Mammography Maintenance:
A longitudinal, population-based study of insured women

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A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Gillings School of Global Public Health (Department of Health Behavior and Health Education).

Chapel Hill
2008

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ABSTRACT

JENNIFER MARIE GIERISCH: Mammography Maintenance: A longitudinal population-based study of insured women

(Under the direction of Jo Anne Earp, Noel Brewer, Barbara K. Rimer, Celette Sugg Skinner and Catherine Zimmer)

Early detection through mammography screening is an effective way to control breast cancer. Rates of mammography screening have increased dramatically over the last decade although recent data suggest that rates may now be declining. To reduce their risk of breast cancer morbidity and mortality, women should maintain regular on-schedule mammography use (i.e., mammography maintenance). Repeat use is a necessary step towards that goal. Many variables have been examined as predictors or correlates of repeat mammography use. However, few studies of mammography maintenance exist.

The data for these secondary analyses come from PRISM (Personally Relevant Information on Screening Mammography), a five-year health communication intervention trial. Participants in this study come from PRISM control group (n=1522). Predictors of interest were informed by behavioral theory and previous research on maintenance of health behaviors. Descriptive statistics and survival analysis were used to assess study aims. Mammography use was calculated at the end of each follow-up period (12, 24 and 36 months). Unsustained maintenance was defined as not having consecutive mammograms on schedule (10 to 14 months apart).

Only 38% of women sustained mammography maintenance over three years. We observed differences in the proportion of women endorsing attitudes and beliefs when trends were plotted according to on-schedule mammography use over time. When variables were examined in longitudinal models, women who reported less satisfaction with their past mammography experience, expressed lower self-efficacy, reported poor/fair health and reported barriers to getting a mammogram were more likely to be non-adherent to mammography maintenance over three years. Additionally, behavioral intentions were significant predictors of unsustained maintenance and mediated the effects of self-efficacy and barriers.

This study provides evidence that we have not yet achieved high levels of compliance with mammography maintenance. Even in a previously adherent, insured population, there still may be important cognitive variables that predict regular mammography use. Continuing to search for additional factors not tested in this study that affect long-term maintenance of episodic behavior remains important. At the same time, we should look at the modifiable factors confirmed as significant variables in this study in order to promote regular mammography use.

For my father, Theodore E. Gierisch.

ACKNOWLEDGEMENTS

I would like to thank the Cancer Control Education Program at Lineberger Comprehensive Cancer Center and Cecil G. Sheps Center for Health Services Research NRSA fellowship for provided funding for my doctoral research. I would also like to thank my chair, Jo Anne Earp, and my academic advisor, Barbara K. Rimer. You were both so very instrumental in my growth as a behavioral scientist and contributed significantly to the shape of this work. I thank Cathy Zimmer for her unwavering support and statistical expertise. I also thank my family and friends, especially my husband, Greg Whitaker. You have supported and nurtured me throughout this process. Finally, I am also grateful to the PRISM participants for making this research possible.

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CHAPTER ONE: INTRODUCTION

1.1 Problem Statement

Early detection through mammography screening is an effective way to control breast cancer (Humphrey, Helfand, Chan, & Woolf, 2002). Rates of mammography screening have increased dramatically over the last decade although recent data suggest that rates may now be declining (Centers for Disease Control and Prevention, 2007). About 85% of age-appropriate U.S. women have had at least one mammogram (Blackman, Bennett, & Miller, 1999) and 66% of women report a recent mammogram (within the last two years) (Breen et al., 2007). Unfortunately, rates of repeat mammography use (minimally, obtaining two consecutive screening mammograms) are not as encouraging. Only 38% of women in the U.S. obtain repeat mammograms on an annual schedule (Clark, Rakowski, & Bonacore, 2003). To reduce their risk of breast cancer morbidity and mortality, women should maintain regular on-schedule mammography use (i.e., mammography maintenance). Repeat use is a necessary step towards that goal.

To translate the success of promoting screening initiation and recent use to mammography maintenance, we need innovative and parsimonious conceptual models on which we can base our intervention programs. Many theoretically informed factors and sociodemographic characteristics have been examined as predictors or correlates of repeat mammography use. However, few studies of mammography maintenance exist. Some factors

known to predict repeat mammography may be more relevant than others in understanding regular use over time (Rothman, 2000).

To date, most of what is known about repeat mammography has been assessed via retrospective cross-sectional data (e.g., claims data, HINTS, BRFSS) or from mammography intervention trials. Cross-sectional approaches allow us to explore associations but not to determine predictors of mammography use. Additionally, claims data and large national survey datasets usually fail to capture a wide variety of variables, such as attitudinal, belief and contextual factors that health behavior theories and past research suggest should be related to mammography use. Attitudes, beliefs, perceptions, fears and other subjective barriers may be the key to understanding why more women do not undergo regular breast cancer screening. Additionally, such factors may be amenable to change through public health interventions. Prospective studies of mammography use, on the other hand, have limitations as well. These studies often take place in the context of interventions to promote screening, making it difficult to disentangle the intervention effects from other predictors. In addition, to date, most intervention studies have followed women through only one cycle of repeat screening.

1.2 Overview of Aims

The three specific aims in this dissertation seek to fill a gap in existing research by examining prospectively, over three annual-interval screening cycles and in the context of usual care, why some women maintain, while others are unable to maintain, an annual schedule for mammography. To this end, the specific aims of this research are to:

(1) explore patterns of mammography use in an insured population and determine how selected theoretically informed and empirically based variables change over time;

(2) examine predictors of mammography maintenance that are theoretically and empirically informed and amenable to intervention efforts; and

(3) determine if factors identified in Aim 2 are stronger predictors of mammography maintenance among certain subgroups than others (e.g., women with a history of false positive mammograms, those in different age groups, those with different patterns of mammography use at baseline).

1.3 Description of Study

The data for these secondary analyses come from PRISM (Personally Relevant Information on Screening Mammography), a five-year health communication intervention conducted as part of a National Cancer Institute-funded intervention trial to assess the impact of stepped interventions on repeat mammography use and to determine the minimal intervention necessary for change. Participants in this study come from the PRISM control groups (n = 1,522), all of whom received some form of annual mammography reminders. (PRISM did not include a non-intervention control for ethical reasons.) For Aim 1, mammography use was calculated at the end of each follow-up period as on- or off- schedule based on a 10 to 14 month window between mammograms. Mammography use for each interval then was used to categorize patterns of mammography use across three years (0, 1, 2, 3 on-schedule mammograms). I assessed trends for each variable of interest by measuring proportions of responses for categorical variables and means of the continuous variables at baseline, 12, 24, and 36 months for participants in each pattern of use.

For Aims 2 and 3, the outcome modeled was unsustained mammography maintenance. I defined unsustained maintenance as not having consecutive mammograms on schedule (10 to 14 months apart). To examine predictors of mammography maintenance in Aim 2 and Aim 3, I used a survival analysis method called discrete event history analysis. I then fit logistic regression models corresponding to each research question. Parameters were considered significant at *p-value* = 0.05.

1.4 Organization of the Dissertation

The dissertation has six chapters. Chapter One is a summary of the problem, aims, research design and organization of the dissertation. Chapter Two provides an overview of the burden of breast cancer and status of mammography use and highlights the limitations of previous research and the utility of behavioral theory to predict mammography maintenance. The chapter concludes with a review of the literature on theoretically informed variables and sociodemographic and health care factors associated with repeat mammography. Chapter Three describes the study's conceptual model and presents research questions and hypotheses to be tested. Chapter Four details the methods, including the parent study design and recruitment, variable construction and measurement and data analysis plan. Chapter Five presents the results of the proposed analysis. Chapter Six summarizes and discusses key findings, limitations and strengths of the research and implications of the finding as they relate to future mammography intervention efforts.

CHAPTER TWO: BACKGROUND

In this chapter, I review: 1) the burden of breast cancer and status of mammography use; 2) limitations of previous research; 3) utility of behavioral theories to predict mammography maintenance; 4) theory-informed factors associated with mammography use; and 5) sociodemographic and health care factors associated with repeat mammography. I conclude the chapter with a summary of the major points of the review and argue for longitudinal studies of mammography maintenance.

2.1 The Burden of Breast Cancer

Breast cancer is the most common non-skin cancer and the second leading cause of cancer-related deaths among women in the United States. The American Cancer Society estimates that there will be 182,460 new cases and 40,480 deaths attributable to female breast cancers in 2008 (American Cancer Society, 2008). Beyond the small proportions (5-10%) of breast cancers that are the result of genetic mutations, the underlying causes of most breast cancers remain elusive, and most breast cancers are sporadic (Claus, Schildkraut, Thompson, & Risch, 1996; Dumitrescu & Cotarla, 2005). As such, there is no guaranteed way to prevent the disease. Many of the known factors that contribute to breast cancer, such as increasing age, being female, having a family history of breast cancer (Dumitrescu & Cotarla, 2005) or inheriting genetic mutations in breast cancer susceptibility genes, such as BRCA1 and BRCA2 (Claus et al., 1996; Domchek et al., 2003), are unchangeable. Although much

research had been conducted on behavioral causes such as fat intake, oral contraceptive use, alcohol consumption, and smoking tobacco, the field is evolving rapidly and lacks consensus or conclusive evidence about potential risk factors.

2.2 Mammography Use

Secondary prevention via mammography is the most effective way to reduce morbidity and mortality from breast cancer. Use of mammography can lead to early diagnosis of breast cancer when tumors are smaller and patients may have more treatment options (Humphrey et al., 2002; McCarthy et al., 2000). Mammography use has been disseminated widely in the U.S. (Breen, Wagener, Brown, Davis, & Ballard-Barbash, 2001). In 1987, only 29% of women aged 40 and over reported a recent mammogram (e.g., within the last two years) (Ghafoor et al., 2003). Currently, about 85% of age-appropriate women have had at least one mammogram (Blackman et al., 1999), and 66% of U.S. women report a recent mammogram (Breen et al., 2007).

To achieve the full morbidity and mortality reducing benefits of mammography, women should be screened regularly (Blanchard et al., 2004; McCarthy et al., 2000; Michaelson et al., 2002). Assessments of regular mammography use should include measures of most recent use and then work backward in time to establish a history of mammography use (Vernon, Briss, Tiro, & Warnecke, 2004). The simplest measure of recurring mammography use assesses the last two mammograms and is commonly referred to in the literature as *repeat mammography*.

Ever and recent screening rates have increased dramatically over the last 20 years; however, rates of repeat mammography are much less encouraging. In a weighted analysis across 37 studies, only 46% of women aged 50 and over had obtained a repeat screening

(Clark et al., 2003). Other estimates of repeat mammography use cite rates as low as 16% (Blanchard et al., 2004) to as high as 82% (Boudreau, Luce, Ludman, Bonomi, & Fishman, 2007). It is difficult to compare study results due to wide variation in sampling frames, inconsistent definitions of repeat mammography, and differences in repeat mammography measurement (Clark et al., 2003).

Although there has been a recent push to standardize operational definitions of mammography use, none have been widely adopted at this time (Boudreau et al., 2007; Clark et al., 2003; Partin, Slater, & Caplan, 2005; Rakowski et al., 2004). Lack of consensus is largely based on disagreement among scientific organizations on the recommended intervals between screenings. While some organizations recommend women be screened every one to two years, (e.g., National Cancer Institute, U.S. Preventive Services Task Force) other organizations recommend every year (e.g., American Cancer Society, American College Radiology). Table 1 defines patterns of mammography use among U.S. women.

Table 1. Patterns of Mammography Use

Type of Use	Definition	Source of Definition
Ever	At least one mammogram in lifetime	N/A
Recent Mammography	A mammogram in last two years	(Rakowski et al., 2006)
Repeat Mammography	Two consecutive mammograms at a specified intervals	(Clark et al., 2003)
Regular Mammography/ Mammography Maintenance	Consecutive mammograms at specified intervals	(Boudreau et al., 2007) (Partin et al., 2005)

Repeat mammography is an essential step toward a pattern of regular mammography use (i.e., mammography maintenance). Increased rates of regular screening at annual intervals could reduce breast cancer deaths by 22% each year (Byers et al., 1999). Research into regular use is especially timely as current reports show a decline in the historically high rates of recent mammography use (Breen et al., 2007; Centers for Disease Control and Prevention, 2007; Feldstein, Vogt, Aickin, & Hu, 2006). Consequently, researchers and practitioners must redouble their efforts in exploring predictors of repeat use as well as factors that promote mammography maintenance.

2.3 Limitations of Previous Research on Mammography Use

Historically, mammography research has focused on prompting women to obtain a mammogram rather that exploring factors that support consistent use over time (Carney, Harwood, Greene, & Goodrich, 2005; Champion et al., 2007; Earp et al., 2002; Lipkus, Rimer, Halabi, & Strigo, 2000; Skinner et al., 2007; Vernon et al., 2004). This focus was appropriate when mammography initially became available as a screening tool, because the primary challenge then was to get women to move from never having had mammograms to having their first mammogram or getting lapsed screeners back on schedule (Vernon et al., 2004). Perhaps this emphasis inadvertently contributed to a lack of research on predictors of mammography maintenance. Because the initial push was to promote mammography screening, the majority of previous research was often retrospective and cross-sectional in nature or took place in the context of an intervention to prompt uptake of mammography, often with limited follow-up. Previous research also focused less on predictors of maintenance for women in their forties, probably because of the debates about recommended screening guidelines for this age group. The implications of using retrospective cross-

sectional designs, short-term interventions studies, and exclusion of women in their forties to explore mammography maintenance are discussed below.

2.3.1 Retrospective Cross-sectional Studies

Many cross-sectional studies, including surveys (e.g., HINTS) and administrative databases, have identified correlates of recent and repeat mammography (Augustson, Vadaparampil, Paltoo, Kidd, & O'Malley, 2003; Barr, Franks, Lee, Herther, & Schachter, 2001; Barr, Reisine et al., 2001; Blanchard et al., 2004; Coughlin, Berkowitz, Hawkins, & Tangka, 2007; Rakowski et al., 2006; Taylor, Taplin, Urban, White, & Peacock, 1995). Fewer predictors of repeat mammography have been confirmed as part of longitudinal studies. Cross-sectional studies add to our knowledge of possible correlates of an outcome. However, these designs cannot provide assessments of causality, especially with respect to attitudes and beliefs about the target behavior (Bastani, Maxwell, & Bradford, 1996). In addition, cross-sectional designs may present problems in explicating indirect influence of one variable on another (e.g., mediation) due to issues of temporality and retrospective assessment of screening behavior. Administrative, cross-sectional datasets often have limited data on cognitive appraisal processes, such as perceived barriers to or perceptions about mammography. Cognitive factors are likely to play an important role in helping to explain why more women do not go for regular breast cancer screening (Orleans, 2000; Rothman, 2000).

2.3.2 Prospective Studies

Prospective studies of mammography, on the other hand, have their own set of problems that limit conclusions about predictors of repeat screening behaviors. Prospective

studies often take place in the context of an intervention to promote screening, making it difficult to disentangle the effects of the intervention from factors that may naturally influence behavior over time. In addition, many intervention trials follow women through only one cycle of repeat screening and thus are limited in their ability to yield robust maintenance-specific findings. Many prospective intervention trials assess mammography use only through self-reported windows of recent use ("Have you had a mammogram in the last 24 months?"). Assessing repeat use through measures of recent use does not allow an examination of whether women are getting mammograms at recommended intervals. Also, self-reports of use over long periods of time may introduce recall bias into women's estimates of mammography use (Bancej, Maxwell, & Snider, 2004; Vacek, Mickey, & Worden, 1997; Vernon et al., 2004). Observational longitudinal studies of repeat use with multiple regular assessments of mammography use may be particularly powerful in exploring factors related to maintenance of behavior change (Bellg, 2003; Orleans, 2000; Wing, 2000).

2.3.3 Limited Studies with Younger Women

Another limitation of many previous prospective studies of mammography screening is a lack of research conducted with women ages 40 to 49, especially on annual screening intervals. Most prospective research has assessed repeat use for women aged 50 and over, perhaps because of the lingering controversy surrounding efficacy and recommended frequency of screening for women in their forties (Armstrong, Moye, Williams, Berlin, & Reynolds, 2007; Han et al., 2007; 1997; Qaseem et al., 2007; Smith et al., 2003). Currently, major health organizations, such as the American Cancer Society and the National Cancer Institute, urge women 40 and over to get regular mammograms, although they differ on the definition of regular use. The American Cancer Society recommends annual-interval

mammograms (Smith et al., 2003) while the National Cancer Institute endorses mammograms every year or two (National Cancer Institute, 2002). Other organizations, such as the American College of Physicians, do not recommend regular breast cancer screening for average-risk women in their forties (Qaseem et al., 2007). As a result of well-publicized controversy over routine screening (Halabi et al., 2000; Rimer, Halabi, Strigo, Crawford, & Lipkus, 1999), predictors of mammography maintenance may differ for younger versus older women.

2.4 Behavioral Theory: Application to Mammography Maintenance

Gaps in our understanding about mammography maintenance also stem from the application of behavioral theory. Overall, health behavior researchers have a much better understanding of strategies to promote short-term behavior change than strategies to facilitate sustained change over time (Bellg, 2003; Rothman, 2000). Partly, this is due to the methodological issues discussed above in section 2.3. However, our lack of understanding about behavioral maintenance of mammography screening may also reflect, in part, how past models and theories expressed behavioral maintenance as a termination point rather than an ongoing process (Marlatt & Donovan, 2005; Nigg & Jordan, 2005; Noar & Zimmerman, 2005; Prochaska & DiClemente, 1983). This conceptualization as a termination point may be especially relevant for more episodic behaviors, such as obtaining regular mammograms.

Refinement of behavioral theories and innovative conceptual models are needed to translate successes achieved in promoting ever and recent mammography use to the complex behavior of mammography maintenance. In the past, models and theories of health behavior, such as the Health Belief Model (Hochbaum, 1958), the Transtheoretical Model (Prochaska & DiClemente, 1983), and the Theory of Planned Behavior (Ajzen, 1991), have provided

conceptual underpinnings of effective mammography promotion interventions (Mandelblatt & Yabroff, 1999; Rimer, Meissner, Breen, Legler, & Coyne, 2000; Yabroff & Mandelblatt, 1999). These models and theories, however, were developed and have been applied almost exclusively to explain why people initiate, rather than sustain, behavior change. As a result, these theories and models may not include the optimal set of constructs to understand long-term use or effectively inform behavioral maintenance programs (Rothman, 2000). Examining the utility of several well-accepted constructs drawn from health behavior theories mentioned above may allow us to contribute to theory building in the service of understanding maintenance of behaviors.

An Institute of Medicine report, *Speaking of Health,* (Institute of Medicine, 2002) reiterated the importance of using theory to design behavioral strategies and concluded that a number of common constructs underlie most health behavior theories. According to the Institute of Medicine report, when there is a strong commitment to perform a behavior (i.e., behavioral intentions) and no constraints (i.e., barriers) to performing the behavior, people are more likely to engage in recommended behaviors. Three key constructs are thought to affect the strength of behavioral intentions: (1) attitudes towards the behavior; (2) perceived norms related to the behavior; and (3) personal agency — individual skills and perceived control for performing the behavior. It is important to note that the relative importance of these constructs may vary depending on the behavior (e.g., recent vs. repeat vs. regular mammography use) or population (e.g., insured vs. uninsured women).

Evidence supports the use of transtheoretical approaches in health behavior research. For example, previous research has suggested that the predictive power of the Health Belief Model is improved when a measure of intentions is added (Quine, Rutter, & Arnold, 1998).

Similarly, adding self-efficacy to the Theory of Planned Behavior has improved its success in predicting mammography screening intentions (Tolma, Reininger, Evans, & Ureda, 2006). Expanded and hybrid models that borrow from tested theories may be most appropriate in examining behavioral maintenance.

2.4.1 Models of Behavioral Maintenance

Models of behavioral maintenance have emerged primarily in response to efforts to help us better understand lapses and motivations to engage in daily, habitual behaviors such as physical activity, dental hygiene, dietary changes, and smoking cessation (Armitage, 2005; Rothman, 2000; Schwarzer et al., 2007; Wing, 2000; Wing & Hill, 2001). These models often couple constructs, such as perceived benefits and barriers, from well-accepted health behavior theories, with more recently studied constructs, such as perceived satisfaction with past outcomes (Baldwin et al., 2006; Rothman, 2000). Conceptual models to explain maintenance of more episodic or annually recommended behaviors may share constructs with models of maintenance of daily activities (Somkin et al., 2004). However, maintenance-oriented conceptual models may also require inclusion of variables, such as implementation intentions (Gollwitzer, 1999), that help with goal setting to account for the planning needed to act on more episodic behavioral intentions. Implementation intentions will be discussed in more detail in section 2.5.6.

2.5 Theory Informed Factors Associated with Mammography Use

2.5.1 The Health Belief Model

The Health Belief Model is one of the most widely used models of behavior change (Hochbaum, 1958; Rosenstock, 1960). It has been used to help explain many health

behaviors, including mammography screening. Modern conceptualization of the Health Belief Model includes six constructs: perceived barriers, benefits, severity and susceptibility, self-efficacy and cues to action. Self-efficacy was not a part of the original conceptualization of the Health Belief Model but was added to the model in 1988 (Rosenstock, Strecher, & Becker, 1988). Self-efficacy was originally proposed as a key construct in the Social Cognitive Theory (Bandura, 1977).

Previous research informed by the Health Belief Model found that perceived barriers (Champion, 1999; Champion & Skinner, 2003; Champion et al., 2007; Champion & Springston, 1999; Farmer, Reddick, D'Agostino, & Jackson, 2007; Finney Rutten & Iannotti, 2003; Hyman, Baker, Ephraim, Moadel, & Philip, 1994; Menon et al., 2007; Miller & Champion, 1996; Russell, Champion, & Skinner, 2006), perceived benefits (Brenes & Skinner, 1999; Champion & Skinner, 2003; Greene, Torio, & Klassen, 2005; Menon et al., 2007), perceived susceptibility (Champion, 1994; Halabi et al., 2000; Lerman, Rimer, Trock, Balshem, & Engstrom, 1990; Lipkus, Rimer et al., 2000; Rakowski et al., 2004), and self-efficacy (Champion & Skinner, 2003; Russell, Champion et al., 2006; Russell, Monahan, Wagle, & Champion, 2007) are related to recent and repeat mammography use. Cues to action are often operationalized in mammography screening research as reminders; they are not usually a theoretically tested construct. Perceived severity has not been a particularly powerful predictor of behaviors (Janz & Becker, 1984) such as mammography use (Menon et al., 2007), as most women find breast cancer a very serious disease. Three of the six Health Belief Model constructs considered here most relevant to repeat and, potentially, to maintenance of mammography use are discussed in more detail below.

2.5.2 Perceived Barriers

The construct of perceived barriers is defined as a person's beliefs about the tangible and psychological costs of engaging in a recommended behavior (Janz, Champion, & Strecher, 2002). This construct is the most salient and well-studied Health Belief Model construct in the area of mammography screening research (Champion, 1999; Champion & Skinner, 2003; Champion et al., 2007; Champion & Springston, 1999; Farmer et al., 2007; Finney Rutten & Iannotti, 2003; Hyman et al., 1994; Menon et al., 2007; Miller & Champion, 1996; Rauscher, Hawley, & Earp, 2005; Rimer et al., 2000; Russell, Champion et al., 2006). Overall, women who perceive or list a greater number of barriers are less likely to get rescreened (Champion, 1994; Farmer et al., 2007; Lipkus, Rimer et al., 2000; Menon et al., 2007; Russell, Champion et al., 2006). Barriers can be logistical (e.g., too busy, lack of transportation) (Partin & Slater, 2003), psychological (e.g., beliefs and attitudes such as fear of finding cancer or not feeling susceptible) (Partin & Slater, 2003; Rauscher et al., 2005) or physical (e.g., pain) (Papas & Klassen, 2005; Somkin et al., 2004). Barriers can also be systems-related (e.g., lack of reminder phone calls or mailings, no physician recommendations) (Finney Rutten, Nelson, & Meissner, 2004; Mayer et al., 2000; Rauscher et al., 2005) or financial (e.g., costs of the procedure) (Makuc, Breen, Meissner, Vernon, & Cohen, 2007; Trivedi, Rakowski, & Ayanian, 2008). During the late 1980s and throughout the 1990s, organizations such as the National Cancer Institute, the Centers for Disease Control and Prevention and the American Cancer Society made major investments in research aimed at understanding and overcoming intrapersonal, health care provider and system-level barriers to mammography use (Legler et al., 2002; Mandelblatt & Yabroff, 1999; Meissner et al., 1998; Meissner et al., 2004; Rimer et al., 2000).

Different types of barriers may play more or less prominent roles in predicting which women seek mammograms, depending on women's previous patterns of use (initial use vs. repeat use vs. mammography maintenance) (Champion & Skinner, 2003; Menon et al., 2007). Some barriers, such as cost, have consistently been associated with failure to receive timely mammograms (Finney Rutten et al., 2004), even among women with insurance (Solanki, Schauffler, & Miller, 2000). Other barriers, such as awareness about and knowledge of mammograms, have played a greater role in explaining recent mammography use rather than repeat mammography use (Finney Rutten et al., 2004; Menon et al., 2007). Currently, we need to explore the mechanisms through which number and type of barriers affect mammography maintenance.

2.5.3 Perceived Susceptibility

Perceived susceptibility, defined as a person's perceptions about the likelihood (i.e. risk) of developing a risk factor or disease, such as breast cancer, (Janz et al., 2002) is an identified concept in multiple theories and models of health behavior (Ajzen, 1991; Fisher & Fisher, 1992; Hochbaum, 1958; Weinstein & Sandman, 1992). Perceptions about risk have long been studied in relation to breast cancer screening; two meta-analyses confirm the positive association between perceived susceptibility and mammography use (Katapodi, Lee, Facione, & Dodd, 2004; McCaul, Branstetter, Schroeder, & Glasgow, 1996).

While some previous research shows a linear relationship between perceived susceptibility and mammography screening, other research shows a more complex relationship. In a few recent studies of repeat use, low to moderate levels of perceived risk as compared to high levels of perceived risk were predictive of repeat screening (Calvocoressi et al., 2004; Calvocoressi, Stolar, Kasl, Claus, & Jones, 2005). Also perceived susceptibility

may be more salient for women aged 40 to 49 (Calvocoressi et al., 2004; Champion, 1994) and those with a history of abnormal mammograms (Lipkus, Halabi, Strigo, & Rimer, 2000).

Risk perceptions have been a particularly useful concept in predicting repeat screening (Champion, 1994; Halabi et al., 2000; Lerman et al., 1990; Rakowski et al., 2004; Taylor et al., 1995). In a study of women aged 50 to 69 enrolled in a Dutch breast cancer screening program, perceived susceptibility was a predictor of screening across two biennial cycles of repeat mammography use (Drossaert, Boer, & Seydel, 2005). Although perceived susceptibility is associated with repeat mammography use in the short term, few longitudinal studies of perceived susceptibly over multiple screening cycles have been conducted.

2.5.4 Self-Efficacy

Self-efficacy is defined as one's confidence in being able to take the actions necessary to perform a recommended health behavior such as obtaining a mammogram (Bandura, 1977; Janz et al., 2002). Although self-efficacy may be viewed as similar to the construct of perceived behavioral control, previous work has demonstrated that these are distinct constructs (Tolma et al., 2006). Perceived behavioral control is discussed further in section 2.5.5. Self-efficacy has been studied less than other Health Belief Model constructs in the context of repeat mammography use (Champion, Skinner, & Menon, 2005), but it has been associated with repeat use (Russell, Champion et al., 2006). Additionally, recent work has illustrated that maintaining levels of self-efficacy is important in women's progression towards regular mammography use (Menon et al., 2007).

Self-efficacy is also an important factor in maintenance of other behaviors such as dietary intake (Schwarzer et al., 2007) and physical activity (Litt, Kleppinger, & Judge, 2002; McAuley, Jerome, Elavsky, Marquez, & Ramsey, 2003). Schwarzer and colleagues

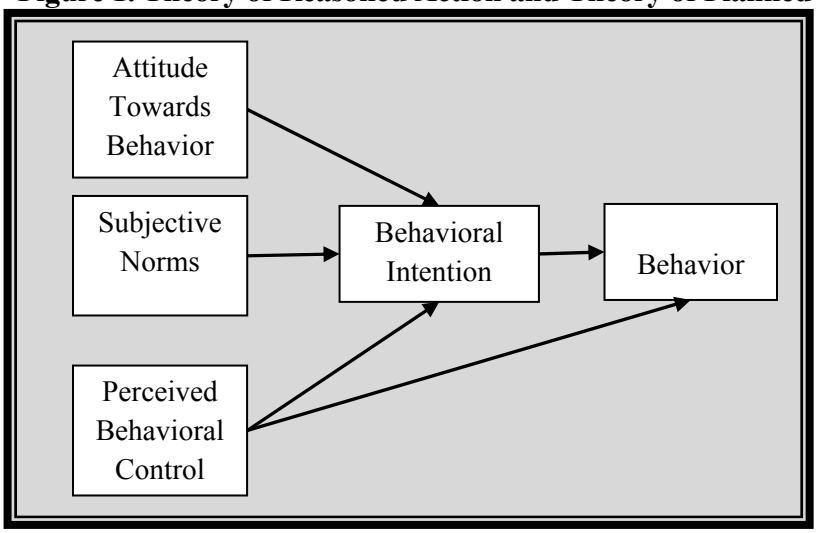
successfully tested a model that postulates that self-efficacy contributes in two key ways to affect long-term maintenance across four daily behaviors (Schwarzer et al., 2007). First, self-efficacy is postulated to act as a motivational force on the behavior via intentions. Second, self-efficacy may act directly as a protective factor, by helping individuals recover from a lapse into non-compliance through prompting planning (Schwarzer et al., 2007). We do not know if such direct and mediated effects of self-efficacy (i.e., phase specific self-efficacy) exist for mammography maintenance. Hence, further exploration of self-efficacy and mammography maintenance is warranted.

2.5.5 The Theory of Reasoned Action and The Theory of Planned Behavior

The Theory of Reasoned Action (Fishbein, 1975) postulates that behavioral intentions are the most important and proximal predictors of a behavior. In turn, behavioral intentions are determined by two constructs: 1) attitude towards the behavior and 2) subjective norms. Attitude toward the behavior is defined as a person's overall evaluation of the behavior. Subjective norms are the beliefs a person holds about whether most people approve or disapprove of the advised action.

The Theory of Planned Behavior (Ajzen, 1991) is an extension of the Theory of Reasoned Action. The Theory of Planned Behavior integrates the construct of perceived behavioral control as another determinant of both behavioral intentions and behavior. Perceived behavioral control is similar to the concept of self-efficacy (Bandura, 1977) and is a measure of a person's overall perceptions about how difficult or easy it would be to take an advised health action, such as getting yearly mammograms. Figure 1 depicts the specific direct and mediated relationships delineated in the Theory of Reasoned Action and Theory of Planned Behavior.

Figure 1. Theory of Reasoned Action and Theory of Planned Behavior Constructs



There is extensive support for the Theory of Planned Behavior, both through formal theory testing and applied interventions, in predicting a variety of health behaviors (Armitage & Conner, 2001; Armitage, Norman, & Conner, 2002; Montaño & Kasprzyk, 2002; Van De Ven, Engels, Otten, & Van Den Eijnden, 2007; White et al., 2007). For example, two meta-analytic reviews of the Theory of Planned Behavior across a variety of health behaviors found that its constructs accounted for 39% to 41% of the variance in behavioral intentions and 20% to 34% of the variance in actual behavior (Armitage & Conner, 2001; Godin & Kok, 1996). In both reviews, attitude toward the behavior and perceived behavioral control were the most important predictors of intention to undertake the behavior (Armitage & Conner, 2001; Godin & Kok, 1996), with subjective norms generally a weaker predictor of intentions than attitude or perceived behavioral control (Armitage & Conner, 2001). Additionally, evidence suggests that perceived behavioral control contributes significantly to the variance explained in a behavior after controlling for intentions (Armitage & Conner, 2001), supporting both indirect and direct effects of perceived behavior control on behavior.

2.5.6 The Theory of Planned Behavior and Behavioral Maintenance

The few studies that have looked at Theory of Planned Behavior and behavioral maintenance have yielded mixed results. In a study of blood glucose testing maintenance, Theory of Planned Behavior constructs accounted for 57% of the variance in self-monitored daily blood glucose levels over a two-week period (Shankar, Conner, & Bodansky, 2007). Sheeran and colleagues (Sheeran, Conner, & Norman, 2001) found that the Theory of Planned Behavior predicted both attendance versus nonattendance and frequency of attendance at annual health screenings. However, Theory of Planned Behavior could not reliably distinguish between consistent on-time users versus delayed users of annual wellness screenings.

It is not unexpected that the Theory of Planned Behavior would fail to distinguish between different patterns of use. The theory was designed to explain effects of attitudes on intention formation and not on behavioral action (Sheeran et al., 2001). For the theory to gain utility in predicting behavioral maintenance, the Theory of Planned Behavior may benefit from inclusion of other constructs more oriented toward goal pursuit (Abraham, Sheeran, & Johnston, 1998; Institute of Medicine, 2002; Sheeran et al., 2001). Gaining specificity to behavioral intentions through the addition of implementation intentions is one way to achieve that goal. Implementation intentions are defined as specific plans as to when, where and how a goal, such as getting a yearly mammogram, is actualized (Gollwitzer, 1999).

Evidence from intervention studies suggest that adding implementation intentions to the Theory of Planned Behavior can increase promotion of a variety of behaviors (Armitage, 2006; Rise, Thompson, & Verplanken, 2003; Sheeran & Orbell, 2000; Sheeran & Silverman, 2003), including cervical cancer screening (Sheeran & Orbell, 2000) and recent

mammography use (Rutter, Steadman, & Quine, 2006). Similarly, the Theory of Planned Behavior plus implementation intentions model has shown validity in predicting repeated daily behaviors (Sheeran & Orbell, 1999). However, results are mixed. One study that integrated both behavioral and implementation intentions in the context of the Theory of Planned Behavior for regular exercise and recycling behaviors found that behavioral intentions were a stronger predictor of behavioral as opposed to implementation intentions (Rise et al., 2003). Adding implementation intentions to an expanded Theory of Planned Behavior model may show promise for mammography maintenance. Validated measures of mammography implementation intentions have not been developed to date.

2.5.7 The Theories of Reasoned Action and Planned Behavior and Mammography Use

The Theory of Reasoned Action and Theory of Planned Behavior have not been applied as widely to mammography screening as have other theories such as the Health Belief Model and Transtheoretical Model. Studies that have applied the Theory of Reasoned Action as their theoretical framework have added constructs such as facilitating conditions and constraints (Montano & Taplin, 1991; Montano, Thompson, Taylor, & Mahloch, 1997), habit (Michels, Taplin, Carter, & Kugler, 1995) and affect (Montano et al., 1997). Results of these studies are mixed perhaps due, in part, to the use of different measures of mammography screening (e.g., intentions, prior 5-year use, recent use). Overall, these expanded models of the Theory of Reasoned Action explained 29% to 39% of the variance in intention to seek a mammogram and 12% to 20% of the variance in behavior.

In the few studies that have applied the Theory of Planned Behavior to mammography screening, constructs displayed modest predictive power and explained 24% of the variance in mammography screening intentions (Steele & Porche, 2005) and 17% of

the variance in behavior (Drossaert, Boer, & Seydel, 2003). One study tested an expanded version of the Theory of Planned Behavior and found that 35% of the variance in mammography intentions could be explained when self-efficacy was added to the model (Tolma et al., 2006). The argument for using an expanded model in attempting to understand mammography screening behavior is strengthened.

Subjective norms were not strong predictor of intentions to seek mammograms in previous theory-based studies (Montano & Taplin, 1991; Steele & Porche, 2005). In other work, however, subjective norms have been a more important factor in mammography screening, particularly in predicting initial (Tolma et al., 2006) or recent mammography use (Champion, 1994; Steadman & Rutter, 2004), especially in a rarely screened population (Tolma et al., 2006). Subjective norms may be less useful in predicting repeat use (Bowie, Curbow, LaVeist, Fitzgerald, & Zabora, 2003; Drossaert et al., 2003) or long-term use.

Of the mammography studies that tested all Theory of Planned Behavior constructs, attitude towards the behavior and perceived behavioral control were the strongest predictors of mammography intentions (Bowie et al., 2003; Drossaert et al., 2003; Steele & Porche, 2005). In intervention trials of repeat mammography informed by Theory of Planned Behavior, perceived behavioral control (Rimer et al., 2002) and attitude towards mammography (Mayne & Earp, 2003; Rauscher, Earp, & O'Malley, 2004) exhibited good predictive ability. In theory testing studies that evaluated actual screening behavior, intentions were the strongest predictor of mammography screening behavior (Drossaert et al., 2003; Rutter, 2000). Intervention studies of repeat mammography support the importance of behavioral intentions in predicting repeat mammography behavior (Lipkus, Rimer et al., 2000; Mayne & Earp, 2003).

We conclude that attitudes towards mammography, perceived behavioral control and behavioral intentions are particularly salient constructs of mammography screening and are good candidate predictors of mammography maintenance. The next step is to explore the best combination of constructs from established theoretical frameworks, such as the Health Belief Model and the Theory of Planned Behavior, to explain mammography maintenance.

2.6 Other Factors Associated with Repeat Mammography Use

In addition to theory-informed attitudes and beliefs discussed above, other perceptions, sociodemographic and health care utilization factors have been examined as predictors or correlates of repeat mammography screening. Some of these factors may be more relevant than others in understanding mammography maintenance over time.

2.6.1 Perceived Satisfaction

Perceived satisfaction had been defined as patients' attitudes towards their health care (Linder-Pelz, 1982). Examination of patients' satisfaction with the mammography experience may add new insights into declining mammography rates and offer other avenues for intervention. Previous qualitative and quantitative work on perceived satisfaction with the mammography experience suggests many distinct domains that might affect satisfaction (Almog, Hagoel, Tamir, Barnett, & Rennert, 2008; Cockburn et al., 1991; Engelman, Cizik, & Ellerbeck, 2005; Fine, Rimer, & Watts, 1993). Perceived satisfaction with obtaining past mammograms could encompass a wide range of perceptions about how one was treated by facility staff , waiting times, impressions of the radiology facility in delivery of the results, and follow-up treatments (Ware, Snyder, Wright, & Davies, 1983).

Although multi-dimensional and hence somewhat complex (Ware et al., 1983), perceived satisfaction shows promise as a predictor of repeat mammography use in empirical studies. Higher rates of repeat screenings among Medicare beneficiaries are associated with facilities that measured patient satisfaction (Engelman, Ellerbeck, Mayo, Markello, & Ahluwalia, 2004). In cross-sectional studies, women who reported more satisfaction with past mammography experiences reported higher rates of repeat mammography use (Peipins, Shapiro, Bobo, & Berkowitz, 2006; Somkin et al., 2004).

To date, no longitudinal studies have assessed perceived satisfaction with past mammography experiences as a predictor of regular mammography use; it may be that perceived satisfaction is a significant element of why past behavior is an important predictor of future behavior (Maxwell, 1996; Mayne & Earp, 2003). Identifying a parsimonious set of mammography maintenance predictors informed by previous studies of repeat mammography use and emerging maintenance-specific constructs (such as perceived satisfaction with past experiences) may be helpful in further developing the next generation of practical interventions focused on long-term mammography use.

2.6.2 Health Care -Related Variables and Sociodemographic Characteristics

Variables such as health care utilization (e.g., recent physician contact, having a regular health care provider, participating in other health screenings) (Augustson et al., 2003; Barr, Franks et al., 2001; Greene et al., 2005), receiving a physician's recommendation for mammography (Halabi et al., 2000; Lerman et al., 1990; Mayne & Earp, 2003; M. S. O'Malley et al., 2001), and having health insurance (Maxwell, 1996) have all been found to be associated positively with repeat mammography. Being a member of an ethic minority group (Blanchard et al., 2004; Calvocoressi et al., 2004; Quinley, Mahotiere, Messina, Lee,

& Mikail, 2004), having less education (Calvocoressi et al., 2004; Fox et al., 2004; Rakowski et al., 2004; Rakowski et al., 2003) and lower income (Calvocoressi et al., 2004; A. S. O'Malley, Forrest, & Mandelblatt, 2002; Rakowski et al., 2004) are characteristics associated with failure to return for repeat screenings. In previous research, mammography use has varied with age. Women in their forties and women aged 65 and over obtain fewer age-appropriate mammograms than women aged 50 to 64 (Champion, 1994; Halabi et al., 2000; Harrison et al., 2003; Mayer et al., 2000; Meissner, Breen, Taubman, Vernon, & Graubard, 2007; Miller & Champion, 1996; A. S. O'Malley et al., 2002; Rimer et al., 2002).

Rates of repeat mammography screening also vary across past mammography experiences and previous patterns of use. Women in the U.S. with a history of false positive mammograms are more likely to seek repeat mammograms on time (Brewer, Salz, & Lillie, 2007; Halabi et al., 2000; Pisano, Earp, & Gallant, 1998). Previous mammography use is a consistent predictor of future use (Bobo, Shapiro, Schulman, & Wolters, 2004; Mayne & Earp, 2003). Although certain groups appear to be at greater risk than others for failure to be screened regularly, there are sub-optimal rates of repeat screening for all ages eligible for screening and across different races, ethnicities, income levels, and insurance status subgroups (Blanchard et al., 2004).

2.7 Summary and Conclusions

Early detection of breast cancer through mammography screening is the most effective way to control this common cancer, by detecting tumors when they are small and potentially more treatable. Only through maintained use of mammography will we achieve meaningful reductions in breast cancer-related mortality (Humphrey et al., 2002). Our public health programs need to be modified to promote consistent, long-term mammography use. To

effectively design interventions that will encourage women to obtain regular mammograms, we need innovative research identifying theoretically based factors linked to this goal.

The majority of findings from earlier research have been from retrospective cross-sectional studies or intervention trials with limited follow-up. Fewer predictors of mammography use have been confirmed by longitudinal studies, and no longitudinal studies have examined predictors of annual-interval mammography maintenance. To isolate a parsimonious set of predictors, amenable to change, that facilitate mammography maintenance for all age-eligible women, our exploration must be guided by behavioral theory and the emerging body of literature on behavioral maintenance as these are tested in observational longitudinal studies.

CHAPTER THREE: CONCEPTUAL MODEL, RESEARCH QUESTIONS AND HYPOTHESES

In this chapter, I present my specific aims and their associated research questions and hypotheses. I also present my conceptual model; it illustrates the relationships between study variables of interest as set out in the research questions and hypotheses.

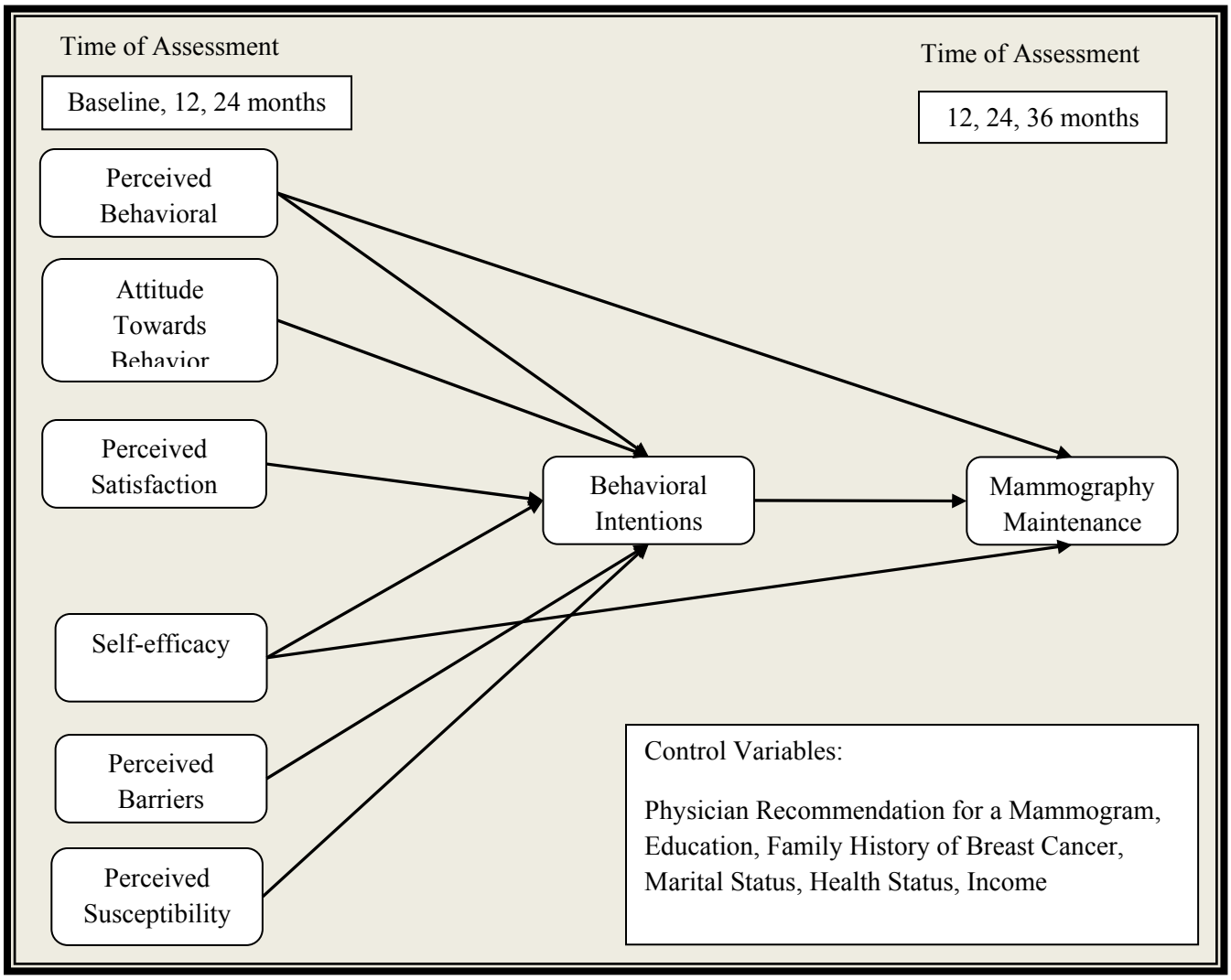
3.1 Conceptual Model Description

The conceptual model (Figure 2) guiding this research suggests direct and indirect relationships among predictor variables and the outcome of interest. As detailed in Chapter Two, the Health Belief Model and the Theory of Planned Behavior provide the theoretical underpinnings for the conceptual model. The model is also informed by previous work on the maintenance of daily behaviors and empirical research on mammography use. The rationale for the selection of specific variables in the conceptual model is detailed in Chapter Two.

The proposed model hypothesizes how key cognitions and attitudes towards mammography affect mammography maintenance. As informed by the Theory of Planned Behavior, and supported by empirical findings, perceived behavioral control is hypothesized to have both mediated and direct effects on mammography maintenance. Similarly, self-efficacy is hypothesized to have a direct effect on behavior as well as a mediated effect via intentions; these relationships are supported by previous work on the maintenance of daily behaviors as outlined in section 2.5.4. Other theoretically and empirically based variables (attitude towards the behavior, satisfaction with past experiences, perceived barriers,

perceived susceptibility) are conceptualized to affect mammography maintenance through behavioral intentions.

Figure 2. Conceptual Model



3.2 Aims, Research Questions and Hypotheses

3.2.1 Aim 1[1]

Aim 1: To explore patterns of mammography use and determine how certain theoretically informed and empirically based variables change over time. See Table 2 for description of patterns of use.

Table 2. Patterns of On-schedule Mammography Use Over 36 Months*

First Screening Cycle	Second Screening Cycle	Third Screening Cycle	Pattern of On-schedule Use
0	0	0	No Mammograms
0	0	1	One Mammogram
1	0	0	
0	1	0	
0	1	1	Two Mammograms
1	0	1	
1	1	0	
1	1	1	Three Mammograms

* 0 = no on-schedule mammogram and 1 = received on-schedule mammogram

Research Question 1.1*:* What are the proportions of insured women who obtained no, one, two or three on-schedule mammograms over a 36-month period?

Research Question 1.2: For each of the four patterns of mammography use, what are the trends in perceived behavioral control, attitude towards the behavior, perceived

[1] The research questions associated with Aim 1 are exploratory; no hypotheses were explicated.

satisfaction with past experiences, self-efficacy, perceived barriers, perceived susceptibility, behavioral intentions and physician recommendation for a mammogram at baseline, 12, 24, and 36 months?

3.2.2 Aim 2

Aim 2: To examine predictors of mammography maintenance that are theoretically and empirically informed and amenable to intervention efforts.

> **Research Question 2.1:** To what extent do perceived barriers, attitudes towards behavior, perceived satisfaction with past experiences, perceived susceptibility to breast cancer, self-efficacy and perceived behavioral control predict mammography maintenance?
>
> > **Hypothesis 2.1.1:** Women with more barriers are less likely to maintain a regular screening schedule.
> >
> > **Hypothesis 2.1.2:** Women with more positive attitudes towards mammography are more likely to maintain a regular screening schedule.
> >
> > **Hypothesis 2.1.3:** Women who are more satisfied with their past mammography experiences are more likely to maintain a regular screening schedule.
> >
> > **Hypothesis 2.1.4:** Women who perceive themselves as more susceptible to breast cancer are more likely to maintain a regular screening schedule.
> >
> > **Hypothesis 2.1.5:** Women who report higher levels of self-efficacy to obtain mammograms are more likely to maintain a regular screening schedule.

Hypothesis 2.1.6: Women who perceive themselves as having more control over their ability to obtain mammograms are more likely to maintain a regular screening schedule.

Research Question 2.2 To what extent do perceived barriers, attitudes towards behavior, perceived satisfaction with past experiences, perceived susceptibility to breast cancer, self-efficacy and perceived behavioral control predict behavioral intentions?

Hypothesis 2.2.1: Women with more barriers are less likely to report they will have mammograms when due for one.

Hypothesis 2.2.2: Women with more positive attitudes towards mammography are more likely to report they will have mammograms when due for one.

Hypothesis 2.2.3: Women who are more satisfied with their past mammography experiences are more likely to report they will have mammograms when due for one.

Hypothesis 2.2.4: Women who perceive themselves as more susceptible to breast cancer are more likely to report they will have mammograms when due for one.

Hypothesis 2.2.5: Women who report higher levels of self-efficacy to obtain mammograms are more likely to report they will have mammograms when due for one.

Hypothesis 2.2.6: Women who perceive themselves as having more control over their ability to obtain mammograms are more report they will have mammograms when due for one.

Research Question 2.3: To what extent do behavioral intentions predict mammography maintenance?

Hypothesis 2.3.1: Women who report they will have mammograms when due are more likely to maintain a regular screening schedule.

Research Question 2.4: Are the relationships between perceived barriers, attitudes towards behavior, perceived satisfaction with past experiences, perceived susceptibility to breast cancer, self-efficacy, perceived behavioral control and mammography maintenance mediated by behavioral intentions?

Hypothesis 2.4.1: Behavioral intentions mediate the relationship between perceived barriers to screening and mammography maintenance.

Hypothesis 2.4.2: Behavioral intentions mediate the relationship between attitudes towards screening and mammography maintenance.

Hypothesis 2.4.3: Behavioral intentions mediate the relationship between perceived satisfaction with past screening experiences and mammography maintenance.

Hypothesis 2.4.4: Behavioral intentions mediate the relationship between perceived susceptibility to breast cancer and mammography maintenance.

Hypothesis 2.4.5: Behavioral intentions partially mediate the relationship between self-efficacy and mammography maintenance.

Hypothesis 2.4.6: Behavioral intentions partially mediate the relationship between perceived behavioral control and mammography maintenance.

3.2.3 Aim 3

Aim 3: To determine if factors identified in Aim 2 are stronger predictors of mammography maintenance among certain subgroups than others.

Research Question 3: Do the relationships explored in Aim 2 vary by certain subgroups in the sample (i.e., those with a history of false positive mammograms, those in different age groups, those with different patterns of mammography use at baseline)?

Hypothesis 3.1: The overall associations among perceived barriers, attitudes towards behavior, perceived satisfaction with past experiences, perceived susceptibility to breast cancer, self-efficacy, perceived behavioral control, behavioral intentions and mammography maintenance will differ across women with and without histories of false positive mammography results.

Hypothesis 3.2: The overall associations among perceived barriers, attitudes towards behavior, perceived satisfaction with past experiences, perceived susceptibility to breast cancer, self-efficacy, perceived behavioral control, behavioral intentions and mammography maintenance will differ for women aged 50 and over as compared to women in their forties.

Hypothesis 3.3: The overall associations among perceived barriers, attitudes towards behavior, perceived satisfaction with past experiences, perceived susceptibility to breast cancer, self-efficacy, perceived behavioral control, behavioral intentions and mammography maintenance will differ for women with histories of recent as opposed to repeat mammography use at baseline.

CHAPTER FOUR: METHODS

4.1 Data Sources

4.1.1 Sampling Frame

The data for these secondary analyses come from PRISM, a five-year health communication intervention conducted as part of a National Cancer Institute-funded intervention trial [as part of the NIH Health Maintenance Consortium (http://hmcrc.srph.tamhsc.edu)] to enhance annual maintenance of mammography. For the proposed analyses, I used data from the baseline, 12, 24 and 36-month telephone interviews. In this chapter, I describe the: (1) sampling frame and study recruitment of the original data source; (2) construction and operationalization of study variables; and (3) analytic strategies by study aim.

The eligible sample frame for PRISM included North Carolina women residents who were enrolled with the North Carolina State Health Plan for Teachers and State Employees (State Health Plan) for two or more years prior to sampling. Potential eligible participants had their last screening mammograms eight to nine months before receiving an invitation to participate in PRISM, to ensure all were adherent to recent mammograms upon study entry. To exclude those who had diagnostic mammograms, potential participants could have only one mammogram within the designated period. Other inclusion criteria were that women had

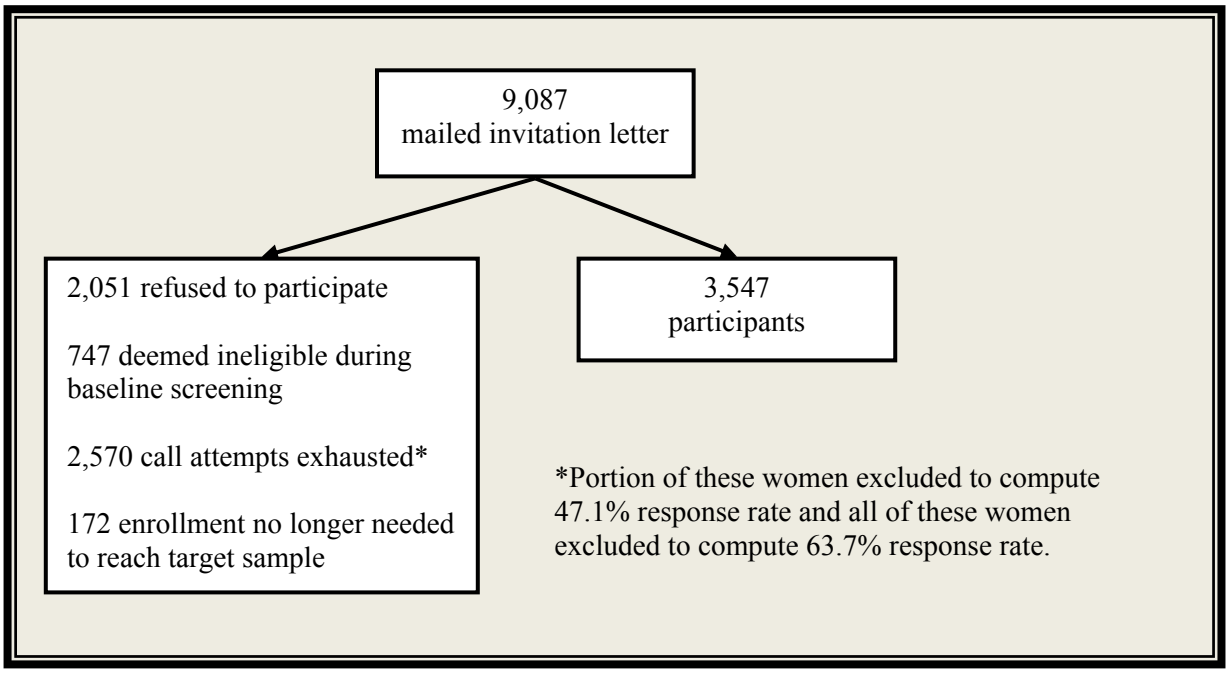
no personal history of breast cancer or other illnesses that would preclude their participation, were able to speak and understand English, and were between the ages of 40 and 75.

4.1.2 Study Recruitment and Randomization

PRISM recruitment occurred from October 2004 to April 2005. Researchers mailed invitation letters to 9,087 women who met the eligibility criteria. Letters included required HIPAA (Health Insurance Portability and Accountability Act of 1996) information and provided instructions for opting out of the study. Trained telephone interviewers from the Battelle Center for Public Health Research and Evaluation contacted potential participants to obtain their consent. The consent process and baseline survey took an average of 31 minutes to complete. Interviewers made up to 12 attempts to contact women.

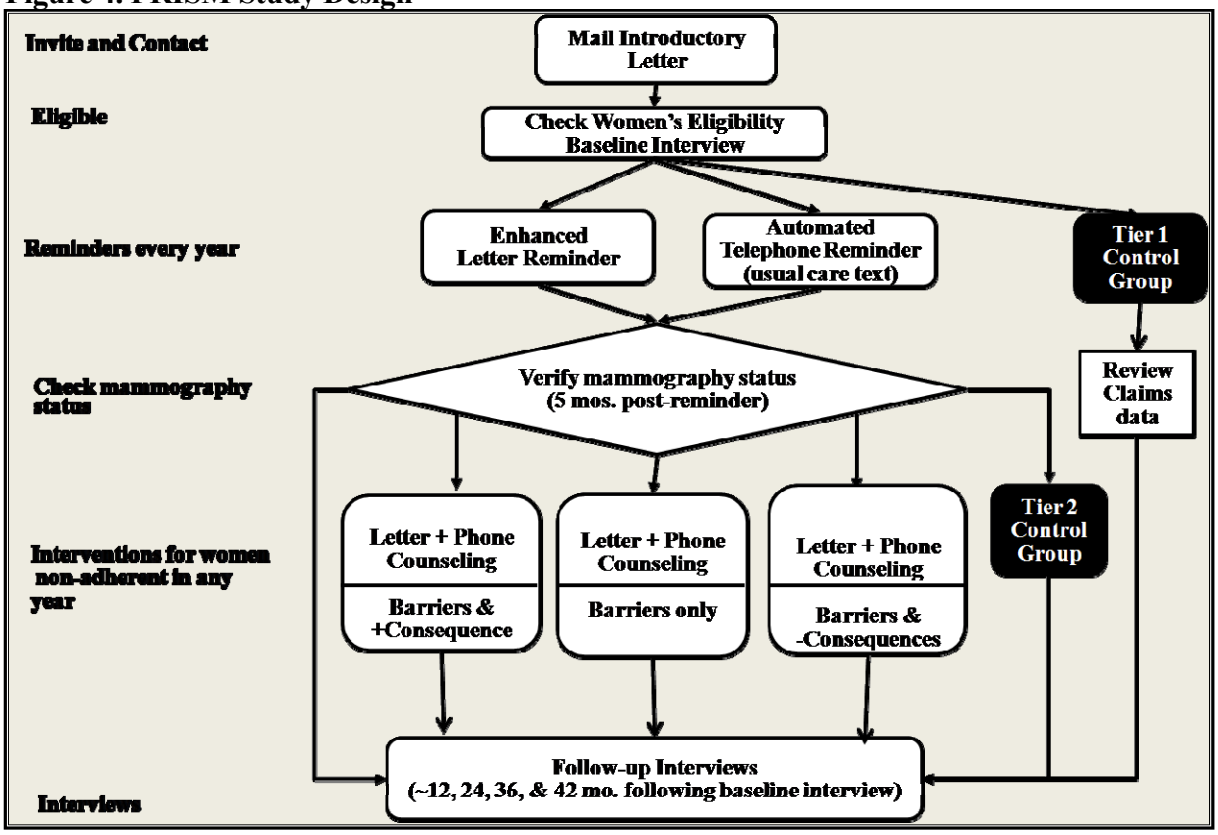
Of those invited, 3,547 women completed baseline telephone interviews, 2,051 refused to participate and 747 were determined to be ineligible. The remaining 2,742 women were classified as of "unknown eligibility" once calls were initiated either because their call attempts were exhausted (n=2,570) or their enrollment was no longer needed to reach the target sample size (n=172). The range in response rates, based on the American Association for Public Opinion Research Standard Definitions, was 47.1% to 63.7% (American Association for Public Opinion Research, 2006). The lower response rate excludes a portion of women with unknown eligibility (n=2,570; call attempts exhausted) from the response rate computation; the higher response rate excludes all women with unknown eligibility (n=2,570; call attempts exhausted). See Figure 3 for details of the sample recruitment. Women were subsequently called annually on or near the anniversary of their baseline interviews.

Figure 3. PRISM Participant Recruitment



Researchers randomized women to one of three reminder groups prior to recruitment: enhanced usual care (24%); enhanced letter reminders (38%); and automated telephone reminders (38%). Larger sample sizes were selected for the enhanced letter reminders and automated telephone reminders groups to permit assessment of supplemental counseling interventions (Tier 2 interventions) for women in these two groups. Participants in the proposed study only come from PRISM Tier 1 control group (n = 847) and Tier 2 control group (n=675), so as not to confound our findings with the effects of the more intensive Tier 2 supplemental counseling intervention (Figure 4). In the control arms of the study, the only prompts women received were mailed or automated telephone letters that included such information as dates of women's last mammograms, information about mammography (such as recommended screening guidelines) and the contact number for the National Cancer Institute's Cancer Information Service.

Figure 4. PRISM Study Design



4.2 Measures

4.2.1 Dependant variable

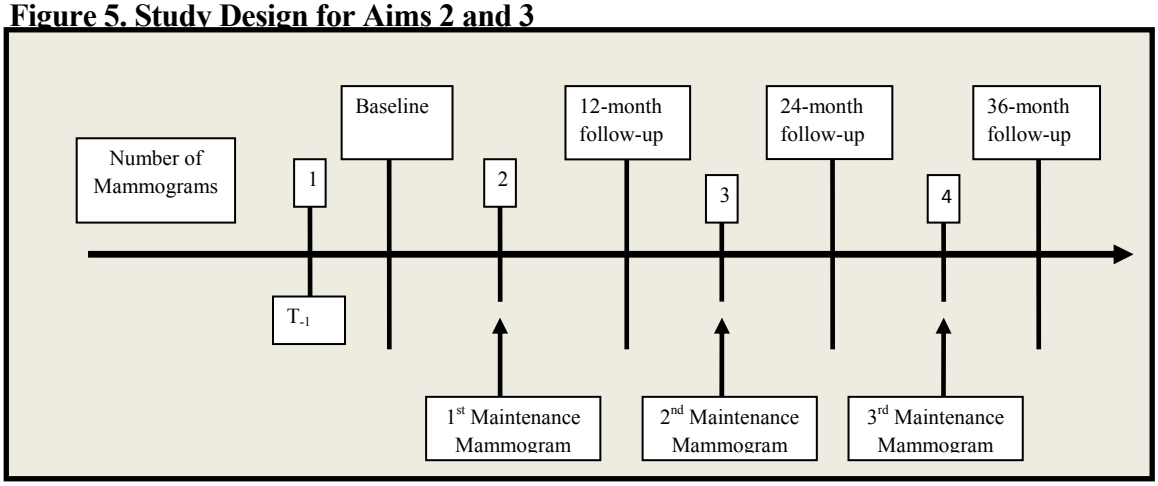
Mammography Use

To assess mammography adherence, interval assessments of mammography use were calculated and coded at the end of each of the three follow-up periods (baseline to 12 months, 12 to 24 months, 24 to 36 months). To categorize mammography use at the end of each follow-up period, we determined if a participant had received a mammogram in the last 14 months and, if so, were her last two mammograms 10 to 14 months apart. We defined on-schedule use as having received a mammogram in the last 14 months and the last two

mammograms were 10 to 14 month apart. At each follow-up period, mammography use was coded *0* = off-schedule use or *1* = on-schedule use.

For Aim 1, mammography use was calculated at the end of each follow-up period and coded *0* = off-schedule use or *1* = on-schedule use. Mammography use codes for each interval then were used to categorize the patterns of mammography use described in Table 2, section 3.2.1. For Aims 2 and 3, the outcome modeled was not sustaining mammography maintenance. We defined unsustained maintenance as not having consecutive mammograms on schedule (10-14 months apart). This means that at the 12-month survey, a woman who had sustained mammography maintenance will have had two consecutive mammograms. At the 24-month survey, she will have had two prior mammograms plus an additional on-schedule mammogram. As such, women who sustained mammography maintenance across all three follow-up periods (baseline to 12 months, 12 to 24 months, 24 to 36 months) will have had four consecutive on-schedule mammograms by the 36-month survey. If a participant misses any mammograms over the course of the 36-month follow-up period, she has not sustained mammography maintenance. See Figure 5 for the study design for Aims 2 and 3.

Figure 5. Study Design for Aims 2 and 3



A yearly interval was selected to be consistent with current screening guidelines of both the National Cancer Institute (National Cancer Institute, 2002) and the American Cancer Society (Smith et al., 2003) and the North Carolina State Health Plan benefits (which cover screening mammograms once every 365 days). The ten-month boundary excludes likely diagnostic mammograms and the 14-month boundary provides a two-month window for scheduling difficulties. Many mammography facilities have waiting queues for appointments.

We assessed mammography use at each of the follow-up periods using self-report survey data and health insurance claims to verify dates of the last two mammograms. When discrepancies between self-report and claims data occurred, self-report data were used. Self-reports are valid measures of recent mammograms (Rauscher, O'Malley, & Earp, 2002; Vacek et al., 1997; Vernon et al., 2004).

4.2.2 Predictor Variables

Attitude towards the behavior. Within the framework of the Theory of Planned Behavior, attitude towards the behavior is comprised of two domains: beliefs about the behavior and the positive or negative evaluation of those beliefs (Montaño & Kasprzyk, 2002). These beliefs and evaluations usually are obtained during an extensive elicitation interview process. In practice, many studies use much simpler approaches to reduce participant burden. In this study, we assessed positive and negative beliefs related to mammography using decisional balance items (Rakowski et al., 1997). The construct of decisional balance from the Transtheoretical Model assesses the balance of positive and negative attitudes toward mammography, expressed as pros and cons (Montaño & Kasprzyk, 2002; Prochaska & DiClemente, 1983; Rakowski et al., 1997). Decisional balance items are compatible with how Theory of Planned Behavior items are framed.

To compute decisional balance scores, women were asked to agree or disagree with a sequence of items tapping positive and negative attitudes towards getting yearly mammograms. Items were adapted from a decisional balance scale of mammography use developed by Rakowski and colleagues (1997). Examples of items include the following: *Having mammograms every year gives you a feeling of control over your health*; *Mammograms are needed even when a woman has no family history of breast cancer*; *Having mammograms causes you worry or anxiety about breast cancer*; *Once you have a couple of mammograms that are normal, you don't need any more for a few years.* Six items were used to compute the pros score and nine items for the cons score. Decisional balance was calculated by computing the pros and cons scores. Cons were subtracted from pros to compute the decisional balance score.

Perceived behavioral control. Participants were asked, *How much control do you have over whether you get a mammogram when you are due?* Responses were scored on a 3-point scale as 0 = *no control*, 2 = *some control* and 3 = *complete control*. Due to low frequencies in one or more categories, I dichotomized the variable as 0 = *complete control* or 1 = *some/no control.*

Satisfaction with previous mammography experience. Participants were asked, *Thinking about the whole process of getting a mammogram, from making the appointment through getting your results, how satisfied or dissatisfied were you with your most recent mammogram?* Responses were scored on a 4-point scale, 1 = *very dissatisfied*, 1= *somewhat dissatisfied,* 2 = *somewhat satisfied* and 3 = *very satisfied.* Due to low frequencies in one or more categories, I dichotomized the variable as 0 = *very satisfied* and 1= *somewhat satisfied/somewhat dissatisfied/very dissatisfied*.

Barriers that might delay mammography. We assessed barriers to mammography through open- and closed-ended questions adapted from previous studies (Champion & Skinner, 2003; Rimer, Keintz, Kessler, Engstrom, & Rosan, 1989). First, *In the past, has anything ever delayed your getting a mammogram?* If yes, this was followed by *What was the main reason that delayed your getting a mammogram? In the past, did anything else delay your getting a mammogram*? This question was asked until no other barriers were offered, up to three times. Then barriers were categorized according to eleven major themes as classified by two independent coders. Dichotomous variables were created to indicate whether a respondent endorsed or did not endorse a barrier theme. The themes were as follows: 1) not at risk for breast cancer/no symptoms; 2) competing problems/priorities; 3) experience with the health care system and mammograms; 4) lack of knowledge/doesn't trust mammography; 5) physician-related barriers; 6) logistical issues; 7) afraid/nervous about mammogram results or breast cancer; 8) cost issues; 9) too busy; 10) forgot; 11) faith/beliefs.

Participants also were asked seven closed-ended questions about what might delay their next mammograms. Responses used four-point scales, including *strongly agree/disagree* and *somewhat agree/disagree*. Barriers were considered present if respondents endorsed somewhat or strongly agree. After accounting for duplication in barriers, responses to open- and closed-ended questions were summed to determine the total number of barriers.

Self-efficacy Participants were asked, *How confident are you that you could get a mammogram when you are due?* (Giles, McClenahan, Cairns, & Mallet, 2004). Responses were scored *0=very confident, 1=somewhat confident, 3=a little confident* and *4=not at all*

confident. Due to low frequencies in one or more categories, I dichotomized self-efficacy as 0 = *very confident* or 1 = *somewhat/not at all confident.*

Perceived susceptibility. Participants were asked, *How likely are you to get breast cancer in your lifetime compared to the average woman your age and race?* Responses were scored, *0=less likely to get breast cancer, 1= about as likely to get breast cancer* and *3=more likely to get breast cancer in your lifetime than the average woman your age and race* and trichotomized as 0 = *higher risk*, 1 = *average risk* or 2 = *lower risk*. This question was not asked at the 24-month interview. Values were imputed from baseline and 12-month survey data and standardized empirical decision rules.

Mammography behavioral intentions. On a 4-point scale (1 = *very unlikely* to 4 = *very likely*), we assessed behavioral intentions using the item, *How likely or unlikely is it that you will have a mammogram when you are due?* Women who said they were *very likely* to have a mammogram when due were categorized as having the strongest behavioral intentions. Due to low frequencies in one or more categories, I dichotomized this variable as 0 = *somewhat likely and somewhat/very unlikely* and 1 = *very likely.*

4.2.3 Moderator Variables

Age. We created two categories for age, 40 to 49, and 50 and over.

History of false positive mammograms. Each year women were asked, *Have you had a mammogram when you were told the results were not normal, but no cancer was found?* Responses were scored 0 = *no* or 1 = *yes.*

Prior mammography use. We assessed prior mammography screening status (recent use, repeat use) by confirming claims data with self-report of last two mammography dates at

baseline telephone interview. If a discrepancy between self-report data and claims data occurred, the self-report data were used. Recent use was defined as having not had their two most recent mammograms prior to baseline interviews in the designated 10 to 14 months window. Repeat use was defined as having a second mammogram no sooner than 10 months and no later than 14 months after a previous mammogram.

4.2.4 Control Variables

Several factors associated with mammography screening were included in the models as covariates.

Marital status was dichotomized as 0 = *married/living as married,* 1 = *not married/not living as married.*

Education was trichotomized as coded 0 = *a college degree or more,* 1 = *some college* and 2 = *twelve or fewer years of education* and then coded as two dichotomous variables, with 0 = *a college degree or more* as the reference category for both.

Perceived financial situation was assessed using a single item, *Without giving exact dollars, how would you describe your household's financial situation right now? Would you say that:* 0 = *after paying the bills, you still have enough money for special things that you want*, 1 = *you have enough money to pay the bills, but little spare money to buy extra or special things*, 2 = *you have money to pay the bills, but only because you have cut back on things*, 3 = *you are having difficulty paying the bills, no matter what you do* (Rimer et al., 2002). Due to low frequencies in one or more categories, I dichotomized this variable as 0 = *enough for special things* vs. 1, 2, 3 = *little spare money.*

Family history of breast cancer was assessed via two questions, *Was your mother ever told by a doctor that she had breast cancer?* and, *Not including step-sisters or adopted family*

members, were any of your sisters ever told by a doctor that they had breast cancer? Positive family history was responding yes to either or both questions. Responses were coded 0= *yes* or 1= *no.*

Health status was assessed with a single item, *How would you describe your current health? Would you say it is* 1= *excellent,* 2 = *good,* 3 = *fair* or *4 = poor.* Due to small frequencies in the *poor* and *fair* category, this item was trichotomized as 0 = *excellent,* 1 = *good* or *2 = fair/ poor* and then coded as two dichotomous variables with 0 = *excellent* as the reference category.

Physician recommendation was assessed via a single item, *In the last year, has a doctor advised you to have a mammogram?* Responses were coded 0 = *yes* or 1 = *no*.

4.3 Data Analysis

4.3.1 Preliminary Analysis

Several statistical methods will be used to achieve study aims. First, descriptive statistics will be conducted to screen data for problems (e.g., outliers, frequencies, skewness and kurtosis). For each variable of interest in the proposed research, missing values were identified and the distributions and patterns of these missing values were evaluated carefully.

4.3.2 Analysis for Aim 1

Aim 1: To examine predictors of mammography maintenance that are theoretically and empirically informed and amenable to intervention efforts.

Research Quesiton1.1: *What are the proportions of insured women who obtained no, one, two or three on-schedule mammograms over a 36-month period*?

To compute proportions of on-schedule mammography use over a 36-month period, mammography use was assessed at each of the 12, 24 and 36 month surveys. Women were coded as "0" for off-schedule use and '1" for on-schedule use at each time point as described above in section 4.2.1. Then I grouped participants according to the patterns of mammography use described in Table 2 in section 3.2.1 and assigned a group code based on pattern of use. Next, I calculated proportions of each group.

Research Question 1.2: *What are the trends in perceived behavioral control, attitude towards the behavior, perceived satisfaction with past outcomes, self-efficacy, perceived barriers, perceived susceptibility, behavioral intentions and doctor recommendation for mammography at baseline, 12, 24, and 36 months for each of the four patterns of use?*

I assessed trends for each variable of interest by measuring proportions of responses for categorical variables and means of the continuous variables at baseline, 12, 24, and 36 months for participants in each patterns of use.

4.3.3 Overview of Method of Analysis for Aim 2 and Aim 3

To examine predictors of mammography maintenance in Aim 2 and Aim 3, I used a survival analysis method called discrete event history analysis (Allison, 1995). In general, survival analysis was designed to analyze longitudinal data for the occurrence of events such as births, deaths, job changes or, in our study, unsustained mammography maintenance. While survival analysis can be used to study the timing of the onset of an event, it is commonly used to estimate predictive models in which the event of interest is dependent on covariates.

Discrete event history analysis treats each participant's life intervals up to the event of interest as separate observations. In the present study, there are three discrete life intervals based on data collection points and potential occurrence of the event: 1) baseline to 12 months; 2) 12 to 24 months; and 3) 24 to 36 months. The predictor variables, including behavioral intentions, were measured at the beginning of each interval and the dependent variable was assessed at the end of each interval. For example, self-efficacy was measured at the beginning of each 12-month interval and the event being modeled, that is unsustained mammography maintenance, was measured at the end of the each of the 12-month intervals. Unsustained mammography maintenance was defined as not having consecutive mammograms on schedule (i.e., 10 to 14 months apart).

The first step in discrete event history analysis is to create a data structure to track predictor variables as they vary over time leading to the event occurring or not occurring at each interval. Each participant contributes observations to the dataset until she experiences the event. Once a participant does not sustain use, she no longer contributes observations. For example, if a participant sustains mammography maintenance over the entire 36-month follow-up period, she contributes three observations based on the three 12-month intervals. If another participant does not sustain use as assessed at the 24-month survey (end of interval two), she only contributes two observations. Observations from each discrete interval are treated as distinct observations that are then pooled into the stacked dataset. Once the data structure has been constructed, the binary outcome of the event occurring (unsustained mammography maintenance) or not occurring (sustained mammography maintenance) is modeled using ordinary logistic regression using the PROC LOGISITC command in SAS (Allison, 1995).

4.3.4 Analysis for Aim 2

Aim 2: *To examine predictors of mammography maintenance that are theoretically and empirically informed and amenable to intervention efforts.*

The research questions associated with Aim 2 are set forth to test the direct and mediated relationships depicted in the conceptual model (Figure 2, Chapter Three). Figure 6 depicts a simplified version of the direct and mediated relationships proposed this is study. There are three ways to statistically test for mediation: 1) causal steps; 2) difference of coefficients and; 3) product of coefficients (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002; MacKinnon, Warsi, & Dwyer, 1995). The causal steps approach (Baron & Kenny, 1986) involves four steps to determine if mediation exists;

1) significant relationship between the predictor variable on the outcome of interest (path τ);

2) significant relationship between predictor variables and proposed mediator (path α);

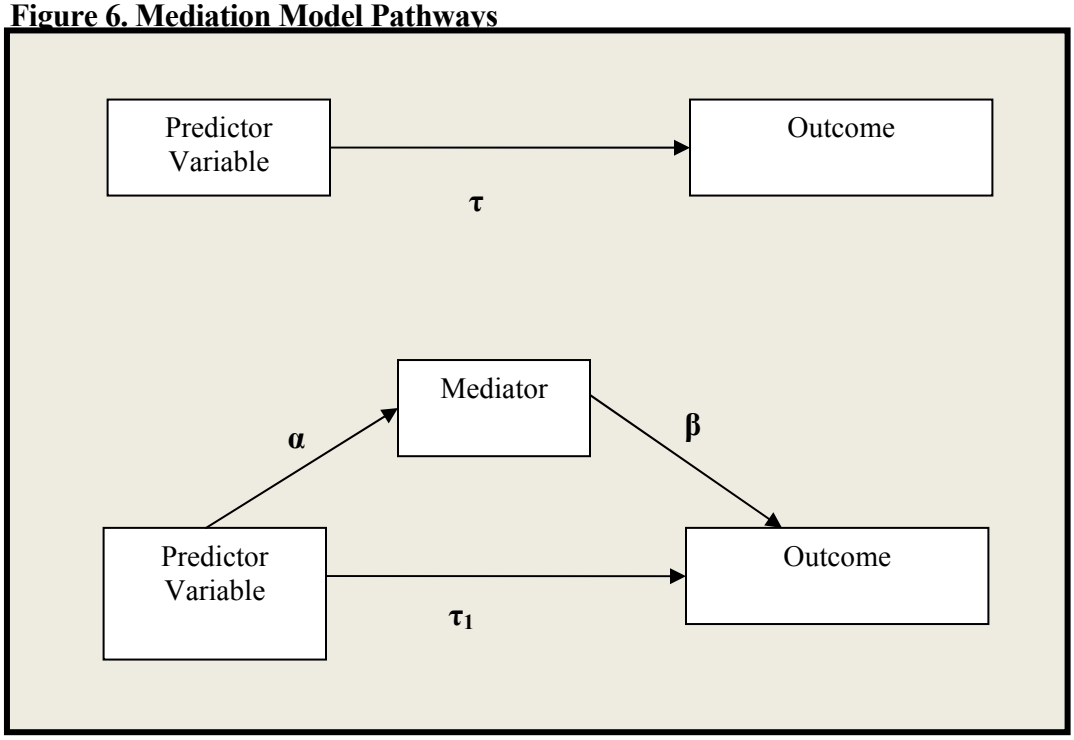
3) significant relationship between mediator and outcome of interest (path β)and;

4) the coefficients of the predictor and outcome variables must be larger than the coefficients of the outcome variables when regressed on the model containing the predictor and mediating variables(path τ_1). The product of coefficients ($\alpha\beta$) or the difference of coefficients ($\tau - \tau_1$) methods can be used to calculate the mediated effect.

Research Question 2.1 tested pathway τ (effects of predictors on outcome). Research Question 2.2 tested pathway α (effect of predictors on mediator) and Research Question 2.3 tested pathway β (effects of mediator on outcome). In Research Question 2.4, I tested if the relationships between predictors and unsustained mammography maintenance are statistically

significant when the mediator (behavioral intentions) is included in the model (pathway τ_1) using the methods outlined by MacKinnon (MacKinnon & Dwyer, 1993; MacKinnon et al., 1995).

Figure 6. Mediation Model Pathways



Research Question 2.1: A logistic regression model using discrete event history analysis was used to examine effects of perceived barriers, attitudes towards behavior, perceived satisfaction with past experiences, perceived susceptibility to breast cancer, self-efficacy and perceived behavioral control on unsustained mammography maintenance. The logistic regression model included control variables. Statistical tests of each coefficient in the model corresponded to the test of hypotheses 2.1.1 through 2.1.6 in section 3.2.2.

Research Question 2.2: To examine the effect of perceived barriers, attitudes towards behavior, perceived satisfaction with past experiences, perceived susceptibility to breast cancer, self-efficacy and perceived behavioral control on behavioral intentions, I fit a

logistic regression model using discrete event history analysis. The logistic regression model included control variables. The statistical tests of each coefficient in the model corresponded to the test of hypotheses 2.2.1 through 2.2.6 in section 3.2.2.

Research Question 2.3: Discrete event history analysis was used to model effects of the proposed mediator, behavioral intentions, on the outcome, unsustained mammography maintenance. The hypotheses associated with this research question were assessed by regressing the outcome on the mediator. The statistical test of the coefficient in the model corresponded to the test for hypothesis 2.3.1 in section 3.2.2.

Research Question 2.4: To test mediation, I fit a logistic regression model that included all variables from the model in Research Question 2.1 plus behavioral intentions. However, the casual effect method of mediation does not set forth any guidance for determining how much the τ_1 path coefficient must change to prove mediation. Also MacKinnon and colleagues established that mediation can occur even if there is no association between the predictor variable and the outcome of interest (MacKinnon, Krull, & Lockwood, 2000). In addition, the causal steps approach has low statistical power (MacKinnon et al., 2002).

As stated above, the product of coefficients ($\alpha\beta$) or the difference of coefficients (τ- τ1) methods can be used to calculate the mediated effect. These methods yield equivalent results if ordinary least squares and maximum likelihood estimations are used (MacKinnon et al., 1995). When using logistic regression or survival analysis, these estimates are not equivalent because the scales of the equations are not constant across models (Jasti, Dudley, & Goldwater, 2008; MacKinnon & Dwyer, 1993). Standardization of regression coefficients

is needed in order to calculate the mediated effects (MacKinnon & Dwyer, 1993). In simulation studies the product of coefficients yielded a better estimate of mediation for logistic regression models (MacKinnon & Dwyer, 1993).

After standardization, the coefficients can be used to conduct significance testing of the mediated effect using the Sobel test (Sobel, 1982). To compute the significance of the mediated effect, the mediated effect (αβ) is divided by its standard error (MacKinnon & Dwyer, 1993). The result is a z-score. See below.

$$z_{ab} = \frac{a*b}{se_{ab}}$$

To compute the standard error of the mediated effect the following equation is used.

$$se_{ab} = \sqrt{(a^2 * seb^2) + (b^2 * sea^2)}$$

4.3.5 Analysis for Aim 3

Aim 3: *To examine if factors identified in Aim 2 are stronger predictors of mammography maintenance among certain subgroups than others.*

Research Question 3: To test the effect of perceived barriers, attitudes towards behavior, perceived satisfaction with past experiences, perceived susceptibility to breast cancer, self-efficacy, perceived behavioral control, and behavioral intentions on unsustained mammography maintenance, I used discrete event history analysis to fit a logistic regression model. Specific hypotheses for Research Question 3 can be found in section 3.2.3. Each hypothesis was tested separately by creating a multiplicative interaction term of the predictor variables, including behavioral intentions, and the proposed moderator (e.g., those with

histories of false positive mammograms, those in different age groups, those with different patterns of mammography use at baseline). I conducted chunk tests (Omnibus

Chi-square tests) to assess the robustness of interaction effects (Kleinbaum & Klein, 2002). As such, I compared the difference of log likelihood values for the full model with the interaction terms and main effects model. The difference was then compared to a chi-square distribution at the appropriate number of degrees of freedom corresponding to the difference in the degrees in freedom of the two models. Significance was evaluated at the *p-value* = 0.05.

CHAPTER FIVE: RESULTS

In this chapter, I present the results of my dissertation research. First, I present sample characteristics, including frequencies of demographic characteristics and variables of interest as well as assessments of missing data. Next, I present the results of the analysis of each research question stated in Chapter Three.

5.1 Participant Characteristics

5.1.1 Sample for Aim 1

Baseline characteristics of the sample used for Aim 1 are presented in Table 3. The sample was composed of women PRISM's Tier 1 control group (n=847). Most of the sample was of Non-Hispanic White race, married, had obtained a college degree or more education and reported a usual source of health care. The average age of women was 55, most of the sample lived with one other person and most reported at least good health status. The majority worked for pay and reported finances that allowed them to "buy special things." Almost 17% reported a family history of breast cancer and a little less than half of the women had at least one false positive mammogram prior to study enrollment. The overwhelming majority of women reported favorable beliefs and attitudes toward obtaining mammograms when they were due. Most women perceived their risk of breast cancer to be about as likely to occur for them as for other women their age and race. Half of the women reported two or more barriers to getting a mammogram when due for one.

Table 3. Selected baseline characteristics of participants for analysis of Aim 1(*n* = 847)

Variable	N (% of sample)	M	SD
Socio-demographic variables:			
Age		55.1	6.2
Race/ethnicity			
Non-Hispanic White	752 (88.8)		
Non-Hispanic Black	83 (9.8)		
Hispanic	5 (0.6)		
American Indian or Alaska Native	4 (0.5)		
Unspecified race/ethnicity	3 (0.4)		
Marital status			
Married/living as married	681 (80.6)		
Not married/living as married	164 (19.4)		
Education			
Grade 12 or less	130 (15.4)		
Some college	191 (22.6)		
College degree or more	526 (62.1)		
Additional members living in the household			
0	105 (12.4)		
1	440 (52.0)		
2	150 (17.7)		
3+	152 (18.0)		
Perceived financial situation			
Enough for special things	538 (64.2)		
Little spare money	300 (35.8)		
Work for pay			
Yes	680 (83.3)		
No	167 (19.7)		
Self-reported medical history and health care -related variables:			
Health status			
Excellent	308 (36.5)		
Good	455 (53.9)		
Fair or poor	82 (9.7)		

Table 3. (continued)

Variable	N (% of sample)	M	SD
Family history of breast cancer			
Yes	140 (16.7)		
No	699 (83.3)		
History of false positive mammograms			
Yes	394 (46.6)		
No	451 (53.4)		
Regular source of routine health care			
Yes	823 (97.2)		
No	24 (2.8)		
Doctor recommendation for a mammogram in past year			
Yes	666 (78.7)		
No	180 (21.3)		
Attitude and belief variables:			
Satisfaction with previous mammography experience			
Very satisfied	748 (88.4)		
Somewhat satisfied/somewhat dissatisfied/very dissatisfied	98 (11.6)		
Perceived control over getting a mammogram when due			
Complete control	693 (81.8)		
Some/no control	154 (18.2)		
Self-efficacy over getting a mammogram when due			
Very confident	777 (91.7)		
Somewhat/ a little/not at all confident	70 (8.3)		
Perceived risk of getting breast cancer compared to an average woman			
Less likely	225 (27.6)		
About as likely	463 (56.8)		
More likely	127 (15.6)		

Table 3. (continued)

Variable	N (% of sample)	M	SD
Intention of getting a mammogram when due			
Very likely	774 (91.4)		
Somewhat likely or Somewhat/very unlikely	73 (8.6)		
Number of barriers to obtaining a mammogram			
No barriers	205 (24.2)		
1 barrier	211 (24.9)		
2 barriers	168 (19.8)		
3 barriers	103 (12.2)		
4+ barriers	160 (18.9)		
Attitude towards mammography as measured by decisional balance score		8.2	3.1

5.1.2 Sample for Aim 2 and 3

A combined group consisting of PRISM Tier 1 and Tier 2 control groups was used as the sample for Aim 2 and Aim 3, Baseline characteristics of the sample used for Aim 2 and Aim 3 are presented in Table 4. Analyses for Aim 2 and Aim 3 were restricted to Non-Hispanic Black women and White women who were in the PRISM Tier 1 or Tier 2 control groups, due to small cell sizes for the remaining racial and ethnic groups, and women who had not received mammograms less than 10 months apart (n=1,219). The outcome for Aim 2 and Aim 3 was unsustained mammography maintenance (the likelihood of women not getting on-schedule mammograms each year).

The sample used for Aim 2 and Aim 3 was similar in composition to the sample used in Aim 1. Most of the restricted sample was of Non-Hispanic White race, married and had obtained at least a college degree. The average age of women was 55 and slightly more than half of participants lived with another person. The majority of the sample reported excellent

or good health at baseline, worked for pay and reported finances that allowed them to "buy special things." Nearly all women reported a usual source of care. Almost half of participants had at least one false positive mammogram prior to study enrollment, 16% reported a family history of breast cancer and about a quarter of the women did not received doctors' recommendations for mammograms in the last year. The overwhelming majority of women reported favorable beliefs and attitudes toward obtaining mammograms when they were due. Most women perceived breast cancer to be about as likely to occur for them as for other women their age and race. Almost a quarter of women reported no barriers to getting a mammogram when one was due.

Table 4. Selected baseline characteristics of participants for Aim 2 and 3 (*n* = 1,219)

Variable	N (% of sample)	M	SD
Number of years of sustained mammography maintenance			
0	331 (27.2)		
1	201 (16.5)		
2	127 (10.4)		
3	560 (45.9)		
Socio-demographic variables:			
Age	-----	55.0	6.3
Race/ethnicity			
Non-Hispanic White	1093 (89.7)		
Non-Hispanic Black	126 (10.3)		
Marital status			
Married/living as married	973 (80.0)		
Not married/living as married	244 (20.0)		

Table 4. (continued)

Variable	N (% of sample)	M	SD
Education			
Grade 12 or less	191 (15.7)		
Some college	272 (22.3)		
College degree or more	756 (62.0)		
Additional members living in the household			
0	135 (11.1)		
1	635 (52.1)		
2	245 (20.1)		
3+	204 (16.7)		
Perceived financial situation			
Enough for special things	763 (62.9)		
Little spare money	450 (37.1)		
Work for pay			
Yes	959 (78.7)		
No	260 (21.3)		
Self-reported medical history and health care -related variables:			
Health status			
Excellent	452 (37.2)		
Good	642 (52.8)		
Fair or poor	122 (10.0)		
Family history of breast cancer			
Yes	190 (15.7)		
No	1019 (84.3)		
History of false positive mammograms			
Yes	555 (45.8)		
No	658 (54.2)		
Regular source of routine health care			
Yes	1179 (96.7)		
No	40 (3.3)		
Doctor recommendation for a mammogram in past year			
Yes	944 (77.6)		
No	273 (22.4)		

Table 4. (continued)

Variable	N (% of sample)	M	SD
Attitude and belief variables:			
Satisfaction with previous mammography experience			
Very satisfied	1086 (89.2)		
Somewhat satisfied/somewhat dissatisfied/very dissatisfied	131 (10.8)		
Perceived control over getting a mammogram when due			
Complete control	973 (79.8)		
Some/no control	246 (20.2)		
Self-efficacy related to getting a mammogram when due			
Very confident	1127 (92.5)		
Somewhat/ a little/not at all confident	91 (7.5)		
Perceived risk of getting breast cancer compared to an average woman			
Less likely	311 (26.6)		
About as likely	681 (58.3)		
More likely	177 (15.1)		
Intention of getting a mammogram when due			
Very likely	1112 (91.3)		
Somewhat likely or Somewhat/very unlikely	106 (8.7)		
Number of perceived barriers			
No barriers	293 (24.0)		
1 barrier	313 (25.7)		
2+ barriers	613 (50.3)		
Attitude towards mammography as measured by decisional balance score	-----	8.1	3.2

5.1.3 Data Structure and Missingness for Aim 2 and 3

The first step in conducting discrete event history analysis was to construct a duration variable that corresponded to the 15 possible combinations of women's maintenance profiles based on the three years of follow-up. The duration variable ranged from a value of 1 to 3. The value of the duration variable corresponded to the year a women experienced the event, non-adherence to mammography maintenance, or the last year she was present in the dataset for those lost to follow up. The duration variable was then used to construct a year variable in the dataset that corresponded to the year of each observation for each participant. The year variable was used to calculate the effect of time on the outcome. The resulting dataset consisted of 2,794 observations from the original 1,219 participant records. Missing values for predictor variables were explored; missingness was considered to be satisfactorily low for each predictor variable (less than 5%). Therefore, listwise deletions were employed for the discrete event history analysis.

5.2 Aim 1 Results: Changes over time

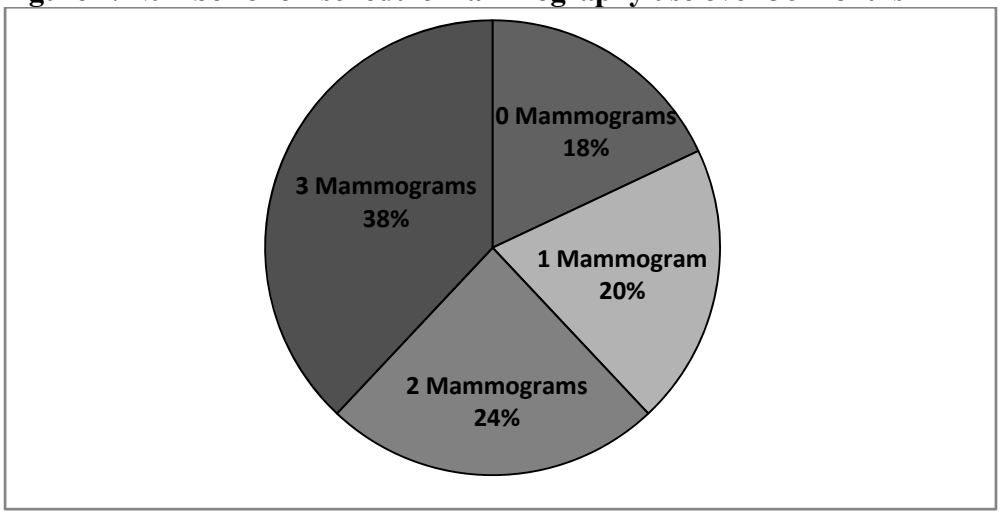
In this aim, I explored patterns of mammography use and determined how certain theoretically informed and empirically based variables changed over time.

5.2.1 Research Question 1.1

Research Question 1.1 was *What proportions of insured women obtained no, one, two or three on-schedule mammograms during a 36-month period*. To answer this question, women were categorized into four groups based on the number of on-schedule mammograms defined as recent and prior mammograms 10 to 14 months apart: no mammograms, one mammogram, two mammograms, three mammograms. Only 38% of women sustained on-

schedule use across the three screening periods. About a quarter of women obtained two on-schedule mammograms, and 20% received only one on-schedule mammogram. Almost 20% did not receive an on-schedule mammograms over the course of the study (Figure 7).

Figure 7. Number of on-schedule mammography use over 36 months



5.2.2 Research Question 1.2

Research Question 1.2 was *What are the trends in certain theoretically informed and empirically based variables at baseline, 12, 24, and 36 months for each of the four patterns of mammography use.* To assess trends over the 36-month period, women were coded based on their mammography use profiles (on- or off-schedule use) for each of the screening cycles and then grouped according to number of on-schedule mammograms. Proportions for categorical variables and means for continuous variables were calculated for each group at baseline, 12, 24 and 36 months. These were then plotted to assess overall trends. This was a descriptive aim; no inferential statistics were performed.

In general, a larger proportion of women with more on-schedule mammograms had favorable attitudes and beliefs compared to women with fewer on-schedule mammograms.

For example, a larger proportion of women in the three-mammogram group had the most favorable satisfaction rating (Figure 8), attitudes towards mammography (as measured by decisional balance scores) (Figure 9), and strong behavioral intentions (as measured by endorsing "very likely to have a mammogram") (Figure 10) at each assessment compared to women who obtained no, one or two on-schedule mammograms.

Figure 8. Proportion of women very satisfied with past mammography experience by number of on-schedule mammograms

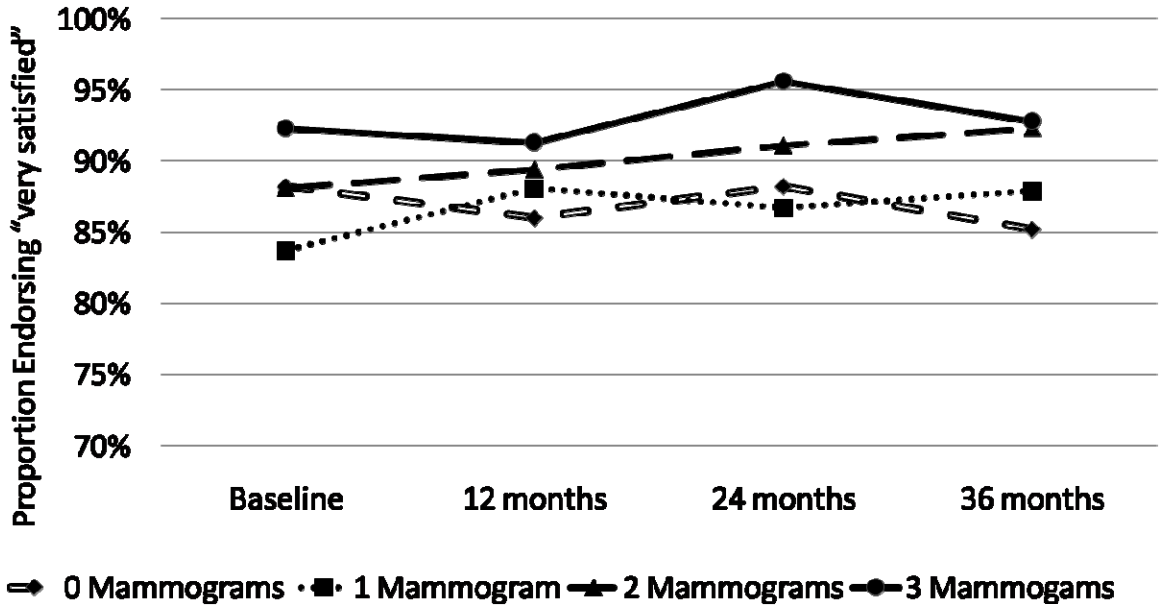


Figure 9. Attitude towards mammography: Average decisional balance scores by number of on-schedule mammograms

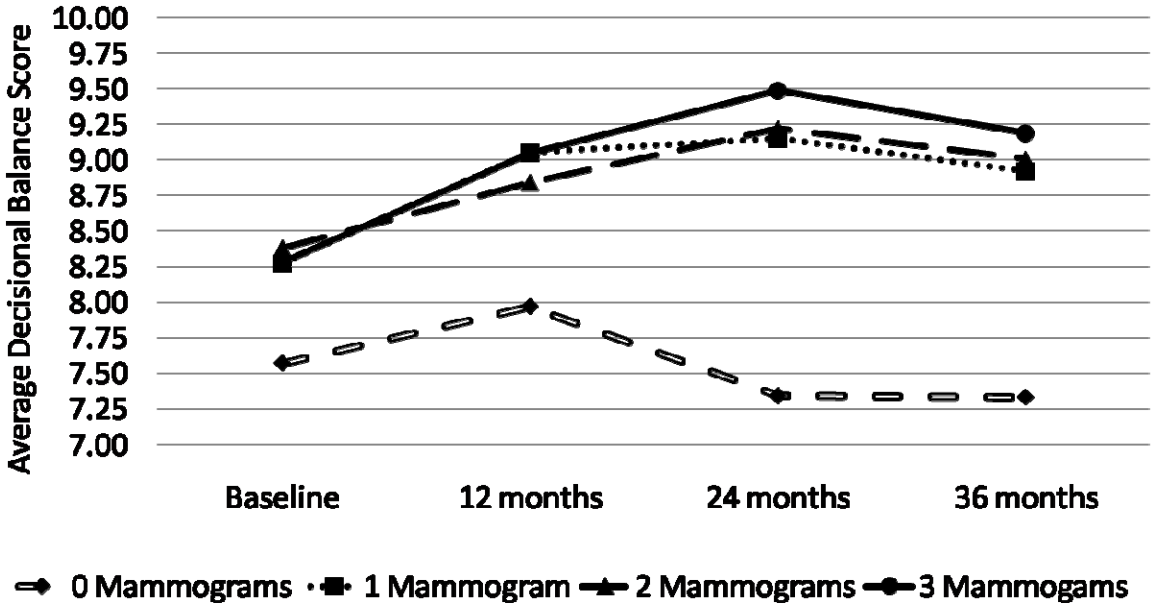
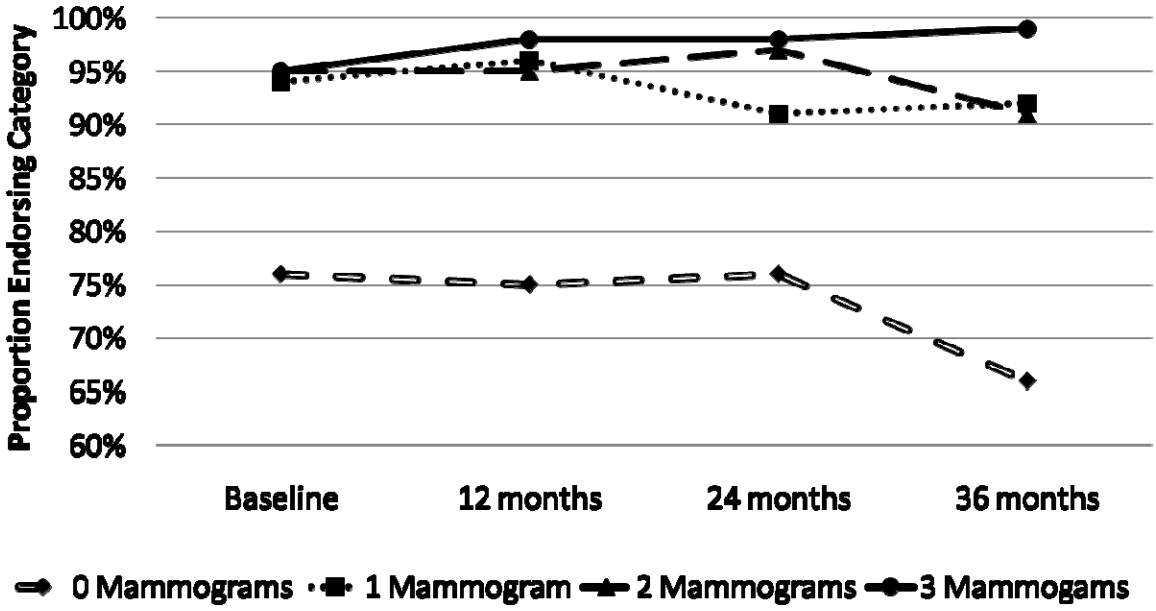
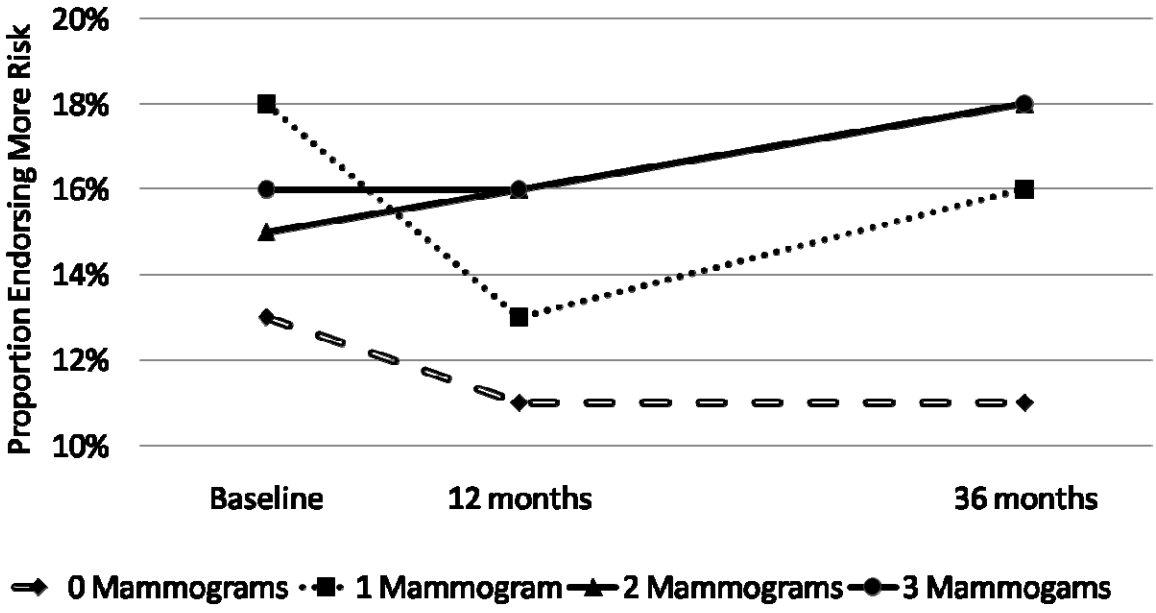


Figure 10. Behavioral intentions as measured by "very likely to have a mammogram" by number of on-schedule mammograms



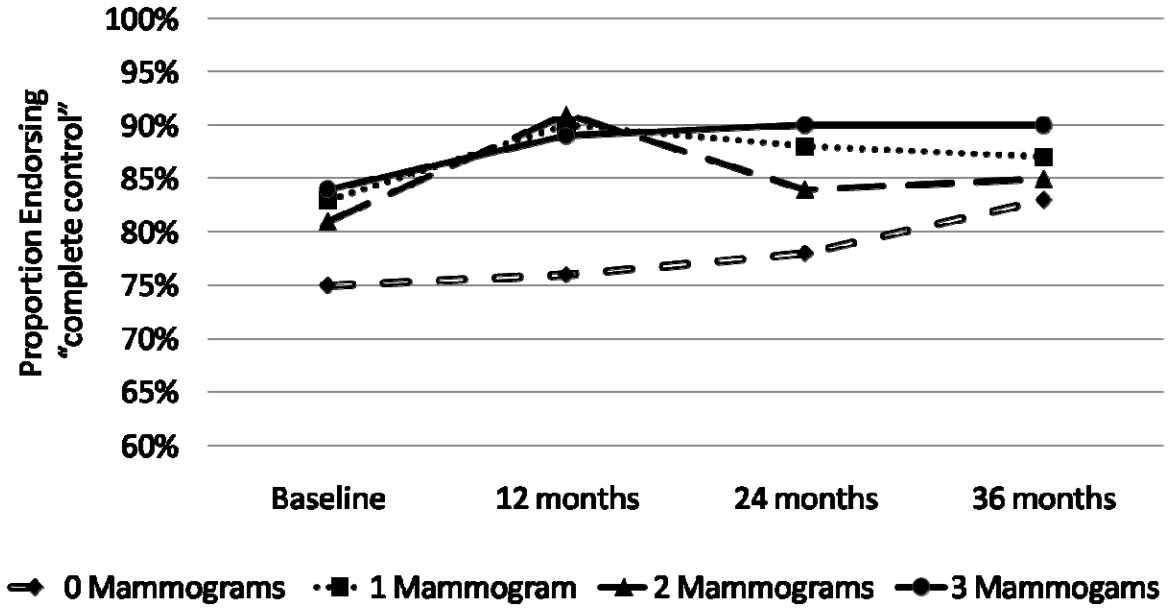
There was an overall upward trend in the proportion of women in the three-mammogram and two-mammogram groups who perceived they were at greater risk of breast cancer compared to women their age and race (16% at 12 months and 18% at 36 months for both groups) (Figure 11). Both the no use and one-mammogram groups experienced downward trends in the proportion of women who perceived they were at greater risk of breast cancer over time.

Figure 11. Perceived susceptibility as measured by "more likely to get breast cancer" by number of on-schedule mammograms



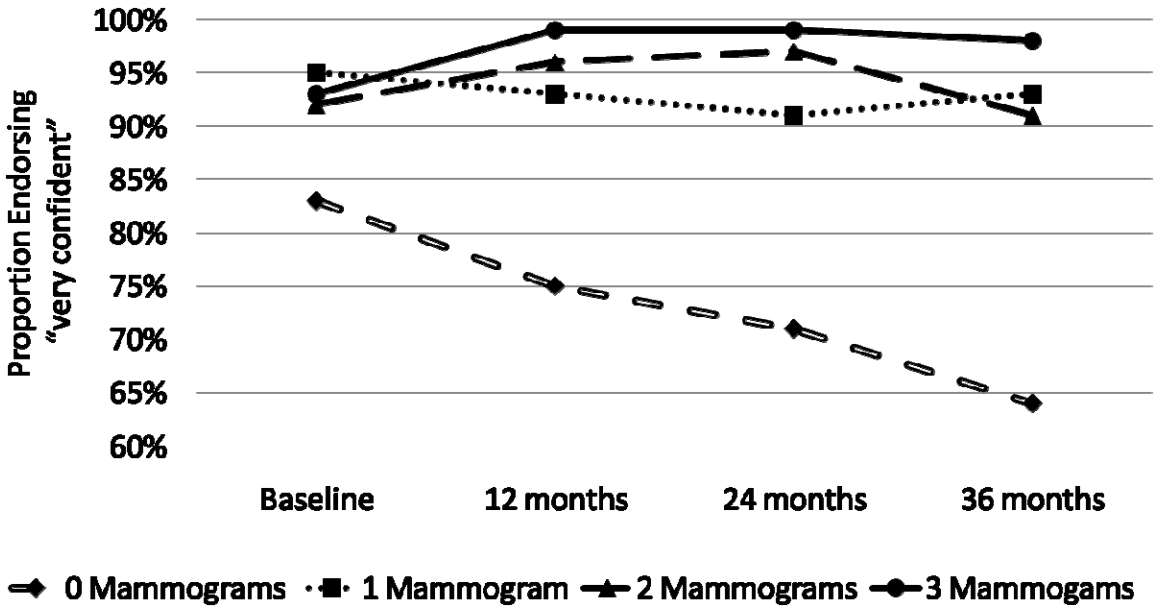
Over time, there was an upward trend in the proportion of women in the three-mammogram group who perceived they had complete behavioral control over getting a mammogram when they were due for one. A similar trend was observed in the no mammogram group as well. However, the proportion of women endorsing complete behavioral control was much less for women in the no mammogram group compared to those in the three-mammogram group. (Figure 12)

Figure 12. Perceived behavioral control as measured by expressing "complete control" by number of on-schedule mammograms



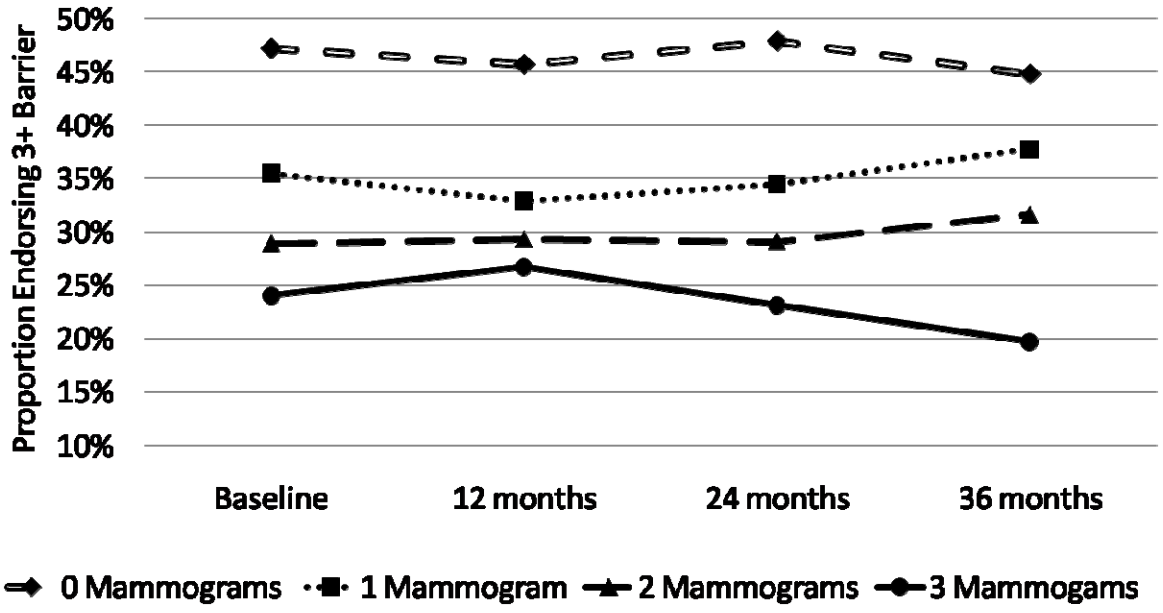
We also found an upward trend in the proportion of women in the three-mammogram group who reported greater self-efficacy (i.e., very confident) in getting a mammogram when due for another as compared to downward trends for all three other mammography use groups, with the most pronounced downward trend found in the no on-schedule mammography use group (Figure 13).

Figure 13. Mammography self-efficacy as measured by "very confident" by number of on-schedule mammograms



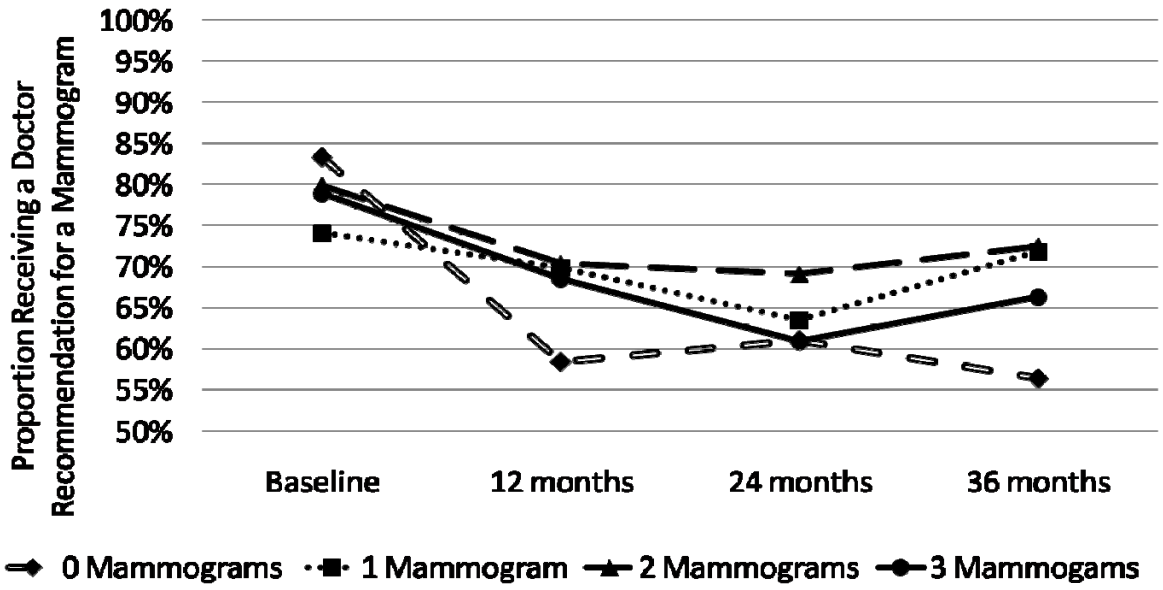
We found consistent trends in the number of mammography-specific barriers for all four groups of mammography users. Across all four assessments, a larger proportion of women in the no on-schedule mammogram group reported three or more barriers to mammography use compared to women who received one or more mammograms on schedule. Fewer women in the three-mammogram group reported 3+ barriers compared to women in any of the other groups (Figure 14).

Figure 14. Proportion of women who identified 3+ barriers to mammography use by number of on-schedule mammograms



All four categories of on-schedule mammography use experienced a downward trend in receiving a physician's recommendation to get a mammogram in the past year. The most pronounced downward trend was observed in the group that obtained no on-schedule mammograms over the course of the study (Figure 15).

Figure 15. Proportion of women who received doctors' recommendations to get a mammogram in the last year by number of on-schedule mammograms



I then conducted chi-square tests to compare differences in key sociodemographic variables across the different categories of on-schedule use. Perceived financial situation, working for pay, race (restricted to Non-Hispanic White/Black) and baseline heath status were associated with on-schedule use. The trend was towards more on-schedule mammography use with the good and excellent groups as compared to the fair/poor health status group. No statistically significant differences were seen in on-schedule mammography use for women who reported good health as compared to women who reported excellent health at baseline.

Table 5. Characteristic of sample by patterns of on-schedule mammography use*

	No Mammograms (*n*=141)	One Mammogram (*n*=166)	Two Mammograms (*n*=191)	Three Mammograms (*n*=307)	p-value
Health status †					0.03
Excellent	44 (14.9)	54 (18.2)	72 (24.3)	126 (42.6)	
Good	80 (18.7)	88 (20.5)	97 (22.6)	164 (38.2)	
Fair or poor	17 (21.8)	23 (29.5)	21 (26.9)	17 (21.8)	
Education					0.87
High school or less	18 (15.3)	23 (19.5)	28 (23.7)	49 (41.5)	
Some college	36 (19.9)	40 (22.1)	38 (21.0)	67 (37.0)	
College degree or more	87 (17.2)	103 (20.4)	125 (24.7)	191 (37.8)	
Perceived Income					< 0.001
Enough for special things	66 (12.8)	103 (20.0)	127 (24.6)	220 (42.6)	
Little to spare/difficulty paying bills	73 (25.9)	62 (22.0)	62 (22.0)	85 (30.1)	
Marital status					0.14
Not married	30 (19.1)	31 (19.8)	27 (17.2)	69 (44.0)	
Married/Living as married	111 (17.2)	134 (20.7)	163 (25.2)	238 (36.8)	
Race					0.05
Non-Hispanic White	118 (16.3)	150 (20.7)	177 (24.5)	279 (38.5)	
Non-Hispanic Black	23 (28.4)	16 (19.8)	14 (17.3)	28 (34.6)	
Work for pay					0.02
Yes	116 (17.9)	133 (20.5)	166 (25.6)	233 (36.0)	
No	25 (15.9)	33 (21.0)	25 (15.9)	74 (47.1)	

*Sample restricted to only Non-Hispanic White and Black race due to small sample size of other race/ethnicity groups. (n=835)
†Comparison between excellent and fair/poor health status was significant X^2=12.74; p=0.005; comparison between good and fair/poor health status was significant X^2=8.29; p=0.040; comparison between excellent and good was not significant X^2=2.97; p=0.396.

5.3 Aim 2 Results: Predictors of Behavior

For this aim, I proposed examining predictors of unsustained mammography maintenance that were theoretically and empirically informed and amenable to intervention efforts. The dataset consisting of 2,794 observations from the 1,219 women in the Tier 1 and Tier 2 control groups was used for these analyses.

5.3.1 Research Question 2.1

Research Question 2.1 addressed whether perceived barriers, attitudes towards behavior, perceived satisfaction with past experiences, perceived susceptibility to breast cancer, self-efficacy and perceived behavioral control predict mammography maintenance non-adherence (i.e., unsustained use) across the three years of follow-up. To address this question, I used discrete event history analysis that fit a multivariable logistic regression model.

To test hypotheses 2.1.1 through 2.1.6, a multivariable logistic regression model was fit that regressed mammography maintenance non-adherence on predictor variables (perceived barriers, attitudes towards behavior, perceived satisfaction with past experiences, perceived susceptibility to breast cancer, self-efficacy and perceived behavioral control), including a variable for years of sustained mammography maintenance. The model also included seven control variables (marital status, educational attainment, perceived financial situation, health status, family history of breast cancer, doctor recommendation for a mammogram in the past year, type of control group).

Overall, 54% of women did not sustain mammography maintenance over the three years. Only satisfaction with previous mammography experience, self-efficacy related to

getting a mammogram when due and number of barriers significantly predicted mammography maintenance non-adherence (Table 6). Women who reported they were less than completely satisfied with their last mammography experience (OR= 1.50, *95% CI* = 1.10, 2.10, $p = .011$), said they were somewhat/a little/not at all confident in getting a mammogram when due (OR= 1.80, *95% CI* = 1.20, 2.66, $p = .005$), and women who reported one (OR= 1.45, *95% CI* = 1.09, 1.92, $p = .009$) or two or more barriers to getting a mammogram (OR= 1.74, *95% CI* = 1.35, 2.24, $p \leq .001$) were more likely to be non-adherent to mammography maintenance over the three years. Time also predicted non-adherence. For each year a woman continued to obtain regular mammograms (sustained use), she experienced a 17% decrease in the odds of not sustaining use. In other words, women who sustained use were more likely to get future mammograms on schedule (i.e., sustain maintenance). Only one control variable predicted mammography maintenance non-adherence. Health status predicted not sustaining mammography use over three years such that women who reported poor or fair health experienced a 76% increase in the odds of not sustaining use as compared to women who reported excellent health.

Table 6. Predictors of unsustained mammography maintenance over three years (*n* =1,219)

	Unadjusted Odds Ratio	95% CI	Adjusted Odds Ratio	95% CI
Satisfaction with previous mammography experience				
Very satisfied	Reference	-----	Reference	-----
Somewhat satisfied/somewhat dissatisfied/very dissatisfied	**1.99**	**1.49-2.66**	**1.50**	**1.10-2.10**
Perceived control over getting a mammogram when due				
Complete control	Reference	-----	Reference	-----
Some/no control	**1.61**	**1.27-2.05**	1.26	0.97-1.63
Self-efficacy related to getting a mammogram when due				
Very confident	Reference	-----	Reference	-----
Somewhat/ a little/ not at all confident	**2.82**	**1.94-4.10**	**1.80**	**1.20-2.66**
Perceived risk of getting breast cancer compared to an average woman				
Less likely	Reference	-----	Reference	-----
About as likely	0.94	0.76-1.16	0.97	0.77-1.21
More likely	0.96	0.71-1.29	1.05	0.74-1.49
Number of perceived barriers				
No barriers	Reference	-----	Reference	-----
1 barrier	**1.58**	**1.20-2.08**	**1.45**	**1.09-1.92**
2+ barriers	**2.07**	**1.63-2.63**	**1.74**	**1.35-2.24**

Table 6. (continued)

	Unadjusted Odds Ratio	95% CI	Adjusted Odds Ratio	95% CI
Attitude towards mammography as measured by decisional balance score	**0.94**	**0.91-0.97**	0.99	0.96-1.02
Years of sustained use	**0.75**	**0.67-0.84**	**0.83**	**0.73-0.94**
Control variables:				
Marital status				
Married/living as married	Reference	-----	Reference	-----
Not married/living as married	1.18	0.94-1.49	1.12	0.88-1.42
Education				
Grade 12 or less	0.84	0.65-1.10	0.84	0.63-1.11
Some college	1.11	0.89-1.39	1.10	0.87-1.39
College degree or more	Reference	-----	Reference	-----
Perceived financial situation				
Enough for special things	Reference	-----	Reference	-----
Little spare money	**1.40**	**1.16-1.70**	1.20	0.98-1.47
Health status				
Excellent	Reference	-----	Reference	-----
Good	1.08	0.88-1.31	0.99	0.80-1.22
Fair or Poor	**2.03**	**1.48-2.78**	**1.76**	**1.26-2.45**
Family history of breast cancer				
Yes	0.86	0.66-1.11	0.84	0.62-1.13
No	Reference	-----	Reference	-----

Table 6. (continued)

	Unadjusted Odds Ratio	95% CI	Adjusted Odds Ratio	95% CI
Doctor recommendation for a mammogram in past year				
Yes	Reference	-----	Reference	-----
No	0.89	0.73-1.09	0.98	0.80-1.22
Control Group				
Tier 1 control group	Reference	-----	Reference	-----
Tier 2 control group	0.91	0.75-1.09	0.92	0.76-1.11

5.3.2 Research Question 2.2

Research Question 2.2 sought to examine to what extent perceived barriers, attitudes towards behavior, perceived satisfaction with past experiences, perceived susceptibility to breast cancer, self-efficacy and perceived behavioral control predicted behavioral intentions. To address this question, I conducted multivariable logistic regression.

To test hypotheses 2.2.1 through 2.2.6, a multivariable logistic regression was fit that regressed behavioral intentions on predictor variables, including a variable for years of sustained mammography maintenance, and seven control variables (marital status, educational attainment, perceived financial situation, health status, family history of breast cancer, doctor recommendation of a mammogram in the past year, type of control group). Table 7 reports these results.

Of the predictors, lower self-efficacy (OR= 0.15, *95% CI* = 0.09, 0.26, *p* = <0.001) and reporting 2+ barriers to mammography use (OR= 0.37, *95% CI* = 0.18, 0.76, *p* = 0.007) were associated with being less likely to report intentions to get mammograms over the three years. Attitude towards mammography as measured by decisional balance scores (OR= 1.23, *95% CI* = 1.17, 1.30, *p* = <0.001) was significantly and positively associated with being more likely to express intentions to get another mammogram. Number of years of sustained use (OR= 2.44, *95% CI* = 1.68, 3.53, *p* = <0.001) were positively and significantly associated with being more likely to express intentions to get another mammogram. Income was the only control variable associated with intentions. Women who reported that they has little money to spare after paying the bills (i.e., worse perceived financial situations) were less likely to report they were "very likely" to get their next mammogram as compared to women who reported they had finances that enabled them to get "special things they want(ed)" (OR= 0.53, *95% CI* = 0.34, 0.82, *p* = 0.004).

Table 7. Associations of predictors and behavioral intentions to get a mammogram when due for one over three years (*n* = 1,219)

	Unadjusted Odds Ratio	**95% CI**	**Adjusted Odds Ratio**	**95% CI**
Satisfaction with previous mammography experience				
Very satisfied	Reference	-----	Reference	-----
Somewhat satisfied/somewhat dissatisfied/very dissatisfied	**0.27**	**0.17-0.41**	0.79	0.46-1.37
Perceived control over getting a mammogram when due				
Complete control	Reference	-----	Reference	-----
Some/no control	**0.49**	**0.32-0.74**	1.36	0.81-2.29

Table 7. (continued)

	Unadjusted Odds Ratio	95% CI	Adjusted Odds Ratio	95% CI
Self-efficacy related to getting a mammogram when due				
Very confident	Reference	-----	Reference	-----
Somewhat/ a little/ not at all confident	**0.080**	**0.05-0.12**	**0.15**	**0.09-0.26**
Perceived risk of getting breast cancer compared to an average woman				
Less likely	Reference	-----	Reference	-----
About as likely	1.48	0.10-2.19	1.21	0.76-1.92
More likely	1.81	0.98-3.36	1.47	0.67-3.20
Number of perceived barriers				
No barriers	Reference	-----	Reference	-----
1 barrier	0.57	0.25-1.30	0.83	0.35-1.96
2+ barriers	**0.14**	**0.07-0.29**	**0.37**	**0.18-0.76**
Attitude towards mammography as measured by decisional balance score	**1.319**	**1.26-1.38**	**1.23**	**1.17-1.30**
Years of sustained use	**3.42**	**2.42-4.84**	**2.44**	**1.68-3.53**
Control variables:				
Marital status				
Married/living as married	Reference	-----	Reference	-----
Not married/living as married	1.07	0.67-1.72	1.37	0.80-2.36

Table 7. (continued)

	Unadjusted Odds Ratio	95% CI	Adjusted Odds Ratio	95% CI
Education				
Grade 12 or less	1.25	0.73-2.13	1.24	0.67-2.33
Some college	1.17	0.74-1.84	1.22	0.72-2.07
College degree or more	Reference	-----	Reference	-----
Perceived financial situation				
Enough for special things	Reference	-----	Reference	-----
Little spare money	**0.43**	**0.30-0.62**	**0.53**	**0.34-0.82**
Health status				
Excellent	Reference	-----	Reference	-----
Good	0.79	0.53-1.17	1.03	0.66-1.63
Fair or Poor	0.63	0.34-1.19	1.03	0.49-2.15
Family history of breast cancer				
Yes	1.48	0.96-2.27	1.48	0.72-3.04
No	Reference	-----	Reference	-----
Doctor recommendation for a mammogram in past year				
Yes	Reference	-----	Reference	-----
No	1.48	0.96-2.27	1.18	0.72-1.92
Control Group				
Tier 1 control group	Reference	-----	Reference	-----
Tier 2 control group	1.268	0.88-1.83	1.21	0.80-1.84

5.3.3 Research Question 2.3

Research Question 2.3 examined to what extent behavioral intentions predicted unsustained mammography maintenance. To test hypothesis 2.3.1, a multivariable logistic regression was fit that regressed unsustained mammography maintenance on behavioral intentions, including a variable for years of sustained mammography maintenance, and seven control variables (marital status, educational attainment, perceived financial situation, health status, family history of breast cancer, doctor recommendation of a mammogram in the past year, type of control group). Table 8 reports these results.

Behavioral intention was a significant predictor of unsustained maintenance. Women who reported that they were less than "very likely" to get another mammogram when due were more likely not to sustain mammography maintenance (OR= 3.53, *95% CI* = 2.42, 5.14, p = <0.001). Similar to the other models, years of sustained use were a significant predictor such that for each year of sustained use, women experienced an 18% decrease in the odds of unsustained use (OR= 0.82, *95% CI* = 0.72, 0.93, p = 0.001). Two control variables were predictive of unsustained maintenance in the expected direction, lower perceived finances and poorer health status.

Table 8. Unsustained mammography maintenance over three years as predicted by behavioral intention to get a mammogram when due for one (n = 1,219)

	Unadjusted Odds Ratio	95% CI	Adjusted Odds Ratio	95% CI
Behavioral intentions				
Very likely	Reference	-----	Reference	-----
Somewhat likely/somewhat unlikely very unlikely	**4.18**	**2.90-6.03**	**3.53**	**2.42-5.14**
Years of sustained use	**0.75**	**0.67-0.84**	**0.82**	**0.72-0.93**
Control variables:				
Marital status				
Married/living as married	Reference	-----	Reference	-----
Not married/living as married	1.18	0.94-1.49	1.12	0.88-1.47
Education				
Grade 12 or less	0.843	0.65-1.10	0.76	0.58-1.02
Some college	1.11	0.89-1.39	1.03	0.82-1.31
College degree or more	Reference	-----	Reference	-----
Perceived financial situation				
Enough for special things	Reference	-----	Reference	-----
Little spare money	**1.40**	**1.16-1.70**	**1.25**	**1.02-1.53**
Health status				
Excellent	Reference	-----	Reference	-----
Good	1.08	0.88-1.31	1.04	0.84-1.28
Fair or Poor	**2.03**	**1.48-2.78**	**1.90**	**1.36-2.64**

Table 8. (continued)

	Unadjusted Odds Ratio	95% CI	Adjusted Odds Ratio	95% CI
Family history of breast cancer				
Yes	0.86	0.66-1.11	0.90	0.70-1.17
No	Reference	-----	Reference	-----
Doctor recommendation for a mammogram in past year				
Yes	Reference	-----	Reference	-----
No	0.89	0.73-1.09	0.96	0.78-1.19
Control Group				
Tier 1 control group	Reference	-----	Reference	-----
Tier 2 control group	0.91	0.75-1.09	0.92	0.77-1.12

5.3.4 Research Question 2.4

Research Question 2.4 examined whether behavioral intentions mediated relationships between perceived barriers, attitudes towards behavior, perceived satisfaction with past experiences, perceived susceptibility to breast cancer, self-efficacy, perceived behavioral control and unsustained mammography maintenance. To assess this question, I conducted multivariable logistic regression using discrete event history analysis.

To test hypotheses 2.4.1 through 2.4.6, a multivariable logistic regression model was fit that regressed unsustained mammography maintenance on predictor variables and the proposed mediator, behavioral intentions. The model included a variable for years of sustained mammography maintenance and seven control variables. Table 9 reports these results.

Of the exogenous predictors, only dissatisfaction with previous mammography experience (OR= 1.48, *95% CI* = 1.08, 2.03, p = 0.016) and reporting one (OR= 1.47, *95% CI* = 1.11, 1.94, p = 0.007) or two plus barriers (OR= 1.70, *95% CI* = 1.32, 2.20, p = <0.001) significantly predicted unsustained mammography maintenance after the proposed mediator was added to the model. Behavioral intention to get another mammogram, the proposed mediator, continued to significantly predict maintenance non-adherence (OR= 2.84, *95% CI* = 1.89, 4.27, p = <0.001) in the full model. Years of sustained use remained a significant predictor of maintenance non-adherence (OR= 0.85, *95% CI* = 0.75, 0.96, p = 0.001). Of the control variables, only self-reported health status was significant and in the expected direction (OR= 1.78, *95% CI* = 1.28, 2.49, p = 0.001).

Table 9. Predictors of unsustained mammography maintenance over three years as mediated by behavioral intentions (*n* = 1,219)

	Unadjusted Odds Ratio	**95% CI**	**Adjusted Odds Ratio**	**95% CI**
Satisfaction with previous mammography experience				
Very satisfied	Reference	-----	Reference	-----
Somewhat satisfied/somewhat dissatisfied/very dissatisfied	**1.99**	**1.49-2.66**	**1.48**	**1.08-2.03**
Perceived control over getting a mammogram when due				
Complete control	Reference	-----	Reference	-----
Some/no control	**1.61**	**1.27-2.05**	1.29	0.99-1.67

Table 9. (continued)

	Unadjusted Odds Ratio	95% CI	Adjusted Odds Ratio	95% CI
Self-efficacy related to getting a mammogram when due				
Very confident	Reference	-----	Reference	-----
Somewhat/ a little/ not at all confident	**2.82**	**1.94-4.10**	1.43	0.94-2.16
Perceived risk of getting breast cancer compared to an average woman				
Less likely	Reference	-----	Reference	-----
About as likely	0.94	0.76-1.16	0.98	0.78-1.22
More likely	0.96	0.71-1.29	1.07	0.76-1.52
Number of perceived barriers				
No barriers	Reference	-----	Reference	-----
1 barrier	**1.58**	**1.20-2.08**	**1.47**	**1.11-1.94**
2+ barriers	**2.07**	**1.63-2.63**	**1.70**	**1.32-2.20**
Behavioral intentions				
Very likely	Reference	-----	Reference	-----
Somewhat likely/somewhat unlikely very unlikely	**4.18**	**2.90-6.03**	**2.84**	**1.89-4.27**
Attitude towards mammography as measured by decisional balance score	**0.94**	**0.91-0.97**	1.01	0.97-1.05
Years of sustained use	**0.75**	**0.67-0.84**	**0.85**	**0.75-0.96**

Table 9. (continued)

	Unadjusted Odds Ratio	95% CI	Adjusted Odds Ratio	95% CI
Control variables:				
Marital status				
Married/living as married	Reference	-----	Reference	-----
Not married/living as married	1.18	0.94-1.49	1.14	0.89-1.45
Education				
Grade 12 or less	0.843	0.65-1.10	0.84	0.63-1.12
Some college	1.112	0.89-1.39	1.11	0.88-1.41
College degree or more	Reference	-----	Reference	-----
Perceived financial situation				
Enough for special things	Reference	-----	Reference	-----
Little spare money	**1.40**	**1.16-1.70**	1.16	0.94-1.42
Health status				
Excellent	Reference	-----	Reference	-----
Good	1.08	0.88-1.31	0.99	0.80-1.23
Fair or Poor	**2.03**	**1.48-2.78**	**1.78**	**1.28-2.49**
Family history of breast cancer				
Yes	0.86	0.66-1.11	0.85	0.62-1.15
No	Reference	-----	Reference	-----

Table 9. (continued)

	Unadjusted Odds Ratio	95% CI	Adjusted Odds Ratio	95% CI
Doctor recommendation for a mammogram in past year				
Yes	Reference	-----	Reference	-----
No	0.89	0.73-1.09	0.99	0.80-1.22
Control Group				
Tier 1 control group	Reference	-----	Reference	-----
Tier 2 control group	0.91	0.75-1.09	0.93	0.77-1.13

Test of Mediation

As outlined in Chapter 4, I employed the MacKinnon methodology to test for mediation (MacKinnon & Dwyer, 1993; MacKinnon et al., 1995). To test the size and significance of the mediated effect, I employed the Sobel test after standardizing the estimates of the coefficients produced in logistic regression. Only two variables, self-efficacy related to getting a mammogram when due and two or more barriers, were significantly mediated by behavioral intentions. Only 3.9% of the effect of stating two or more barriers was mediated via behavioral intentions. Almost 40% of the effect of self-efficacy was mediated by behavioral intentions. Attitude towards mammography was not significantly mediated; results of the test of significance cannot be interpreted due to values close to the null (OR=.99 without mediator or OR=1.01 with mediator). Table 10 reports the results of the test of significance of the mediated effect.

Table 10. Test of the mediating role of behavioral intentions *

Predictor	Indirect effect (αβ)	Sobel test	p-value	Proportion of direct effect mediated
Satisfaction with previous mammography experience	0.013	1.599	0.055	-----
Perceived control over getting a mammogram when due	0.009	1.398	0.0810	-----
Self-efficacy related to getting a mammogram when due	**0.123**	**4.601**	**<0.001**	**39.68%**
Perceived risk of getting breast cancer compared to an average woman				
Less risk vs. average risk	0.005	0.935	0.175	-----
Less risk vs. more risk	0.008	1.007	0.157	-----
Number of perceived barriers				
0 vs 1 barrier	0.004	0.732	0.232	-----
0 vs 2+ barriers	**0.011**	**1.943**	**0.026**	**3.92%**
Attitude towards mammography	0.009	4.575	**-----**	**-----**

*Models controlled for marital status, educational attainment, perceived financial situation, health status, family history of breast cancer, doctor recommendation of a mammogram in the past year, years of sustained use and type of control group.

5.4 Aim 3 Results: Subgroup Analysis

For this aim, I proposed examining whether predictors of mammography maintenance that were theoretically and empirically informed and amenable to intervention efforts were quantitatively different for certain subgroups of the population. The dataset for these analyses consisted of 2,794 observations from the 1,219 women in Tier 1 and Tier 2 control groups.

Research Question 3.1 examined, across three years of follow-up, if relationships explored in Aim 2 varied by whether women had histories of false positive mammograms, differed in age, or had different patterns of mammography use at baseline. To answer this question, I used discrete event history analysis to fit a logistic regression model. The model regressed unsustained mammography maintenance on predictors (perceived barriers, attitudes towards behavior, perceived satisfaction with past experiences, perceived susceptibility to breast cancer, self-efficacy, perceived behavioral control) and on behavioral intentions. The models also included a variable for years of sustained use and seven control variables. Each hypothesis was tested separately by creating a multiplicative interaction term for each of the predictor variables, including behavioral intentions, and the proposed moderators (those with a history of false positive mammograms, those in different age groups, those with different patterns of mammography use at baseline).

To test robustness of interaction effects for each of the three proposed moderators, I conducted an Omnibus Chi-square Test. Difference in the log likelihood values for each of the three models with interactions terms and without interaction terms (main effects) was computed. That difference was compared to a chi-square distribution with the corresponding degrees of freedom. None of the tests were significant; thus, all interaction terms were dropped from final models. Table 11 shows the test statistics for each of the models corresponding to the tests of each of the interactions.

Table 11. Omnibus Chi-square test for moderation

Proposed Moderator	**Log Likelihood Difference (DF)**	***p-value***
History of false positive mammograms (yes, no)	10.68 (9)	0.298
Age (40-49, 50 and over)	10.99 (9)	0.276
Mammography use at baseline (recent, repeat)	14.93 (9)	0.093

The findings for the results are summarized in Chapter Six.

CHAPTER SIX: DISCUSSION

This chapter includes discussion of my findings. First, I summarize findings organized by specific aim and research question and offer explanations for them. Then, I present the study's strengths and challenges. I conclude the chapter with the public health implications of the research and areas for further research consideration.

6.1 Discussion of Findings

6.1.1 Summary of Findings for Aim 1

The goal of the first aim was to examine proportions of mammography use in an insured population and plot trends over time in certain empirically and theoretically informed variables. Descriptive univariate statistics were used to plot trends in variables of interest by number of on-schedule mammograms across three years. In addition, I conducted chi-square tests to compare differences in key sociodemographic variables across the different categories of on-schedule use. No hypotheses were proposed, because Aim 1 was exploratory.

Overall, adherence to mammography maintenance was low. Of women in Tier 1 control group, only 38% of women obtained on-schedule mammograms each year. However, well over 50% of women in any category of mammography use (0, 1, 2, or 3 on-schedule mammograms) reported favorable attitudes and beliefs about mammography. Differences in the percentages of women endorsing these attitudes and beliefs were observed when trends were plotted according to on-schedule mammography use over time.

A larger proportion of women who had adhered to mammography maintenance consistently said they were "very satisfied" with their last mammography experience, reported more favorable attitudes towards mammography and reported higher self-efficacy and complete behavioral control over getting another mammogram. Women with sustained mammography use reported at a higher rate that they were "very likely" to intend to get another mammogram compared with women who did not get mammograms every year. Clear patterns emerged when I plotted proportions of women who endorsed three or more barriers across time. Women with more on-schedule mammograms were consistently less likely to have reported three or more barriers. For example, an average of only 23% of women who had obtained three on-schedule mammograms (adhered to mammography maintenance) reported three or more barriers as compared to 29% of women who had obtained two on-schedule mammograms. Similarly, an average of 35% of women in the one on-schedule mammogram group and 46% of women who did not receive any on-schedule mammograms reported three or more barriers over the course of the study. I also observed a downward trend in women reporting receipt of physicians' recommendations to get mammograms across all use categories, with the most pronounced downward trend being for the no on-schedule mammogram group over the course of the three years.

Next, I conducted chi-square tests to explore differences in patterns of on-schedule use by key sociodemographic variables. Education and marital status were not significantly associated with use. Health status, race, perceived income and working for pay were associated with the number of on-schedule mammograms received over three years. The most pronounced differences were observed in comparing key demographics between no versus three on-schedule mammograms. Findings are discussed below.

6.1.2 Discussion of Findings for Aim 1

I found a somewhat lower rate of mammography use than some previous studies (Clark et al., 2003; Rakowski et al., 2004; Rakowski et al., 2006). This lower rate may have occurred for several reasons. First, I observed use over three cycles of repeat mammography use. Many previous studies of mammography have only assessed repeat use and/or followed women through only one cycle of repeat use. It makes sense that the longer women are followed, the lower their rates of compliance will be. Each subsequent year presents an opportunity for women to fail to sustain use and thus lower the proportion of adherent women. In addition, many other studies used longer screening intervals to compute use (e.g. every two years), compared to an approximately annual interval used in this study. The proportion of women categorized as screened and thus classified as adherent increases as the length of time between screenings is enlarged (Partin & Slater, 2003; Rakowski et al., 2006). In one study by Clark and colleagues (2003), the rate of repeat mammography use increased by 11% when the definition of repeat use was changed from an approximately annual window to a biennial window.

This study also included women aged 40 to 49, the youngest age-eligible category recommended for regular screening. Many past studies of repeat screening have only included women age 50 and over (Mayne & Earp, 2003; Rakowski et al., 2004; Rauscher et al., 2005). Women in their forties may be less adherent to annual screening schedules due to lingering controversies about the efficacy and intervals of regular screenings for this age group (Calvocoressi, Sun, Kasl, Claus, & Jones, 2008; Qaseem et al., 2007; Rimer et al., 1999). I also used a combination of self-report and claims data to assess use at regular annual intervals. Other studies have relied on either retrospective reporting via claims data

(Augustson et al., 2003; Harrison et al., 2003) or self-report recall over longer time periods (A. S. O'Malley et al., 2002; Rauscher et al., 2005; Russell, Champion et al., 2006). Use of self-reports to validate claims data may have yielded more accurate mammography use rates.

Being of Non-Hispanic Black race and perceiving finances that gave women "little to spare" were associated with fewer on-schedule mammograms. These findings support previous work that found similar relationships between race, income and mammography use (Calvocoressi et al., 2005; Kim & Jang, 2008; Miller & Champion, 1993; Rakowski et al., 2004). However, other recent studies did not find significant differences between Black and white women in the United States and rates of mammography use (Chagpar, Polk, & McMasters, 2008; Sabatino et al., 2008). In fact, some evidence supports the notion that the most pronounced national declines in mammography use recently have been observed for white women (Breen et al., 2007; Lian, Jeffe, & Schootman, 2008). This finding highlights the need to address mammography maintenance across all segments of age-eligible women. Even in an insured population, as others have shown (Michielutte et al., 2005; Trock et al., 1993), coverage is necessary, but not sufficient, and may not erase the race and ethnicity differences in mammography use.

Reporting poor or fair health status was associated with obtaining fewer on-schedule mammograms over three years. This finding is in line with previous studies that reported a link between less-than-good health status and declining rates of recent and repeat mammography use (Bobo et al., 2004; Rakowski et al., 2004). My study extends these results to sustained mammography maintenance. Women with health issues may find it difficult to make and keep preventive health visits such as those for regular cancer screenings.

Not working for pay was associated with more on-schedule use. To my knowledge, this variable has not been reported as a significant predictor of repeat mammography use in previous studies. Making time to get a mammogram may be more difficult for women who work. Being too busy has been one of the most consistently voiced barriers in the literature to mammography use (Finney Rutten et al., 2004; Partin & Slater, 2003). Women who work for pay may have a more difficult time juggling the multiple demands of work, family and other needs, such as personal health visits, compared to women who do not work for pay.

I also assessed trends in variables across time. Overall, different categories of mammography use yielded distinguishing patterns of cognitions. Patterns observed in this study coincide with previous research and extend findings to mammography maintenance adherence. For example, a larger proportion of women who perceived multiple barriers were less likely to adhere to mammography maintenance. This finding is consistent with previous studies that reported women who perceived more barriers to mammography use are less likely to be screened (Farmer et al., 2007; Menon et al., 2007; Russell, Champion et al., 2006). Similarly, previous studies found that women with higher self-efficacy (Menon et al., 2007; Russell, Champion et al., 2006) and higher perceived behavioral control over getting mammograms were more likely to be rescreened (Rimer et al., 2002). These results show that women with more on-schedule use reported greater self-efficacy and more perceived behavioral control.

I also found distinct patterns in the proportions of women who received doctors' recommendations for mammograms. In previous studies, receiving a doctor's recommendation was one of the strongest predictors of repeat mammography use (Bobo et al., 2004; Calvocoressi et al., 2005; Halabi et al., 2000; Juon, Kim, Shankar, & Han, 2004;

O'Malley et al., 2001). My findings lend support to previous research that physicians' recommendations are important in supporting on-schedule screening. Over time, fewer women with no and one on-schedule mammogram received physicians' recommendations compared to the women who received two or more on-schedule mammograms. Somewhat surprisingly, all women in this study experienced a downward trend in receiving physician's recommendation to get a mammogram regardless of number of on-schedule mammograms. For example, a significant proportion (range: 21-39%) of women who maintained mammography use each year (three on-schedule mammogram group) said they did not receive a physician's recommendation in any given year, thus raising the question of what other factors may promote sustained mammography use. Women who consistently get mammograms may be less reliant on physicians' recommendations for mammograms each year.

Results reported in Chapter Five for Aim 1 are descriptive and no inferential statistics were performed to assess significance of differences across time. Interpretation of these data should be approached with caution. Furthermore, most women had favorable attitudes and beliefs about mammography regardless of the number of on-schedule mammograms they received over the course of the study. Further study is needed to assess if these cognitions and attitudes are predictive of mammography maintenance. In addition, more research is needed to explore whether key mammography attitudes and cognitions are more important for certain subgroups of the population as facilitators or barriers to mammography maintenance. These were the goals of Aim 2 and Aim 3 whose findings are discussed below.

6.1.3 Summary of Finding for Aim 2

The goal of Aim 2 was to examine predictors of mammography maintenance that were theoretically and empirically informed and amenable to intervention. Discrete event history analysis methods were used to fit logistic regression models corresponding to the four research questions set forth in Aim 2. Some factors were consistently predictive of unsustained mammography maintenance (number of barriers, satisfaction with past mammography experience, self-efficacy, poor/fair health status). Also, years of sustained use were a strong predictor of mammography maintenance adherence, as was the proposed mediator, behavioral intentions. Of the proposed mediated effects, only self-efficacy and perceived barriers to getting another mammogram were significantly mediated via behavioral intentions. These finding are discussed in the following section.

6.1.4 Discussion of Finding for Aim 2

Many variables have been associated with repeat mammography use (Greene et al., 2005; Quinley et al., 2004; Rakowski et al., 2006; Rimer, Trock, Engstrom, Lerman, & King, 1991). However, no studies have extended findings to adherence to mammography maintenance on an annual interval. Research questions set forth in Aim 2 corresponded to testing the direct and mediated effects of key cognitive variables on unsustained annual-interval mammography maintenance. Variables were selected based upon empirical research from previous studies and informed by the Health Belief Model (Hochbaum, 1958) and the Theory of Planned Behavior (Ajzen, 1991).

Self-efficacy was predictive of unsustained mammography maintenance, as postulated in the Health Belief Model and other theories (Bandura, 1977). This finding also supports the limited previous work on repeat mammography use and self-efficacy (Russell,

Champion et al., 2006). In addition, it further supports research that found self-efficacy is important in moving women from thinking about getting mammograms to seeking a mammogram (Menon et al., 2007; Russell, Perkins, Zollinger, & Champion, 2006).

Extending these findings to adherence to mammography maintenance confirms research on self-efficacy and maintenance of daily behaviors. Previous research has found that self-efficacy is a key variable in sustaining other health behaviors such as physical activity (Litt et al., 2002; McAuley et al., 2003). In addition, self-efficacy has both direct and indirect effects on maintenance of daily behaviors (Schwarzer et al., 2007). My results provide evidence for the multiple, phase-specific roles that self-efficacy may play in mammography maintenance adherence. (See section 2.5.4 for description of phase-specific self-efficacy.) Self-efficacy was a predictor of maintenance; this relationship was partially mediated via intentions.

Such phase-specific self-efficacy has been demonstrated for other daily health behaviors (Rodgers & Sullivan, 2001; Schwarzer & Renner, 2000) and breast self-exams (Luszczynska & Schwarzer, 2003). To continue to be adherent, women must engage in a series of planning and action behaviors ranging from scheduling appointments to traveling to and keeping appointments. In the first phase of mammography maintenance, self-efficacy may serve as a motivator of behavior intentions. Later on, self-efficacy may act as a protective factor that prompts planning needed to obtain mammograms on a regular schedule.

The Health Belief Model postulates that perceived barriers affect behavior. Here, number of perceived barriers was a significant predictor of mammography maintenance adherence. This finding is consistent with much of the previous research on recent and repeat mammography use (Champion & Skinner, 2003; Lipkus, Rimer et al., 2000; Menon et al.,

2007; Russell, Champion et al., 2006) and extends these finding to mammography maintenance. Women who report multiple barriers to regular mammograms may have more difficulty overcoming barriers. Being too busy and forgetting were commonly cited barriers to mammography use among women sampled for this study and in previous research (Partin & Slater, 2003). It is possible that, for some women, competing demands will supersede their own health protection.

While results of this study are consistent with most previous work on barriers and mammography use, one key study does not coincide. Rauscher and collaborators (2005) found that more personal barriers were associated with initiation but not maintenance of mammography. My study differs from Rauscher's study is several ways. First, I assessed maintenance using an approximately annual interval via a mix of claims and self-report data. Rauscher used self-reports of recent use collected approximately every two and a half years. I assessed mammography behavior across three cycles of repeat use, and all women had obtained recent mammograms prior to study entry. Rauscher and colleagues assessed two potential cycles of repeat use; women could have been non-adherent to a recent mammogram at study entry. In addition, I assessed the number of barriers each year while Rauscher assessed barriers at baseline only. Allowing the number of barriers to vary across time more closely links predictors with the behavior. Finally, my sample was predominantly women who were white, insured and included women in their forties. Most reported finances that allowed them "enough for special things" and were college-educated. Rauscher's study was predominantly composed of a less social and economically advantaged population of black women aged 50 and over. These differences may explain why these two studies found different relationships between perceived barriers and mammography maintenance.

Relationship between mammography maintenance and number of perceived barriers was mediated partially via behavior intentions. A possible explanation for this finding is that number of barriers may affect action of strong behavioral intentions. Findings support this reasoning. The effect of barriers on maintenance was mediated only for women who reported multiple barriers. The mediated effect was not significant for women with one barrier. The percent of the effect mediated was small. It is possible that perceived barriers may act as a moderator of intentions, as other research has hypothesized (Sheeran, 2004). This potential moderator relationship was not assessed here, but may warrant further consideration.

As the Theory of Planned Behavior postulates (Ajzen, 1991), behavioral intentions were a strong, significant predictor of mammography maintenance. Behavioral intentions were the only Theory of Planned Behavior construct assessed in this study that predicted maintenance. While there has been considerable research on the importance of intentions on behavior change (Armitage, 2006; Armitage & Conner, 2001; Fife-Schaw, Sheeran, & Norman, 2007; Godin & Kok, 1996), few studies have examined this relationship in the context of behavioral maintenance, and even fewer for episodic behaviors, such as cancer screening (Drossaert et al., 2003, 2005). This study is one of the few that extends these findings to behavioral maintenance and, to my knowledge, is the only study to do so in the context of annual-interval mammography use.

In the context of behavioral maintenance, strong intentions may serve as a motivating force that prompt planning. Some research supports the planning role that intentions may play in maintenance of daily behaviors (Sheeran & Orbell, 1999). More specifically, implementation intentions may be important in prompting planning to achieve a behavioral goal (Abraham et al., 1998; Gollwitzer, 1999; Sheeran & Orbell, 1999, 2000), including

recent mammography use (Rutter et al., 2006).While a significant body of literature found a gap between intentions and behavior change (Sheeran, 2004), intentions may be a good predictor of sustained mammography use. As women have more experience with seeking and successfully obtaining mammograms, the gap between intentions and actual behavior may diminish.

Previous studies have found that repeat mammography rates are affected by patients' satisfaction with mammography experiences (Hofvind, Wang, & Thoresen, 2003; Orton et al., 1991; Peipins et al., 2006; Somkin et al., 2004). This study supports these findings and offers evidence that satisfaction may also be an important factor in sustaining long-term behavior change. As hypothesized, satisfaction with past mammography experiences predicted adherence to mammography maintenance. However, effects were not mediated via behavioral intentions. In Linder-Pelz's Theory of Patient Satisfaction (1982), patient satisfaction is defined as an attitude akin to the Theory of Reasoned Action's construct of attitude towards the behavior. In this study, however, attitude towards the behavior was not a predictor of adherence to mammography maintenance. Thus, patient satisfaction may be a specific domain of attitudes that is more closely linked with maintenance than attitudes towards the behavior itself.

Increasing patient satisfaction may be very important in promoting adherence to a regular screening schedule. Understanding the underlying experiences and beliefs that lead to patient satisfaction is essential if we want to modify the mammography experience in such a way that promotes sustained use. In previous health services research, continuity of care has consistently been associated with patient satisfaction (Barido, Campbell-Gauthier, Mang-Lawson, Mangelsdorff, & Finstuen, 2008; Fan, Burman, McDonell, & Fihn, 2005; Morgan,

Pasquarella, & Holman, 2004; A. S. O'Malley, Mandelblatt, Gold, Cagney, & Kerner, 1997) and may be a central component of patient satisfaction. Continuity of care pertains to both perceptions about the coordination of care and interpersonal aspects of care. Thinking one has been treated in a consistently caring fashion, perceiving nothing has been overlooked and knowing what to expect in the future all are associated with perceptions of good continuity of care (Gulliford, Naithani, & Morgan, 2006; King et al., 2008). Such expectations may be especially important in promoting maintenance of elective, but recommended, episodic screening behaviors such as mammography (Fine et al., 1993).

Of the remaining cognitive variables, perceived susceptibility to breast cancer (Health Belief Model construct) and perceived behavioral control (Theory of Planned Behavior construct) were not predictive of adherence to mammography maintenance. Furthermore, these variables were not associated with the proposed mediator, behavioral intentions, in the adjusted models. While perceived susceptibility has been a predictor of repeat use (Calvocoressi et al., 2004; Rakowski et al., 2004), and the Health Belief Model postulates its affect on behavior change, it may not be a predictor of maintenance of episodic behaviors. Risk perceptions may be a necessary component of why people contemplate engaging in a behavior. However, risk perceptions may not be a vital factor in what motivates women to stay on a regular screening schedule. In previous work, risk perceptions were not a significant predictor of the maintenance of daily behaviors (Schwarzer et al., 2007) and exerted a negligible effect on breast self-examinations in short-term follow-up (Luszczynska & Schwarzer, 2003). It is conceivable that perceived susceptibility may involve a more complex relationship with maintenance. I was not able to evaluate such relationships in this

study. I had only one item with three levels of perceived susceptibility (less, equal, more). More sensitive measures of risk may yield different results and warrant further exploration.

It was reasonable to expect that perceived behavioral control would be associated with intentions to get a mammogram and mammography maintenance. The Theory of Planned Behavior hypothesizes that perceived behavioral control affects behavior both directly and indirectly via intentions. Many studies support these hypothesized relationships (Armitage & Conner, 2001; Shankar et al., 2007; Van De Ven et al., 2007). In addition, previous studies of mammography use have demonstrated the importance of this construct in predicting mammography intentions (Bowie et al., 2003; O'Neill et al., 2008; Steele & Porche, 2005) and repeat use (Drossaert et al., 2003; Rimer et al., 2002). However, my study did not support this hypothesis. My finding may be an artifact of have a single 3-point item to detect differences, possibly tapping only into part of the construct. On the other hand, my finding may lend further support that perceived behavioral control is a similar, yet distinct, cognition from self-efficacy (Tolma et al., 2006; Trafimow, Sheeran, Conner, & Finlay, 2002).

Ajzen (2002) argued that perceived behavioral control is composed of two domains: 1) self-efficacy in dealing with the difficulty or ease of the behavior; and 2) the extent to which people feel in control of performing the actual behavior. Control may be important in behavior change through building confidence about performing the behavior. However, control over doing the behavior may play a less significant role in sustaining behavior, because mastery is achieved through repeated successful attempts. Over time, perceptions about the ease or difficulty of performing the behavior may be a more vital component of behavioral maintenance. In this study, women with multiple perceived barriers to

mammography and women with less self-efficacy also were less likely to sustain maintenance.

The Theory of Planned Behavior postulates that the effect of attitudes toward the behavior is mediated via behavioral intentions. I found partial support for this relationship. Attitude toward the behavior was associated with behavioral intentions. However, I did not find evidence that attitude toward the behavior predicted mammography maintenance adherence directly or indirectly though behavioral intentions. Attitude towards the behavior may be a good predictor of motivation to adhere to mammography maintenance (O'Neill et al., 2008). However, such favorable attitudes may not translate into action. Moreover, for women with a history of mammography use, attitudes toward mammography may not be as important a predictor of sustained use as women's past mammography experiences.

Years of sustained mammography use were robust, strong predictors of adherence to mammography maintenance. In previous research, past behavior was a strong predictor of future mammography use (Maxwell, 1996; Mayer et al., 2000; Mayne & Earp, 2003; O'Neill et al., 2008). The more attempts a woman has at successfully obtaining on-schedule mammograms, the more likely she is to overcome challenges to that behavior.

Health status was a significant, robust predictor of adherence to mammography maintenance. This finding in congruent with previous research that has found health status to be a predictor of other health behaviors, including repeat mammography (Bobo et al., 2004; Greene et al., 2005; Rakowski et al., 2004). Early detection behaviors, such as regular mammography use, may not be a priority for women with competing health issues.

6.1.5 Discussion of Finding for Aim 3

Aim 3 examined whether factors identified in Aim 2 were stronger predictors of mammography maintenance among certain subgroups than others. None of the moderated effects met criteria for significance. However, age and mammography use history at baseline were predictive of unsustained maintenance. Being aged 40 to 49 and having a recent, as opposed to a repeat, mammogram at study entry were predictors of unsustained mammography maintenance.

Evidence supports that age (Rimer et al., 2002), history of false positive mammograms (Brewer et al., 2007) and prior mammography use (Bobo et al., 2004; Mayne & Earp, 2003) are significant predictors of mammography use. No evidence supports the role of these factors as moderators of mammography use. There are several reasons why I may not have found evidence of moderation in this study. Some of the previous work comes from cross-sectional studies; correlations found in cross-sectional studies may not translate into longitudinal research. Previous samples did not include women in their forties (Bobo et al., 2004; Mayne & Earp, 2003), and none evaluated screening across more than two cycles. In addition, many studies used biennial intervals to define repeat use. Furthermore, I may not have had adequate power to detect differences due to unequal sample sizes across groups. However, sub-optimal rates of repeat mammography use persist across all segments of society (Blanchard et al., 2004; Breen et al., 2007; Clark et al., 2003). Finding no evidence of moderation may also highlight the need to address maintenance for all groups of age-eligible women, regardless of characteristics.

6.2 Limitations and Strengths

The research reported here, building on previous studies of mammography use, sought to understand why some women adhere to regular mammography screening schedules, while others do not. The findings discussed above may help pinpoint key maintenance of behavior change targets for future public health cancer screening promotion efforts. The study has both limitations and strengths. These discussed below.

First, all participants had health insurance, most were white, reported finances that allowed them "enough for special things", had a college education, and 97% reported a usual source of health care at study entry. Therefore, the findings cannot be generalized beyond these groups. Study participation of African Americans and women of other ethnic groups was lower than predicted. Previous analyses suggested there was only slight differential non-response by race (DeFrank, Bowling, Rimer, Gierisch, & Skinner, 2007).

In most cases, constructs were measured via a single item with four or fewer categories. Having multiple items or scales may contribute to the validity and reliability of measured constructs (DeVellis, 2003). Responses to several study variables were skewed. Having multiple items to assess variables may enhance variability in the predictors. More complex, multi-item measures, with higher validity and greater reliability, however, increases participant burden. It was essential that women remain in the study over time. Increasing participant burden may lead to higher rates of withdrawal from studies, especially in longitudinal studies where repeated measurements are taken.

This study had several strengths. Because all women in PRISM received mammograms eight to nine months before entering the study and were then followed for 36 months, the prospective follow-up period allowed me to ascertain PRISM participants'

mammography maintenance profiles over three annual screening cycles. Most studies to date have assessed only short-term patterns of repeat use, defined as receipt of more than one (but usually limited to two) recent screenings over a specific period. PRISM data also allowed me to confirm intervals between mammograms, using claims data verified by annual self-reported assessments of mammography use, instead of viewing only a general pattern of screening across three years. Accurate assessment of mammography use is a growing concern for applied researchers as study findings differ according to how this outcome is operationalized (Boudreau et al., 2007; Rakowski et al., 2004).

Another strength of this study is that it took a transtheoretical approach to studying mammography maintenance. Evidence supports using a transtheoretical approach in health behavior (Institute of Medicine, 2002; Quine et al., 1998; Tolma et al., 2006). PRISM dataset included many belief, attitude, health care utilization and demographic variables traditionally associated with mammography use, informed by multiple theories of health behavior. These data allowed me to assess associations with a range of theoretically and empirically based predictors of mammography maintenance.

The sample for this study was also unique in that all women in the study had private health insurance in North Carolina, were predominately white, college-educated and worked for pay. This relatively demographically advantaged population, who in the past have been more likely to obtain repeat screening than other groups, have recently experienced a drop in their rates of regular screening (Breen et al., 2007). Being able to assess patterns of use in the PRISM population provided some insights into why we are seeing such declines in rates of screening.

The PRISM sample also includes women in their forties, thus allowing us to examine variables associated with regular screening on an annual interval for the youngest age-eligible group. Women in their forties have been an understudied group, especially in annual-interval mammography use research. Lastly, limiting our analysis to the control groups of PRISM increases the generalizability of the conclusions of the research since the only prompts these women received were mailed or automated telephone mammography reminders. This condition may make them similar to the way in which insured women seen in private medical practices are treated.

I assessed behavior longitudinally, in a prospective cohort design, with repeated assessments of the behavior and predictors. This design lends support to the causal plausibility of the finding. The statistical approach, discrete event history analysis, also has many strengths. First, if a participant was lost to follow-up, she could be censored at the point of withdrawal from the study. For example, if a woman withdrew (a rare event) after the second interval, she was censored at that interval and only contributed as much information per interval as data has been collected up to that interval. Another strength of this approach is that predictor variables that time-vary can be assessed at each interval. Also, discrete event history allows for modeling the effect of time on mammography maintenance. For modeling mammography maintenance, one of the greatest strengths of this approach is that discrete event history analysis allowed us to model mammography use as an ongoing process (mammography maintenance) instead of assessing mammography maintenance at one point in time or as average use over time.

6.3 Implications of Research

Findings of this research have multiple methodological, theoretical and practice implications. First, this study was informed by several theories of health behavior. No one theory may be best at unpacking the complex set of actions and goals that compose maintenance of episodic behaviors such as mammography screening. This study provides some support that elements of well-studied constructs, such as self-efficacy and perceived barriers, have utility for explaining maintenance. Only a subset of variables predicted maintenance adherence. Findings of this research highlight the need to continue to explore maintenance-specific factors. For example, attitude toward mammography was not predictive of sustained use even though this has been a predictor of mammography use in other studies. On the other hand, experiences with mammography were predictive of maintenance adherence. Future research should continue to search for factors that can explain how and why predictors of maintenance may differ from predictors of recent and repeat mammography use.

Study finding may have methodological implications. Many measures used in this study were one-item measures. While most had been used repeatedly in previous studies of mammography research, this study extends their use to the concept of mammography maintenance. This study also underscored the importance of using both insurance claims and self-reports of mammography use. Checking claims data against self-reported use of the last two mammograms helped add specificity to the measurement of regular mammography use by triangulating intervals between mammograms and potentially limiting forward telescoping (Rauscher, Johnson, Cho, & Walk, 2008). Gaining specificity of these intervals is a growing concern for applied researchers (Partin et al., 2005; Rakowski et al., 2004).

The study has a number of practice-oriented implications. First, it highlights the importance that satisfaction with the mammography experience may have on long-term patterns of use. Future intervention efforts could consider increasing patient satisfaction by interventions such as improving interpersonal skills of health care providers or providing avenues for patient feedback to providers. Such efforts have been seen to improve patient satisfaction (Cheraghi-Sohi & Bower, 2008; Earp, French, & Gilkey, 2007; Engelman et al., 2004). However, it will be critical before intervening to understand why satisfaction affects mammography maintenance and if the results here represent national trends or are characteristics specific to North Carolina or the State Health Plan.

A significant body of literature documents the effectiveness of reminders in promoting recent and repeat mammography use (Baron et al., 2008; Legler et al., 2002; Masi, Blackman, & Peek, 2007). All women in this study received some sort of mammography reminder annually. However, only 46% of women received mammograms annually. Other types of reminders such as email with links for making appointments may be a useful strategy to improve the return on relatively simple reminders. Additionally, adding persuasive information to reminders may enhance their effectiveness. This was one of the aims of PRISM and results about this achievement are forthcoming. More intensive interventions such as providing multiple reminders per year or coupling reminders with other intervention efforts may be necessary to gain greater levels of mammography maintenance.

Women with poor or fair health were particularly vulnerable to unsustained maintenance. Compliance may be a more complicated issue, suggesting a need for better understanding of competing health requirements for this group.

6.4 Conclusions and Areas for Future Research

Health behavior researchers have focused more on promoting behavior change than learning how to sustain behavior change, especially for episodic screening behaviors such as mammography. This study provides evidence that, while most women in the U.S. have had prior mammograms, we have not yet achieved high levels of compliance with mammography maintenance. This is an especially striking finding in an insured sample. Some factors that predict repeat use, such as intentions, barriers and self-efficacy, also are important in maintenance of behavior change. Three hypothesized predictors, however, were not associated with mammography maintenance: more research is needed to identify other important factors that affect long-term maintenance of episodic behaviors.

If conceptualized as a process, behavioral maintenance includes both facilitators and constraints. The research described here endeavored to advance our understanding of factors that constrain mammography maintenance. Equally important research must also look at factors that promote mammography maintenance. Additionally, there are a number of areas for future research that could advance our understanding of mammography maintenance. These are outlined below.

Even though I found a somewhat lower rate of mammography use in this sample as did other studies, rates of mammography maintenance may be even lower in other groups. All women in our sample had health insurance. Most had a college degree, were of Non-Hispanic white race and reported comfortable finances. Lower rates of compliance may be expected in other sociodemographic groups who have historically lower rates of mammography use. Future research should consider longitudinal studies of mammography maintenance in more ethnically and socially diverse samples. Similarly, I only followed

women over three years. Future studies may consider following women for a longer period to see if there is a point at which women may become at greater risk of becoming non-adherent to mammography maintenance.

If maintenance is indeed a distinct process from behavior change, further qualitative work may be needed to explore these distinctions. Most qualitative work on mammography use has focused on short-term behavior change Qualitative work with maintainers and non-maintainers (women who have relapsed in and out of maintenance) may help isolate new mammography maintenance factors for further research consideration. Qualitative work with maintainers and non-maintainers may also help unpack why perceived satisfaction with the mammography experience is a predictor of adherence to mammography maintenance.

While extensive research has examined multiple types of barriers related to recent and repeat use (Champion & Skinner, 2003; Finney Rutten et al., 2004; Rimer et al., 2000), little research exists on types of barriers that affect mammography maintenance. Perceiving multiple barriers was a robust predictor of mammography maintenance. However, I did not explore which types of barriers predicted adherence. Future research should seek to catalogue and test mammography maintenance barriers by type (e.g., systems-related, patient-related). Such information could be used to inform future mammography maintenance interventions.

Though not specifically tested in this study, my findings support the multiple roles that self-efficacy plays in mammography maintenance. The notion of phase-specific self-efficacy has been applied to a variety of behaviors with success (Luszczynska & Schwarzer, 2003; Marlatt, Baer, & Quigley, 1995; Schwarzer & Renner, 2000; Schwarzer et al., 2007). Such domains have not been explored for mammography maintenance. In future research we

should develop and test measures of mammography phase-specific self-efficacy to inform maintenance promotion efforts.

Finally, this study provided evidence of the value of behavioral intentions as a predictor of mammography maintenance. Other research has applied the construct of implementation intentions to predict maintenance of daily behaviors (Sheeran & Orbell, 1999). Future research should focus on how best to operationalize implementation intentions in the context of maintenance of episodic behaviors. Implementation intentions may be especially important for maintenance of behaviors that are not one single action but, in fact, are composed of several steps. Mammography maintenance is such a behavior, compromised of multiple planning and action steps. Using measures of implementation intentions also may improve the predictive ability of intentions on mammography maintenance.

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