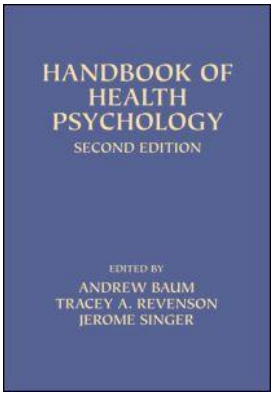

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Subjective Risk and Health-Protective Behavior

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6 Subjective Risk and Health-Protective Behavior
Prevention and Early Detection

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This chapter explores the role of perceived risk in health-protective behavior. In models of health behavior, perceived risk for disease occupies the role of distal motivator for health-protective action. We explore the origins of perceived risk, its role in health behavior models, and the linkages between perceived risk and health-related behavior. We intend that the chapter provide a broad picture of the literature on risk perception in health psychology. We have chosen to contextualize the chapter with research on perceived risk for cancer as a putative determinant of cancer prevention and cancer screening. The body of research on the role of perceived risk in cancer detection and prevention is extensive. Moreover, cancer prevention and cancer screening encompass primary and secondary prevention of disease from a public health perspective, that is, primary prevention to both prevent disease onset and promote health, and secondary prevention to detect disease in its earliest state before it becomes symptomatic. Although our empirical research examples are in the main limited to cancer-related behaviors, our presentation is completely general from the perspective of theory and measurement of perceived susceptibility and its empirically supported role in health-protective behavior.

CHAPTER OVERVIEW

We set the stage for the chapter with a brief overview of cancer prevalence and cancer screening in the United States. We then move to the definition of perceived risk and the role of perceived risk in models of health behavior. We follow with the complex issue of the measurement of perceived risk (equivalently perceived susceptibility). We then address how perceived risk comes about, exploring classes of determinants of perceived risk for a range of diseases, including but not limited to cancer. This work leads to an exploration of the relationship between objective and subjective risk. We then

provide an extensive examination of the relationship between perceived risk and cancer detection–related behaviors. We follow with the role of perceived risk in interventions to increase screening, with a focus on tailored interventions. Stepping back from the specifics of perceived risk and health behavior, we address the important role of mediation analysis to uncover the mechanisms by which interventions work to bring about behavior change. In a final brief section, we argue for the use of mediation analysis of interventions to understand the constructs, such as perceived susceptibility, that underlie health-protective behavior and health behavior change. Throughout, we integrate considerations of cognitive and emotional aspects of risk perception.

Setting the Health Context for Perceived Risk: Cancer Prevalence, Prevention, and Detection

Prevalence

In the course of their lifetimes, 45% of men and 38% of women will develop invasive cancer (American Cancer Society, 2009), the second leading cause of death in the United States. In all, there were expected to be 1.44 million new cases of cancer and slightly over a half million cancer deaths in the United States in 2008 (Jemal et al., 2009).

Detection and Prevention Recommendations

The American Cancer Society (ACS) recommends cancer screening (American Cancer Society, 2010a) for breast, cervical, and colorectal cancer, as does the U.S. Preventive Services Task Force (2009). New genetic testing for cancer genes has opened a highly complex and difficult area of consideration. As of 2005, the U.S. Preventive Services Task Force (2005) recommended that women at risk for inheritance of the breast cancer susceptibility gene (BRCA1 or BRCA2) be referred for "genetic counseling and evaluation for BRCA testing" (p. 355). Beyond screening are recommendations for cancer prevention through a range of activities, including skin protection, diet, exercise, limitation of alcohol consumption, and, of course, smoking cessation. A new human papillomavirus (HPV) vaccine was approved by the U.S. Food and Drug Administration (FDA) in June 2006; vaccination is recommended for primary prevention of cervical cancer by the Centers for Disease Control (CDC) for all females 11 to 12 years of age (Markowitz et al., 2007). This recommendation opens an avenue of widespread cancer prevention because 70% of cervical cancer cases are associated with viruses targeted by the vaccine (American Cancer Society, 2010b).

Screening Utilization in the United States

The United States is far from achieving universal access to screening and compliance with screening recommendations for major cancers. In 2005, 66% of eligible women received mammography screening, a decline from previous years (Ryerson, Miller, Eheman, Leadbetter, & White, 2008). By 2005, 47% of the population had had some form of colorectal cancer screening, and 43% of men 50 and over had a prostate-specific antigen (PSA) at an appropriate schedule. Race/ethnic disparities are still evident (American Cancer Society, 2008), and socioeconomic differences contribute to race/ethnic disparities (Purc-Stephenson & Gorey, 2008). Screening rates for all tests were substantially higher for those born in the United States than for immigrants. Breen and Meissner (2005) address challenges to cancer screening in the United States from a public health system perspective.

Classes of Cancer-Protective Behaviors

For our exploration of perceived risk and behavior, we first divide cancer-protective behaviors into two broad categories: secondary prevention through screening for early detection and primary prevention with protective behaviors. Detection through screening is associated with intermittent access to medical services, whereas most preventive behaviors—among them diet control, exercise,

and sun protection—require sustained effort (Gerend, Shepherd, & Monday, 2008). In contrast, new to cancer prevention is the use of HPV vaccine to protect against cervical cancer, which requires simply three vaccine administrations (Markowitz et al., 2007). Our illustrations in the main are taken from literature on screening for early detection; in this regard we note that 16 of the 20 clinical preventive services recommended by the U.S. Preventive Services Task Force (2009) were screening services.

PERCEIVED RISK: DEFINITION AND ROLE IN MODELS OF HEALTH BEHAVIOR

Definition of Perceived Risk

Health psychology is rich in models of the putative determinants of health-protective behavior (see Glanz and Kegler, Chapter 5, this volume). At the core of essentially all these models is the concept of perceived risk, that is, the extent to which an individual believes that he or she is subject to a health threat (Becker, 1990; Gerrard, Gibbons, & Bushman, 1996; Kowalewski, Henson, & Longshore, 1997; van der Pligt, 1998; Weinstein, 1993). Some but not all authors add to the definition of perceived risk the condition that perceived risk refers to the judgment of risk if no action is taken to protect against the threat (Weinstein, 2000; Weinstein et al., 2007), a characterization termed conditional risk by others (Ronis, 1992). Health psychology draws on a theoretically based literature in risk perception and its determinants (Kahneman & Tversky, 1973; Kasperson et al., 1988; Slovic, 1987; Tversky & Kahneman, 1974). Formal models of risk (Kasperson et al., 1988) postulate that risk is a joint function of the *probability of occurrence* of a negative event and the *magnitude* of its consequences; risk is the product of these factors. Literature applying perceptions of risk to health behavior is less precise. The term *perceived risk*, as well as the terms *perceived susceptibility* and *perceived vulnerability*, are used interchangeably to refer to the subjective likelihood of contracting a disease, absent any consideration of severity. Consistent with typical applications in health, we will use the terms *perceived risk*, *perceived susceptibility*, *perceived vulnerability*, and *perceived likelihood* to refer to subjective estimates of the likelihood of personally contracting a disease, not to the combination of likelihood and severity of consequences. Recently, Weinstein et al. (2007) provided a more nuanced characterization in which vulnerability is viewed as a more affective aspect of perceived risk. We will use *perceived severity* to refer to perceptions of seriousness of consequences independent of likelihood (Weinstein, 2000).

Models of health behavior assume that the motivation for health-protective behavior stems from anticipation of some negative health outcome coupled with hope of avoiding the outcome. Anticipation of a negative outcome involves foremost the perception that one is personally susceptible to some disease; for strong health motivation to be achieved, this perception must be coupled with the anticipation that the disease consequences are severe (Weinstein, 1993).

Our particular interest in this chapter is the linkage of perceived susceptibility to health-protective behavior. A theoretical context for this linkage is provided by consideration of how perceived susceptibility is used in models of health-protective behavior. Three widely applicable models of health behavior—the health belief model (HBM; Becker & Maiman, 1975; Rosenstock, 1966, 1974a, 1974b, 1990), protection motivation theory (PMT; Prentice-Dunn & Rogers, 1986; Rogers, 1975, 1983), and the precaution adoption process model (PAPM; Weinstein, 1988; Weinstein & Sandman, 2002)—employ the perceived susceptibility construct as a driving force in health-protective behavior. Perceived risk appears as well in the transtheoretical model of change (TTM; Prochaska, DiClemente, & Norcross, 1992), cognitive-social health information processing (C-SHIP) model (S. M. Miller, Shoda, & Hurley, 1996), and the health action process approach (HAPA; Schwarzer, 2008). Perceived risk is also implicit in the theory of reasoned action (TRA; Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) and its extension, the theory of planned behavior (Ajzen, 1991), as well as subjective expected utility theory (Ronis, 1992; Weinstein, 1993), as they are applied to health behavior.

Although perceived susceptibility is consistently cast as the motivating engine for health-protective behavior, the specific role of perceived susceptibility and assumptions about how it combines with other constructs vary in informative ways across models. We provide a brief characterization of the role of the perceived susceptibility construct in several health behavior models. A characterization of the complete health models is beyond the scope of this chapter, however; Conner and Norman (2005), Glanz, Rimer, and Viswanah (2008), Weinstein (1993), and Weinstein, Rothman, and Sutton (1998) provide explications of these and other models. Conner and Norman (2005) also provide extensive reviews of literature employing these models. Curry and Emmons (1994) provide a thorough summary of applications of the HBM, TRA, and the TTM to breast cancer screening.

Perceived Susceptibility as Motivator: Health Belief Model (HBM)

The HBM traces its origins to problems encountered in the U.S. Public Health Service nearly half a century ago—problems of asymptomatic individuals failing to undergo screening tests or to engage in preventive health behaviors (Rosenstock, 1966, 1974a, 1990). According to the HBM, individuals will undertake a health action to the extent that they believe themselves to be susceptible to a health threat (perceived susceptibility), believe that the consequences of the disease are serious (perceived severity or seriousness), believe that the proposed health action will offer protection against the health threat (perceived benefits), and believe that barriers to performing the health action can be overcome (perceived barriers). Finally, individuals must receive some trigger or cue in order to act (cue to action). Both physicians' recommendations for screening (Fox, Siu, & Stein, 1994) and reminder letters (Bastani, Marcus, Maxwell, Das, & Yan, 1994) serve as cues in interventions to increase screening.

Perceived susceptibility is, in a sense, the centerpiece of the HBM. There are two aspects to perceived susceptibility: (1) an individual's belief that contracting a disease is a realistic possibility for him- or herself, and (2) an individual's belief that he or she may have the disease in the complete absence of symptoms (Rosenstock, 1990). Failure to utilize cancer-screening tests may be attributed to a lack of belief that pathology can exist in the absence of symptoms (Rosenstock, 1990). Perceived susceptibility and perceived severity combine to form perceived threat, a determinant of the likelihood of adopting a health action; this combination closely reflects the formal definition of risk (Kasperson et al., 1988), provided earlier. The HBM is silent on the nature of the combinatorial rules for the constructs; in most applications of the health belief model, simple additive effects of the constructs have been explored. The interplay of perceived threat with perceived benefits is important for cancer screening, in that high-risk individuals, though they perceive heightened vulnerability, may avoid seeking screening if they believe that cancer treatment cannot save them (e.g., Lerman & Schwartz, 1993, for breast cancer; M. D. Schwartz, Lerman, Daly, Audrain, Masny, & Griffith, 1995, for ovarian cancer). Ronis (1992) has suggested a combinatorial rule for HBM constructs in which perceived susceptibility and severity are necessary precursors to the perception of benefits of health action, a characterization on which we draw in our discussion of mediational analysis of interventions. The HBM has made sustained contributions as a heuristic for the study of psychosocial correlates of preventive health behavior. (See reviews by Harrison, Mullen, & Green, 1992; Janz & Becker, 1984; Sheeran & Abraham, 1996.) Typically, the perceived barriers construct has been the strongest correlate of nonbehavior, whereas perceived susceptibility has typically exhibited low to moderate positive correlations with protective behavior.

Although perceived susceptibility is expected to combine with perceived severity to motivate health-protective behavior, perceived severity by itself rarely correlates with preventive behavior or screening behavior (Harrison et al., 1992; Janz & Becker, 1984). This finding is certainly true for cancer research: Perceived severity has failed to show predictive utility and has not been amenable to change through intervention because cancer is apparently seen as uniformly serious (Champion, 1994; Curry & Emmons, 1994; Rimer, 1990; but see Ronis & Harel, 1989, for an exception). Researchers often forgo the measurement of perceived severity in characterizing the HBM for cancer-related behavior (e.g., Hyman, Baker, Ephraim, Moadel, & Philip, 1994; Vernon, Myers, &

Tilley, 1997). Thus, perceived susceptibility by itself, rather than the combination of susceptibility and severity, is de facto characterized as the motivating force for cancer protective behavior. In contrast, across a range of diseases Weinstein (2000) found interactions between perceived susceptibility and severity to predict motivation for protection.

Fear-Arousing Communication, Perceived Susceptibility, and Behavior: Protection Motivation Theory

Perceived susceptibility also plays a central role as a motivator of health-protective behavior in protection motivation theory (PMT), a model that arose from consideration of the impact of fear-arousing communication on the adoption of health-protective behavior (Beck & Frankel, 1981; Rogers, 1975). In PMT, perceptions of susceptibility and severity that result from fear communications are expected to combine with perceptions of the existence of an effective health-protective behavior to arouse protection motivation, which in turn leads to intentions to adopt the health-protective behavior (Rogers, 1975). In its revised form (Rogers, 1983; Prentice-Dunn & Rogers, 1986), PMT provided a special motivational role for perceived susceptibility coupled with perceived severity, that of lowering the probability of a maladaptive response (e.g., delay in seeking treatment for suspected cancer symptoms, persistence in behaviors that put one at increased cancer risk). A number of recent studies have drawn on PMT in studying cancer prevention (e.g., Helms, 2002, for genetic testing for breast cancer; Azzarello, 2006, and Grunfeld, 2004, for skin cancer screening and protection, respectively). De Hoog, Stroebe, and de Wit (2007) provide a comprehensive meta-analysis of the distinct roles of vulnerability to and severity of a health risk on the processing of fear communications.

How Perceptions of Susceptibility Accrue: The Precaution Adoption Process Model

Models of health behavior assume that in order for perceived susceptibility to act as a motivational force, perceptions of susceptibility must be personal; that is, individuals must feel that they are themselves vulnerable. Weinstein (1988) proposed the precaution adoption process model (PAPM) as a stage model of the adoption of health behavior. In general, stage models (Weinstein, Rothman, & Sutton, 1998) characterize individuals as falling into a series of ordered categories with regard to adoption of a health behavior. In PAPM, these stages move from lack of awareness of the health issue (Stage 1) through health behavior maintenance (Stage 7). Consistent with this stage structure, beliefs about perceived susceptibility are assumed to develop in a series of cumulative stages. First, an individual is assumed to become aware of a health hazard (awareness), then to believe in the likelihood of the hazard for others (general susceptibility), and finally to acknowledge his or her own personal vulnerability (personal susceptibility). Personal susceptibility is assumed to be critical in the decision to take precautionary action (Weinstein, Rothman, & Sutton, 1998). Assessment of discrepancies between general susceptibility and personal susceptibility has uncovered optimistic biases (Weinstein, 1980). The PAPM has been applied to home testing for radon gas, an environmental cancer threat (Weinstein & Sandman, 1992), and to mammography screening as well (Clemow et al., 2000).

The Growth of Perceived Susceptibility and the Process of Adopting Health Behaviors: Transtheoretical Model of Change

The transtheoretical model of change (TTM), like the PAPM, is a stage model of health behavior adoption (Prochaska et al., 1992). It is hypothesized that individuals pass through five stages as they initiate and maintain a health-protective behavior or cease a health-threatening behavior: (1) *precontemplation*, during which the individual has no intention to undertake behavior change and is uninformed of the consequences of the behavior in question; (2) *contemplation*, during which the individual is aware of the benefits (pros) of behavior change but also is strongly aware of the barriers

(cons) to behavior change; (3) *preparation*, during which the individual makes definite plans to act in the very near future; (4) *action*, in which a new behavior is in place; and (5) *maintenance*, in which the behavior is carried out over an extended time. Accompanying these stages of change are processes of change; these processes rise and fall in intensity across the stages. The earliest process of change is consciousness raising, through which an individual gains increasing awareness of a health problem and its consequences. According to TTM, consciousness raising as a process begins in the precontemplation stage, peaks during contemplation, and then gives way to other, more action-oriented processes in the remaining three stages. Put another way, progress through the first two stages is hypothesized to be driven by the growth of awareness of perceived risk from a health threat. The TTM has been applied to both cancer screening and cancer prevention. For example, Lipkus, Rimer, and Strigo (1996), Rakowski et al. (1998), and Pruitt et al. (2009) have applied this model to mammography screening; other applications include sun exposure, exercise, dietary change, and alcohol consumption, all related to cancer risk and prevention.

Cognitive-Social Health Information Processing

The cognitive-social health information processing (C-SHIP) model (S. M. Miller et al., 1996) is a comprehensive model of the genesis and maintenance of health-protective behavior, initially expounded in the context of the complex sustained behavior of breast self-examination (BSE). The model considers five classes of determinants of health behavior that incorporate both cognitions and affect. Among these, two classes address issues of perceived susceptibility: (1) *health-relevant encodings*, including health risks and vulnerabilities, as well as attention strategies for gathering versus avoiding health relevant information; and (2) *health beliefs and expectancies*, including how such vulnerabilities as genetic predisposition affect subjective likelihood of disease development. The model specifies how information about objective risk and resulting perceptions of susceptibility interact with emotions associated with receiving health information, with health goals, and with self-regulation in producing health behaviors. That the model addresses the interplay of emotion with cognitions about one's vulnerability is important for our understanding of cancer screening, especially among individuals at high risk for cancer.

The Health Action Process Approach

The health action process approach (HAPA) model (Schwarzer, 2008) is a two-stage model, of which the first stage, or *motivational phase*, characterizes the factors that lead to the intention to adopt a health behavior, and the second stage, or *volitional phase*, characterizes the factors that link these intentions to the initiation of behavior and the maintenance of behavior over time. The model is unique in its elaboration of factors that support the intention–behavior link. In HAPA, as in other models of health behavior, perceived susceptibility is an early motivating factor at the outset of the motivational stage; it is expected to relate to intentions, though less strongly than other predictors of intention, among them outcome expectancies associated with the health behavior. HAPA has been applied to cancer-preventive behaviors, including dietary modification, exercise, cessation of smoking, and sun protection (Lippke, Ziegelmann, Schwarzer, & Velicer, 2009; Scholz, Keller, & Perren, 2009; Schwarzer, Luszczynska, Ziegelmann, Scholz, & Lippke, 2008). An exceptional Web site provides a complete up-to-date bibliography of this research (http://www.hapa-model.de/). Schwarzer (2011) provides a rich summary of the major models of health behavior and their core constructs that complements this brief review.

Perceived Susceptibility as a Predisposing Factor in Complex Models

A number of authors have proposed extensive integrative frameworks of the putative determinants of health-protective behavior, which have been employed in the design of interventions to increase

health behavior. Four such frameworks are summarized in Curry and Emmons (1994). Each framework specifies a complex causal chain of variables that ultimately leads to health behavior. Most important for our consideration is the fact that perceived susceptibility is included as a predisposing factor for health behavior adoption early in the causal chain. Perceived susceptibility may facilitate overcoming barriers to the health-protective behavior (McBride, Curry, Taplin, Anderman, & Grothaus, 1993) and lead to receptiveness to health promotion interventions (the PRECEDE-PROCEED model of Green and Kreuter, 1991).

Perceived Susceptibility as a Predisposing Factor for Health Behavior Adoption

Not surprisingly, models of health behavior have matured and increased in complexity. Early models have been augmented with new variables, for example, the addition of self-efficacy for health behavior to both the HBM (Rosenstock, Strecher, & Becker, 1988) and PMT (Rogers, 1983). New stage models have viewed health behavior adoption as dynamic, in part driven by perceived susceptibility. The interplay of susceptibility cognitions with emotion has been elucidated. Hybrid models have incorporated a complex network of environmental and medical system variables along with individual cognitions, including perceived susceptibility. The evolution of these models has clarified the role of perceived susceptibility as a potentially powerful predisposing factor at the outset of the process of adoption of health behaviors, a factor that motivates this process of adoption. In sum, health behavior models conceptualize perceived susceptibility to disease as a distal construct in a mediational chain of constructs that eventuate in protective health behavior.

Risk, Emotion, and the Parallel Response Model of Self-Regulation

Models of health behavior characterize perceived susceptibility as a cognitive judgment of the likelihood of experiencing a negative health outcome, which judgment influences the decision to act to mitigate the threat. Yet, emotion (or affect) is a powerful factor in decision making (Damasio, 1994), as reflected in the C-SHIP model. Current considerations of how we perceive risk distinguish between *risk as analysis* and *risk as feelings* (Epstein, 1994; Lowenstein, Weber, Hsee, & Welsh, 2001; Slovic, Finucane, Peters, & MacGregor, 2004). Whereas risk as analysis draws on logic and reason, risk as feelings "refers to our fast, instinctive, and intuitive reactions to danger" (Slovic et al., 2004, p. 311). These distinct aspects of risk are argued to arise from two distinct systems of thinking, an analytic system and an experiential system (Slovic et al., 2004), for risk as analysis versus risk as feeling, respectively. Decisions concerning health actions, to obtain cancer screening or genetic screening for cancer heritability, may involve such intense emotions as fear and distress. Emotion or affect may, in fact, mediate the relationship between cognitive risk judgments and behavior (Lowenstein et al., 2001). Leventhal (Cameron & Leventhal, 2003; Leventhal, 1970; Leventhal, Brissette, & Leventhal, 2003; Leventhal, Leventhal, & Cameron, 2001; see also Chapter 1, this volume) proposed a self-regulation theory (or parallel response model) of reaction to health threat. It is characterized by two distinct responses to health threat, reflective of the cognitive and emotional components of risk. The first response, danger control, is problem focused, for mitigating the threat through effective action. The second response, fear control, is emotion focused, for mitigating the strong affective response to the threat. As explained next, which coping mechanism is invoked in response to a health threat depends on an individual's belief as to whether danger control is possible.

MEASUREMENT OF PERCEIVED SUSCEPTIBILITY

Approaches to the measurement of perceived susceptibility are cognitively based. Two broad classes of measures are *absolute measures*, in which personal ratings are made without reference to any outside group, and *comparative measures*, in which personal perceived susceptibility is compared

to susceptibility in some normative group (Weinstein & Klein, 1996). There is lack of consensus as to optimal measurement approaches (Vernon, 1999); multiple measures are employed in individual studies (e.g., Gerend, Aiken, West, & Erchull, 2004; McQueen, Swank, Bastian, & Vernon, 2008).

Absolute Measures

Absolute measures vary widely in structure, involving rating scales, frequency scales, and percentage estimates. These scales lead to widely differing estimates of perceived risk. Frequency judgments (e.g., 25 out of 100 people) lead to higher perceived risk than percentage judgments (25%; Peters, McCaul, Stefanek, & Nelson, 2006), perhaps because of the vividness of thinking in terms of individual cases. Anchors on scales (e.g., 1% to 100% versus 1% to 50%) change risk ratings (Peters et al., 2006). Katapodi, Lee, Facione, and Dodd (2004) summarize scale format effects in a meta-analysis of judgments of perceived susceptibility to breast cancer.

Rating Scales

Among absolute measures, typical rating scales ask individuals for Likert-scale judgments of their likelihood of developing cancer, for example, "What do you believe is the chance you will develop breast cancer in your lifetime?" (Gerend, Aiken, West, et al., 2004; see also Bastani, Marcus, & Hollatz-Brown, 1991; McQueen et al., 2008).

Numerical Estimates

Numerical estimates of the chance of contracting cancer are also taken as absolute indicators of perceived susceptibility, for example, "Risk of developing breast cancer in the next 10 years" (< 1%, 1%–5%, 6%–10%, 11%–20% or >20%; Dolan, Lee, & McDermott, 1997; percent risk likelihood, 0% through 100%; McQueen et al., 2008). Perceived risk has also been measured with rate judgments, for example, "the number of women out of 1000 whom you think would develop breast cancer in the next 10 years" (Black, Nease, & Tosteson, 1995; see also L. M. Schwartz, Woloshin, Black, & Welch, 1997).

Comparative Risk

Direct Comparative Risk

Direct comparative risk is measured with some form of the following question: "What do you believe are your chances of getting (disease) compared to other (men/women) your own age?" with such typical responses as "a lot lower, somewhat lower, about the same, somewhat higher, and a lot higher." This measure has been applied to cancer in general (Kreuter & Strecher, 1995); lung cancer, skin cancer, and cancer in general (Weinstein, 1987); breast cancer (e.g., Aiken, Fenaughty, West, Johnson, & Luckett, 1995; Gerend, Aiken, West, et al., 2004), and colorectal cancer (e.g., Blalock, DeVellis, Afifi, & Sandler, 1990).

Indirect Comparative Risk

Indirect comparative risk is assessed by having an individual rate the likelihood of developing the disease herself and also the likelihood that similar others (e.g., of the same age) will develop the disease. The difference between these two ratings—own absolute minus other absolute—reflects comparative risk (Weinstein & Klein, 1996).

Discrepancies Among Risk Measures

Measures of comparative risk are sometimes used in combination with absolute rating scales in the formation of multi-item susceptibility measures. Some researchers have argued that individuals' perceptions of their own risk appear to drive both own absolute and direct comparative risk

judgments (Covey & Davies, 2004; Gerend, Aiken, West, et al., 2004; Klar & Ayal, 2004; Klar & Giladi, 1999); absolute and direct comparative risk form a single factor psychometrically (Gerend, Aiken, West, et al., 2004). Yet, some authors have found that these two measures make independent contributions to prediction; for example, Klein (2003) found differential relationships of comparative and absolute risk information to judgments of safety. Indirect comparative risk does not consistently relate to other perceived susceptibility measures. Moreover, indirect comparative risk may correlate positively, not at all (Covey & Davies, 2004), or even negatively (Price, Pentecost, & Voth, 2002) with risk factors that correlate positively with own absolute and direct comparative risk.

Ranby, Aiken, Gerend, and Erchull (2010) provide an explanation for this discrepancy with indirect comparative risk that draws on recent explications of the cognitive factors underlying social comparative judgments and the algebra of the computation of indirect comparative risk. Following Chambers and Windschitl (2004), we distinguished between the processing of *personal factors* that underlie one's perception of one's own risk (e.g., one's own family history or symptoms experienced, one's perceived similarity to those that contract the disease) versus such *general factors* as base rate, prevalence, or commonness of a disease that underlie perceptions of risk for generalized others' risk. Ranby et al. (2010) provided a straightforward algebraic demonstration that the correlation of a risk factor with indirect comparative risk—computed as own absolute risk minus other absolute risk—is necessarily determined by the correlation of the risk factor with own absolute risk and with other absolute risk. If such a personal risk factor as one's own family history is positively correlated with one's own absolute risk judgment but is not correlated with other absolute risk, then the risk factor must algebraically be correlated with indirect comparative risk. Ranby et al. (2010) found that for perception of risk for breast cancer among a community sample of mature women, women's own Gail epidemiological risk index (an objective risk estimate for breast cancer based on age, menses onset, parity, previous biopsies, and family history; Gail, 1989) positively correlated with their ratings of their own absolute risk ($r = .27$, $p < .001$), was uncorrelated with their ratings of others' absolute risk ($r = -.09$, NS), and was therefore positively correlated with the calculated indirect comparative risk score ($r = .29$, $p < .001$). On the other hand, if such a general risk factor as perceived commonness of a disease exhibits no correlation with own absolute risk but a strong positive correlation with other absolute risk, then the risk factor will correlate negatively with indirect comparative risk; again, an algebraic necessity. Ranby et al. (2010) found that for perception of risk for breast cancer among the same community sample, perceived commonness of breast cancer was uncorrelated with their own absolute risk ($r = .09$, NS), was strongly positively correlated with their ratings of others' absolute risk ($r = .67$, $p < .001$), and therefore was negatively correlated with the calculated indirect comparative risk score ($r = -.41$, $p < .001$). If a risk factor correlates equally with own and other absolute risk, then this risk factor will be uncorrelated with indirect comparative risk. Ranby et al. (2010) recommended against the use of indirect comparative risk measures, having demonstrated that the anomalous patterns of correlations of risk factors with the indirect comparative risk measure were attributable to the algebra of indirect comparative risk.

CONDITIONAL HEALTH THREAT

Perceptions of susceptibility and severity are in part governed by beliefs about personal actions that mitigate or increase cancer risk. Ronis (1992) characterized *conditional health threat* as the perception of threat under some behavior specification, that is, if the individual were to take a specific health-protective action versus taking no health-protective action (see also Rogers, 1983). Ronis (1992) and van der Pligt (1998) argued that the measurement of conditional health threat would provide better understanding of health-protective behavior because such conditional measures untangle the influence of current protective behavior on perceived vulnerability. Weinstein and Nicolich (1993) theorized that the discrepancy in level of perceived risk associated with participation versus nonparticipation in a health-protective behavior reflected perceived effectiveness of the health precaution. Further, Weinstein, Rothman, and Nicolich (1998) argued that the use of

conditional health threat clarifies the interpretation of risk. Finally, Cameron (2003) argued that conditional health threat better captures how people think about behavior and health status, as a "dynamic, conditional relationship" (p. 6), rather than in terms of an unconditional level of risk, not tied to specific behavior. We propose that the components of conditional health threat, that is, conditional susceptibility versus conditional severity, will have differential associations with preventive versus screening behavior. For preventive behavior, we expect high perceived susceptibility given inaction coupled with high perceived benefits of the health action to produce preventive behavior, with a subsequent reduction in perceived susceptibility. For screening, the matter is different because susceptibility is not reduced by screening; rather, the argument for screening is that consequences (severity) of cancer will be reduced with early detection, so the appropriate conditional characterizations of perceived severity are "severity if treated early" versus "severity if treated late" (Ronis & Harel, 1989). Ronis and Harel (1989) applied this dual conception of perceived severity to BSE (breast self-examination) performance and showed a link of these severity measures—but not conditional susceptibility—to BSE, yielding new insight into the potential role of perceived severity in screening. Jackson and Aiken (2000) applied conditional perceived susceptibility and severity to skin cancer–preventive behaviors and found the opposite effect—conditional measures of perceived susceptibility but not severity predicted skin protection. Measures of conditional threat may provide help to clarify the links of perceived susceptibility and severity to detection versus preventive behaviors.

Perceived Susceptibility Versus Cancer Worry and Cancer Distress

Perceived susceptibility has been distinguished from more emotional aspects of vulnerability in studies of cancer-related health behaviors, consistent with theorizing on risk as feelings (Sjoberg, 1998). Measurement of cancer worry has varied widely and has captured a range of levels of emotional effects. The item "During the past month, how often have you thought about your own chances of developing breast cancer" indicates mild worry, whereas "How often have your thoughts about breast cancer affected your mood" indicates moderate worry (M. D. Schwartz, Taylor, & Willard, 2003). More extreme worry is captured by "Thinking about breast cancer makes me feel upset and frightened" (McCaul, Schroeder, & Reid, 1996). Intrusive thoughts about cancer—for example, "I have had dreams about it," from the Impact of Events Scale (Horowitz, Wilner, & Alvarez, 1979)—have served as measures of cancer-related distress (Hay, Buckley, & Ostroff, 2005; M. D. Schwartz et al., 2003). McCaul and Goetz (2003) provide a review of these measures.

The assumption has been made that cancer worry is distinct from perceived susceptibility. Hay et al. (2005) provide a comprehensive analysis of the role of cancer worry in cancer screening, subsuming a variety of terms, including *cancer fear*, *cancer-related distress*, and *cancer anxiety* under the term *cancer worry*. The two variables are moderately related (correlations of .2 to .4; reviewed in Zajac, Klein, & McCaul, 2006; see also McQueen et al., 2008) and form independent factors in the measurement of predictors of colorectal cancer–screening adherence (Ritvo et al., 2008; Vernon et al., 1997). Fear of cancer and cancer treatment (Berman & Wandersman, 1992; Salazar & de Moor, 1995), cancer anxiety (Gram & Slenker, 1992), morbid concern about breast cancer (Irwig et al., 1991), and cancer-related distress (Rees, Fry, Cull, & Sutton, 2004) also have been included in research. A growing literature on breast and ovarian cancer screening among high-risk women (e.g., Audrain et al., 1997; M. D. Schwartz et al., 1999; M. D. Schwartz et al., 2003) has employed such measures of cancer-specific distress.

Determinants of Perceived Susceptibility and the Relationship of Perceived Susceptibility to Objective Risk

Two literatures inform the question of the determinants of perceived susceptibility. The first is a broad literature on classes of risk factors that relate to judgments of absolute risk. The second

examines individuals' rationales for their comparative ratings of their own risk of cancer relative to some comparison group, typically individuals of the same gender and age (Weinstein, 1984).

Threat, Heuristics, Personality, Emotion, and the Perception of Susceptibility

Gerend, Aiken, and West (2004) identified three traditions in characterizing the determinants of perceived risk. First is a *threat-based approach*, namely, that perceptions of susceptibility are rooted in disease characteristics, for example, the preventability of a disease. Second is a *heuristic-based approach*; rooted in cognitive psychology and decision science, this approach posits that cognitive heuristics shape risk perceptions. Third is an *individual-based approach*, namely, that personality factors color perceptions of risk independent of the particular threat. Gerend, Aiken, and West (2004) integrated these approaches in a mediational model in which threat-based and heuristic-based factors mediated the relationship of individual-based personality factors to perceived susceptibility. Most other research has considered first-order relationships of each class of predictors to perceived susceptibility; Katapodi et al. (2004) and Vernon (1999) provide extensive reviews of this work.

Cognitive Heuristics

Individuals rely on cognitive heuristics in estimating uncertain events (Kahneman & Tversky, 1973; Tversky & Kahneman, 1973, 1974), and these heuristics may underlie inaccurate perceptions of risk in the health domain. Peters, McCaul, Stefanek, and Nelson (2006) provide a comprehensive survey of heuristics that may contribute to the understanding of risk perception. Among these heuristics, the *availability heuristic* (Tversky & Kahneman, 1973) stipulates that we base frequency estimates on the salience of the event in question or the ease with which the event comes to mind. Personal experience with other individuals who have cancer (Wardle, 1995) and the extensive media coverage of cancer may contribute to the observed overestimates of cancer risk (Slovic, Fischhoff, & Lichtenstein, 1979; van der Pligt, 1998). The *representativeness heuristic* (Kahneman & Tversky, 1973) stipulates that we base likelihood estimates for a hypothetical event (e.g., a personal diagnosis of breast cancer) on our similarity to events with comparable characteristics (e.g., our similarity to others diagnosed with breast cancer). Gerend, Aiken, West, et al. (2004) explored the relationship of correlates of perceived risk that reflected both heuristics and disease characteristics; perceived similarity to those who get breast cancer was the strongest correlate of perceived risk. Peters et al. (2006) recommended the use of heuristics to aid the public in understanding risk estimates for cancer and other diseases. Further, they argue that if health providers take into account heuristic thinking about risk, they can improve the information provided to patients, who are increasingly involved in shared medical decision making.

Characteristics of the Health Threat

Bias in perceptions of comparative risk has been hypothesized to depend on disease characteristics (Weinstein, 1984, 1987; Weinstein & Klein, 1996). Harris (1996) and Weinstein (1987) reported a positive relationship between the perceived controllability or preventability of a disease and optimistic bias concerning risk. Both age and heritability play a strong role in risk perception, reflecting an interaction between characteristics of the threat (increasing occurrence with age and genetic risk). Women most often mention heredity as a source of the perceived elevated risk of breast cancer (Aiken et al., 1995; Lipkus et al., 1996). Although cancer incidence increases with age, the "absent/exempt" principle (If I haven't gotten the disease by now, I won't get it; Weinstein, 1987) is associated with lower perceived risk with increasing age (e.g., Aiken, West, Woodward, & Reno, 1994; Gerend, Aiken, West, et al., 2004). Women who may be at genetic risk for breast cancer, because of the possibility of inheriting the BRCA1/2 genetic mutation that greatly increases breast cancer risk, overestimate lifetime risk of developing breast cancer, even following genetic counseling to clarify their risk (Kelly et al., 2005). In a unique study, Fletcher et al. (2006) found that among first-degree

relatives (FDRs) of women with newly developed breast cancer, their own perceived risk of developing breast cancer was associated with their perception of their relative's cancer prognosis.

Leventhal (e.g., Leventhal et al., 2003) characterized the lay public's understanding of illness in a *commonsense model* of disease that informs the relationship between disease characteristics and perceived risk. This representation is related to Leventhal's self-regulation theory, with its two coping strategies in the face of health threat: fear control versus danger control. Whether fear control or danger control is the response to a health threat is hypothesized to depend on an individual's preexisting cognitive schema or commonsense (lay) representation of an illness threat, that is, how the individual understands the identity, causes, timeline, consequences, and control of the illness. Rees et al. (2004) found that perceived susceptibility, disease identity, acute timeline, and consequences were all correlated with both cancer worry and general elevated distress among women at increased risk of breast cancer. Three aspects of the lay representation of cancer—the causes of cancer, whether cancer can be controlled or cured, and the timeline for developing cancer—relate to perceptions of lifetime risk of breast cancer (Kelly et al., 2005).

Personality Characteristics and Modes of Information Processing

A variety of personality dimensions have been associated with perceived risk. Among them are monitoring-blunting (M. D. Schwartz, Lerman, Miller, Daly, & Masny, 1995), psychological defense (Dziokonski & Weber, 1977; Paulhus, Fridhandler, & Hayes, 1997), anxiety (MacLeod, Williams, & Berekian, 1991; Robb, Miles, Campbell, Evans, & Wardle, 2006), neuroticism (Darvill & Johnson, 1991; Gerend, Aiken, & West, 2004), emotional distress (Zajac et al., 2006), self-deceptive enhancement, health locus of control, and worry as general aspects of personality (Gerend, Aiken, & West, 2004). This may explain linkages noted between personality factors and breast-screening behavior (Siegler, Feaganes, & Rimer, 1995) reviewed by Siegler and Costa (1994).

Affect and Perceived Susceptibility

Affect contributes strongly to human judgment (Finucane, Alhakami, Slovic, & Johnson, 2000; Lowenstein et al., 2001; Slovic et al., 2004). Finucane has argued that affective reactions to a stimulus may drive perceptions of risk. An affect heuristic for judgments of risk has been characterized (Damasio, 1994) in which the affect associated with mental images of experiences is brought to bear with immediacy when judgments are made (Peters et al., 2006). Decision making depends on the intensity of the affect in a communication. For example, in an experimental study, Slovic, Monahan, and MacGregor (2000) found that the judgment by experienced psychologists and psychiatrists as to whether a mental patient should be released depended on whether or not the communication evoked images of a violent patient.

Considerations of the link between affect and perceived risk have utilized measures of stable affect-related personality traits (e.g., Gerend, Aiken, & West, 2004; McQueen et al., 2008; Zajac et al., 2006) and specific worry about cancer. A substantial literature, summarized in Katapodi et al. (2004), has shown positive relationships between perceived risk of a disease and specific worry, fear, and distress associated with cancer. More recent literature has shown cross-sectional associations among risk perceptions, general emotional distress, and specific worry about cancer (Hay, Coups, & Ford, 2006; Zajac et al., 2006). McQueen et al. (2008) has provided evidence of longitudinal associations of both specific breast cancer worry and general anxiety to perceived susceptibility. Lipkus, Klein, Skinner, and Rimer (2005) showed longitudinal associations in both directions between perceived risk and cancer worry.

Experience of Symptoms

Experience of symptoms is associated with increased perceived risk. For example, breast symptoms, among them having ever found a breast lump (Aiken et al., 1995) and number of previous biopsies and atypical hyperplasia (McQueen et al., 2008), are associated with increased perceived breast cancer risk.

Determinants of Comparative Risk

Weinstein (1984) coded the reasons generated by individuals for their comparative risk judgments into five categories: actions and behavior patterns, heredity, physiology or physical attributes, environment, and psychological attributes. This scheme has been used frequently for studying the determinants of both perceived and absolute risk (Gerend, Erchull, Aiken, & Maner, 2006; Robb, Miles, & Wardle, 2007). For cancer in general, breast cancer (Aiken et al., 1995; Lipkus et al., 1996), and colorectal cancer (Blalock et al., 1990; Hay, Coups, & Ford, 2006; Lipkus, Rimer, Lyna, et al., 1996; Robb et al., 2007), personal lifestyle–related actions were seen as both decreasing risk (e.g., proper diet, exercise) and increasing risk (e.g., red meat consumption, sedentary lifestyle). For lung cancer, personal actions (smoking) were seen as increasing risk (Lek & Bishop, 1995). Across cancers, attributions for heredity were that the absence of disease in the family reduced risk below average. In contrast, women who believed their risk to be above average for breast cancer mentioned heredity most often as the determining factor (Aiken et al., 1995; McCaul & O'Donnell, 1998; Savage & Clarke, 1996). There is lack of understanding of the role of heredity in cancer. Absence of family history is viewed as highly protective, even though most cancers are not associated with family history. Robb et al. (2007) pointed out that experiential and affective influences on judgments of cancer risk appear more salient in judgments of cancer risk than do more cognitive factors, consistent with the conception of risk as analysis and risk as feelings (Slovic et al., 2004).

Processes Underlying Optimistic Bias

Optimistic bias for perceived personal risk relative to risk of others has historically been attributed to a motivation to protect oneself from feelings of distress or anxiety about future negative events (see extended discussion in Chambers & Windschitl, 2004). This protection may accrue from downward social comparisons, (i.e., comparisons of one's own risk with the risk of others who are actually more vulnerable; Klein, 1996; Klein & Weinstein, 1997; Perloff & Fetzer, 1986). Chambers and Windschitl (2004) have provided an alternative and comprehensive account that is based on information-processing limitations and biases in judgment processes. A component of their account is the processing of prevalence or base rate information, which people appear to apply more to the judgment of others than to their own risk. Interventions that emphasize only prevalence information may have more impact on one's perception of others' risk than on one's own risk. This finding is of interest for interventions that provide prevalence information to modify perceived risk in service of encouraging cancer prevention and protection.

NUMERACY AND THE RELATIONSHIP BETWEEN OBJECTIVE AND SUBJECTIVE RISK

A fundamental assumption underlying the examination of the relationship of perceived susceptibility to cancer-related behaviors is that perceived susceptibility is a motivator for protective action. Further, there is an implicit assumption that "increasing the match between perceived risk (beliefs) and actual risk (reality) will encourage individuals to initiate and maintain preventive and treatment behaviors at a level that is appropriate to their actual risk and its source" (Leventhal, Kelly, & Leventhal, 1999, p. 81). Here we review literature on the relationship of perceived to objective risk and then discuss fundamental issues in studying these relationships.

Objective Versus Perceived Risk

Population Estimates

When determined from actual versus estimated population rates, community samples overestimate their probability of developing and dying of cancer (e.g., Helzlsouer, Ford, Hayward, Midzenski, & Perry, 1994, for cancer in general; Ward, Hughes, Hirst, & Winchester, 1997, for prostate cancer).

Epidemiological Estimates and Individual Assessments

Individuals' risk estimates based on epidemiological models have been compared with their own subjective numerical risk estimates (see reviews by Katapodi et al., 2004, and by Vernon, 1999). The Gail model (Gail et al., 1989), a five-factor epidemiological model of breast cancer risk, predicts risk for breast cancer among women who obtain annual mammograms. Using this model, Black et al. (1995), Dolan et al. (1997), Bowen et al. (2003), Katapodi et al. (2004), and Quillin, Fries, McClish, deParedes, and Bodurtha (2004) found on average that women grossly overestimate their chances of developing breast cancer (e.g., 13% by the Gail model versus 51% subjective estimate in Bowen et al., 2003). In more refined analyses, women at heightened risk, including those with a first-degree relative (FDR) or second-degree relative with breast cancer and also women recruited from health care settings greatly overestimated their personal risk (Katapodi et al., 2004). More than 60% of FDRs greatly overestimated their lifetime risk of breast cancer compared to Gail estimates (Lerman et al., 1995). In contrast, optimistic bias, that is, rating one's own risk as lower than that of the average woman, was exhibited in community samples (Aiken et al., 1995; Katapodi et al., 2004). Whereas the average subjective estimate of risk may diverge from actual risk level defined in terms of disease prevalence, subjective and objective estimates do correlate moderately—for example, $r = .46$ (Siegler et al., 1995); $r = .41$ (Gerend, Aiken, West, et al., 2004). Yet, among FDRs, Gail model risk components were found to be unrelated to numerical ratings (0% to 100%) of the chance of getting breast cancer someday (Daly et al., 1996).

Comparative Risk and Unrealistic Optimism

Although people overestimate their absolute risk of cancer, studies of comparative risk suggest that individuals do exhibit unrealistic optimism, or *optimistic bias* (Weinstein, 1980, 1987; Weinstein & Klein, 1996); that is, they believe they are less likely to contract specific cancers than are others their own age. This bias has been demonstrated for breast cancer (Aiken et al., 1995), skin cancer (A. J. Miller, Ashton, McHoskey, & Gimbel, 1990), and colorectal cancer (Blalock et al., 1990; Lipkus et al., 1996), as well as brain cancer, leukemia, and lung cancer (Lek & Bishop, 1995). When asked to compare their risk to that of women without a family history of breast cancer, FDRs of women with breast cancer accurately estimate their comparative risk as high (Audrain et al., 1997; Lerman, Kash, & Stefanek, 1994). However, when asked to compare their risk to that of others their own age with family history unspecified, a substantial portion of FDRs incorrectly rate their risk as lower than average (Aiken et al., 1995; Blalock et al., 1990). Harris and Smith (2005) found little understanding of communications of either absolute or comparative risk concerning health risks of low probability, and they recommended against providing information about comparative risk to communicate low risk.

Numeracy and Lay Understanding of Risk

The level of numeracy in the lay public, defined as "facility with basic probability and numerical concepts" (L. M. Schwartz et al., 1997) is critical in risk-related research (Fischhoff, Bostrom, & Quadrel, 1993), in the comprehension of risk (Reyna, Nelson, Han, & Dieckmann, 2009), and in treatment settings (L. M. Schwartz et al., 1997). Communications to the public about risk are often given in numerical terms; in turn, individuals' numerical estimates of perceived risk are taken as being meaningful assessments of perceived susceptibility. The lay public has difficulty with both comprehending and employing estimates of probability (Weinstein et al., 2007). Gigerenzer, Gaissmaier, Kurz-Milcke, Schwartz, and Woloshin (2008) highlight the pervasiveness of innumeracy among the lay and professional public and how risk communications obscure understanding.

Over four decades ago, a literature developed in applications of Bayesian decision theory in psychology (W. Edwards, Lindman, & Savage, 1963), which examined how individuals estimate the probability of events and revise their probability estimates based on new information. Two

principles emerged that may help to explain biases in the lay public's understanding of risk for cancer. First, people overestimate low probabilities and underestimate high probabilities (Mueller & Edmonds, 1967; see also Lichtenstein, Slovic, Fischhoff, Layman, & Combs, 1978). This finding may partially explain the overestimates of rates of specific cancers, which are low percentage on a cancer-by-cancer basis. Second, people are conservative in revising their estimates of probabilities in the face of new information (Phillips & Edwards, 1966), which may partially account for some failures of training to eradicate biases in perceived risk.

Substantial effort has been devoted to improving the communication of risk, including at the federal level by the U.S. National Cancer Institute (1999, 2003). Research has focused on approaches for communication of risk. Ancker, Senathirajah, Kukafka, and Starren (2006) reviewed the design of graphs for communicating health risk. Lipkus (2007) provided a comprehensive review of current practices for communicating health risks verbally, numerically, and visually. He concluded that at the present time there were few overall recommendations for risk communication strategies. In but two examples from a broad literature on risk communication, Galesic, Garcia-Retamero, and Gigerenzer (2009) provided an example of the exploration of effective graphical displays for risk communication; de Wit, Das, and Vet (2008) explored the use of objective statistics versus personal testimonials for increasing perceived personal risk. Lundgren and McMakin (2009) provide a comprehensive handbook on communication of risk.

Modifying Perceived Susceptibility and Cancer Distress Through Training

Interventions have aimed at modifying perceptions of susceptibility, once again, under the assumption that an accurate understanding of one's risk will serve as a motivator to cancer control and prevention–related activities. These interventions may aim either to increase or to decrease perceived susceptibility. Population targets of these interventions include individuals at high risk for cancer, among them FDRs of those with cancer, and also the population at large.

High-Risk Individuals

First-degree relatives of individuals with cancer may exhibit excessive perceived risk and associated high cancer distress associated with failure to follow screening recommendations (M. D. Schwartz et al., 2003). Interventions to reduce perceived susceptibility among FDRs have sometimes been successful (Alexander, Ross, Sumner, Nease, & Littenberg, 1995), though not in all cases (Bloom, Stewart, Chang, & You, 2006). However, women with high cancer distress benefit less from such susceptibility-focused interventions, suggesting that both cancer distress and inaccurate perceptions of risk must be simultaneously addressed (Lerman et al., 1995). Reductions in cancer distress have been achieved through individual counseling (Lerman et al., 1996; M. D. Schwartz et al., 1998). An important issue is whether clarifying that perceived risk is overestimated will lead to underutilization of mammography screening (M. D. Schwartz, Rimer, Daly, Sands, & Lerman, 1999).

General Population

The extent to which estimates of subjective risk can be made more accurate through intervention has also been explored in the general population (Weinstein & Klein, 1995), where perceived risk typically exceeds objective risk. Results have been mixed. Kreuter and Strecher (1995) reported increased accuracy in perceived risk (i.e., decreased perceived risk) for cancer in the general population following an educational intervention. Lipkus, Green, and Markus (2003) were able to increase perceived risk for colorectal cancer in a well-educated sample seen in a laboratory setting. However, providing risk information in the form of mailed pamphlets did not increase cancer worry in an older community sample (Robb et al., 2006), neither did the information on risk have any effect on perceived risk (Robb, Campbell, Evans, Miles, & Wardle, 2008). Both Quillin et al. (2004) and McCaul, Canevello, Mathwig, and Klein (2003) were able to modify perceived risk of developing cancer, but not to the substantially lower level indicated by the Gail epidemiological model. Lipkus

et al. (2004) attempted to increase understanding of risk factors for colorectal cancer (CRC) under the assumption that accurate risk attributions might motivate CRC screening in a population with elevated occupational risk for CRC. Greater knowledge of CRC risk factors exhibited small correlations with perceived risk.

Examination of relationships between objective and perceived risk and interventions to improve the accuracy of perceived risk rest on the assumption that levels of objective risk are known. This may be so at a population level or for strata (e.g., ethnic groups) within the population. However, at the individual level, models of cancer risk are becoming increasingly complex, incorporating biologic and genetic data with clinical and epidemiological risk factors. The U.S. National Cancer Institute workshop "Cancer Risk Prediction Models: A Workshop on Development, Evaluation and Application" highlights these complexities (Freedman et al., 2005).

PERCEIVED SUSCEPTIBILITY AND CANCER-RELATED BEHAVIOR

In this section we consider the relationships of perceived susceptibility to both screening for early detection of cancer and cancer-preventive behavior. A critical issue for health psychology is the implication of perceptions of susceptibility for protective behavior. As we have already indicated, models of health behavior conceptualize perceived susceptibility to disease as a distal construct in a mediational chain of constructs that eventuate in health behavior. Relationships of perceived susceptibility to behavior are likely to be complex, to be mediated, moderated, or nullified by other determinants of the particular behavior in question, determinants that we explore in our discussion of perceived susceptibility and protective behavior. Given space limitations, we do not provide a comprehensive review but reference and summarize existing reviews and highlight important themes (see Katapodi et al., 2004, and Vernon, 1999, for comprehensive reviews).

The Medical Context of Screening

A vast literature in the public health domain provides documentation of medical system determinants of the use of medically based cancer-screening tests. Health care coverage involves a usual source of care, age, and educational attainment, which are all associated with breast, colorectal, and cervical cancer screening (Meissner et al., 2009). Racial and ethnic disparities persist (Halbert & Wetter, 2008). Beyond financial and health system barriers, these disparities are associated with access, language and acculturation, literacy, and cultural beliefs (Peek & Han, 2004), as well as general mistrust of the health care system, racial profiling, and discrimination (Gerend & Pai, 2008). These variables set limits on the impact of psychosocial variables on screening utilization.

Temporal Issues in the Perceived Risk–Behavior Relationship

The nature of the relationship of perceived risk to behavior is more complex than a unidirectional conception of perceived risk as a force that motivates behavior. Brewer, Weinstein, Cuite, and Herrington (2004) suggest three hypotheses concerning the manner in which risk and behavior may be related, of which the first two propose opposite causal relations between perceived risk and behavior; the third is purely correlational. The behavior *motivation hypothesis*, consonant with models of health behavior, proposes that risk perceptions precede and increase protective action. The reverse is also possible, that taking health-protective action may lower actual risk, leading to a reduction in perceived risk, the *risk reappraisal* hypothesis. The third proposal, the *accuracy hypothesis*, holds that risk perception at any point in time accurately reflects one's level of risk behavior combined with other risk factors operating at that time. Much research linking risk perception to behavior is cross-sectional and correlative in nature and cannot distinguish among these hypotheses (Brewer et al., 2007).

For both prevention and detection, the cross-sectional relationship of perceived risk to behavior changes in complex ways as health innovations diffuse over time (Weinstein & Nicolich, 1993). When a health-protective behavior is first introduced, those who perceive themselves at the highest risk for the health threat may self-select the behavior, occasioning a strong positive correlation between perceived risk and behavior. If the behavior is screening, then perceived vulnerability to the occurrence of the disease should not diminish as the behavior is adopted, because screening is not, of course, preventive. In fact, perceived severity may diminish if people come to believe in the benefits of early detection for cancer survival. However, as a screening innovation is adopted broadly by the medical profession and increasing numbers of individuals are screened, the pool of screened individuals will contain individuals at lower perceived risk, thus diluting the correlation of perceived risk and screening. For preventive behavior, the initial self-selection of high-risk individuals may again result in substantial positive correlations between perceived risk and behavior. However, should the disease risk be mitigated or substantially lessened by the preventive behavior, then a negative correlation may, in time, be observed between perceived risk and behavior; thus those who reliably engage in the behavior may correctly perceive themselves to be at lower risk. (See Aiken et al., 1995, for a consideration of temporal factors in perceived and objective risk as related to mammography screening; see Gerrard et al., 1996, for a critical discussion of these relationships in the HIV/AIDS context.)

Perceived Susceptibility and Cancer Screening

In a review of cervical, breast, and colorectal cancer screening, Vernon (1999) highlighted inconsistent relationships of perceived risk to screening. McCaul, Branstetter, Schroeder, and Glasgow (1996) provided a meta-analysis of the relationship between perceived breast cancer risk and mammography screening, which has been extended by Katapodi et al. (2004). In a combined sample of 52,766 cases across studies, perceived risk exhibited a small significant correlation with mammography-screening adherence (see Katapodi, 2004, Table 9). When considered in the context of Leventhal's characterization of the lay representation of cancer, only perceived risk was associated with intentions to obtain a mammogram or to undergo genetic testing (Bowen et al., 2003). Perceived susceptibility is also associated with colorectal cancer–screening compliance (Brawarsky, Brooks, & Mucci, 2003; Weinberg, Turner, Wang, Myers, & Miller, 2004). Manne et al. (2003) reported a small correlation between perceived susceptibility and intentions for colonoscopy among FDRs with colon cancer. Perceived susceptibility is not a proxy for family history but predicts screening compliance above and beyond family history (Aiken, West, Woodward, & Reno, 1994). Perceived susceptibility also predicts intention to sun protect and to avoid sunbathing more strongly than does objective risk based on skin type (Jackson & Aiken, 2000). As we have argued, the relationship of perceived susceptibility to intentions and behavior has been found to be moderated by other psychosocial variables. Aiken, West, Woodward, and Reno (1994) found that susceptibility related to compliance with mammography screening only when perceived barriers to screening were low; under high perceived barriers, no such relationship was observed.

Fear, Worry, Cancer Distress, and Screening Behavior

In both the general population and in FDRs of individuals with cancer, fear of cancer, worry about cancer, and cancer distress have been associated with both insufficient screening and excessive screening, thus providing a plethora of conflicting results across studies.

General Population

In an extensive literature summary, Hay et al. (2005) reported both positive and negative cross-sectional relationships between worry and cancer screening. They argue that cross-sectional associations may reflect increased screening in response to worry or decreased worry as a result of negative test outcomes. In a meta-analysis of longitudinal studies including both the

general population and high-risk individuals, Hay, McCaul, and Magnan (2006) reported an averaged weighted correlation of .12 of cancer worry with subsequent screening. However, in an inner-city population, an inverted U-shaped relationship was observed; moderate worry about breast cancer was associated with greater attendance at a first mammography screening than was either extreme (Sutton, Bickler, Sancho-Aldridge, & Saidi, 1994). The same inverted U-shaped relationship was observed between BSE frequency and breast cancer worries (Lerman et al., 1991).

Ethnic and demographic differences in the association between emotional aspects of cancer and screening have yielded inconsistent results. Among older low-income Mexican American women, fear of and fatalism about cancer were associated with lower Pap smear rates (Suarez, Roche, Nichols, & Simpson, 1997), as was fear of cancer among a wide range of low-acculturated Hispanic women (Coronado, Thompson, Koepsell, Schwartz, & McLerran, 2004). Worry negatively related to mammography screening among African American women (Friedman et al., 1995) but positively in a noteworthy study of the role of emotional characteristics to screening in six urban-residing ethnic groups (Consedine, Magai, & Neugut, 2004). In a sample with a substantial inner-city component, Bastani et al. (1994) reported a strong negative association between fear of finding breast cancer and screening; similar findings were reported for cervical screening among rurally residing women (Coronado et al., 2004).

High-Risk Individuals

There is debate coupled with conflicting results as to whether cancer worry and cancer-specific distress increase or decrease screening among high-risk individuals. Among women who had just received a biopsy for breast cancer diagnosis, a third of the women, those most distressed, did not pursue medical follow-up (Andrykowski et al., 2001). An inverted U-shaped relationship between cancer worry and mammography screening has been observed in a higher risk community sample (Andersen, Smith, Meischke, Bowen, & Urban, 2003). Ovarian cancer worries among FDRs have been positively associated with screening (M. D. Schwartz, Lerman, Daly, et al., 1995). In contrast, high breast cancer distress (i.e., extreme worry, intrusive thoughts about breast cancer) among FDRs is associated with reduced screening (Lerman et al., 1993; see also Kash, Holland, Halper, & Miller, 1992; Lerman et al., 1994), though the opposite has also been found (Stefanek & Wilcox, 1991). Most studies are cross-sectional, posing difficulty in directional interpretation between distress and screening. Among a community sample of FDRs of women with breast cancer, M. D. Schwartz et al. (2003) showed that together cancer worry and general distress both negatively predicted screening at 12-month follow-up. Cancer distress among FDRs of women with breast and ovarian cancer is associated with high perceived risk of cancer and low perceived control over cancer development (Audrain et al., 1997).

Conflicting Findings and the Elusive Inverted U-Shaped Function

In the classic fear communication literature, Janis and Feshbach (1953) argued that fear served as a positive motivator for protective behavior up to some critical level of fear. Above that critical fear level, avoidance of the threat was expected to replace protective behavior, yielding an inverted U-shaped relationship between level of fear and behavior. If this U-shaped relationship exists, then in general community samples with very few highly distressed individuals, the relationship of worry to screening would be positive; it would reverse only in samples with a substantial representation of at-risk highly distressed individuals, as in the findings of M. D. Schwartz et al. (2003). The meta-analyses of susceptibility and worry in relation to screening cited here have included a predominance of individuals who are not at extreme high risk (Hay, McCaul, & Magnan, 2006; Katapodi, 2004; McCaul, Branstetter, et al., 1996); here, positive relationships of perceived risk and cancer worry to screening have been observed. Consedine, Magai, Krivoshekova, Ryzewicz, and Neuget

(2004) provide a critical review of fear, anxiety, and worry in relation to breast cancer screening; they caution that the specificity of fears is critical for the direction of relationship to screening.

INTERVENTIONS TO INCREASE SCREENING

In this section we address interventions to increase cancer screening and, more specifically, attempts to link manipulations of perceived susceptibility to increased screening. There is a vast literature on mammography screening and a newer literature on colorectal screening. Experimental interventions provide the vehicle for untangling the causal impact of such putative determinants as perceived vulnerability on cancer-protective behavior. They potentially speak to the temporal issues in the relationship between perceived susceptibility and screening raised by Brewer et al. (2004). We provide a brief review of screening interventions, particularly those involving tailored messages.

From the perspective of health psychology, theory-based interventions that employ such models as the HBM to design program components are most of interest because they potentially permit us to link changes in constructs in the model (e.g., perceived susceptibility) to changes in screening behaviors. A number of early mammography-screening interventions included components designed to increase perceived susceptibility to breast cancer (e.g., Aiken, West, Woodward, Reno, & Reynolds, 1994; Champion, 1994; Curry, Taplin, Anderman, Barlow, & McBride, 1993; Rimer et al., 1992; Skinner, Strecher, & Hospers, 1994; Zapka et al., 1993). In some studies, the perceived susceptibility component was only one small part of a large complex intervention, and no attempt was made to establish a direct linkage from this component to behavioral outcomes (Champion, 1994; Rimer et al., 1992; Zapka et al., 1993).

Tailored Interventions

With advances in computer technology, a newer generation of tailored intervention has emerged. Tailoring of messages is defined as "any combination of strategies and information intended to reach one specific person, based on characteristics that are unique to that person, related to the outcome of interest, and derived from an individual assessment" (Kreuter, Farrell, Olevitch, & Brennan, 2000, p. 277). From the perspective of perceived susceptibility, the provision of tailored risk information would theoretically modify perceived susceptibility in service of increasing cancer detection and prevention–related behaviors. Early studies of tailored messages (Curry et al., 1993) showed that providing tailored personal objective risk information to FDRs of breast cancer victims increased screening; the same result was reported by Skinner et al. (1994) in a community sample.

Three meta-analyses have addressed the relationship of individualized tailoring of interventions to screening. In a Cochrane review of 13 interventions that communicated individualized risk information, including 10 mammography programs (A. Edwards, Unigwe, Elwyn, & Hood, 2003), individualized risk communication was associated with increased screening (odds ratio = 1.5, 95% CI: 1.11–2.03). However, a reduction in screening was noted in the two interventions that provided the most detailed risk estimate information. This meta-analysis provided no information as to the relationship of perceived susceptibility (rather than objective risk information provided) to screening. In a more recent meta-analysis of 57 behavior change interventions, the 13 interventions for mammography, colorectal, or cervical (PAP) screening yielded a positive effect size (r = .083, 95% CI: .069–.097) of tailored messages over generic messages on screening (Noar, Benac, & Harris, 2007). Across all 57 interventions, the presence of perceived susceptibility as a component of the intervention was associated with a smaller effect size than not having this component (r = .043, 95% CI: .031–.055; versus r = .100, 95% CI: .089–.111, respectively). A third meta-analysis of tailored interventions to promote mammography screening (Sohl & Moyer, 2007) showed a small positive effect of tailoring on screening (odds ratio = 1.42, 95% CI: 1.27–1.60) and also reported that interventions that used the health belief model (which includes perceived susceptibility as a key

construct) were associated with higher screening rates (weighted aggregate odds ratio for interventions tailored based on the complete HBM = 3.33).

That Noar et al. (2007) reported a smaller effect size for tailored interventions that included a perceived susceptibility component led us to review in detail the 13 articles from the meta-analysis that targeted mammography, colorectal, or cervical screening. Among these articles, Rimer et al. (2001, 2002) communicated to each participant her own Gail risk score for breast cancer and any specific factor (e.g., nullparity) that led to her particular elevated risk. The intervention substantially reduced the initial great overestimation of breast cancer risk by participants. However, perceived risk following the tailored intervention did not relate to increase in screening. Similarly, Bastani, Maxwell, Bradford, Das, and Yan (1999) found perceived risk to be unrelated to screening. Others of the interventions targeted specific cancer risk in individualized communications but did not provide information that could relate perceived risk to screening. Recent tailored colorectal-screening interventions (Glanz, Steffen, & Taglialatela, 2007; Lipkus, Skinner, et al., 2005) reported increases in perceived risk as a function of intervention but no association between perceived risk and screening. Finally, recent tailored interventions for mammography and colon cancer screening (Champion et al., 2007; Rawl et al., 2008) integrated perceived risk manipulations into tailored messages but did not report the impact on perceived susceptibility or the relationship of perceived susceptibility to screening.

MEDIATION ANALYSIS: UNCOVERING HOW INTERVENTIONS INDUCE CHANGE

It is apparent from the brief review of interventions to increase screening, particularly tailored interventions, that there is a great opportunity to assess not only whether interventions increase screening but also to examine the mechanisms by which interventions have brought about behavior change. Mediation analysis provides a vehicle for uncovering these mechanisms of change (Aiken, in press; MacKinnon, 2008; West & Aiken, 1997). Mediation analysis is a class of statistical procedures employed to establish chains of relationships among a series of constructs. For mediation analysis of interventions, we examine chains from the intervention through one or more constructs (e.g., perceived susceptibility to a disease, perceived benefits of a health action) to some outcome (e.g., mammography screening). We present mediation analyses of three interventions from our own laboratories. These three examples cover the classes of cancer-related behavior we identified at the outset of the chapter: cancer screening, protective behaviors, and new HPV vaccination. Our examples illustrate how mediation analysis characterizes the mechanisms underlying an intervention, with particular emphasis on the role of perceived susceptibility.

We note several other examples of the use of mediation analysis in recent cancer-screening literature. Manne et al. (2003) provide an example of a mediation analysis of a psychosocial study of intention to undergo colonoscopy. Hall, French, and Marteau (2009) provide a mediation analysis of interventions for smoking cessation; Reynolds, Buller, Yaroch, Maloy, and Cutter (2006), for sun protection.

Intervention Design and Measurement Requirements for Mediation Analysis

In order to test the theory of an intervention through mediation analysis, the following are required: (a) a specified theoretical model on which the program will be built, (b) a measurement instrument that provides distinct measures of each construct in the model that will serve as a mediator, (c) a translation of each construct of the model into a distinct component of the intervention, (d) assessment of postintervention levels on each of the constructs targeted in the model in an experimental group versus a control group (with adequate statistical control of pretest levels), and (e) measurement of the outcome. West and Aiken (1997) summarize the conditions that must be met in order to demonstrate that a putative mediator is associated with or produced

change in the outcome, as specified by Judd and Kenny (1981), Baron and Kenny (1986), and MacKinnon (2008).

Mediation Analysis of a Mammography-Screening Intervention

Aiken, West, Woodward, Reno, et al. (1994) implemented an HBM-based mammography intervention, with individual program components that targeted each of the four HBM constructs: perceived susceptibility, severity, benefits, and barriers. We used mediation analysis to test the linkages from an intervention through intermediate *mediators* (the HBM components) to mammography compliance. We amended the HBM by assessing intentions for screening at immediate posttest, as well as actual compliance 3 months following the intervention. We established paths from perceived susceptibility and perceived benefits to intentions and established a strong link from intentions to subsequent screening. The role of perceived susceptibility in the causal chain from intervention through compliance is of interest here. Our model of the impact of HBM constructs on outcomes is illustrated in Figure 6.1. It differs from typical characterizations of the HBM in that the four HBM constructs are not treated as coequal predictors of the outcome. Rather, following Ronis (1992), we specified a model in which perceived susceptibility and perceived severity were antecedents of perceived benefits, under the assumption that a woman would not perceive the benefits of mammography screening unless she felt threatened (perceived susceptibility plus severity) by breast cancer. Again following Ronis (1992), we specified that the effect of perceived susceptibility on the outcome would be mediated through perceived benefits—that is, that the effect of susceptibility would be an *indirect effect* through benefits—in the following causal sequence: intervention → susceptibility → benefits → intentions → behavioral steps to mammography compliance. This mediational chain was supported. In addition, we observed a *direct path* from susceptibility to intentions: intervention → susceptibility → intentions. The size of the indirect effect of susceptibility, over and above the direct effect, was substantial. The full details of the mediation analysis, including our explorations of possible roles for perceived susceptibility, are provided in West and Aiken (1997). What is criti-

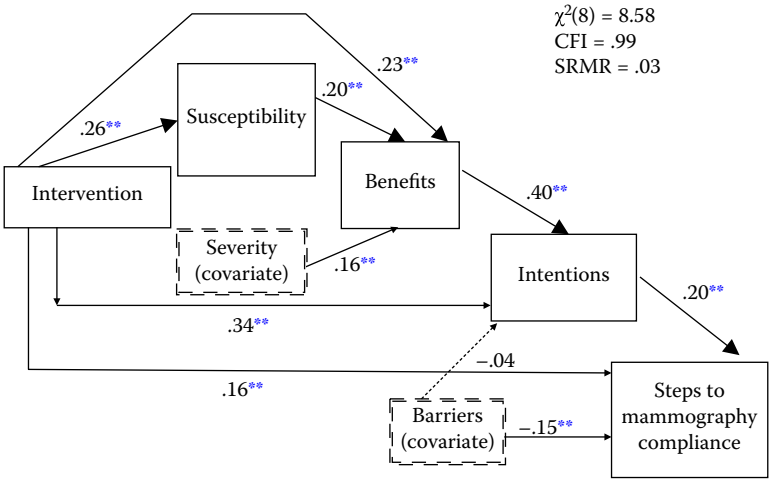

FIGURE 6.1 Mediation analysis of the impact of a health belief model (HBM)–based intervention on compliance with mammography-screening recommendations. The indirect mediational path from intervention to perceived susceptibility through perceived benefits to intentions for screening illustrates how perceived susceptibility serves as an apparent precursor to benefits in the HBM. For paths, ** $p < .01$. (Modified from Aiken, L. S., West, S. G., Woodward, C. K., Reno, R. R., and Reynolds, K. D., *Health Psychology*, *13,* 534, 1994. With permission.)

cal here is a conception of perceived susceptibility at the outset of a causal chain that flows through other constructs.

Mediation Analysis of a Sun Protection Intervention

Jackson and Aiken (2006) provided a mediation analysis of a sun protection intervention designed to increase sun protection and decrease sunbathing. Given a youthful female population, the intervention targeted susceptibility to photoaging as a proximal damaging effect of sun exposure. Jackson and Aiken (2006) provided full details of the mediation analysis, which is illustrated in Figure 6.2. The analysis illustrates a powerful role for perceived susceptibility to photoaging. The link from intervention to susceptibility to benefits to intentions was again observed, consistent with Aiken, West, Woodward, Reno, et al. (1994). In addition, there was a link from intervention to susceptibility to both intention to sunbathe and to sun protect and also to hours of sun bathing and of sun protection of the face and body. Mediation analysis offered a characterization of the rich, multifaceted role of perceived susceptibility in effecting behavior change.

Perceived Susceptibility and HPV Vaccination

Studies of the new HPV vaccination have examined both the acceptability of the vaccine and the initiation of use as a function of perceived susceptibility to HPV infection. Reiter, Brewer, Gottlieb, McRee, and Smith (2009) found parents' perceived risk for their daughters contracting HPV was associated with initiation of the HPV vaccination among their daughters. Gerend, Shepherd, and Monday (2008) examined the effect of message framing on acceptability of the HPV vaccination. Gain-framed messages highlight the benefits of a health-protective action, whereas loss-framed messages characterize the negative consequences of failure to adopt the action. As explained by Gerend et al. (2008), loss-framed messages are expected to engender increased perceptions of risk and severity of consequences, which should serve as a mediator from the message to action. Gerend

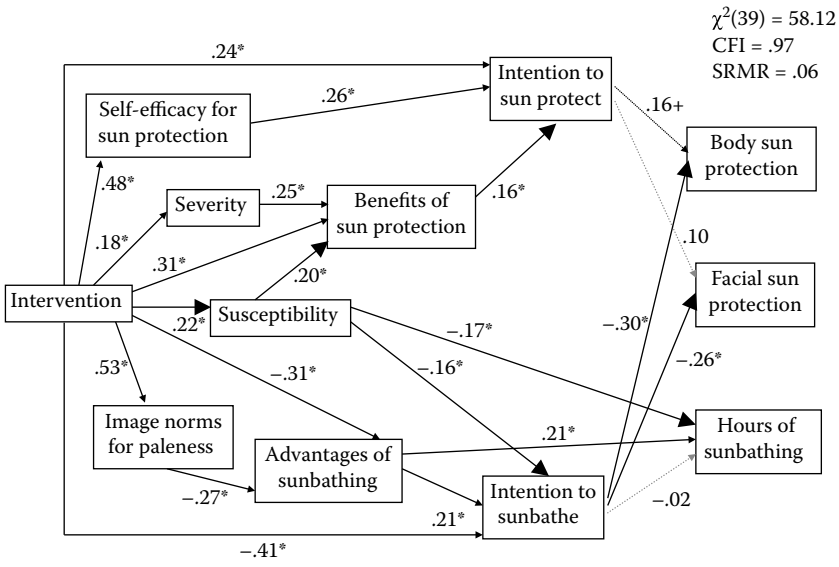

FIGURE 6.2 Mediation analysis of the impact of a hybrid model–based intervention on sun protection and sunbathing. Perceived susceptibility serves as mediator from the intervention to perceived benefits to intentions for sun protection and also through intention to sunbathe to sun protection, and directly to sunbathing. (Modified from Jackson, K. M. and Aiken, L. S., *Health Psychology*, *25,* 42, 2006. With permission.)

et al. (2008) found support for a mediational role of perceived susceptibility to HPV in accounting for the acceptability of HPV vaccination among college-aged women. Gerend et al. (2008) provide an extensive discussion of the role of message framing in health behaviors that are effortful over time as opposed to being one-shot behaviors. They expand on an earlier review by Rothman and Salovey (1997). Earlier studies of message framing for cancer-related behavior include Meyerowitz and Chaiken (1987), Rothman, Salovey, Antone, Keough, and Martin (1993), and Banks et al. (1995) for breast self-examination, skin protection, and mammography utilization, respectively.

THE NEED FOR MEDIATION ANALYSIS OF INTERVENTIONS: IDENTIFYING PROCESSES UNDERLYING HEALTH-PROTECTIVE BEHAVIOR

We end with a message to our colleagues about the utility of the examination of interventions to uncover the processes that lead to behavior change. A powerful conception of perceived susceptibility in models of health behavior is that perceived susceptibility stands at the outset of a causal chain that flows through other constructs to health behavior. Clearly, tailored interventions that provide individualized information about risk factors implicitly assume that knowledge of risk factors will lead to modified perceptions of perceived vulnerability that will in turn lead to enhanced health protection through early detection and preventive action. Consideration of mediational chains from intervention to perceived susceptibility to behavior or through other constructs to behavior is critical for advancing our understanding of how health behaviors accrue. Examination of both the direct effect and the indirect effects of susceptibility through other variables on behavior is required to estimate accurately the total effect of perceived susceptibility on health-protective behavior. Examining only the direct effects of susceptibility on intentions or behavior may obscure the role of perceived susceptibility in the behavioral compliance process, potentially leading to underestimates of the total effect of perceived susceptibility on behavior.

What we argue here is not at all limited to perceived risk. Our understanding of whether, how, and to what extent many individual variables operate in determining health-protective behavior is best advanced through the evaluation of model-based interventions, with research structured so that mediation analysis of the effects of putative determinants of behavior can be accomplished (Aiken, in press; West & Aiken, 1997). A distinguishing feature of psychology as a discipline is our strength in theory and experimentation. Thus, health psychologists may provide a special role in health behavior research, providing careful theory testing in controlled settings and placing the refinement of our models of health behavior on a strong empirical base.

CONCLUSION

We conclude where we began, with the theoretical perspective that perceived susceptibility to disease is an important early force in the adoption of health-protective behavior. We caution researchers who seek high correlations of perceived susceptibility with behavior that even when individuals perceive themselves at high risk for a threat to health, other forces mediate and moderate and even nullify the susceptibility–behavior relationship. Critical to the link of perceived susceptibility to behavior is an effective vehicle to mitigate threat. Levanthal's (1970) theorizing over four decades ago rings true—that people who perceive themselves to be at risk will act to protect their health if there is an effective action to be taken, but that they will deny the risk if there is no protective action available. Stated otherwise, the availability of an effective health-protective action moderates the relationship of perceived susceptibility to behavior; the absence of an effective health-protective behavior nullifies the impact of perceived susceptibility. We have seen repeatedly in our own intervention research that perceived benefits of a health action mediate the relationship of perceived susceptibility to health-protective behavior. Even when there is effective protective action, barriers to that action (e.g., access to appropriate medical care, difficulty of carrying out the protective behavior itself) moderate the relationship of perceived susceptibility to health-protective behavior.

There are added complexities in uncovering and understanding the relationship of perceived susceptibility to health-protective behavior. Temporal issues abound—when a health-protective action first becomes available (e.g., mammography screening), the early adopters may be those who perceive themselves at greatest risk. Later, when adoption is widespread, it may be those who have not taken protective action who feel most at risk; thus the correlation between perceived susceptibility and behavior may change from positive to negative over time. The measurement of perceived susceptibility is fraught with challenges—these include the innumeracy of the public and the multiple approaches to measurement. In our own work we have shown that one commonly used measure of perceived susceptibility correlates negatively with behavior if the prevalence of the health risk is high (Ranby et al., 2010); the reason for this anomaly lies in the measurement strategy. Better approaches to communicating and assessing perceived susceptibility are needed. Perceptions of risk are multiply determined, with correlates based in the threat itself (e.g., preventability of the threat), in heuristic thinking (e.g., availability of a positive instance), and individual characteristics (e.g., neuroticism). Other factors, among them worry about a particular disease, often associated with a strong family history, contribute complexity to defining a distinct role for perceived susceptibility.

Despite the challenges to uncovering the role of perceived susceptibility to health-protective behavior, the vast existing literature and our own intervention research program lead us to conclude that perceived susceptibility is, in fact, an important distal force in a chain of constructs leading to health behavior. The strongest tests of hypotheses concerning the role of perceived susceptibility are implemented in the context of randomized trials of interventions that are specifically designed to permit mediation and moderation analyses of the putative mechanisms through which perceived susceptibility may shape health-protective behavior.

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