic variables significantly influencing one or more constructs were retained in a final model. This procedure was performed independently for general screening intentions and each screening modality.

***General colorectal cancer screening.*** The model of general screening intention (Figure 33) retained six sociodemographic factors: perceived health status, risk status, previous diagnosis of polyps, previous diagnosis of another cancer, sex, and income. The model's fit statistics include: $\chi^2_{df=343} = 971.587$, $p < 0.001$; RMSEA = 0.068; CFI = 0.897; and TLI = 0.882. The variance of general colorectal cancer screening intention explained by the model is $R^2 = 0.818$.

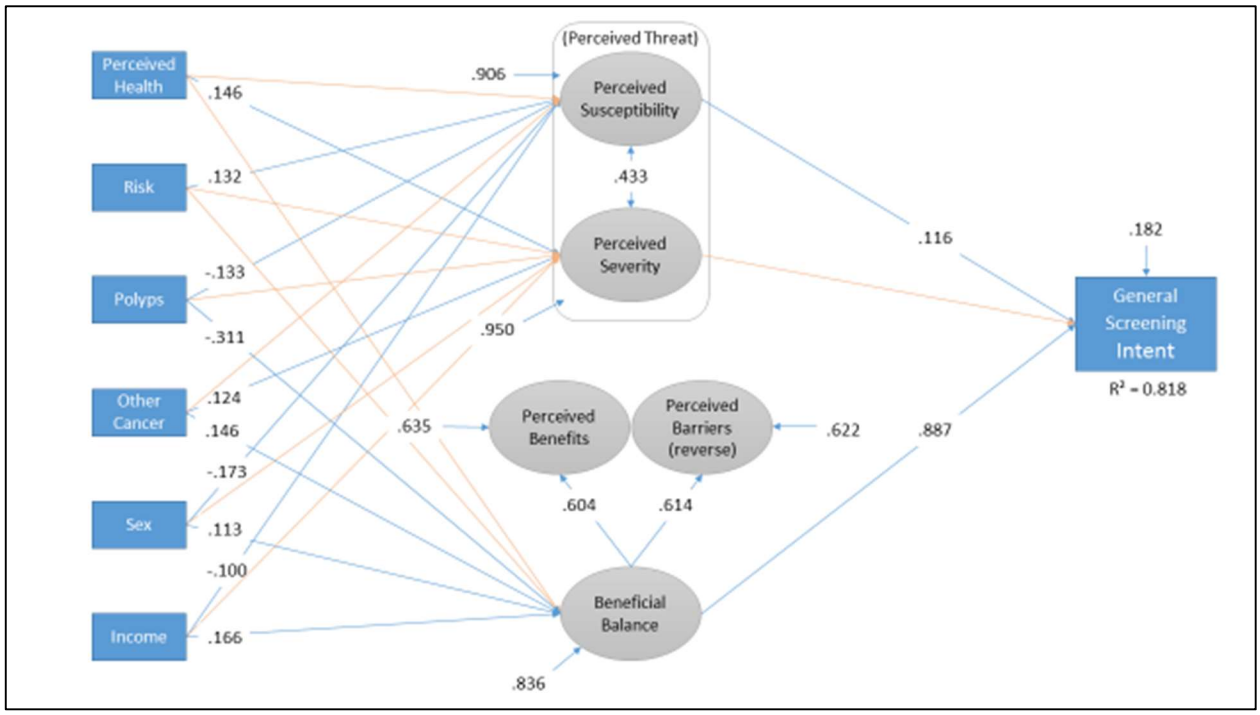


*Figure 33. General CRC screening SEM: Health Belief Model.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

Perceived health was associated with perceived severity such that as one's perception of his/her health worsened, his or her perceived severity of colorectal cancer increased. Risk status of the individual was associated with perceived susceptibility such that greater risk was associated with more severe perceived susceptibility. A previous diagnosis of polyps was

associated with both increased perceived susceptibility and more positive beneficial balance. A previous diagnosis of another cancer was negatively associated with both perceived severity and beneficial balance. Sex was associated with perceived susceptibility and beneficial balance such that being male was associated with greater perceived susceptibility and being female as associated with more positive beneficial balance. Finally, income was negatively associated with perceived susceptibility and positively associated with beneficial balance.

Both perceived susceptibility and beneficial balance were positively associated with general screening intention. However, perceived severity was not significantly associated with intention.

***FOBT/FIT.*** The model associated with FOBT/FIT screening intention (Figure 34) retained six sociodemographic factors as well: perceived health status, risk status, previous diagnosis of polyps, previous diagnosis of another cancer, age, and sex. The model's fit statistics include: $\chi^2_{df=343} = 976.992$, $p < 0.001$; RMSEA = 0.068; CFI = 0.893; and TLI = 0.878. The variance of FOBT/FIT screening intention explained by the model is $R^2 = 0.171$.

Perceived health status was associated with all HBM constructs such that worse perceived health was positively associated with perceived susceptibility, severity, and beneficial balance. Higher risk status was positively associated with perceived susceptibility. A previous diagnosis of polyps was positively associated with perceived susceptibility and beneficial balance. Diagnosis of another form of cancer, while significantly associated with constructs in the preliminary model, was not significantly associated with any constructs in the final model. Age was positively associated with beneficial balance. Finally, being male was associated with greater perceived susceptibility.

Perceived threat – both perceived susceptibility and severity – was not associated with FOBT/FIT screening intention. Beneficial balance was positively associated with screening intention using FOBT/FIT.

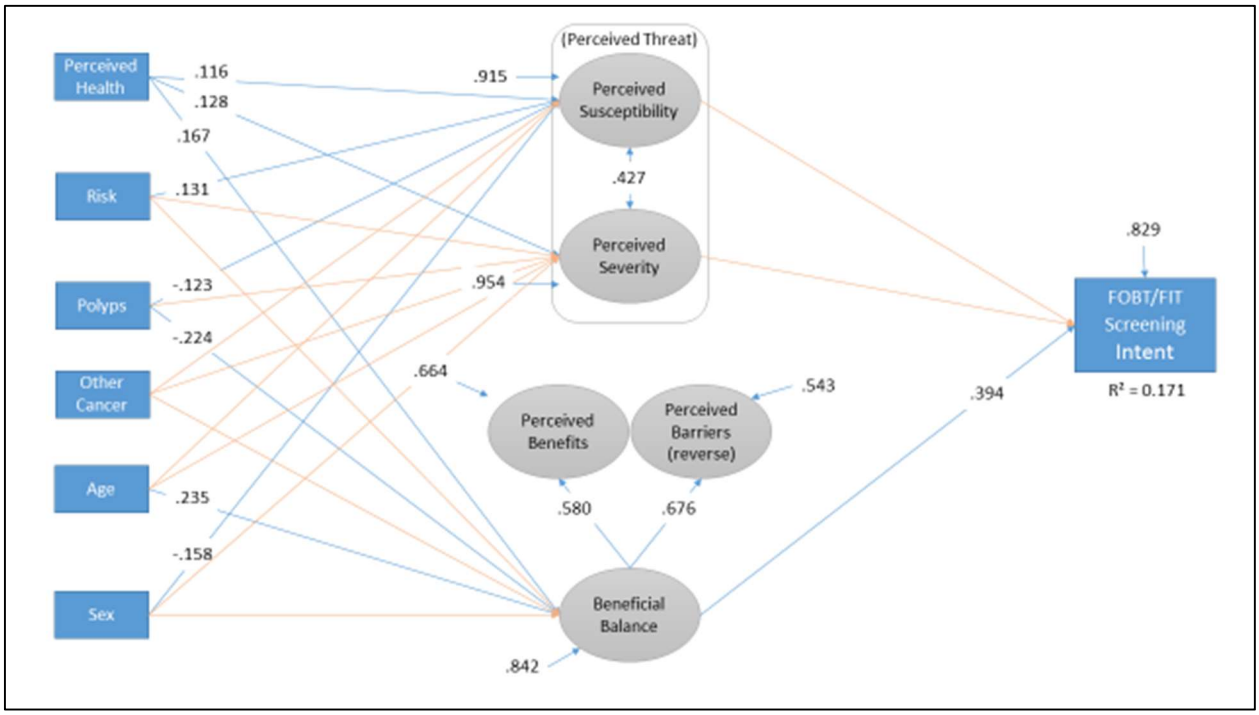


*Figure 34. FOBT/FIT SEM: Health Belief Model.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

***Sigmoidoscopy.*** The model of sigmoidoscopy screening intention (Figure 35) retained seven sociodemographic factors: perceived health status, risk status, previous diagnosis of polyps, previous diagnosis of another cancer, age, sex, and race. The model's fit statistics include: $\chi^2_{df=343} = 1050.293$, $p < 0.001$; RMSEA = 0.066; CFI = 0.888; and TLI = 0.872. The variance of sigmoidoscopy screening intention explained by the model is $R^2 = 0.120$.

A worse perceived health was positively associated with perceived threat – both susceptibility and severity, while negatively associated with beneficial balance. A higher risk status was associated with greater perceived susceptibility. The diagnosis of polyps was associated with greater perceived susceptibility and beneficial balance. Diagnosis of another

cancer, similar to the FOBT/FIT model, was not significant with any constructs in the final sigmoidoscopy model. Age was positively associated with beneficial balance. Being male was associated with greater perceived susceptibility. Finally, being African American compared to White was associated with greater beneficial balance.

Beneficial balance as well as perceived susceptibility were positively associated with sigmoidoscopy screening intention. However, perceived severity was not associated with intention.

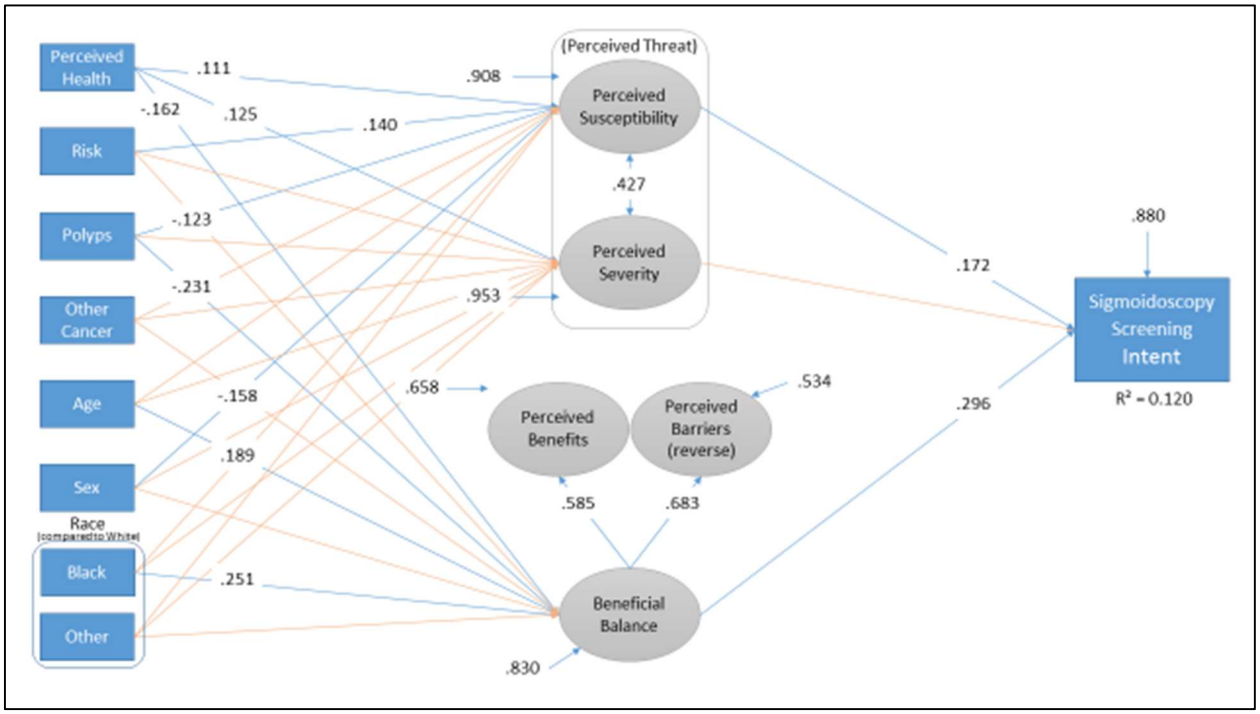


*Figure 35. Sigmoidoscopy SEM: Health Belief Model.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

***Colonoscopy.*** The colonoscopy screening intention model (Figure 36) also retained seven sociodemographic factors: perceived health status, risk status, previous diagnosis of polyps, previous diagnosis of another cancer, sex, income, and race. The model's fit statistics include: $\chi^2_{df=343} = 999.978$, $p < 0.001$; RMSEA = 0.063; CFI = 0.898; and TLI = 0.883. The variance of colonoscopy screening intention explained by the model is $R^2 = 0.723$.

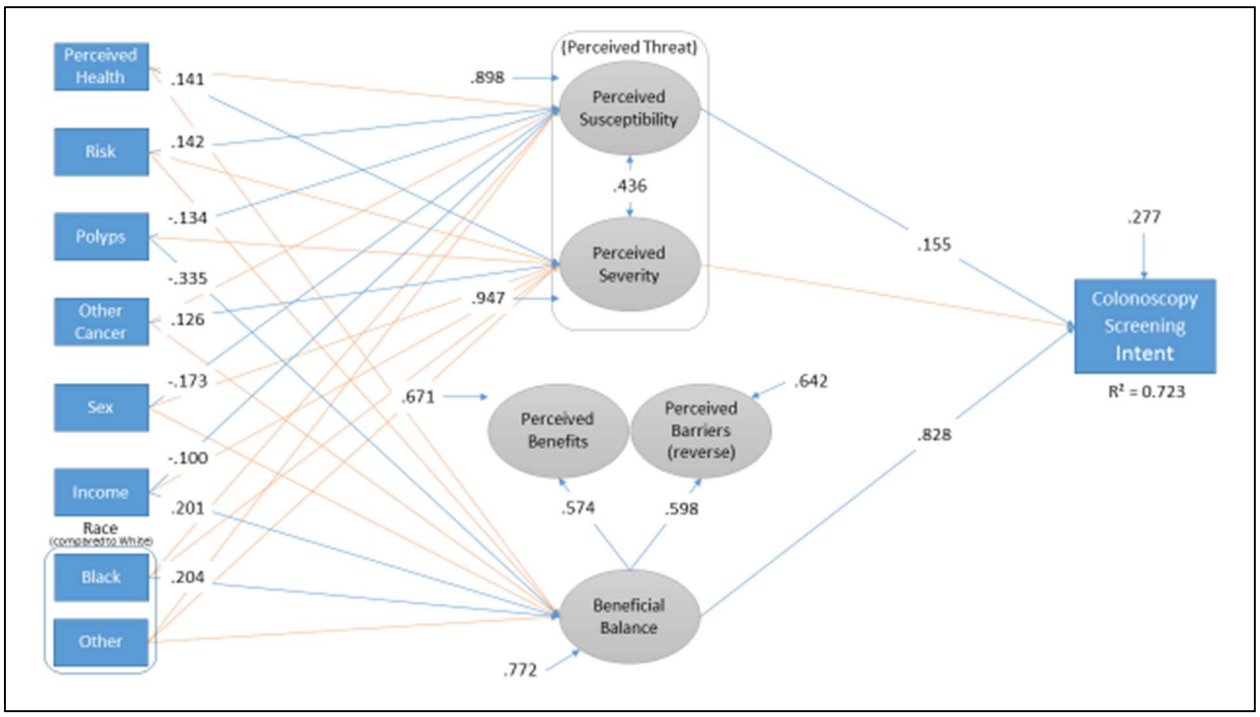


*Figure 36. Colonoscopy SEM: Health Belief Model.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

A worse perceived health status was positively associated with perceived severity. Greater risk status was positively associated with perceived susceptibility. The previous diagnosis of polyps was positively associated with perceived susceptibility and beneficial balance. The diagnosis of another cancer was negatively associated with perceived severity. As with the other models, being male was positively associated with perceived susceptibility. Income was negatively associated with perceived susceptibility while positively associated with

beneficial balance. Finally, similar to the sigmoidoscopy model, being African American compared to White was positively associated with beneficial balance.

As with the majority of the Health Belief Model models, perceived susceptibility and beneficial balance were positively associated with colonoscopy screening intention while perceived severity was not significant.

**Theory of Reasoned Action.** The Theory of Reasoned Action models include the correlated constructs of attitudes and subjective norms explaining screening intention. In turn, screening intention explains screening behavior. Due to the cross-sectional nature of the study, previous screening behaviors were used to represent screening behavior (Ajzen, 1991). For the general screening model, general adherence was used to represent screening behavior. For modality-specific models, time since screening was used as previously described (Table 5).

***General colorectal cancer screening.*** The general colorectal cancer screening model is depicted in Figure 37. Fit statistics of the model are the following: $\chi^2_{df=60} = 233.159$, $p < 0.001$; RMSEA = 0.085; CFI = 0.915; and TLI = 0.890. The variances explained by the model for general colorectal cancer screening and behavior are $R^2 = 0.326$ and $R^2 = 0.219$, respectively. Attitudes and subjective norms were significantly, positively correlated. Subjective norms was positively associated with general screening intentions. Additionally, screening intentions were positively associated with observed screening behavior. Attitudes were not significantly associated with intentions.

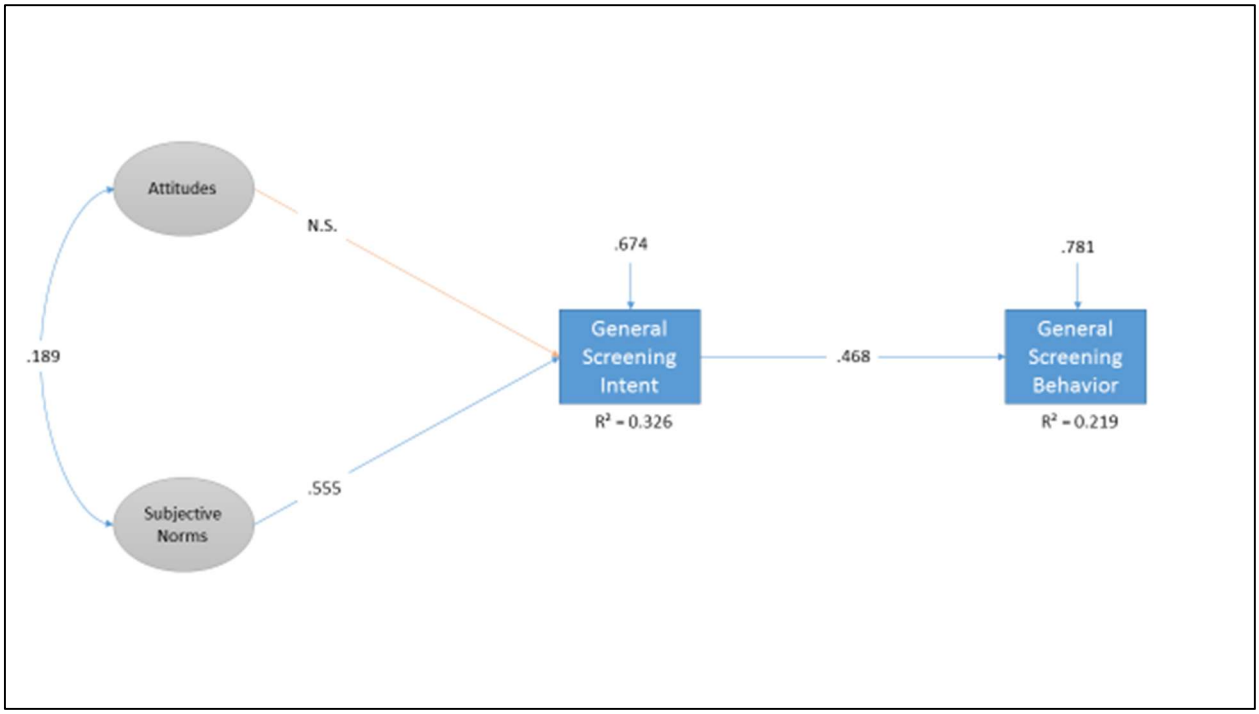


*Figure 37. General CRC screening SEM: Theory of Reasoned Action.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

***FOBT/FIT.*** The FOBT/FIT screening model is depicted in Figure 38. Fit statistics of the model are the following: $\chi^2_{df=60} = 153.646$, $p < 0.001$; RMSEA = 0.062; CFI = 0.949; and TLI = 0.933. The variances explained by the model for FOBT/FIT screening and behavior are $R^2 = 0.121$ and $R^2 = 0.127$, respectively. Attitudes and subjective norms were significantly, positively correlated. All pathways in the model were significant and positively associated.

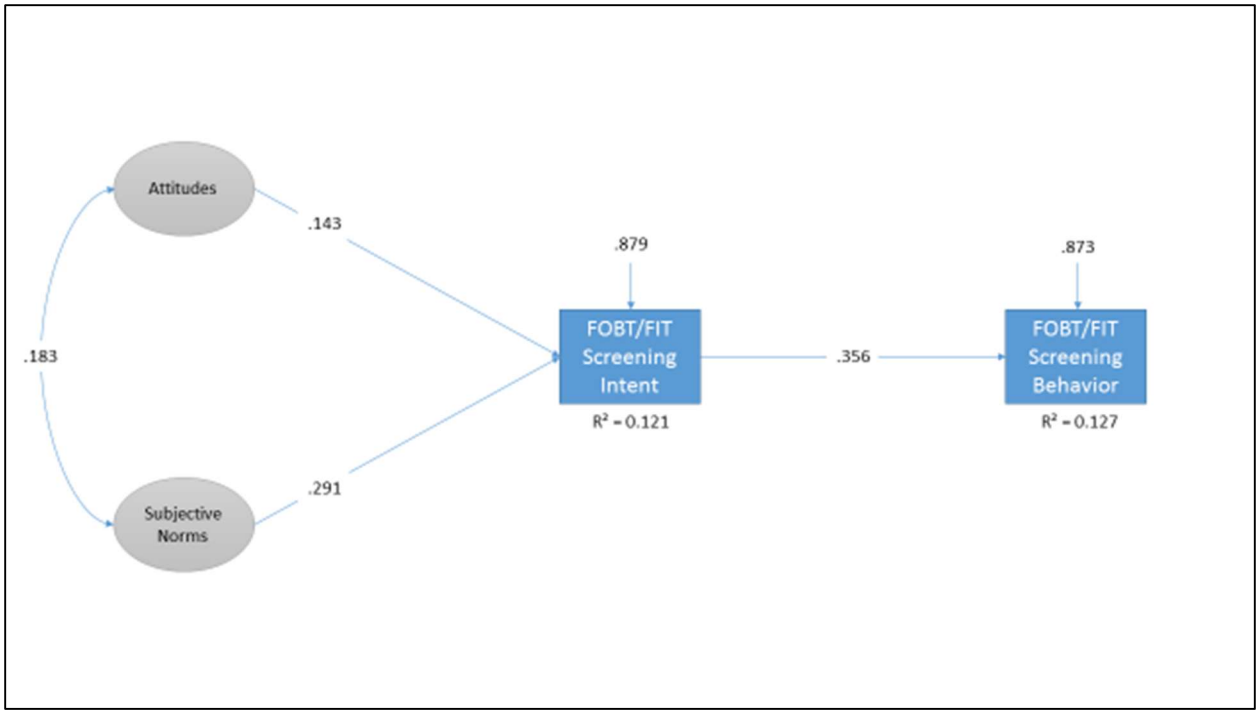


*Figure 38. FOBT/FIT SEM: Theory of Reasoned Action.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

***Sigmoidoscopy.*** The sigmoidoscopy screening model is depicted in Figure 39. Fit statistics of the model are the following: $\chi^2_{df=60} = 153.209$, $p < 0.001$; RMSEA = 0.062; CFI = 0.948; and TLI = 0.932. The variance explained by the model for sigmoidoscopy screening is $R^2 = 0.115$. The variance explained for previous sigmoidoscopy behavior was not significant. Attitudes and subjective norms were significantly, positively correlated. All pathways in the model were also significant and positively associated.

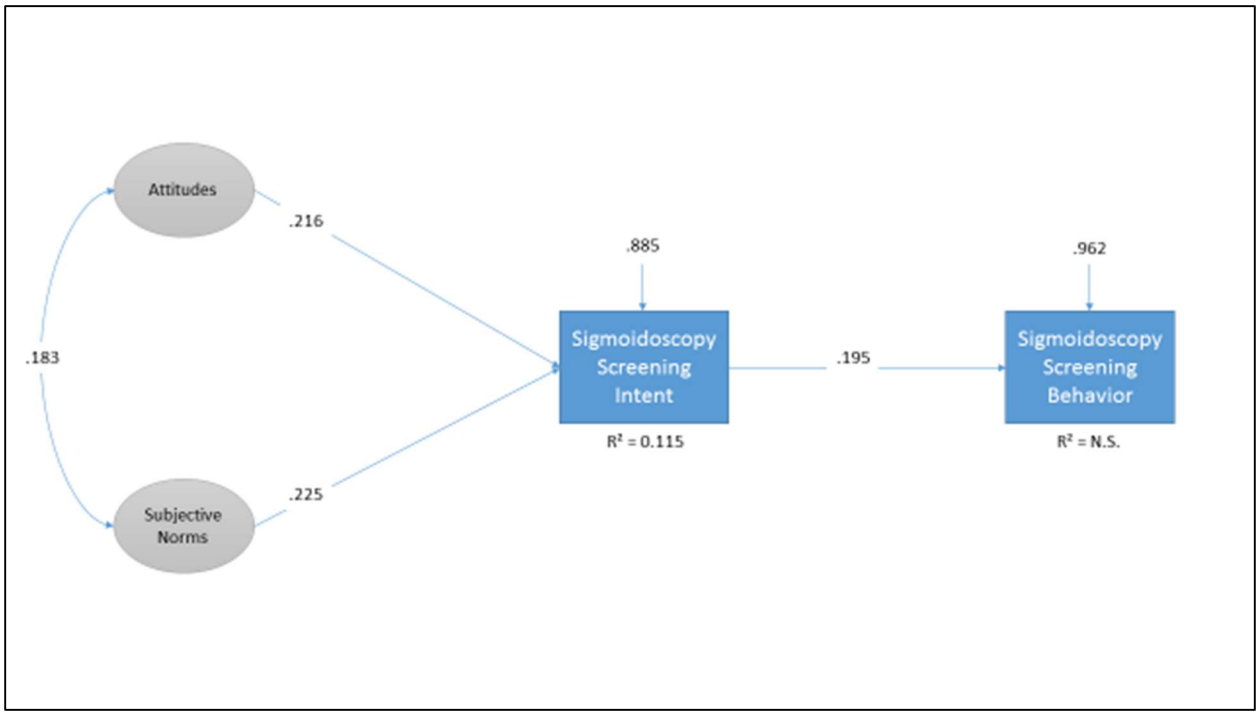


*Figure 39. Sigmoidoscopy SEM: Theory of Reasoned Action.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

***Colonoscopy.*** The colonoscopy screening model is depicted in Figure 40. Fit statistics of the model are the following: $\chi^2_{df=60} = 240.612$, $p < 0.001$; RMSEA = 0.086; CFI = 0.910; and TLI = 0.883. The variances explained by the model for colonoscopy screening and behavior are $R^2 = 0.270$ and $R^2 = 0.202$, respectively. Attitudes and subjective norms were significantly, positively correlated. As with the other screening modalities, all pathways in the model were significant and positively associated.

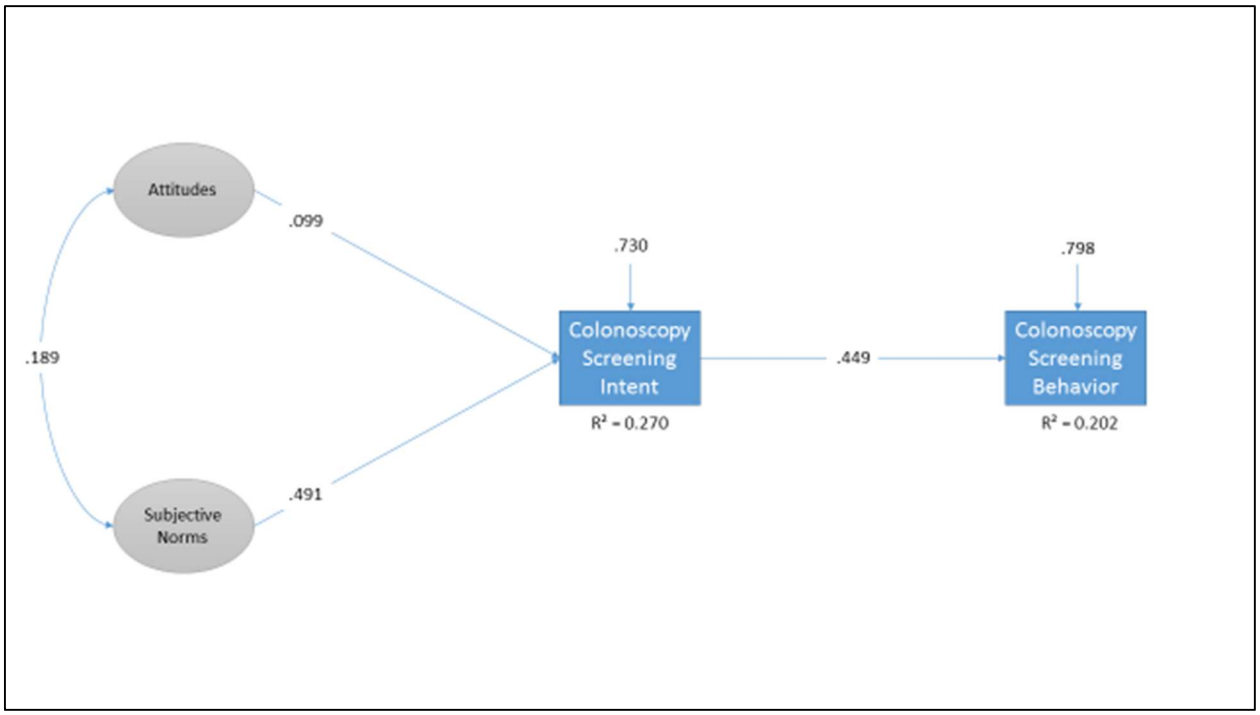


*Figure 40. Colonoscopy SEM: Theory of Reasoned Action.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

**Theory of Planned Behavior.** The Theory of Planned Behavior models retain all pathways of the Theory of Reasoned Action models. Additionally, the construct of Perceived Behavioral Control is included. This construct is modeled with correlations with attitudes and subjective norms. Also, the model tests both a direct pathway to observed screening behavior and an indirect pathway through screening intent.

***General colorectal cancer screening.*** The general colorectal cancer screening model is depicted in Figure 41. Fit statistics of the model are the following: $\chi^2_{df=180} = 652.332$, $p < 0.001$; RMSEA = 0.081; CFI = 0.918; and TLI = 0.905. The variances explained by the model for general colorectal cancer screening and behavior are $R^2 = 0.463$ and $R^2 = 0.232$, respectively. Attitudes and subjective norms were significantly, positively correlated as were subjective norms and perceived behavior control. The correlation between attitudes and perceived behavioral control was not significant. Both subjective norms and perceived behavioral control were

positively associated with general screening intentions. However, attitudes were not significant. The direct pathway of perceived behavioral control with screening behavior was also significant and positive. Finally, screening intention was positively associated with observed screening behavior.

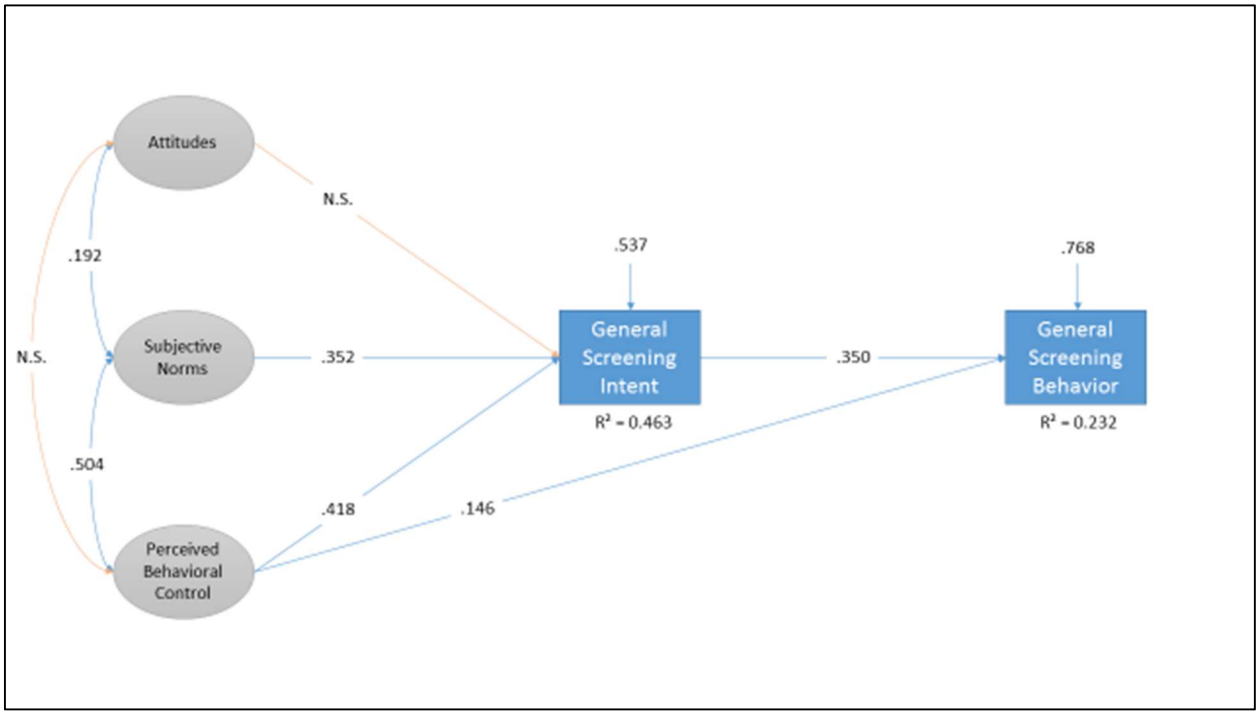


*Figure 41. General CRC screening SEM: Theory of Planned Behavior.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

***FOBT/FIT.*** The FOBT/FIT screening modality model is depicted in Figure 42. Fit statistics of the model are the following: $\chi^2_{df=180} = 621.535$, $p < 0.001$; RMSEA = 0.078; CFI = 0.920; and TLI = 0.907. The variances explained by the model for FOBT/FIT screening and behavior are $R^2 = 0.136$ and $R^2 = 0.132$, respectively. Again, attitudes and subjective norms were significantly, positively correlated as were subjective norms and perceived behavior control, but the correlation between attitudes and perceived behavioral control was not significant. All constructs were significantly and positively associated with FOBT/FIT screening intention. Also,

screening intentions was positively associated with observed screening behavior. However, the direct pathway of perceived behavioral control with screening behavior was not significant.

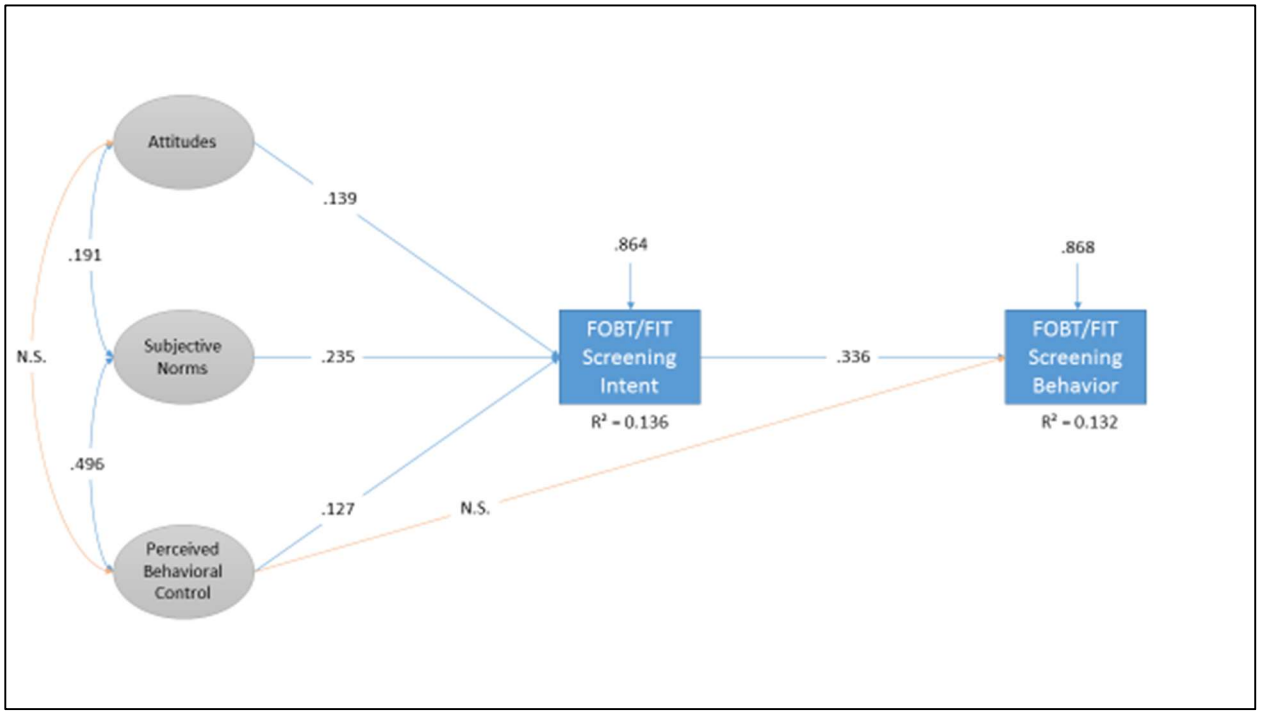


*Figure 42. FOBT/FIT SEM: Theory of Planned Behavior.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

***Sigmoidoscopy.*** The sigmoidoscopy screening model is depicted in Figure 43. Fit statistics of the model are the following: $\chi^2_{df=180} = 606.273$, $p < 0.001$; RMSEA = 0.077; CFI = 0.922; and TLI = 0.909. The variances explained by the model for sigmoidoscopy screening and behavior are $R^2 = 0.120$ and $R^2 = 0.042$, respectively. As with the other models, the correlation between attitudes and perceived behavioral control was not significant, while attitudes and subjective norms were significantly, positively correlated as were subjective norms and perceived behavior control. Both subjective norms and attitudes were positively associated with general screening intentions. However, perceived behavioral control was not significant with either screening intention or observed behavior. Finally, screening intentions was positively associated with observed screening behavior.

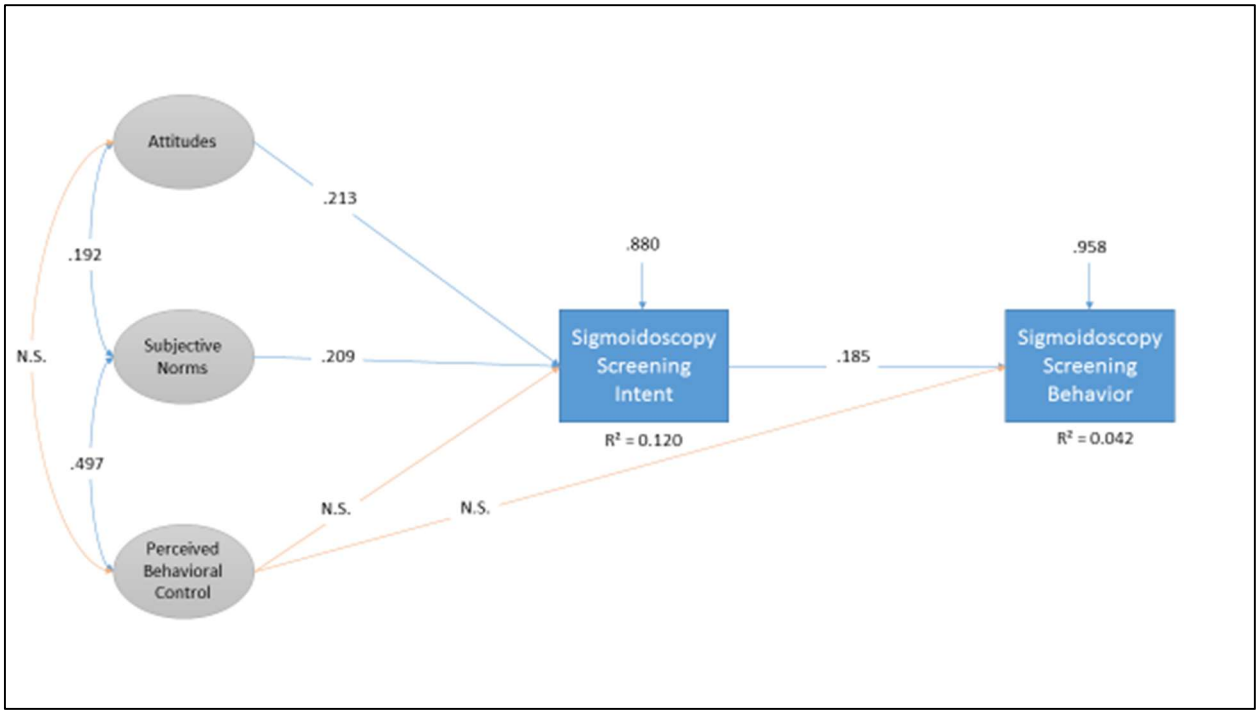


*Figure 43. Sigmoidoscopy SEM: Theory of Planned Behavior.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

***Colonoscopy.*** The model for colonoscopy screening is depicted in Figure 44. Fit statistics of the model are the following: $\chi^2_{df=180} = 646.365$, $p < 0.001$; RMSEA = 0.080; CFI = 0.919; and TLI = 0.905. The variances explained by the model for colonoscopy screening and behavior are $R^2 = 0.381$ and $R^2 = 0.215$, respectively. Again, the correlation between attitudes and perceived behavioral control was not significant, while the correlations between attitudes and subjective norms as well as subjective norms and perceived behavior control were significantly, positively correlated. All pathways in the model were significant and positive.

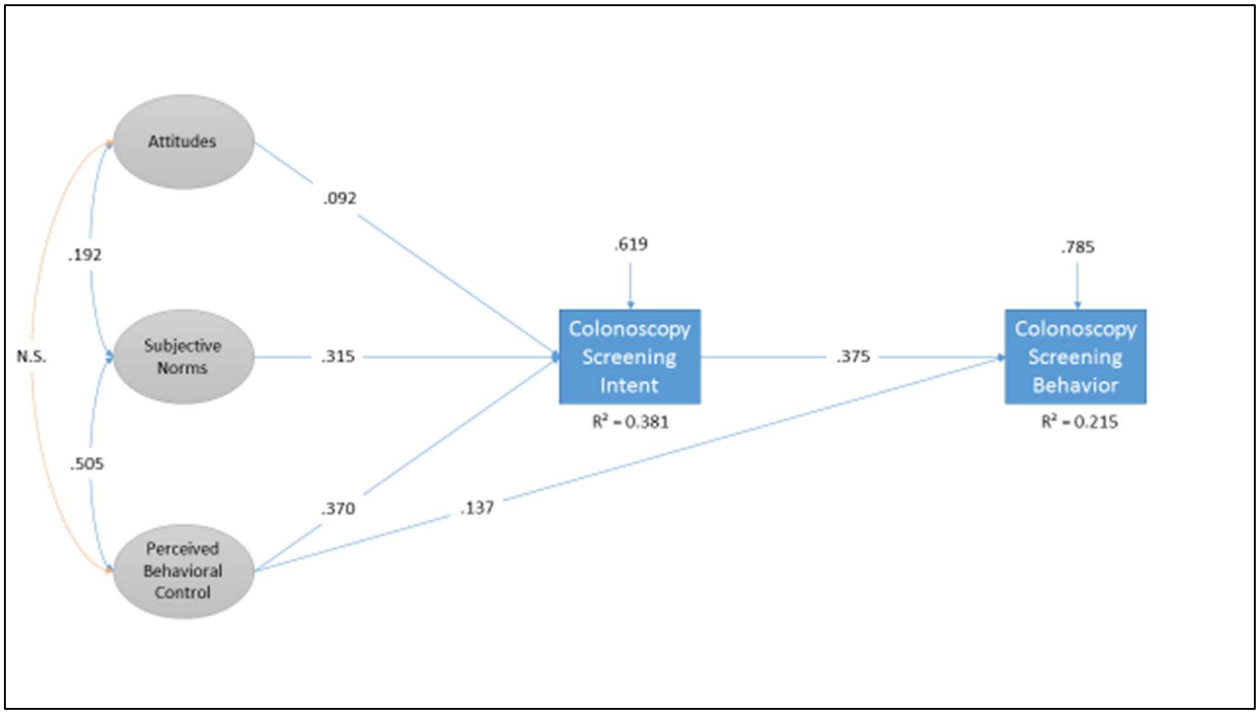


*Figure 44. Colonoscopy SEM: Theory of Planned Behavior.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

**Attribution Theory.** The Attribution Theory models are comprised of the stability and internal locus of control constructs. Stability is defined as a two-dimensional construct as a result of the CFA analysis performed during the first step of model construction. The models assert that the intersection of the two constructs explain screening intention.

***General colorectal cancer screening.*** The general colorectal cancer screening is depicted in Figure 45. Fit statistics of the model are the following: $\chi^2_{df=86} = 362.243$, $p < 0.001$; RMSEA = 0.089; CFI = 0.903; and TLI = 0.882. The variance of general colorectal cancer screening intention explained by the model is $R^2 = 0.118$. Stability and internal locus of control were significantly, positively correlated. However, only stability was significantly, and positively associated with screening intention. Internal locus of control was not significant.

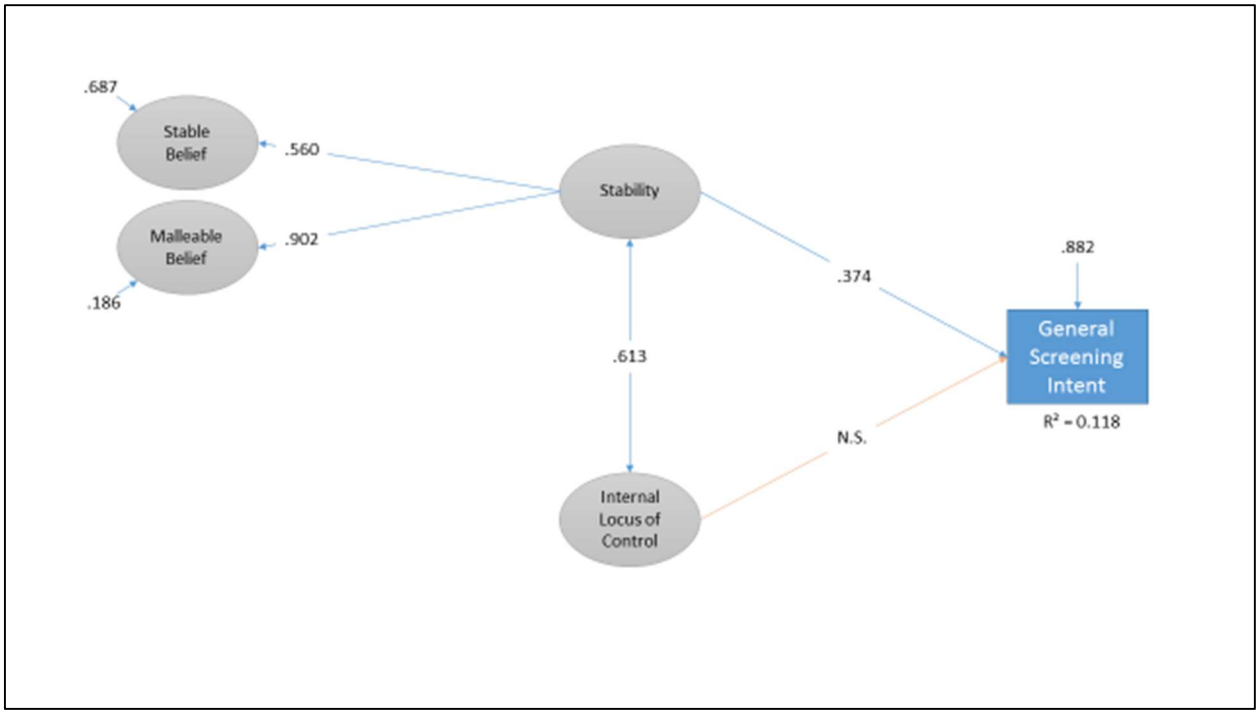


*Figure 45. General CRC screening SEM: Attribution Theory.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

***FOBT/FIT.*** The FOBT/FIT cancer screening is depicted in Figure 46. Fit statistics of the model are the following: $\chi^2_{df=86} = 339.385$, $p < 0.001$; RMSEA = 0.086; CFI = 0.910; and TLI = 0.890. The variance of FOBT/FIT screening intention explained by the model is $R^2 =$ 0.077.Again, stability and internal locus of control were significantly, positively correlated. Only stability was significantly and positively associated with FOBT/FIT use intention, while internal locus of control was not significant.

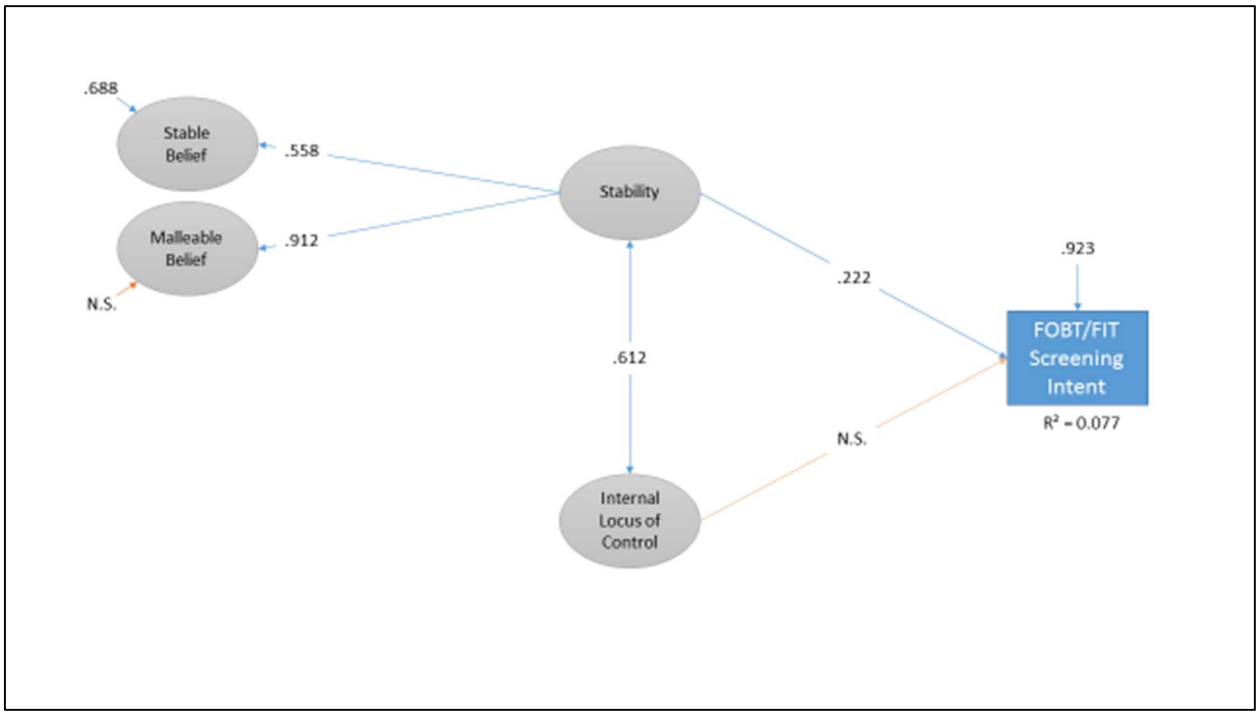


*Figure 46. FOBT/FIT SEM: Attribution Theory.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

***Sigmoidoscopy.*** The sigmoidoscopy screening model is depicted in Figure 47. Fit statistics of the model are the following: $\chi^2_{df=86} = 326.354$, $p < 0.001$; RMSEA = 0.083; CFI = 0.915; and TLI = 0.896. The variance of sigmoidoscopy screening intention explained by the model is $R^2 = 0.138$.The positive correlation between stability and internal locus of control was, again, significant. Additionally, the sigmoidoscopy use model was the only one of the four Attribution Theory models where both stability and internal locus of control were significantly and positively associated with screening intention.

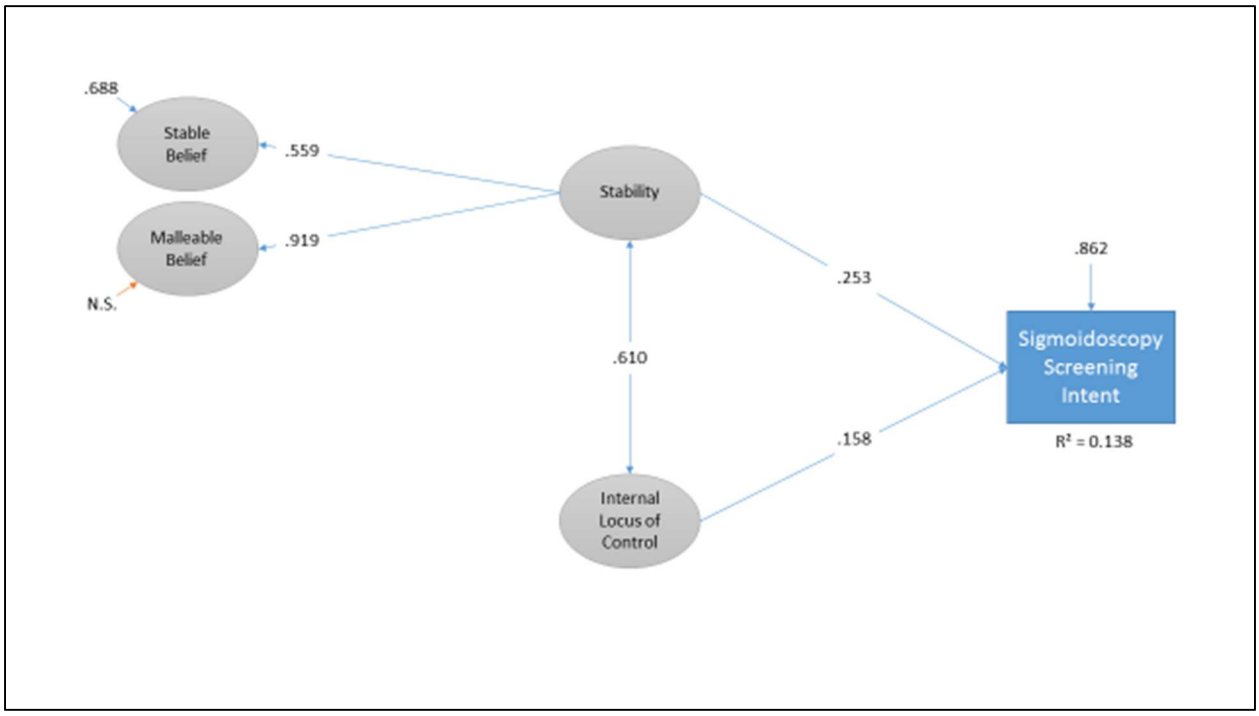


*Figure 47. Sigmoidoscopy SEM: Attribution Theory.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

***Colonoscopy.*** The model for colonoscopy screening use is depicted in Figure 48. Fit statistics of the model are the following: $\chi^2_{df=86} = 347.497$, $p < 0.001$; RMSEA = 0.087; CFI = 0.908; and TLI = 0.887. The variance of colonoscopy screening intention explained by the model is $R^2 = 0.122$. As with all other Attribution Theory models, stability and internal locus of control remained significantly and positively correlated. As with the general and FOBT/FIT models, only stability was significantly and positively associated with screening intention while internal locus of control was not significant.

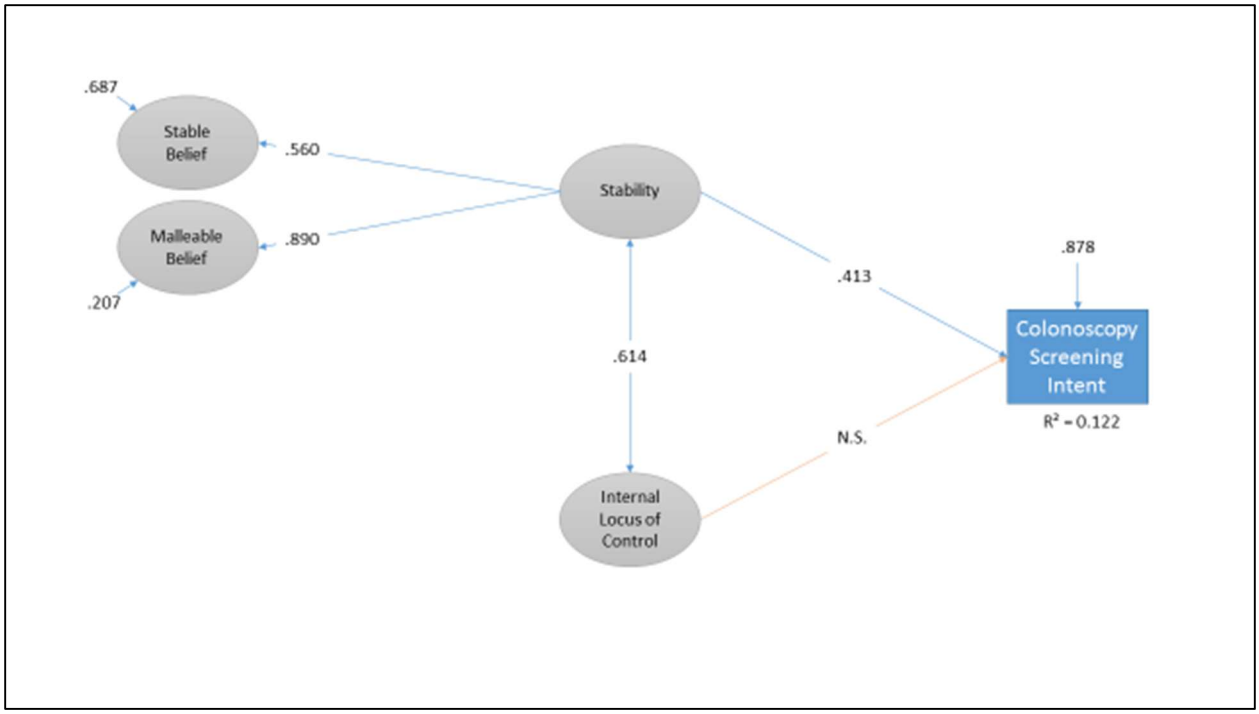


*Figure 48. Colonoscopy SEM: Attribution Theory.*
*Note: Sociodemographic correlations and manifest variables for latent constructs not show.*

# Discussion

## Model Analyses

**Confirmatory Factor Analyses.** Each construct of the theories evaluated were measured separately using three to eight items of the survey instrument. The original measures included or adapted to be used in the survey instrument have been validated and shown reliable in previous studies. Nevertheless, confirmatory factor analyses of the items provide additional support for the ability of the measures to reliably assess the constructs. The confirmatory factor analysis model for each construct indicates how well the items represent the given construct based on model fit statistics and item factor loadings. Ideally, the CFA models should indicate good fit without any modification as these measures have been previously established and determined reliable as used. However, necessary modifications were made to models in order to ensure that the constructs were estimated as effectively as possible.

The majority of the constructs measured did require some degree of modification to their models to improve fit. In all instances, $\chi^2$ were significant, suggesting poor fit. This may have occurred, in part, due to the relatively large sample size and low degrees of freedom for each model (Fan, Thompson, & Wang, 1999). As a result, RMSEA values were also inflated (i.e. > 0.05). However, model fit was evaluated based on a cadre of indices. Therefore, even if $\chi^2$ and

RMSEA values did not indicate good fit after modifications, model fit was considered acceptable based on the remaining fit criteria including CFI and TLI.

***No modifications.*** Only the models for Perceived Susceptibility and Perceived Behavioral Control were unmodified. Both models did have significant $\chi^2$ p-values (<0.001) and high RMSEA: 0.147 for Perceived Susceptibility and 0.131 for Perceived Behavioral Control. However, all remaining fit indices for both models indicated good fit of the CFAs. Similarly, the reliability indices are also high for both models. Finally, factor loading for the items of both models are all high, ranging from $0.651 \leq \lambda \leq 0.942$. With these values, it was decided not to modify the models and to preserve the original measures.

***Minor modifications.*** Minor modifications to improve fit were made to the constructs representing Perceived Benefits, Perceived Barriers, Attitudes, Subjective Norms, and Internal Locus of Control. Modification to all of these constructs except Perceived Barriers included correlating the residual error of one to two sets of items. Items from Attitudes and Perceived Barriers were removed from their respective models to improve fit.

The correlated residuals improve the model fit by taking the similarity of questions into account (Gignac, Bates, & Jang, 2007). That is, the commonality of the items extends beyond the common factor to the error term of the items as well. While all items are intended to represent a single factor, the wording or item content of the items with correlated residuals may err to side of redundancy. For example, each of the items of the Attitudes construct refers to an attitude towards colorectal cancer screening. However, item 3 (“Screening for colorectal cancer takes a lot of preparation”) and item 6 (“Screening for colorectal cancer makes me do a lot of work”) both refer to the “preparation” and “work” involved in screening. These items may have been

perceived as somewhat synonymous to the study sample. Therefore, the correlation of these items' residuals takes this perception into account.

Items were dropped from a model if the item did not significantly correlate with other items, did not have a sufficiently high factor loading with respect to the other items in the model, and/or removal from the item set substantially improved internal reliability. For the Attitudes construct, questions 7 ("Screening for colorectal cancer prevents cancer") and 8 ("Screening for colorectal cancer finds cancer before it spreads") were removed from the model. The items did not correlate with the remaining items nor did they have reasonable factor loadings ($\lambda \leq 0.027$). Additionally, removal of the items improved Cronbach's $\alpha$ from 0.664 to 0.753. These items may have had poor fit with the remaining items because items 7 and 8 relate more to attitudes of screening benefit while the remaining items relate to the act of screening itself. Similarly, item 67 ("Having regular checkups to detect colon cancer will make me worry about colon cancer.") was removed from the Perceived Barriers construct. It was removed due to its low factor loading relative to the other items of the construct, and its removal provided a substantially improved model fit. The item's poor performance may be due to its focus on feelings of anxiety while the remaining items are more tangible barriers such as comfort, time, and cost.

***Significant modifications.*** Two constructs required significant modifications to their models following initial analyses: Perceived Severity and Stability.

*Perceived Severity.* The results of the initial CFA of Perceived Severity suggested removal of item 57 ("Colon cancer would threaten a relationship with my partner.") due to its relatively low factor loading. Removal of the item was also conceptually relevant as it is the only item of the seven items intended to measure Perceived Severity that relates to relationships and other individuals. The remaining items all focus on the individual. The dichotomous factor loadings in the subsequent factor analysis suggested the need to also modify the model so that the items are represented by two related factors. The first factor includes items 53 through 55. This factor can be conceptualized as an Immediate Severity of colorectal cancer and the fear that it invokes. In contrast, the remaining items – items 56, 58, and 59 – are conceptualized as Long Term Severity of colorectal cancer and the perception of the cancer's effect on the individual's life and survival.

The conceptualization of the Perceived Severity construct as a second-order, two-factor model is unique compared to previous analyses of Jacobs' (2002) measure. In part, this is due to reliability and validity of the measure being attributed solely to Cronbach's α and conceptual validity, respectively. Jacobs (2002) and subsequent uses of its CRC version of the HBM measure (Fletcher et al., 2007; Ingrand et al., 2008; Kinney et al., 2014; McClish, Carcaise-Edinboro, Esinhart, Wilson, & Bean, 2014; Taouqi, Ingrand, Beauchant, Migeot, & Ingrand, 2010; Zheng, Saito, Takahashi, Ishibashi, & Kai, 2006) did not analyze the factor structure of the measure. However, Champion (1984) did assess the factor structure of the original measure pertaining to breast cancer. This analysis supported multiple factors associated with Perceived Severity relating to "physical symptoms of fear, long-term effects of breast cancer, and financial or career problems" (p.82). Given that 'financial or career problems' questions were not translated to Jacobs' (2002) measure, the final model and factor structure of Perceived Severity

observed in this analysis was consistent with the results of Champion (1984). Subsequent use of Jacobs' (2002) CRC HBM measure should make note of the two-factor nature of the measure's Perceived Severity items.

*Stability.* Initial analysis of the Stability construct had poor model fit and clearly indicated a two-factor model with 4 items with high factor loadings ($\lambda \geq 0.738$) and the remaining 4 items with low factor loadings ($\lambda \leq 0.488$). When modeled with each set of 4 items as a separate, related factor of stability, the model displayed much improved fit and reliability. The sets of items directly corresponded to the questions intended to represent stable belief orientation (i.e. a fixed chance of getting colorectal cancer) and the questions intended to represent malleable belief orientation (i.e. being able to modify your chance of getting colorectal cancer) (Abd-El-Fattah & Yates, 2006).

Stability as originally measured and scored by Dweck (2000) as well as Burnette (2010) would suggest that the construct is a one-factor model. In both instances, items representing a stable belief orientation are reverse-coded and item scores are totaled to indicate the participant's degree of malleable belief orientation (i.e. a higher score indicates a more malleable belief). As such, all items are being used as a single, unidimensional construct that is anchored by completely stable and completely malleable belief orientations. Similarly, internal reliability was assessed by these previous studies as a single set of items. However, the results of the factor analyses support the notion that stability is a two-dimensional construct. The data and factor loadings suggest that stability and malleability are separate constructs. While this contrasts the original conceptualization of the measure, this two-factor model is supported by other analyses including: Bråten and Strømsø (2005); Cury, Elliot, Da Fonseca, and Moller (2006); and Diseth, Meland, and Breidablik (2014).

In both the instance of Perceived Severity and Stability, the instrument used to measure each construct was originally scored and conceptualized in a manner consistent with a single factor. The factor analyses completed clearly indicated that single-factor models were not appropriate for the observed sample. While a two-factor model was a better fit for each construct, these results are contrary to the previous studies that assessed the reliability and validity of these instruments. However, item correlations and internal consistency may still indicate satisfactory reliability due to the factors within the construct being closely related. The indication of a two-factor model is only accomplished when factor analyses were employed.

The use of factor analyses to support the items of a given construct allows for better estimation of the latent constructs based on model fit (Floyd & Widaman, 1995). Additionally, the factor analyses illustrate the need for continuing development of the construct measures. While only two of the CFAs illustrated major modifications – i.e. the need to reconceptualize the constructs as multiple factors – the vast majority of the constructs assessed required some degree of model modification. The removal of items suggests that the initial measures have items that are somewhat unrelated to the factor as defined by the rest of the item set. The correlation of residual error terms suggests potential redundancy of items and concepts or even the potential of a minor, secondary factor. These modifications illustrate how each construct's instrument can be further refined to create more parsimonious and focused measures.

**Whole Theoretical Models.** With the confirmatory factor analyses of the previous section completed to estimate constructs to the measures' best abilities, emphasis of analysis shifts from the individual constructs to the structural equation models representing each theoretical model and screening modality. While modifications could have been performed to improve the fit of each SEM theoretical model, the purpose of the study was not to improve upon

the evaluated theories. Rather, each theory was evaluated only as originally conceptualized by each theory's authors as well as how they have been statistically modeled in previous studies. This is because the purpose of the study is to determine how well (or how poorly) the current behavioral theories model colorectal cancer screening. In the future, subsequent analyses may be performed to evaluate how modifications to the current theoretical models may improve the model fit and ability of the theories to explain colorectal cancer screening intentions and behaviors.

***Health Belief Model.*** The Health Belief Model (HBM) is the only theory of those evaluated that explicitly includes sociodemographics in the model. A two-step approach was used to determine which evaluated sociodemographics were retained in each screening modality model. If a sociodemographic variable did not have any significant pathways in the initial analysis of the model, the variable was removed from the final model. All models retained the following sociodemographic variables: perceived health status, CRC risk status, previous diagnosis of polyps, previous diagnosis of another cancer, and sex. Income was retained in the general and colonoscopy screening models. Age was retaining in the FOBT/FIT and sigmoidoscopy screening models. Race (compared to White/Caucasian) was retained in the colonoscopy and sigmoidoscopy screening models.

With the exception of perceived health status influence on beneficial balance within the FOBT/FIT and sigmoidoscopy screening models, all other sociodemographic pathways were consistent in directionality across models when significant. Within the sigmoidoscopy model, better perceived health predicted a more favorable beneficial balance of colorectal cancer screening beliefs. For the remaining HBM constructs of the sigmoidoscopy model (i.e. perceived severity and perceived susceptibility) as well as all of the HBM constructs within the FOBT/FIT

model, a worse perceived health predicted a greater degree of CRC threat and benefit to screening. In the general and colonoscopy screening models, worse perceived health predicted a higher degree of perceived severity. This is consistent conceptually such that those that believe that they are of poorer health believe that they are more threatened by the possibility of being diagnosed with CRC. Similarly, increased risk for CRC predicted greater perceived susceptibility to be diagnosed with CRC. Given that risk was assessed based on established criteria rather than the participant's perception of his or her risk, this association may be due to acknowledgement of comorbidities or it may persist without the awareness of the participant.

Variables associated with previous experience with polyps and other cancer diagnoses produced noteworthy results. Regarding the previous diagnosis of polyps, the expected directionality of its effect on HBM constructs was observed. That is, the previous diagnosis of polyps predicted greater perceived susceptibility and beneficial balance within all modality models. This is consistent because one who has had polyps – potential precursors to CRC – would be more aware of the possibility of developing a malignant growth. Additionally, having been diagnosed with and most likely treated for polyps, the participant would have firsthand knowledge of the benefit of screening procedures.

Interestingly, the diagnosis of another cancer did not have a similar protective factor. A previous diagnosis negatively predicted perceived severity within the general and colonoscopy models. Additionally, previous diagnosis negatively predicted beneficial balance. The inverse effect of cancer diagnosis on severity may be due to the participant's exposure and experience with cancer. Having already been through the experience, one may not see cancer as severe of a diagnosis as someone who has not had to deal with such a diagnosis (Mellon, Northouse, & Weiss, 2006). The inverse relationship to the benefit of screening may be due to a sense of

futility. That is, individuals may not see the value in screening or preventative measures as they have already been previously diagnosed (Shin, Baik, et al., 2011; Shin, Cho, Kim, Jung, & Park, 2013; Shin, Kim, et al., 2011). Also, individuals may not always know that they can get multiple cancers and may see their previous diagnosis as a protective factor against new forms of cancer (MacDonald, Sarna, Uman, Grant, & Weitzel, 2005). Alternatively, the relationship may be influenced by the notion that individuals with perceptions of low threat or high medical mistrust also perceive less benefit in screening (Purnell et al., 2010).

Demographic variables of sex, income, age, and race were consistent throughout the models as well. The influence of sex was present in the general, colonoscopy, and sigmoidoscopy models. Across the models, being male predicted a greater perceived susceptibility. While this relationship was also observed by Al-Dubai et al. (2013), the authors note that the reverse relationship as well as multiple instances of no relationship between sex and susceptibility have also been observed. However, Friedemann-Sánchez, Griffin, and Partin (2007) observed that women may perceive CRC as a male disease leading to feelings of less susceptibility.

Additionally, being female predicted a greater beneficial balance. Previous studies have also observed gender differences associated with CRC screening perceptions and beliefs (Bass et al., 2011; Farraye et al., 2004; Friedemann-Sánchez et al., 2007; Rawl, Menon, Champion, Foster, & Skinner, 2000; Ritvo et al., 2013; Wong et al., 2013). These studies suggest that men are less likely to want to be screened based on more negative views and barriers associated with embarrassment, lack of desire to go to the doctor and less frequent use of health systems, procrastination, and fear of results. Additionally, women were observed to have a better relationship with their physicians and were more knowledgeable about screening (Bass et al.,

2011; Friedemann-Sánchez et al., 2007; Ritvo et al., 2013). Therefore, while females may be more cognizant of the barriers associated with CRC screening, they may also be more aware and accepting of the benefits of screening as indicated by the current analyses.

Income was observed to have a significant influence within the general and colonoscopy screening models. Particularly, lower income was associated with a greater degree of perceived susceptibility. Also, a higher income was associated with a greater beneficial balance. This is consistent with the review by Vernon (1997) that discovered multiple positive associations between income and screening completion. The positive association between income and screening was also more recently observed by Shariff-Marco, Breen, Stinchcomb, and Klabunde (2013). Additionally, Bandi, Cokkinides, Smith, and Jemal (2012) observed a national trend in improving screening rates among higher socioeconomic status (SES) than lower SES. The contrast in relationships between influences on susceptibility and benefit may be due, in part, to higher income participants feeling less susceptible to CRC because of their greater belief in the benefits of screening.

Within the FOBT/FIT and sigmoidoscopy modality models, age was positively associated with beneficial balance. As older individuals are more likely to have a more beneficial perception of screening as observed in the study sample, this may lead to improved screening rates. This is consistent with findings that older individuals are more likely to have a more advanced stage of readiness to be screened as well as more likely to have been screened (Hughes et al., 2015; Paskett et al., 2013; Wang et al., 2014).

Finally, participant race was observed to be associated with beneficial balance within the sigmoidoscopy and colonoscopy models. Specifically, those identifying as Black/African-American participants were more likely to have a greater beneficial balance compared to

White/Caucasian participants. This may seem contrary to results indicating African-Americans being less likely to be screened for CRC (Doubeni et al., 2010; Hall, Ruth, & Giri, 2012; McAlearney et al., 2008). However, lack of screening does not necessarily translate directly from perceived beneficial balance. Exogenous factors may influence actual screening rates of an individual while their perceived benefit of screening is high and perceived barriers are minimal. For example, McAlearney et al. (2008) report that African-American women reported being less likely to report embarrassment as a barrier compared to white women. Additionally, limited knowledge of screening and screening options have been commonly cited as preventing screening in African-American samples (Ruggieri et al., 2013). As such, limited practical or logistical knowledge may prevent screening while the beneficial balance remains positive (i.e. perceived pros outweigh the cons of screening).

The main constructs of the Health Belief Model – Perceived Susceptibility, Perceived Severity, Perceived Benefits, and Perceived Barriers – were estimated by their respective items as depicted in the final models of the factor analyses. These constructs were arranged in the theoretical models to be consistent with the conceptual framework of the Health Belief Model (Rosenstock, 1966).

Perceived Threat – the intersection of Perceived Susceptibility (Su) and Perceived Severity (Sv) – was conceptualized in the model through the correlation of these two constructs with screening intent regressed on each construct separately. In each modality model, there was a significant relationship between these two constructs with Corr(Su,Sv) ranging from 0.427 – 0.436. Therefore, support for the relationship of the two constructs as a concept of Perceived Threat is supported.

Some noteworthy observations were witnessed regarding perceived threat. Primarily, all significance associated with perceived threat was due to perceived susceptibility. All of the HBM models except the FOBT/FIT model contained a significant positive association between Perceived Susceptibility and screening intent ranging from $\beta = 0.116$ to 0.172. In no instance of the model was perceived severity significantly associated with screening intent. Reviewing the responses of items associated with perceived severity, there was no indication of a ceiling effect or other departure from normality. In other words, the lack of association was not due to a consensus in severity across the study sample. Additionally, because perceived susceptibility was also not significant within the FOBT/FIT model, no component of perceived threat had an influence on screening intention. The models would suggest that the motivating component of perceived threat that influences screening intention is the individual's perceived chance of contracting CRC while the individual's perception of how impactful CRC can be on one's life does not influence the intention to be screened.

The second primary construct of the HBM, Beneficial Balance, is the amalgamation of the individual's perceived benefits and barriers of CRC screening. As expected, there was an observed significant positive association between Beneficial Balance and screening intent for all screening modality models of the HBM. This association suggests that individuals with stronger perceived benefits and weaker perceived barriers will have stronger intentions to be screened for CRC.

This association was particularly strong with general intention screenings and colonoscopy screening intentions ($\beta = 0.887$ and 0.828, respectively). These associations may also be what contributed to the exceptionally high variance of general and colonoscopy screening intent explained by the models. The FOBT/FIT and sigmoidoscopy modality associations were

weaker with β = 0.394 and 0.296, respectively. This dichotomy may be due to individuals' concepts of CRC screening when responding to general questions regarding the benefits and barriers to screening. When responding to these questions, individuals may be inadvertently considering the benefits and barriers of colonoscopy along with associating their general screening intentions with intentions of using colonoscopy as their modality. This would explain both the similar association strengths between general and colonoscopy models as well as the differential between these models and the other modality models.

In general, the HBM models were consistent with the three primary HBM theoretical concepts evaluated. First, sociodemographics influence the perceived threat and perceived benefits and barriers of the individual. Second, perceived threat influences an individual's behavioral intention. A greater perceived threat of CRC will strengthen screening intention. Lastly, the beneficial balance associated with the behavior influences an individual's behavioral intention. A more positive perception of screening will strengthen intention.

Additionally, the results of the HBM models are consistent with previous analyses of HBM constructs and CRC screening modalities. The review of previous health behavior constructs use in the literature by Kiviniemi et al (2011) provides the best illustration of this consistency. Kiviniemi et al (2011) provides a summary of the results of associations between individual constructs and CRC screening in 81 studies throughout the literature. Due to the observations of multiple modalities within studies, the following observation descriptives exceed the number of studies reviewed.

The results of the review indicate that perceived barriers was significantly and negatively associated with screening in 73.4% (n=80) of observations within the studies (n=109), ranging between 70.4% and 76.5% predicted for the three screening modalities included in this study.

One study (2.9%) evaluating sigmoidoscopy screening observed a positive association, counter to the hypothesis of the HBM. Perceived benefits was significantly and positively associated with screening in 67.6% (n=73) of the studies that included the construct, ranging between 62.9% and 69.2% predicted for the three screening modalities included in this study. No study observed a relationship opposite to the predicted association (Kiviniemi et al, 2011).

Sixty-four percent (n=73) of the observations, including perceived susceptibility (n=114), observed the predicted positive association with cancer screening. No study observed a relationship opposite to the predicted association. However, the significant association was observed less often with FOBT (57.9%) than sigmoidoscopy (64.7%) and colonoscopy (64.0%) (Kiviniemi et al, 2011). This less-observed relationship is consistent with the significance observed in the general, colonoscopy, and sigmoidoscopy models of the current study and non-significance in the FOBT/FIT model.

Perceived severity was evaluated in a total of 37 observations across the studies, considerably fewer studies than the other HBM constructs. Unlike the other constructs, more studies also observed a significant association opposite to the predicted directionality (n=11; 29.7%) than those consistent with the predicted directionality (n=6; 16.2%) as hypothesized with the HBM (Kiviniemi et al, 2011). The mixed results of previous observations illustrates the inconsistent relationship of perceived severity and CRC screening. Therefore, the non-significant relationships of this study's models are justified and not surprising.

The SEM of the HBM models in this study displayed a reasonable fit and should not be rejected as models to explain CRC screening intentions. In terms of consistency with the HBM, no pathways of the model were observed to be the opposite of that hypothesized by the theory. For example, the association between perceived susceptibility and screening intent was not such

that lower susceptibility was associated with stronger intent to screen. Additionally, only perceived severity displayed no relation with screening intentions. While this presents some objection to the HBM, this single pathway should not discount the entire model. Particularly, the HBM postulates that perceived severity influences behavior as a component of perceived threat. While the direct effect of perceived severity was not significant in the models, it is still significantly correlated with perceived susceptibility and influenced by perceived health status. Therefore, the construct still maintains value within the model and contributes to the overall construct of perceived threat. The remaining constructs were all observed to be associated as the HBM predicts. Therefore, the models support the use of the Health Belief Model for CRC screening.

***Theory of Reasoned Action.*** The Theory of Reasoned Action (TRA) is a much more parsimonious model compared to the Health Belief Model. This is primarily because the TRA does not explicitly include sociodemographic influences on the constructs as does the HBM. The statistical models for the TRA were constructed as suggested by Hankins et al. (2000) and similar to past statistical analyses of the reasoned action theories (Ahmad et al., 2014; Christiana, Davis, Wilson, McCarty, & Green, 2014; Eggers et al., 2015; Levin, 1999; Morrison, Golder, Keller, & Gillmore, 2002; Roncancio et al., 2015; Vallerand et al., 1992; Van den Putte & Hoogstraten, 1997). All four modality models of the TRA displayed sufficient fit.

All four models displayed a significant correlation between attitudes toward screening and subjective norms ranging between $\rho = .183$ and .189. This relationship is expected and hypothesized in the TRA. Additionally, this positive correlation between constructs has been observed extensively in previous analyses of the theory (Dillard & Pfau, 2002). The relationship suggests that individuals who believe more strongly that people important to them think that they

should be screened also tend to have more favorable attitudes toward screening. This type of relationship is to be expected as people influential to an individual's behaviors are also likely to be influential to the individual's attitudes and beliefs as well.

The association between attitudes and general screening intent was not significant. However, a positive association was significant in each of the specific modality models ranging from $\beta = 0.099$ to 0.216. This association suggests, as hypothesized by the TRA, that more favorable attitudes regarding screening strengthens the intention to be screened. Both the meta-analysis by Cooke and French (2008) and literature review by Kiviniemi et al (2011) observed similar relationships of the TRA attitude-intention association in colorectal cancer. Relatively few studies measuring the TRA construct were found by Kiviniemi et al (2011). Three observations were detected in total with one observation for each screening modality. Each of the three observations did include significant, positive associations as hypothesized by TRA. The meta-analysis of Cooke and French (2008) observed a medium effect-size, $r_{+}=0.43$, using the average of three sample correlation coefficients weighted by sample size. The relatively few studies that explicitly evaluate the TRA construct of attitudes and its association with behavioral intention in CRC inhibit much generalization of the observation. However, the observed associations contribute to the limited body of work that does suggest support for the influence of attitudes on screening intent.

The second latent construct, subjective norms, consistently displayed a significant, positive association across all modality models as predicted by the TRA. The strength of association between subjective norms and intention was greater than the attitude-intention association for all models ranging between $\beta = 0.225$ and 0.555. Subjective norms was observed to be evaluated more frequently in the review by Kiviniemi et al (2011). Of the 35 observations

evaluating subjective norms, all but two (94.3%) observed a similar association to those observed in the current study. The remaining two observations did not detect any significant associations. The meta-analysis of Cooke and French (2008) also observed a medium effect size of $r_+ = 0.52$, similar to the attitude-intention relationship.

Additionally, the observation of subjective norms having a larger impact on intent compared to attitude within each CRC screening modality model is supported by previous studies. Smith-McLallen and Fishbein (2008) compared the reasoned action constructs' ability to predict cancer screening intentions between Black and White adults. While significance between standardized regression coefficients was not explicit for the Black population sample, the coefficient for subjective norms was more than twice that of attitudes: $\beta = 0.30$ and 0.12, respectively. Within the White sample, significant difference was noted between the coefficients of subjective norms ($\beta = 0.46$) and attitudes ($\beta = 0.25$). Furthermore, Fishbein and Cappella (2006) noted results indicating that "among adults older than 40 years… the intention to get a colonoscopy is almost completely under normative control" (p.53).

The two latent constructs of the TRA accounted for 11.5% to 32.6% of the variance in screening intent across modalities. Consequently, screening intentions were significantly and positively associated with screening behavior for all modalities. The standardized coefficients were relatively similar with significant variance explained for general screening ($\beta = 0.468$; $R^2 = 0.219$), FOBT/FIT screening ($\beta = 0.356$; $R^2 = 0.127$), and colonoscopy ($\beta = 0.449$; $R^2 = 0.202$). The variance explained in these models is on par with previous studies across disciplines using the TRA (Arvola, Lahteenmaki, & Tuorila, 1999; Fisher, Kohut, Salisbury, & Salvadori, 2013; Folta, Bell, Economos, Landers, & Goldberg, 2006; Goldenberg & Laschinger, 1991; Laschinger & Goldenberg, 1993; Laschinger, Goldenberg, & Dal Bello, 1995; Trafimow, 2004). However,

the sigmoidoscopy screening model resulted in a lower standardized coefficient of $\beta = 0.195$, which did not explain a significant percent of the variance in screening behavior. This difference may be a result of significantly lower sigmoidoscopy use in the study sample.

Generally, the Theory of Reasoned Action models displayed good fit statistics. Additionally, the three specific modality models contained all significant pathways in the directions predicted by the TRA. In the general screening model, only one pathway – attitudes influencing screening intention – was not significant. However, some incongruities did exist between the theory and model results. The univariate association between attitudes and screening intent was significant. The non-significance of the association is due to the presence of subjective norms and the observed correlation of the two latent variables, and the inclusion of attitudes in the general screening model is still of value. Additionally, variance of sigmoidoscopy screening behavior was not explained by the model. This observation may be explained as an artifact of the study sample. Therefore, the TRA models all performed well enough to not reject their use as a means of explaining individual-level influences on CRC screening behavior. However, the relatively low variance of the models indicate that additional pathways and constructs could be included beyond the hypothesized TRA to better explain the observed intentions and behavior. It is this observation – particularly in regard to volitional control – that led to the development of the Theory of Planned Behavior (Ajzen, 1991).

***Theory of Planned Behavior.*** The Theory of Planned Behavior (TPB) is an extension of the TRA that does not assume the individual to have complete volitional control of his/her behaviors. As such, the theory includes the construct of perceived behavioral control (PBC) as a direct effect on both intentions and behavior. The construct is the only one of the three latent constructs that is hypothesized and evaluated to have a direct effect on behavior in addition to its

influence on behavioral intentions. Similar to the preceding TRA models, all four TPB models also displayed sufficient fit statistics.

As expected, the constructs of the TPB that are also included in the TRA behaved similarly across models. The inclusion of PBC did not substantially alter the relationships and effects of the other latent constructs. In all of the TPB models, attitudes and subjective norms were positively correlated with $\rho = 0.191$ to 0.192. Attitudes were, again, not significantly associated with general screening intentions, but a positive association was observed in each specific modality model ranging between $\beta = 0.092$ and 0.213. Subjective norms was observed to be positively associated with screening intent for all modality models. These observations are similar to the TRA. Therefore, the justification and explanation of these associations will not be reiterated as they are discussed in the previous section.

The correlations of PBC with the other latent constructs was consistent across models. No relationships were observed between attitudes and PBC. This observation can be justified as control beliefs are operational while attitudinal beliefs are subjective. The perceived control over whether or not an individual can complete screening should not have much of an association with whether an individual possesses a positive or negative attitude towards screening. PBC did have a positive correlation with subjective norms ranging from $\rho = 0.496$ to 0.505. This association is also justified as an increase in perceived social support should correlate with increased PBC since the individual would believe that he or she could seek help from those that approve of or encourage the behavior.

The effect of PBC on screening intention was significant for the general model, FOBT/FIT, and colonoscopy with coefficients ranging from $\beta = 0.127$ to 0.418. A significant direct effect of PBC on screening behavior was also observed in the general and colonoscopy

screening models. The beta coefficients of the direct effect on behavior were smaller than intentions for both the general model (β = 0.146) and colonoscopy (β = 0.137). However, PBC was not significantly associated with intent for the sigmoidoscopy model or behavior for both sigmoidoscopy and FOBT/FIT.

The positive association between PBC and screening was supported in 72.2% (n=26) of the observations reviewed (n=36) by Kiviniemi et al (2011) with no studies observing a significant relationship counter to that predicted by the TPB. Additionally, the present though weaker impact of PBC on screening behavior compared to intent is hypothesized within the TPB (Ajzen, 1991). PBC is the only latent construct of the three within TPB that is posited to have both an indirect influence on behavior through intention as well as a weak influence on behavior itself. The general and colonoscopy models support these influences of PBC. The FOBT/FIT model was only observed to have a significant effect on intent and not actual behavior. This lesser influence may be indicative of more perceived volitional control in regard to the less invasive modality. While the same argument may be justified for the sigmoidoscopy model, the non-significant effects on intention and behavior may also be associated with low sigmoidoscopy use and preference in the study sample.

Overall performance of the TPB to explain colorectal cancer screening was good. The models are generally consistent with the concepts and hypotheses of the theory. In no instance was an observation inconsistent with the TPB, demonstrating an inverse relationship to that hypothesized in the theory. Only the colonoscopy model was observed to have all pathways hypothesized by the theory significant. The direct effect of PBC on FOBT/FIT behavior was not significant, but the latent construct did significantly influence FOBT/FIT screening intention. Given the lesser influence of the direct effect of PBC hypothesized by the theory, an argument

for the model's relatively complete consistency with the theory may be made. However, both the general model and the sigmoidoscopy model contain a latent construct with no significant pathways: attitudes in the general model and PBC in the sigmoidoscopy model. While the lack of significant influence provides inconsistencies with the theory, even Ajzen (1991) points out that not all latent constructs of the model may have an influence on behavior depending on the behavior in question. Therefore, while the inconsistences may weaken support for the use of the theory, the observations made do not support rejection of the Theory of Planned Behavior as a tool for explaining CRC screening beliefs and behaviors.

***Attribution Theory.*** The evaluation of Attribution Theory (AT) examined the Outcome Value component of the conceptual framework. While the other evaluated theories concentrate on the beliefs and attitudes associated with the act of screening itself as the motivating factors for screening behavior, the emphasis of AT as a component of Outcome Value focuses on if an individual believes that there is utility associated with the results of screening. Through AT, this utility is indicated by the control one believes he or she has in developing or eliminating cancer. This is broken down into the perceived degree of malleability/stability and internality/externality of control over cancer seen within the models. All four AT models displayed reasonable enough fit to not be rejected.

In each AT modality model, the theoretical constructs of stability and internal locus of control were significantly, positively correlated ranging from $\rho = 0.610$ and 0.614. This suggests that as an individual's causal belief about cancer becomes more malleable, he or she also tends to believe causal attribution to be more internal. In relation to the quadrants of AT, this correlation would position most individuals along a continuum for causal attribution of cancer to range between a belief such as fatalism or futility (i.e. a stable, external cause) and individual behaviors

(i.e. a malleable, internal cause). Individuals would be less likely to fall within the quadrants representing a causal attribution such as genetics (i.e. a stable, internal cause) or their surrounding environment (i.e. a malleable, external cause).

Stability had a significant effect on screening intent within each model ranging from $\beta$ = 0.222 to 0.413. This effect within the model suggests that as one's beliefs of causal attribution become more malleable the intent to screen strengthens. This observation is justified as an individual with a more stable causal attribution of cancer would most likely consider the outcome value of screening to be low. An individual with a stable causal attribution would believe that knowledge of whether or not one has cancer would not affect his or her ability to further prevent a diagnosis or treat the condition if previously diagnosed. Conversely, an individual with a more malleable causal attribution of cancer would most likely believe that the information learned from screening would help further prevent or treat a cancerjun diagnosis. This observation also supports the results of Jun and Oh (2013) regarding the adverse effect of fatalism beliefs on screening rates.

Influence of internal locus of control on screening intent was only significant in the sigmoidoscopy model ($\beta$ = 0.158). The observation suggests a positive association such that a more perceived internal locus of control is associated with a stronger intent to complete a sigmoidoscopy screening. This observation is not shared among the other modalities as no significant association between locus of control and screening intent was observed for the remaining AT models. However, the non-significant results concerning internal locus of control are consistent with the primary results of Gili et al. (2006).

The associations of both locus of control and stability with sigmoidoscopy screening intent supports the use of AT in this model. Since both associations are positive, the model

suggests that sigmoidoscopy screening intent strengthens as one aligns more with the quadrant associated with a malleable and internal causal attribution. Because only stability is significantly associated with screening intent in the remaining modality models, both dimensions of AT may not be necessary. These models suggested that only the degree of perceived malleability influences screening intent regardless of perceived internal or external locus of control. While locus of control did not directly affect screening intent in most models, its utility and influence on stability cannot be ignored. While stability is the influential factor on screening intent, the correlation between stability and locus of control suggest that an emphasis on malleable, internal causal attributions over external causal attributions of CRC should be made when attempting to elicit behavioral change and strengthen intentions to be screened as fewer individuals are likely to possess malleable, external causal attribution.

Overall, the models are consistent with Attribution Theory and do not warrant rejection of its use to help explain CRC screening behaviors. Both constructs of AT present utility and influence within the model. The models account for a significant, though modest, amount of variation within screening intent ranging between 7.7% and 13.8% of the variance explained for each modality. Although this represents a small portion of the variance in screening intent, it suggests that the perceived outcome value of screening may have some influence on screening intentions complementary to the behavioral value of screening as represented in the conceptual framework.

**Theoretical Models Comparison.** The estimate values and fit of structural equation models can only be statistically compared to each other when they possess all of the same variables. Given that each model in this analysis represents a different theory and modality, no two models contain the same variable set. As such, the models in this analysis cannot be

compared in a manner to declare which theory is a better fit for CRC screening. However, the models can be assessed based on how consistent each model is with its own data. These observations can help justify a subjective comparison of the theories and their use in CRC screening. The consistency of the models is based on model fit, significant pathways, hypothesized directionality of the pathways, and explanation of the variance in screening intent and behavior.

All models displayed adequate fit statistics. As such, no theory or specific modality within a theory model was rejected outright. Similarly, of the pathways in each model that were significant, no estimate was the inverse in directionality to that hypothesized. Therefore, no model suggested a relationship between constructs that was opposite to the relationships suggested by the theories. These two factors – sufficient model fit and no opposing pathways – provide support that each theory lends some explanatory power and none of the theories evaluated detract from understanding CRC screening intentions and behaviors.

The models representing the Health Belief Model (HBM) were the only ones to contain a primary construct that was not significantly associated with CRC screening for any modality, i.e. perceived severity. As such, a principal assumption of the theory was consistently vacant while at least one model of each other theory supported every assumption. However, the HBM models and theory are also the only ones to explicitly hypothesize the influence of sociodemographics on its constructs. Therefore, the scope of these models extend well beyond the other theories' models and provide additional information lacking in the other theories.

Proportionally, the models of Theory of Reasoned Action (TRA) have the most significant pathways occurring. Only one pathway was not significant in one model. However, the TRA was the only represented theory where the variance of screening behavior was not

explained in one of the models. This is not the case with the models associated with the Theory of Planned Behavior (TPB). While the TPB models contain more non-significant pathways that are hypothesized to have influence on behavior, the TPB models still contain more information compared to the TRA models. Specifically, the inclusion of perceived behavioral control provides an additional explanatory component to the theory and models. If PBC had no significant pathways within the models, the case could be made that its exclusion from the models and theory (i.e. reversion to the TRA) would create a more parsimonious model. However, as this is not the case, the critical review of the models would support favoring the TPB over the TRA.

The Attribution Theory (AT) models are perhaps the simplest models of the theories. Additionally, in three of the four instances, the model only explains how a single construct influences screening intent. However, the context and information provided by the model is fundamentally different from the other three theories. The AT models help to understand the individual's explanation of why a person develops cancer affects screening rather than the emphasis being on one's behavioral beliefs towards cancer.

While a clearly superior theory cannot be deduced empirically or subjectively, comparison of the theories' models can illustrate the advantages one theory has over another. In this analysis, it is evident that the Health Belief Model provides the most information regarding which factors influence screening. The Theory of Planned behavior displays the most consistency with its theoretical assumptions while not sacrificing its explanatory power through the elimination of a construct. Finally, Attribution Theory demonstrates the influence of constructs outside of the domain typically evaluated. Evaluating the advantages and

disadvantages of each theory provides insight into how each theory should be applied in future use as well as how to advance behavioral theory in general.

**Theoretical Application**

Any scientific model – including behavioral theory – is a simplified representation of a process or phenomena. No model or theory can capture every force or construct acting on the represented phenomena in reality. Nevertheless, models provide utility in practice by identifying the critical factors influencing that process or phenomena. The theoretical models observed in this study exemplify this concept as each model provides information regarding the influences on screening behavior. As such, each model provides utility, yet collectively illustrate that not all significant factors are represented in a single model.

Testing and refinement of behavioral theory is limited yet necessary, as discussed by Noar and Zimmerman (2005) – one of the most influential articles to call for theory development. Since its publication, subsequent reviews such as Davis et al. (2014) have reinforced the need for theory refinement, demonstrating the underuse, misuse, and redundancy of behavioral theories. However, the task of evaluating and comparing whole theories is complex and intensive (Brewer and Gilkey, 2012) and, therefore, rarely completed (Korbin et al., 2015). The results of this task and the theoretical models analyzed by this study beg the question of how the information learned can help move behavioral theory forward and create a more complete model explaining CRC screening behavior. This discussion will focus on using Noar and Zimmerman (2005) as a framework to approaching behavioral theory development using the current study.

**Theory Evaluation.** Noar and Zimmerman (2005) proposed three approaches of health behavior theory development: (1) proliferation and testing of theories, (2) integration of theories,

or (3) comparison and competition of theories. Noar and Zimmerman (2005) endorse the third approach of empirically comparing theories using $R^2$ values, regression coefficients, and SEM fit indices across multiple outcome variables per theory. The use of these metrics is critical to the evaluation of each theoretical model and its data as performed in this study. However, the issue still remains that since all theories do not contain the same variables, comparing the values of these metrics across theoretical models is not good practice. Even so, many studies have subscribed to this method as a means of comparing theories and theoretical models (Brewer & Gilkey, 2012; Gerend & Shepherd, 2012; Plotnikoff et al., 2014; Roncancio et al., 2015).

Because metrics are not available to empirically determine whether one model is better than another, discounting a theory as suggested may ignore critical constructs or pathways that influence intentions and behaviors. For example, if the $R^2$ value comparison suggested by Noar and Zimmerman (2005) was used, it could be concluded that the Health Belief Model is the leading theory for CRC screening behaviors based on this study. This determination would then exclude the findings of the Reasoned Action theories that subjective norms have a significant impact on an individual's screening intentions since a similar construct is not present in the Health Belief Model. However, the subjective norm is a valuable construct both in understanding what influences behavior as well as a potential avenue for behavioral change.

While empirical evaluation of theoretical models as suggested by Noar and Zimmerman (2005) may not be best suited for theory comparison, such metrics are important tools in determining the value of each theory with respect to its own data. This notion is echoed throughout the current study. Whole theoretical model testing – especially employing SEM to retain theory structure – is paramount in understanding theoretical model performance as well as individual construct performance with respect to concurrent constructs of the theory. The

empirical metrics employed (model fit statistics, $R^2$ values, and β coefficients) provide support to reject a theory's model or determine which constructs are most important within a model that has failed to be rejected. Therefore, competition among models can only be completed if one theory can be rejected based on fit statistics while another model cannot be rejected.

Given the empirical model evaluation benefits and shortcomings, a better approach to theoretical advancement may be first to employ empirical theoretical model testing recommended by Noar and Zimmerman (2005) but then to use this statistical information to inform restructuring and integration of the models into a more cohesive theory. Integration of theories was a second direction discussed but ultimately dismissed by Noar and Zimmerman (2005). Noar and Zimmerman (2005) did note that "integrated models begin to move us in the direction where this line of inquiry may ultimately take us" (p. 284). However, the issues presented with the integrated approach are centered on disagreement among behavioral theorists regarding the core determinants retained from each theory used and the pathways through which these constructs affect behavior (Noar and Zimmerman, 2005). The resolution for these issues may come from the aforementioned empirical testing. Preliminary theory testing will identify which theories and constructs should be included in a subsequent round of integrated model analysis. Basing a reconstructed model's components on empirical findings from the original theories' analyses removes a degree of subjectivity and discourse within theory integration.

The current study evaluates the employed theoretical models in a manner consistent with these methods in an effort to advance the field of behavioral theory. The constructs associated with each theory were evaluated using measures that were developed for the given theory. Using specific measures rather than general measures or fitting preexisting data allows for the correct conceptualizing of each construct. Additionally, the theories were evaluated as

completely as possible retaining the pathways of the theory through SEM. Therefore, the theories were evaluated to the fullest extent possible as recommended by Noar and Zimmerman (2005).

The process of evaluation was the approach previously derived, beginning with the empirical evaluation of each theory. Every theoretical model displayed adequate fit statistics. Subsequently, no model could be rejected, and no theory could be abandoned as insufficiently explaining CRC screening. Therefore, the extent to which the theories could be empirically compared was exhausted. This result is despite the fact that SEM fit statistics would declare the Theory of Reasoned Action superior to the other. Similar comparative methods would conflict with this declaration and suggest that the Health Belief Model general and colonoscopy screening models were superior based on their substantially higher screening intent $R^2$ values compared to all other models. However, these statistical values cannot traverse models as the models do not contain identical variable sets.

The subjective theoretical comparison illustrates the benefits of each theory and the significant constructs therein. Each theory contains constructs that significantly influence CRC screening intent, and each theory contains other constructs that were not observed to significantly influence screening. Therefore, the results of the study suggest that further refinement of the behavioral theories evaluated is warranted. For instance, it may be the case that certain constructs could be deemphasized or reconceptualized. Specifically, the models demonstrated little benefit from the inclusion of perceived threat (particularly the perceived severity dimension of threat) in the Health Belief Model, attitudes in the Theory of Reasoned action, and internal locus of control in Attribution Theory. The remaining constructs demonstrated generally consistent and stronger influences on CRC screening intent and behavior within their respective models.

**Theory Integration.** With each model demonstrating utility in different respects of explaining health behavior, proposed integration of the models into a unified theory is justified. Analyses of the included theories identified the most influential constructs of each model when entire theoretical models are represented and evaluated. This, in turn, allows for recommendations to amend the theories to include influential concepts absent from other theories and create an integrated model. This model can advance our understanding of behavioral theory as it more completely represents the factors that affected CRC screening intention within the study sample.

The first construct to be included in an integrated model would be the beneficial balance of perceived benefits and barriers given its strong influences within its models. Beneficial balance could closely resemble the attitudes construct of the Reasoned Action Approach models. However, attitudes did not have a meaningful influence on screening intent within its evaluated models. This discrepancy may be due to differences in measurement and instrument use. Also, the items presented as attitude towards screening may conceptualize a more emotional construct while beneficial balance conceptualizes a broader realm of pros and cons. It may also be the case that the influence on screening is not so much the positive or negative leaning attitude towards screening but the absolute net balance of benefits outweighing barriers.

Another consistent influence observed was that of subjective norm on screening intent. This construct explicitly takes into account the impact of 'significant others' and the perceptions of their beliefs on an individual's behaviors. The effect of social norms suggests the possibility of wanting to appease others trumping one's own attitudes and beliefs when deciding to engage in a behavior. This notion demonstrates the substantial individual-level influence of exogenous factors even through an individual's perceptions only. That is, the construct of subjective norm

only conceptualizes what an individual thinks these 'significant others' believe and does not encapsulate the true actions or beliefs of these 'significant others.' Therefore, this unique and influential construct should be incorporated into an integrated model.

Additionally, the evaluated models lend support for inclusion of perceived behavioral control in an integrated model. The improvement in utility of the Theory of Planned Behavior compared to the Theory of Reasoned Action that was previously discussed is predominantly based on the added value of perceived behavioral control when incorporated into the models. The construct represents the idea that the behavior in decision is not under the complete volitional control of the deciding individual (Ajzen, 1991). While certain barriers to volitional control such as cost and accessibility have been reduced through healthcare coverage of cancer screenings and multiple modalities including home screening kits (Joseph, King, Miller, Richardson, & Centers for Disease Control and Prevention, 2012), reliance on the assistance of healthcare professionals as well as other logistical issues such as the time required to complete screening hinder the behavior from being assumed as under complete volitional control by the individual. Therefore, the influence of such a construct should be accounted for in the behavioral model.

Finally, the Attribution Theory models demonstrate the significant influence of perceived malleability on screening intent. The inclusion of perceived malleability in an integrated model provides a novel component to the health behavior theory. As identified in the conceptual framework of the study, Attribution Theory identifies the perceived outcome value of screening. The remaining theories evaluated identified the behavioral value of screening. Therefore, the inclusion of perceived malleability in a model that otherwise represents behavioral value constructs allows for representation of the entire conceptual framework within the model. As

such, the integrated model conceptualizes both the beliefs associated with the behavior as well as the perceived outcome efficacy of the behavior.

An additional argument can be made for the inclusion of perceived threat, or at least perceived susceptibility, of the condition associated with the behavior. The presence of perceived threat in behavioral theories such as the Health Belief Model hypothesizes the need for an individual to believe he or she may be affected by a condition before that individual will engage in a behavior that may alter said condition (Rosenstock et al., 1988). Within this study, this would be the assumption that the intention to screen for CRC is influenced by the individual's belief that he or she is likely to develop CRC. The idea of susceptibility would complete a causal chain associated with a behavior within the integrated model: an individual must believe he or she is threatened by a condition; the individual must have a favorable belief towards the engagement of the behavior associated with the condition; and the individual must believe that his or her status associated with the condition can be altered through the outcomes associated with the behavior.

It is unclear based on the evaluated models how the constructs may interact with one another in addition to their direct effects on intention. Therefore, only recommendation of included constructs is proposed. A proposed structural framework associated with a newly integrated model is beyond the scope of the results of the current study. However, based on the models that the included constructs derive from, it can be assumed that all constructs at least have a direct effect on behavioral intention.

It is important to understand that while the results of this study aid in the advancement of behavioral theory, the theories were subjected to only one type of health behavior, i.e. colorectal cancer screening. The information learned from this study demonstrates that each theoretical

model contains enough value to not be rejected as a model of behavioral change. However, within those models, certain constructs presented themselves as having a greater influence than other constructs. These observations should not be generalized to the theory's overall performance within behavioral science. The variance in construct influence on behavior within a given theory but across behaviors is recognized. For example, the Health Belief Model recognizes the distinction between discrete (i.e. one-time) behaviors such as vaccination and chronic behaviors such as diabetes self-care. As such, the Health Belief Model recognizes the specific influence of self-efficacy among chronic care behaviors while self-efficacy is more implicitly recognized within the original constructs of the model among discrete behaviors (Rosenstock et al., 1988). Similarly, Ajzen (1991) explicitly recognizes that within the Theory of Planned Behavior, "the relative importance of attitude, subjective norm, and perceived behavioral control in the prediction of intention is expected to vary across behaviors and situations" (p. 189).

Head and Noar (2013) use the Reasoned Action Approach to further discuss the variability of construct performance across multiple behavioral domains. The discussion illustrates the struggle between generalizability and utility of a widely used behavioral theory. Specifically, retention of constructs that demonstrate some degree of influence across multiple behaviors retains the generalizability of the theory, but the modification of a theory and its constructs based on a given behavior improves the utility of the theory regarding its application and use in intervention design (Head and Noar, 2013).

Therefore, theoretical development using such results as those from this study should employ a two-pronged approach. First, the theoretical model analyses function as a single component of generalized theory evaluation. Recommendation of significant theory alteration

should be restrained since the current study's results are limited to one type of behavior. Second, the results can be more aggressively used to inform reconstruction of CRC screening, behavior-specific versions of the theoretical models, as well as an integration of the models. Behavior-specific adaptations of health behavior theories are commonly employed in public health research design and program implementation (Head and Noar, 2013). These behavior-specific models should not be considered advancement of the general theory, but rather a corollary of the generalized theory. The value of these corollary theories is their ability to be applied to practical use such as improving colorectal screening rates among at-risk individuals.

**Colorectal Cancer Screening Practical Application**

Message and content design is critical for a campaign to successfully improve colorectal cancer (CRC) screening rates. Multiple approaches can be used to provide a consumer with the best suitable content for him or her. Message design can follow many tactics. For example, a campaign may strictly provide information of the risks of CRC, benefits associated with screening, and dispel false perceptions (Eastern Idaho Public Health, 2010; Exact Sciences, 2014; Iowa Department of Public Health, 2015; Minority Health & Health Disparities Research Center, 2004; The Prevent Cancer Foundation, 2011). Messages may also employ scare tactics (Witte, 1992) or humor to further impact the consumer of the campaign. Many recent campaigns have employed the use of humor to dispel barriers of embarrassment or stigma associated with CRC screening procedures (Aiello, 2012; Chris4Life Colon Cancer Foundation, 2015; Kuruvilla, 2013; Rogers, 2012).

Jensen et al. (2014) demonstrated how imperative message design and content is regarding CRC screening campaigns. Individuals who received a narrative designed, CRC screening campaign approach were more likely to engage in colonoscopies, while a campaign

design tailored to the individual was not likely to predict increased odds of screening. The results also illustrated the additional effect of "cancer information overload (CIO)" (Jensen et al., 2014 p. 33). CIO describes an inundation of information related to cancer prevention and treatment recommendation to the point when an overwhelmed individual will begin to shut down or reject new information. High CIO was found to significantly reduce the odds of colonoscopy screening (Jensen et al., 2014).

This detrimental effect of CIO on effectively processing cancer information such as screening recommendations illustrates the need to carefully curate and disseminate only the most influential information to improve screening behaviors. The results of this study can inform CRC prevention and control primarily through informing program and campaign message development. Particularly, the results provide insight regarding which constructs are most influential even in the presence of all of the theories constructs. As such, campaign designs can emphasize these constructs to streamline message content and avoid CIO.

Past campaign development typically has employed mention of theory, broad or vague application of a theory's conceptualization and hypotheses, or isolation of one or few constructs extracted from a theory (Braun, Fong, Kaanoi, Kamaka, & Gotay, 2005; Krok-Schoen et al., 2015; Noar, 2006; Noar & Head, 2011; Skubisz, 2015). For example, the Centers for Disease Control and Prevention (CDC) *Screen for Life: National Colorectal Cancer Action Campaign* has been an ongoing campaign since 1999 to advocate CRC screening (Ekwueme, Howard, Gelb, Rim, & Cooper, 2014). The campaign includes multiple sources of print and digital media including messages featuring a diverse array of celebrities (CDC). However, the mention of behavioral theory to inform the campaign is limited to using theory such as the Theory of

Planned Behavior to design focus group questions to explore the attitudes and behaviors of the target population (Jorgensen, Gelb, Merritt, & Seeff, 2001).

The use of theory to inform qualitative methods such as focus group guides is beneficial since it ensures that focus group discussions explore the critical constructs of behavioral theory. However, the use of theory in CPC program design should not end with focus groups. Once the qualitative methods identify the particular and relevant content with constructs, quantitative evaluation of the constructs and their relationships with screening intentions and behaviors is warranted. Such evaluation is employed in the current study. This evaluation of the theories' performances provides novel and more reliable data as to how these theories and constructs influence CRC screening behaviors. As a basis for CRC programs, the use of the information provided in this study grounds the program in better theoretical foundations and statistical support for its program design.

The *Screen for Life* campaign has a vast reach across the entire country. The campaign's ads span all U.S. TV media markets; 3,000 radio stations; 350 print outlets; 50 major public places including airports, shopping centers, and office buildings; and maintains a significant social media presence (Ekwueme et al., 2014) (CDC, Ekwueme et al). The campaign messages of *Screen for Life* are the following:

- "Of cancers affecting both men and women, colorectal cancer is the second leading cancer killer in the U.S.
- If you're 50 or over, see your doctor and get screened for colorectal cancer.
- Screening for colorectal cancer saves lives.
- Screening helps prevent colorectal cancer.
- Screening tests help find precancerous polyps so they can be removed before they turn into cancer.
- Screening helps find colorectal cancer early, when treatment can be very effective.
- Because polyps or cancer in the colon or rectum don't always cause symptoms, it is important to be screened regularly for colorectal cancer.

- Most insurance plans, including Medicare, help pay for colorectal cancer screening." (CDC *Screen for Life: National Colorectal Cancer Action Campaign* Campaign Overview – 2015 p. 1)

The messages of the largest CRC prevention and control campaign appear to emphasize two major constructs: perceived threat and perceived benefits. Review of the additional print material also illustrates the use of dispelling perceived barriers. The identification of theoretical constructs within the campaign messages and design is promising. However, the question remains of whether or not the emphasized constructs are the most influential and efficient for improving CRC screening rates.

The results of the current study would suggest that the constructs most influential to improve CRC screening intentions are somewhat represented in the campaign. Certain messages contain aspects of constructs included in the CRC-specific integrated model. For example, messages explaining how screening can prevent cancer by removing non-cancerous polyps evokes outcome value and the malleability of cancer. Similarly, barriers addressed such as cost lend themselves to beliefs of perceived behavioral control. Also, all messages endorsing benefits of screening while dispelling barriers will positively affect the beneficial balance of CRC screening.

The campaign messages may benefit from a more explicit emphasis on the malleability of cancer (e.g. "colorectal cancer caught early can be cured") and perceived behavioral control of screening (e.g. screening can be done at home, multiple methods to match patient preference, etc.). Additionally, the use of subjective norms is vastly understated in the campaign. While celebrity endorsement may allude to the use of subjective norms, more aggressive messages can be employed. Subject norm-based messages can be presented as recommendations by 'significant others' to be screened. For example, Katz et al. (2011) recognizes physician

recommendations of screening (e.g. “my doctor wants me to be screened”) as a significant predictor of CRC screening adherence. The use of subjective norms in message design could also be employed through appealing to secondary populations associated with the at-risk population. For example, the campaign can direct attention to spouses, children, or friends, asking them to tell the at-risk people they care about to get screened.

Improvement of the message design of a campaign such as *Screen for Life* would not create a trivial impact on the health of our nation. Multiple exposure – i.e. greater than one-time exposure – to the information associated with the *Screen for Life* campaign demonstrated significantly elevated odds of screening participation that improved with additional exposure (Cooper, Gelb, & Hawkins, 2014). Furthermore, Ekwueme et al. (2014) illustrates the potential impact of the campaign as a greater number of those exposed elect to be screened. Over the course of the campaign (until 2012), the study estimates an additional 251,000 people screened with an effect size of 0.5% of the target population. Ekwueme et al. (2014) also estimate that at an effect size of 10% of the target population, this would result in the additional screening of 5.01 million people. This would all be accomplished “well below thresholds typically used to assess whether services are cost-effective” (Ekwueme et al., 2014, p. 754). Increases in the number of at-risk individuals screening could translate to a significant decrease in morbidity and mortality associated with CRC. Improvements in effect size of the campaign and similar cancer prevention and control campaigns may be accomplished through the application of information associated with individual-level CRC screening intention influences such as the information obtained through this study.

## Limitations

While this study provides valuable information for understanding and advancing behavioral theory and CRC screening behavior in particular, the study is not without its limitations. The limitations of the study are primarily due to feasibility associated with the design and execution of the study as well as the constraints imposed on the study due to the established practices associated with the behavioral theories evaluated.

**Design Limitations.** The primary design limitation of the study is its cross-sectional nature. Future behaviors could not be assessed necessitating the use of previous behaviors as proxy. While this practice has been established by previous studies, there is still uncertainty that consistency in behavior will persist. Also, the possibility remains that the previous behavior has influenced the related attitudes and beliefs of the individual and should be considered a predictor rather than the outcome by proxy. Additionally, the predictive nature of the theories was inferred and assumed through reasoning. However, a study of CRC screening behaviors that is longitudinal in nature would require a minimum of ten years. This is because screening guidelines recommend colonoscopy every ten years after a negative screening. Therefore, individuals adherent to screening behaviors may not engage in future screening until a decade after initial contact. Such timeframes are beyond the scope of this study.

A second design limitation is that the survey instrument was implemented through an online survey service. Therefore, the surveyed population are all individuals that have access to the internet and have opted in to the SurveyMonkey Audience program. This will exclude individuals that not only do not have access to the internet but also those that are unfamiliar with SurveyMonkey. Typically, this will bias a population towards an older, female, and higher SES demographic. However, as previously noted, the online population sampled through

SurveyMonkey is sufficiently large and their participant pool encompasses a diverse, national population. Additionally, since SurveyMonkey only provides completed data, access to participants with incomplete data is unavailable for subsequent analysis. This includes a lack of data from individuals with incomplete surveys as well as non-responders to the survey solicitation. Therefore, non-response bias – systematic bias against completion of the survey – cannot be assessed. As such, only a complete case analysis was performed with the available data. However, non-response bias did not appear to be a major concern since the sample was fairly representative of the at-risk population and 89% of respondents completed the survey.

**Execution Limitations.** The measures employed were either preexisting measures specific to the theoretical constructs evaluated or measures adapted to the topic of colorectal cancer screening. In previous studies, the measures were considered both reliable and valid. However, through the CFA of the measures, shortcomings in the measures that necessitated some modifications were observed. These observed shortcomings may have been the result of reliability claims made only through assessments of internal reliability such as Cronbach's alpha, the necessary modifications of the measures to suit the topic of the study, or inherent characteristics of the study sample of this study. To improve the reliability of the measures employed to conceptualize the latent variables of the theories evaluated, measure analyses and refinement could have been completed prior to their use in the current study. However, this would have necessitated additional population samples and time that were not feasible for the current study. Therefore, the post-hoc modifications made were the most feasible approach to best capturing the latent variables desired through the instruments available.

The concern of representativeness with the design of the study was somewhat realized in the study sample. While the sample obtained contained an even or representative spread across

most demographics (i.e. age, sex, education, income, marital status, and employment), clear underrepresentation was observed for race and ethnicity. Particularly, the study sample overrepresented the White/Caucasian population while underrepresenting African-American and Asian-American populations. Additionally, individuals with Hispanic/Latino ethnicity were severely underrepresented in the study sample. Therefore, generalizability of the results should be practiced with caution, particularly with respect to minority populations.

**Theoretical Limitations.** Certain aspects of the conceptualization of the theoretical constructs also provide limitations to the theory's evaluation. One such issue is that of unobservable constructs within a theory. Typically, these constructs represent actual exogenous factors that affect individual-level intentions and behaviors. Within the Health Belief Model, the construct of concern is cue to action (Rosenstock, 1974b). In later iterations of the Theory of Planned Behavior, the inclusion of actual behavioral control provides the same concern (Ajzen, 2011). Both of these constructs relate to events or factors that may not be realized by the individual and, therefore, not able to be reliably captured by a survey instrument. Therefore, these constructs could be factored into models of the theories even though they may have a substantial influence on the individual's behaviors.

Similarly, the design of – or lack thereof – the theoretical pathways restrict full statistical exploration of the theoretical models. Nebulous constructs of a theory – those that are described within a theory as having a general influence on behavior but not given a specific pathway of influence – are difficult to accurately place within a statistical model of a theory. Additionally, theoretical hypotheses of construct interactions without explicit conceptualization of the interaction leaves the interpretation of the interaction up to the study design. Without a definitive statistical conceptualization of the interaction (e.g. summations, products, or intersections of

constructs), models evaluating the theory can vary by study. Conversely, explicit constraints on model pathways may restrict the full evaluation of a theory. For example, the Reasoned Action Approach theories and subsequent analyses explicitly state the fully mediated pathways of beliefs to behaviors through intentions. As such, models that also evaluate partially mediated pathways by including direct effects of beliefs on behavior would not be consistent with the theory. Such models, however, may help fully understand the relationships of the theoretical constructs and variance of behavior explained by the theories.

**Future Approach**

The information learned from the results of this study provides foundational work for future engagements across multiple domains of public health and behavioral science. Particularly, the data will help inform behavioral measurement, refined behavioral theory, and colorectal cancer prevention programs.

Regarding behavioral measurement, the current study provides preliminary measures of colorectal cancer screening beliefs specific to the latent variables of leading behavioral theories. The measures used were derived from existing measures that displayed consistent internal reliability and validity in previous studies. With mostly minor modifications, the measures provided estimated latent constructs suitable for theoretical evaluation. However, the current study's employment of CFA with each measure exposed limitations to the measures and the need for further measure refinement. To accomplish this, critical evaluation of the instrument items that did not perform well (e.g. low factor loadings or extraneous correlation with other items) must be completed. Rationale for the poor performance of the items must be determined as well as an effort to remedy the items through clarification, combination, or possible removal of the item(s).

With a new study sample, cognitive interviewing of the instruments may be completed to expose the thought process of respondents associated with completion of each item. CFA will determine the performance of the revised measures along with evaluations of reliability including item correlations and Cronbach's alpha. Iterations of this process must continue until all items contained in the measure have sufficiently high factor loadings without residual correlation of item error terms. Finally, validation studies should be completed to determine that the measures are capturing the true conceptualizations of the theories' constructs as intended. These refined measures will aid in the reliability of future theoretical model evaluation and validity of future behavioral theory claims.

The structural equation models evaluated in this study provide a single component for the critical and empirical evaluation of behavioral theory. The models represent entire behavioral theories to the extent that representation is feasible. As reviewed, analyses of complete behavioral theories are scant yet critical to further development of the field. While the analysis of the models within this study provide valuable insight into the utility of these theories, recall that these models are restrained to a single type of health behavior. In order to truly evaluate the generalized ability of these behavioral theories to explain health behaviors, replication of this study must be completed across multiple behaviors. Patterns in the consistency of the theory's performance within each data set will provide support for the theory, its constructs, and its pathways or illustrate the need for revision.

Additionally, the aims of this study were to evaluate the ability of behavioral theories as they are currently conceptualized to explain health behavioral intentions and behaviors. As such, the models were analyzed without the luxury of modification to improve the fit and performance of the models. In future iterations of this study intended to revise the theories, alternative

representations of the theories should be analyzed in addition to the currently accepted versions. This includes the representation of partial mediation where full mediation pathways are currently conceptualized, the explicit inclusion of sociodemographics' effects on latent constructs, correlation of latent constructs where currently constrained, as well as the addition/deletion of constructs. Once theories are reconceptualized, the new models should be evaluated with a new population sample to assess support for the refined theoretical model.

The results also provide the foundational work for a CRC-specific behavioral theory. While the behavior-specific theory would most likely not function as a new, generalized behavioral theory, a behavior-specific theory does provide a high degree of utility in explaining the behavior for which it was designed. The current study illustrates the individual-level constructs that may be most influential to screening behaviors. However, construction of new models with the constructs identified was beyond the scope of the study. Future exploration of the data will include the construction of a model of CRC screening behavior integrating the influential constructs from the theories evaluated. The pathways of the model will result from existing hypothesized pathways from the constructs' current models, statistical analyses and modification of the integrated model, and rationale from previous literature regarding the conceptualization and use of the constructs. As with evaluation of the other behavioral theories, evidence for the theory's utility will come from the evaluation of the integrated model using a new sample data set.

Finally, the culmination of the information learned can provide theoretical grounding for the development and evaluation of new public health initiatives across behaviors. Primarily, the data obtained through this and subsequent studies will provide structured and useful information to guide CRC prevention campaigns intended to improve screening rates. Demonstrated in the

section regarding CRC screening application, refined and evaluated theories of CRC screening intention and behavior can be used as aids and decisional tools for selecting program direction and content. As the measures and theories are further evaluated as recommended, a similar approach for public health program designs can be taken across multiple health behaviors.

The constructs of the theory can establish discussion topics to explore within preliminary, qualitative research of target audiences. The hypothesized pathways of the models illustrate the interactions of the constructs and how the influence of one belief or behavior may alter the remaining constructs. Preliminary quantitative analysis associated with the theoretical models can establish a baseline of the beliefs and behaviors of the target population. Program design can then be based upon this work. Furthermore, analysis of a program within the framework of the applied theory can facilitate systematic implementation and evaluation of the program.

## Summary

There has been limited research evaluating entire behavioral theory models even though they are often cited as the basis of many research and program designs. This study contributes necessary information to both behavioral theory and applied cancer prevention research. Regarding behavioral theory, the use of structural equation models to simultaneously evaluate all of the pathways of entire behavioral theories as they are hypothesized has given evidence to support the consistency of the theories with regard to observed behavioral intentions and behaviors in a national sample. The constructs of the Health Belief Model, Theory of Planned Behavior, and Attribution Theory all provide adequate explanations of individual-level health behavior influences. Although, further review and refinement of the theories is warranted and recommended.

Similarly, the evaluation of the theories within CRC research illustrates the relative advantage associated with each theory along with the most influential constructs on CRC screening. The burden associated with CRC in the United States is high, yet CRC is a disease that can be successfully curbed when appropriate measures such as early screening and detection are employed. This study has discussed multiple individual-level influences affecting screening and their practical applications. As such, the results of the study can help guide public health

practitioners in cancer prevention program design to choose the most appropriate theory, significant constructs, and theoretical pathways in an effort to provide the greatest impact on CRC screening, cancer prevention and control, and its associated morbidity and mortality.

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# Appendix A – Survey Instrument

# CRC Screening Measures

## Welcome!

Information Sheet

The following survey is about your attitudes and behaviors related to colorectal cancer. Colorectal cancer is cancer of the colon (large bowel, large intestine) or rectum. Please answer each question to the best of your ability. Remember, these questions are about your attitudes and behaviors; there are no "right" or "wrong" answers to these questions.

The data from this survey will be used for behavioral research and is anonymous. Names and other identifiers will not be collected by this survey or other research data. There are no foreseeable risks for participating in this research, nor are there any additional benefits to you as a respondent of this survey.

Your activity in this research by completing this survey is voluntary. If you wish to participate, click "Next" below. If you do not wish to participate, click "Exit this survey" at the upper right corner of your web browser.

Thank you for taking the time to complete this survey. To agree that you are willing to answer the questions in this survey and begin, please click "Next"

# CRC Screening Measures

## Attitudes

The following set of questions is about your attitude towards screening specifically and not your attitude towards cancer in general.

**1a. Screening for colorectal cancer worries me because of what it might find**

Strongly Disagree ○ ○ ○ ○ ○ ○ ○ Strongly Agree

**1b. Worrying about what the colorectal cancer screening might find**

Can be a bad thing ○ ○ ○ Doesn't Matter ○ ○ ○ Can be a good thing

**2a. Screening for colorectal cancer makes me afraid**

Strongly Disagree ○ ○ ○ ○ ○ ○ ○ Strongly Agree

**2b. Being afraid of colorectal cancer screening**

Can be a bad thing ○ ○ ○ Doesn't Matter ○ ○ ○ Can be a good thing

**3a. Screening for colorectal cancer takes a lot of preparation**

Strongly Disagree ○ ○ ○ ○ ○ ○ ○ Strongly Agree

**3b. Having to do a lot of preparation**

Can be a bad thing ○ ○ ○ Doesn't Matter ○ ○ ○ Can be a good thing

**4a. Screening for colorectal cancer is uncomfortable or painful**

Strongly Disagree ○ ○ ○ ○ ○ ○ ○ Strongly Agree

**4b. Having discomfort or pain from the screening**

Can be a bad thing ○ ○ ○ Doesn't Matter ○ ○ ○ Can be a good thing

**5a. Being screened for colorectal cancer is embarrassing**

Strongly Disagree ○ ○ ○ ○ ○ ○ ○ Strongly Agree

**5b. Being embarrassed by the screening**

Can be a bad thing ○ ○ ○ Doesn't Matter ○ ○ ○ Can be a good thing

## CRC Screening Measures

**6a. Screening for colorectal cancer makes me do a lot of work**

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**6b. Having to do a lot of work to get screened**

| Can be a bad thing | | | Doesn't Matter | | | Can be a good thing |
|---|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**7a. Screening for colorectal cancer prevents cancer**

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**7b. Preventing cancer**

| Can be a bad thing | | | Doesn't Matter | | | Can be a good thing |
|---|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**8a. Screening for colorectal cancer finds cancer before it spreads**

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**8b. Finding cancer before it spreads**

| Can be a bad thing | | | Doesn't Matter | | | Can be a good thing |
|---|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## CRC Screening Measures

### Perceived Norm

The following set of questions is about how you think people around you would feel about colorectal cancer screening and you.

**9a. My spouse/significant other wants me to regularly get screened for colorectal cancer**

| Strongly Disagree | | | | | | Strongly Agree | N/A |
|---|---|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**9b. Generally speaking, how much do you care what your spouse/significant other thinks you should do about colorectal cancer screening?**

| Not at all | | | | | | Very Much | N/A |
|---|---|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**10a. Most family members who are important to me want me to regularly get screened for colorectal cancer.**

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**10b. Generally speaking, how much do you care what your family members think you should do about colorectal cancer screening?**

| Not at all | | | | | | Very Much |
|---|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**11a. Most friends who are important to me want me to regularly get screened for colorectal cancer.**

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**11b. Generally speaking, how much do you care what your friends think you should do about colorectal cancer screening?**

| Not at all | | | | | | Very Much |
|---|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**12a. Most people like me get screened for colorectal cancer exactly when the guidelines suggest.**

| Strongly Disagree | | | | | | Strongly Agree |
|---|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**12b. Generally speaking, how much do you care what people like you think you should do about colorectal cancer screening?**

| Not at all | | | | | | Very Much |
|---|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ | ○ |

## CRC Screening Measures

**13a. My healthcare providers want me to regularly get screened for colorectal cancer.**

Strongly Disagree ○ ○ ○ ○ ○ ○ ○ Strongly Agree

**13b. Generally speaking, how much do you care what your healthcare providers think you should do about colorectal cancer screening?**

Not at all ○ ○ ○ ○ ○ ○ ○ Very Much

## CRC Screening Measures

### Perceived Behavioral Control

The following set of questions is about your ability to get screened for colorectal cancer.

**14a. I expect that I could make a decision about whether or not to get colorectal cancer screening**

Very Unlikely ○ ○ ○ ○ ○ ○ ○ Very Likely

**14b. Making the decision about whether or not to get colorectal cancer screening is up to me.**

Strongly Disagree ○ ○ ○ ○ ○ ○ ○ Strongly Agree

**15a. I expect that I could complete colorectal cancer screening**

Very Unlikely ○ ○ ○ ○ ○ ○ ○ Very Likely

**15b. Being able to complete colorectal cancer screening is up to me.**

Strongly Disagree ○ ○ ○ ○ ○ ○ ○ Strongly Agree

**16a. I expect that I could complete colorectal cancer screening even if I was nervous about getting screened.**

Very Unlikely ○ ○ ○ ○ ○ ○ ○ Very Likely

**16b. Completing colorectal cancer screening even if I am nervous about it is important.**

Strongly Disagree ○ ○ ○ ○ ○ ○ ○ Strongly Agree

**17a. I expect that I could complete colorectal cancer screening even if I was embarrassed about it**

Very Unlikely ○ ○ ○ ○ ○ ○ ○ Very Likely

**17b. Completing colorectal cancer screening even if I am embarrassed is important.**

Strongly Disagree ○ ○ ○ ○ ○ ○ ○ Strongly Agree

**18a. I expect that I could find the time to complete colorectal cancer screening**

Very Unlikely ○ ○ ○ ○ ○ ○ ○ Very Likely

## CRC Screening Measures

**18b. Having the time to complete colorectal cancer screening would allow me to get screened.**

Strongly Disagree ○ ○ ○ ○ ○ ○ ○ Strongly Agree

**19a. I expect that I could talk to my doctor about colorectal cancer screening**

Very Unlikely ○ ○ ○ ○ ○ ○ ○ Very Likely

**19b. Talking to my doctor about colorectal cancer screening would enable me to get screened.**

Strongly Disagree ○ ○ ○ ○ ○ ○ ○ Strongly Agree

**20a. I expect that I could carry out any necessary preparation for colorectal cancer screening**

Very Unlikely ○ ○ ○ ○ ○ ○ ○ Very Likely

**20b. Being able to complete any necessary preparation for colorectal cancer screening would enable me to get screened.**

Strongly Disagree ○ ○ ○ ○ ○ ○ ○ Strongly Agree

**21a. I expect that I could get support from family or friends to help me complete colorectal cancer screening**

Very Unlikely ○ ○ ○ ○ ○ ○ ○ Very Likely

**21b. Having support from family or friends to help me complete colorectal cancer screening would enable me to be screened.**

Strongly Disagree ○ ○ ○ ○ ○ ○ ○ Strongly Agree

## CRC Screening Measures

### Locus of Control

Each item below is a belief statement about colorectal cancer with which you may agree or disagree. For each item we would like you to select the choice that represents the extent to which you agree or disagree with that statement.

**22. If I were to get colorectal cancer, it is my own behavior which determines how quickly I recover.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**23. As to getting colorectal cancer, what will be will be.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**24. If I see my doctor regularly, I am less likely to have problems with colorectal cancer.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**25. Most things that affect getting colorectal cancer happen to me by chance.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**26. Whenever symptoms that may indicate colorectal cancer worsen, I should consult a medically trained professional.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**27. If I were to have colorectal cancer, I am directly responsible for colorectal cancer getting better or worse.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**28. Other people play a big role in whether my chance of getting colorectal cancer improves, stays the same, or gets worse.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**29. Whatever goes wrong with colorectal cancer is my own fault.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**30. Luck plays a big part in determining if I get colorectal cancer.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

## CRC Screening Measures

**31. In order to improve my chance of preventing colorectal cancer, it is up to other people to see that the right things happen.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**32. Whatever improvement occurs with colorectal cancer is largely a matter of good fortune.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**33. The main thing which affects getting colorectal cancer is what I myself do.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**34. I deserve the credit when my chance of getting colorectal cancer decreases and the blame when it increases.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**35. Following doctor's orders to the letter is the best way to keep my chance of getting colorectal cancer from getting any worse.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**36. If my chance of getting colorectal cancer worsens, it's a matter of fate.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**37. If I am lucky, my chance of getting colorectal cancer will decrease.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**38. If my chance of getting colorectal cancer increases, it is because I have not been taking proper care of myself.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

**39. The type of help I receive from other people determines my chance of getting colorectal cancer.**

| Strongly Disagree | Moderately Disagree | Slightly Disagree | Slightly Agree | Moderately Agree | Strongly Agree |
|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ |

## CRC Screening Measures

### Stability

Read each sentence below and then select the choice that indicates how much you agree with each statement, using the scale below each item.

**40. You have a certain chance of getting colorectal cancer, and you can't really do much to change it.**

| Strongly Disagree | Mostly Disagree | Somewhat Disagree | Somewhat Agree | Mostly Agree | Strongly Agree |
|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**41. Your chance of getting colorectal cancer is something about you that you can't change very much.**

| Strongly Disagree | Mostly Disagree | Somewhat Disagree | Somewhat Agree | Mostly Agree | Strongly Agree |
|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**42. No matter who you are, you can significantly change your chance of getting colorectal cancer.**

| Strongly Disagree | Mostly Disagree | Somewhat Disagree | Somewhat Agree | Mostly Agree | Strongly Agree |
|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**43. To be honest, you can't really change your chance of getting colorectal cancer.**

| Strongly Disagree | Mostly Disagree | Somewhat Disagree | Somewhat Agree | Mostly Agree | Strongly Agree |
|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**44. You can always substantially change your chance of getting colorectal cancer.**

| Strongly Disagree | Mostly Disagree | Somewhat Disagree | Somewhat Agree | Mostly Agree | Strongly Agree |
|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**45. You can change your health related behaviors, but you can't really change your basic chance of getting colorectal cancer.**

| Strongly Disagree | Mostly Disagree | Somewhat Disagree | Somewhat Agree | Mostly Agree | Strongly Agree |
|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**46. No matter how high your chance of getting colorectal cancer is, you can always change it quite a bit.**

| Strongly Disagree | Mostly Disagree | Somewhat Disagree | Somewhat Agree | Mostly Agree | Strongly Agree |
|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**47. You can change your basic chance of getting colorectal cancer considerably.**

| Strongly Disagree | Mostly Disagree | Somewhat Disagree | Somewhat Agree | Mostly Agree | Strongly Agree |
|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## CRC Screening Measures

### Colorectal Cancer Health Beliefs

**48. It is extremely likely I will get colon cancer in the future.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**49. I feel I will get colon cancer in the future.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**50. There is a good possibility I will get colon cancer in the next 10 years.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**51. My chances of getting colon cancer are great.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**52. I am more likely than the average person to get colon cancer.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**53. The thought of colon cancer scares me.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**54. When I think about colon cancer, my heart beats faster.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**55. I am afraid to think about colon cancer.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**56. Problems I would experience with colon cancer would last a long time.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**57. Colon cancer would threaten a relationship with my partner.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**58. If I had colon cancer my whole life would change.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

## CRC Screening Measures

**59. If I developed colon cancer, I would not live longer than 5 years.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

## CRC Screening Measures

### Colorectal Cancer Health Beliefs

**60. If I had regular check-ups to detect colon cancer, I would feel good.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**61. If I had regular check-ups to detect colon cancer, I wouldn't worry as much about colon cancer.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**62. Having regular check-ups to detect colon cancer will allow me to find cancer early.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**63. If I have regular check-ups to detect colon cancer, I will decrease my chance of dying from colon cancer.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**64. If I have regular check-ups to detect colon cancer, I will decrease my chances of requiring radical or disfiguring surgery if colon cancer occurs.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**65. If I have regular check-ups to detect colon cancer, it will help me to detect something that may be cancer early.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**66. I feel uncomfortable talking about colon cancer.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**67. Having regular check-ups to detect colon cancer will make me worry about colon cancer.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**68. Regular check-ups to detect colon cancer will be embarrassing to me.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

## CRC Screening Measures

**69. Regular check-ups to detect colon cancer will take too much time.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**70. Regular check-ups to detect colon cancer will be unpleasant.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**71. Having regular check-ups to detect colon cancer will cost too much money.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

## CRC Screening Measures

### Colorectal Cancer Health Beliefs

**72. I know how to get regular check-ups to detect colon cancer.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**73. I am confident that I could schedule regular check-ups to detect colon cancer if I needed them.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**74. If I were to develop colon cancer, I would continue to get regular check-ups.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**75. I can recognize normal and abnormal changes in my bowel habits.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

**76. I will be able to detect colon cancer early if I have regular check-ups.**

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ |

# CRC Screening Measures

## Past Behavior

The next few questions are about some different tests you may have already had to look for signs of colorectal cancer.

FECAL OCCULT BLOOD TEST (FOBT)

First, there are two types of stool blood tests also known as fecal occult blood tests (FOBT) that you might have had.

One test (gFOBT) IS DONE AT HOME using a **set of 3 cards** to determine whether your stool contains blood. You smear a sample of your fecal matter or stool on a card from 3 separate bowel movements and return the cards to be tested.

### 77. Have you ever had this stool blood test?

(Mark one answer.)

| | |
|---|---|
| No, have never had one done | ◯ |
| Yes, 1 year ago or less | ◯ |
| Yes. more than 1 but not more than 2 years ago | ◯ |
| Yes, more than 2 but not more than 5 years ago | ◯ |
| Yes, more than 5 years ago | ◯ |
| Don't know if I have | ◯ |

The other test (iFOBT/FIT) IS DONE AT HOME using **1 tube** to determine whether your stool contains blood. You take small samples of your fecal matter or stool with a stick and place it in a tube and return the tube to be tested.

### 78. Have you ever had this stool blood test?

(Mark one answer.)

| | |
|---|---|
| No, have never had one done | ◯ |
| Yes, 1 year ago or less | ◯ |
| Yes. more than 1 but not more than 2 years ago | ◯ |
| Yes, more than 2 but not more than 5 years ago | ◯ |
| Yes, more than 5 years ago | ◯ |
| Don't know if I have | ◯ |

# CRC Screening Measures

## Past Behavior

The next two questions are about sigmoidoscopy and colonoscopy. These are two other tests to check for colorectal cancer. Both tests examine the colon using a narrow, lighted tube that is inserted in the rectum.

SIGMOIDOSCOPY

A sigmoidoscopy (pronounced: sig-MOY-DAHS-kuh-pee) is also referred to as flexible sigmoidoscopy or "flex sig." Sigmoidoscopy examines only the lower part of the colon. You are **awake** during the test, can **drive yourself** home, and can **resume normal activities** after the test.

### 79. Have you ever had a sigmoidoscopy?

(Mark one answer.)

- No, have never had one done ◯
- Yes, 1 year ago or less ◯
- Yes. more than 1 but not more than 5 years ago ◯
- Yes, more than 5 but not more than 10 years ago ◯
- Yes, more than 10 years ago ◯
- Don't know if I have ◯

COLONOSCOPY

A colonoscopy (pronounced: koh-luh-NAHS-kuh-pee) is a test that uses a narrow, lighted tube to examine the entire colon. With a colonoscopy, you are **sleepy or asleep** during the test, **need someone to drive** you home, and **need to take the rest of the day off** from normal activities.

### 80. Have you ever had a colonoscopy?

(Mark one answer.)

- No, have never had one done ◯
- Yes, 1 year ago or less ◯
- Yes. more than 1 but not more than 5 years ago ◯
- Yes, more than 5 but not more than 10 years ago ◯
- Yes, more than 10 years ago ◯
- Don't know if I have ◯

## CRC Screening Measures

### Behavioral Intention

**81. I intend on getting screened for colorectal cancer**

| Very Unlikely | | | | | | Very Likely |
|---|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**82. I intend on using a Fecal Occult Blood Test (gFOBT/iFOBT/FIT) to screen for colorectal cancer in the next year**

| Very Unlikely | | | | | | Very Likely |
|---|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**83. I intend on having a sigmoidoscopy to screen for colorectal cancer in the next 5 years**

| Very Unlikely | | | | | | Very Likely |
|---|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**84. I intend on having a colonoscopy to screen for colorectal cancer in the next 10 years**

| Very Unlikely | | | | | | Very Likely |
|---|---|---|---|---|---|---|
| ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**85. Of the three most commons methods of colorectal cancer, I am most likely to do:**

| | (select one) |
|---|---|
| Sigmoidoscopy | ◯ |
| Fecal Occult Blood Test (gFOBT/iFOBT/FIT) | ◯ |
| Colonoscopy | ◯ |

## CRC Screening Measures

### Demographics

The following set of questions is about you and your background.

**86. In general, how would you rate your overall health?**

- ◯ Excellent
- ◯ Very good
- ◯ Good
- ◯ Fair
- ◯ Poor

**87. Are ANY of the following statements true for you:**

- **I have been diagnosed with diabetes.**
- **I have been told by a healthcare professional that I have obesity.**
- **I am a current smoker.**

- ◯ Yes
- ◯ No

**88. Are ANY of the following statement true for you:**

- **I have a history of inflammatory bowel disease (e.g. ulcerative colitis or Crohn's disease).**
- **At least one of my parents, siblings, or children has been told they have polyps or colorectal cancer.**
- **I have a known family history of hereditary colorectal cancer syndrome such as *familial adenomatous polyposis* (FAP) or *hereditary non-polyposis colon cancer* (HNPCC).**

- ◯ Yes
- ◯ No

## CRC Screening Measures

**89. Have you ever been told by a doctor or other healthcare provider that you have polyps in your colon or rectum?**

◯ No

◯ Yes

What Year?

_____

**90. Have you ever been told by a doctor or other healthcare provider that you have colorectal cancer?**

◯ No

◯ Yes

What Year?

_____

**91. Have you ever been told by a doctor or other healthcare provider that you have any other type of cancer?**

◯ No

◯ Yes

What Year?

What type of cancer?

# CRC Screening Measures

## Demographics

### 92. What is you date of birth?

Date MM / DD / YYYY

### 93. Are you male or female?

- ◯ Male
- ◯ Female

### 94. Which of the following best describes you?

- ◯ White or Caucasian
- ◯ Black or African American
- ◯ Asian
- ◯ Native Hawaiian or Other Pacific Islander
- ◯ American Indian or Alaska Native
- ◯ Other (please specify)

### 95. Are you of Hispanic or Latino origin or descent?

- ◯ Yes, Hispanic or Latino
- ◯ No, not Hispanic or Latino

### 96. What is the highest level of education you completed?

- ◯ Less than high school or some high school
- ◯ High school graduate or Graduate Equivalent Degree (GED)
- ◯ Some college, but no degree
- ◯ Associate degree from an occupational, technical, vocational or academic program
- ◯ Bachelor's degree
- ◯ Some postgraduate work
- ◯ Master's degree
- ◯ Doctoral degree

## CRC Screening Measures

**97. What is your employment status?**

- ◯ Employed full-time
- ◯ Employed part-time
- ◯ Unemployed
- ◯ Retired
- ◯ Homemaker
- ◯ Disability

**98. What is your marital status?**

- ◯ Never married
- ◯ Married/Cohabit
- ◯ Divorced/Separated
- ◯ Widowed

**99. Which of the following ranges best describes your household's total yearly income?**

- ◯ Under $10,000
- ◯ $10,000-19,999
- ◯ $20,000-29,999
- ◯ $30,000-39,999
- ◯ $40,000-49,999
- ◯ $50,000-59,999
- ◯ $60,000-69,999
- ◯ $70,000-79,999
- ◯ $80,000-89,999
- ◯ $90,000-99,999
- ◯ $100,000 +