Risk Perceptions and Their Relation to Risk Behavior

Noel T. Brewer, Ph.D., Neil D. Weinstein, Ph.D., and Cara L. Cuite, Ph.D.
Rutgers University

James E. Herrington, Jr., Ph.D., M.P.H.
Centers for Disease Control and Prevention

ABSTRACT

Background**: Because risk perceptions can affect protective behavior and protective behavior can affect risk perceptions, the relations between these 2 constructs are complex and incorrect tests often lead to invalid conclusions.* ***Purpose: *To discuss and carry out appropriate tests of 3 easily confused hypotheses: (a) the behavior motivation hypothesis (perceptions of personal risk cause people to take protective action), (b) the risk reappraisal hypothesis (when people take actions thought to be effective, they lower their risk perceptions), and (c) the accuracy hypothesis (risk perceptions accurately reflect risk behavior).* ***Methods:*** *Longitudinal study with an initial interview just after the Lyme disease vaccine was made publicly available and a follow-up interview 18 months later. Random sample of adult homeowners (N = 745) in 3 northeastern U.S. counties with high Lyme disease incidence. Lyme disease vaccination behavior and risk perception were assessed.* ***Results:*** *All 3 hypotheses were supported. Participants with higher initial risk perceptions were much more likely than those with lower risk perceptions to get vaccinated against Lyme disease (OR = 5.81, 95% CI 2.63–12.82, p < .001). Being vaccinated led to a reduction in risk perceptions,* $\chi^2(1, N = 745) = 30.90, p < .001$, *and people vaccinated correctly believed that their risk of future infection was lower than that of people not vaccinated (OR = .44, 95% CI .21–.91, p < .05).* ***Conclusions:*** *The behavior motivation hypothesis was supported in this longitudinal study, but the opposite conclusion (i.e., that higher risk led to less protective behavior) would have been drawn from an incorrect test based only on cross-sectional data. Health researchers should take care in formulating and testing risk-perception-behavior hypotheses.*

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INTRODUCTION

Perceived risk—also called perceived *probability, likelihood, susceptibility*, or *vulnerability*—is a central construct in most theories of health behavior (for reviews, see 1,2). This construct is typically assessed through self-report with a question such as, "What is your chance of getting Lyme disease in the next year?"

These health behavior theories agree that a high perceived risk of harm should encourage people to take action to reduce their risk (1–3). Although this implied positive relation between perceived risk and subsequent protective behavior is observed in many empirical studies, it is often weaker than expected. Some studies, however, find no association or even a negative one (4,5). Such inconsistency may cause some researchers to question the role of perceived risk in health behavior.

We argue in this article that the inconsistent findings are, at least in part, due to inadequate specification of the links between risk perception and behavior, to improper measurement (5), and to incorrect interpretations of data. To clarify these issues, we briefly discuss the measurement of risk perception, describe three distinct hypotheses (all of which relate perceived risk to health behavior), and test these hypotheses with data from a study of Lyme disease vaccination.

Measuring Risk Perception

The first paragraph of this article ends with an example of a typical risk perception question. The question specifies three essential aspects of risk perception, but it misses a fourth. The question indicates who is at risk (you), for what hazard (Lyme disease), and over what period of time (the next year). What is left unspecified is the person's own behavior. In the question's present, ambiguous form, people may or may not factor into their risk estimate any changes in behavior that they anticipate in the next year. For example, a woman might report that her risk for Lyme disease is low, thinking that she plans to start using tick repellent when she visits wooded areas. Despite her report of low risk, she knows that her risk would be high without the tick repellent. Another woman might say her risk is low because she is unaware that ticks carrying Lyme disease are found in her neighborhood. This second woman's risk judgment is not predicated on any future behavior, and she would probably have little interest in protective measures. Thus, two people with the same response to a risk question—"My risk is low"—could have very different degrees of interest in protective measures because the risk assessment left unspecified important behavioral and temporal factors (6). As these examples demonstrate, questions about future risk that omit any mention of behavior can confound risk perceptions with intentions. An improved question

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Reprint Address: N. Brewer, Ph.D., Department of Psychology, Rutgers University, 152 Frelinghuysen Road, Piscataway, NJ 08854. E-mail: brewer@aesop.rutgers.edu

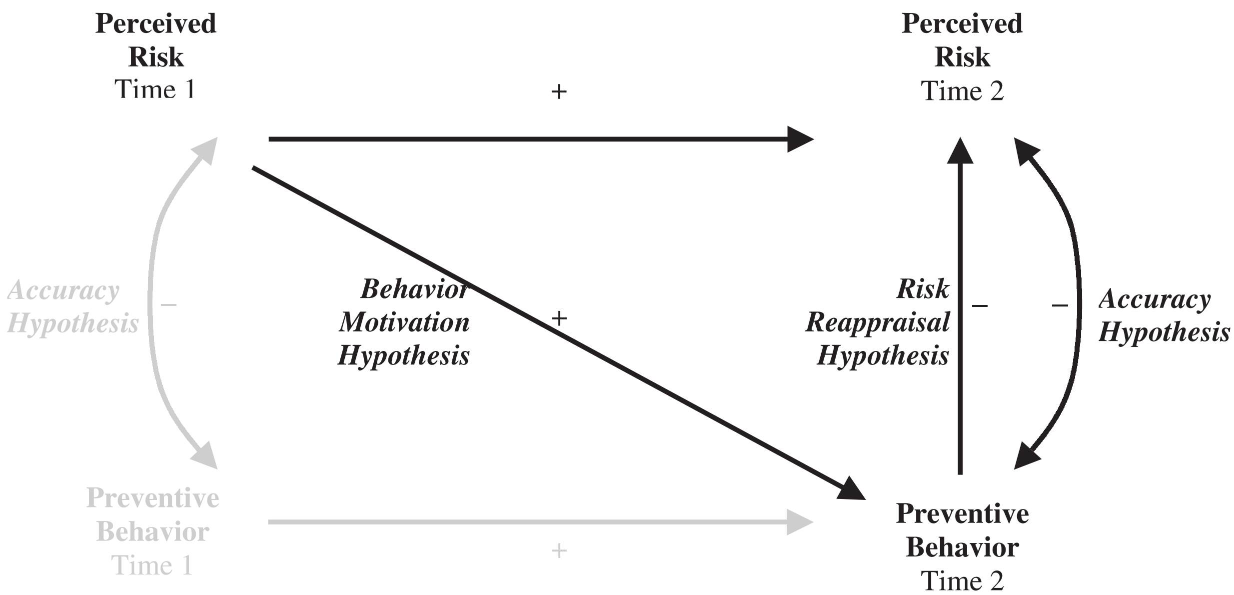

FIGURE 1 A model of risk perception and risk behavior. Pathways in gray are included for completeness but are not examined in our study. Straight lines indicate causal relations and curved lines indicate noncausal relations. Four of the six pathways are labeled with names of hypotheses about the relation of risk perception and behavior. The signs (i.e., + or –) indicate a positive or a negative relation. For example, the accuracy hypothesis is represented by a negatively signed, curved pathway to indicate that higher levels of risk perception are expected to accompany lower levels of preventive behavior but that the causal direction of the relation cannot be determined.

would be, "If you don't change any Lyme related behaviors, what is your chance of getting Lyme disease in the next year?"

Three Risk Perception/Risk Behavior Hypotheses

Tests of the relation between personal risk perception and risk behavior can address any of three distinct hypotheses (4,7,8). Here, we call them the *accuracy hypothesis*, the *behavior motivation hypothesis*, and the *risk reappraisal hypothesis*. The relation tested in each hypothesis is shown in Figure 1, using the example of a risk-*reducing* behavior[1] (e.g., smoking cessation, vaccination). If all three hypotheses were true, the signs of the correlations would be as shown in the figure. As we see, each hypothesis requires a different statistical test, and two of the three can only be tested with longitudinal data.

Accuracy hypothesis. Holding other risk factors constant, people who engage in risky behaviors have higher actual risk and should have higher perceived risk. The accuracy hypothesis asserts that perceptions of risk at any given time properly reflect one's risk behaviors and other risk factors at that time. For example, one might want to know whether the people who believe they have a low risk of contracting Lyme disease are truly correct. The accuracy hypothesis is a descriptive statement about the relation between risk perceptions and behavior but does not imply any causal connection between these constructs. This hypothesis is typically tested by examining the simple correlation between risk behaviors and risk judgments at a single point in time. In Figure 1, this correlation is indicated by the curved arrows within Time 1, or within Time 2, that connect risk perceptions with behavior. Because the test requires only cross-sectional data, the correlation is widely reported. Unfortunately, this correlation is often misinterpreted as a test of the behavior motivation hypothesis described next.

A more complete test of accuracy would go far beyond the sign and significance of the correlation coefficient. It would compare risk estimates made on a numerical scale of probability with a quantitative model of risk that contains the full range of known risk factors, such as the Gail model for breast cancer (9,10).

Behavior motivation hypothesis. The behavior motivation hypothesis describes the effects of perceptions of risk on *changes* in behavior. As mentioned earlier, most models of health behavior endorse the motivation hypothesis (4), which states that elevated risk today leads to increased preventive behavior (i.e., to a change in behavior) in the future. This is a hypothesis about cause (perceived personal risk) and effect (change in behavior thought to affect risk). Although not always stated explicitly, there is a clear temporal order here and testing the hypothesis requires a longitudinal design that measures risk perception at one time and behavior at a later time. In Figure 1, the causal connection is indicated by the diagonal pathway linking risk perceptions at Time 1 and preventive behavior at Time 2. An example of the type of thought captured by the motivation

[1]Risk-reducing behaviors are assumed to have been engaged in recently enough to remain protective. In some cases, a one-time risk-reducing behavior will have been engaged in substantially prior to measurement (e.g., 2 years ago, received a vaccine believed to offer lifetime protection). In other cases, the behavior will be ongoing, recent, or both (e.g., stopped smoking 2 years ago and continue to not smoke).

hypothesis is, "I feel at risk for Lyme disease, so I'll get vaccinated."

Risk reappraisal hypothesis. The risk reappraisal hypothesis describes the effects of changes in behavior on changes in perceived risk. It says that if an action is believed to reduce risk, people who take the action will lower their personal risk perceptions (i.e., increasing preventive behavior leads to decreased perceived risk). Testing the reappraisal hypothesis requires a longitudinal design with risk perception and behavior assessed at an initial date and then reassessed at a later date. The risk reappraisal hypothesis is indicated in Figure 1 by the straight pathway connecting preventive behavior at Time 2 to risk perceptions at Time 2. An example of the type of thought captured by the reappraisal hypothesis is "Now that I am vaccinated, my risk is lower." Note that risk perceptions may change not only after preventive action but also *in anticipation of* preventive action (e.g., "I don't think I will get Lyme disease because I plan to get vaccinated"). For this reason, risk questions need to specify a behavioral context.

There is no reason to expect that precautions will be seen as eliminating risk entirely. People who felt at high risk and were prompted to action may or may not lower their risk perceptions below those of people who felt at lower risk. Consequently, in a particular context, it is possible that the behavior motivation hypothesis will be true (i.e., people high in perceived risk are more likely to act) and the reappraisal hypothesis will be true (i.e., people who act lower their perceived risk), even though the accuracy hypothesis will be false (i.e., people who act still have higher risk perceptions than those who do not act). This discussion implies that the correlation assessing accuracy can be positive, negative, or zero depending on the initial risk beliefs of those who act and on how much those perceptions are reduced after action. Misuse of the cross-sectional accuracy correlations to test the behavior motivation hypothesis can appear to demonstrate that risk perceptions facilitate action, impede action, or have no affect, even when the motivation hypothesis (risk perceptions facilitate action) is in fact true.

This Study

We conducted a study that tests the three hypotheses just described. The project investigated a novel preventive health behavior—Lyme disease vaccination. We used a two-wave longitudinal design with the first wave of data collection timed to begin shortly after the vaccine was approved for public use (11). The vaccine was reported to be approximately 80% effective for healthy adults (12). A particular benefit of this design is that all participants had the same initial status on our behavioral criterion (i.e., all were unvaccinated). Thus, there was no need to control for prior behavior when testing any hypothesis.

The study's predictions were derived from the hypotheses presented earlier. From the behavior motivation hypothesis, we predicted that the people who perceived themselves to be at high risk for Lyme disease at Time 1 would be those more likely to have been vaccinated by Time 2. From the risk reappraisal hypothesis, we predicted that those who became vaccinated by Time 2 would show a decrease in risk perceptions between Time1 and Time 2. Finally, the accuracy hypothesis predicted that at Time 2 perceived risk would be negatively related to vaccination status.

METHOD

Participants

Using random-digit dialing, we recruited adult homeowners in three counties of the northeastern United States with high Lyme disease rates: Middlesex County, CT; Putnam County, NY; and Hunterdon County, NJ. Time 1 interviews took place in spring 1999. Participants were screened to make certain that they had not been vaccinated against Lyme disease but had heard about the new vaccine. The interview completion rate (taking into account people who were theoretically eligible but could not be contacted) was 45%, yielding a total sample size of 1,005. Participants were interviewed again for Time 2 in fall 2000. The follow-up completion rate was 74% yielding a final sample of 745.

Respondents were more likely to be women (60%) than men, had a mean age of 42 (range = 20–70), and were primarily White (94%). They were well-educated, with three quarters having had at least some college. Just over half of participants (55%) had children. People who participated only in the first wave did not differ from those who participated in both waves in county of residence, education, income, or number of children. The two groups did differ on several measures. Complete data were more likely to be obtained from respondents who were older ($M = 42$ vs. 38 years), $t(998) = 3.84$, $p < .001$; White (94% vs. 88%), $\chi^2(1, N = 1{,}005) = 11.30$, $p < .001$; and women (60% vs. 52%), $\chi^2(1, N = 1{,}005) = 5.48$, $p < .05$. Missing data for participants who did not report age ($n = 4$), education ($n = 2$), or both ($n = 3$) were replaced by the mean values.

Procedures and Measures

Interviews were conducted by telephone. At Time 1, participants estimated their risk for Lyme disease and answered other questions about themselves and their perceptions of Lyme disease. To assess perceived risk, interviewers stated, "Let's say that you do not get the Lyme vaccine. What do you think the chance would be that some time in the future you would get Lyme disease? Do you think that it's likely or that it's unlikely that you would get Lyme disease in the future?" (Several other risk questions that used different response scales—a six-choice, percentage scale and a five-choice, verbal category scale—were also asked at Time 1. All risk questions gave the same results when the three hypotheses were tested. The dichotomous measure was both the simplest and the best predictor of behavior. Because our primary goal is to discuss the different hypotheses rather than to describe the empirical data, only the calculations based on the dichotomous scale are presented here.)

At Time 2, participants were asked whether they had received at least one of the three inoculations that make up the Lyme disease vaccination regimen and were again asked to estimate their risk for Lyme disease (dropping the sentence, "Let's say that you do not get the Lyme vaccine" if they had already been vaccinated).

Some people were unable to categorize their risk using the unlikely–likely dichotomy ($n = 48$ at Time 1; $n = 71$ at Time 2). An examination of their responses on other measures of risk perception suggested that they felt themselves to be at moderate risk (e.g., they selected 50% or "have equal change of getting it or not getting it" on the other risk scales). As a conservative measure, we randomly assigned the responses "unlikely" or "likely" to these individuals in proportion to the distribution of the other participants' responses. Analyses that simply omitted respondents who had missing values on this question, or that assigned them a risk perception intermediate between unlikely and likely, yielded risk perception–vaccination behavior associations that were the same as or slightly larger than those reported next.

RESULTS

At Time 2, 6% ($n = 46$) of respondents had received the Lyme vaccine. The statistical tests of our three hypotheses controlled for age, gender, education, and ethnicity by including these variables as covariates (although analyses without demographic covariates yielded similar findings). Income was not included because a large number of people declined to answer the question ($n = 145$). However, including income in those cases where it was available did not alter the results. Analyses that also controlled for environmental risk factors (e.g., deer sighted near home, pets having ticks) and risk preventive behaviors (e.g., wearing long pants, using tick repellant) showed the same pattern of results as those without these variables. These control factors are not mentioned again.

Behavior Motivation Hypothesis

The behavior motivation hypothesis was supported by the data. People who at Time 1 perceived their risk to be high were more likely to have been vaccinated by Time 2. Because vaccination behavior was a dichotomous outcome, we used a logistic regression analysis to test the hypothesis that the Time 1 risk judgment predicted being vaccinated by Time 2. There was no need to control for Time 1 vaccination behavior as only those people unvaccinated at Time 1 were included in the study. The calculations showed a significant positive relation between the Time 1 risk and Time 2 behavior (OR = 5.81, 95% CI 2.63–12.82, $p < .001$). Of those who said at Time 1 that they were at high risk, 10% were vaccinated against Lyme disease by Time 2, compared to 2% of those who said they were at low risk.

Accuracy Hypothesis

The accuracy hypothesis was also supported. In this test, a logistic regression was used to predict the Time 2 risk judgment from vaccination status assessed at Time 2. As predicted, there was a significant negative relation between the two (OR = .44, 95% CI .21–.91, $p < .05$). People who had been vaccinated perceived themselves to be at lower risk at Time 2 than people who had not been vaccinated. Of those who were vaccinated, 22% still said at Time 2 that they were likely to get Lyme disease, compared to 40% of those who remained unvaccinated. (It was not possible to test the accuracy hypothesis at Time 1 because there was no variation in vaccination behavior among those included in the study.)

Risk Reappraisal Hypothesis

The risk reappraisal hypothesis was supported. A crude test of this idea would focus on people who acted between Time 1 and Time 2 and look for a decrease in their risk perceptions (e.g., a difference in mean values) between these two times. However, we would like to rule out the alternative hypothesis that risk perceptions might have changed over time even without vaccination. A way to do this is to compare the change in risk perceptions of those who acted with the change (if any) in risk perceptions of those who did not act.

An appropriate statistical test would be to conduct a repeated measures analysis of variance (in this case, a repeated measures logistic regression) in which risk perceptions at Times 1 and 2 are the repeated measures and risk behavior (vaccinated vs. not vaccinated) is the between-group variable. Support for the reappraisal hypothesis would come from a significant interaction between the risk behavior and the repeated measures factor. In this study, this interaction was significant, $\chi^2(1, N = 745) = 30.90$, $p < .001$. Figure 2 shows that a substantial decrease in risk perception between Times 1 and 2 occurred only in the vaccinated group.

Figure 2 presents our data in a format that makes it easy to examine the validity of all three hypotheses. The motivation hypothesis predicts higher perceived risk at Time 1 for those who were vaccinated by Time 2 than for those who were not vaccinated. The accuracy hypothesis requires a difference in risk perceptions at Time 2 between those who were and were not vaccinated, such that the former report lower risk than the latter. Tests of the risk reappraisal hypothesis refer to the difference in slopes between the two lines, expecting that the vaccinated group will show a greater decline in perceived risk than the unvaccinated group.[2] As related earlier, the critical elements in Figure 2 were, in fact, significantly different, supporting all three hypotheses.

DISCUSSION

This study provides clear support for the oppositely signed predictions of the behavior motivation and risk reappraisal hypotheses in the context of Lyme disease vaccination. Higher risk judgments appear to have encouraged people to engage in protective behavior (i.e., being vaccinated). Having engaged in the protective behavior, in turn, apparently led people to reduce their risk judgments. Supporting the accuracy hypothesis, people who had the vaccine correctly viewed their risk as being lower than those who had not been vaccinated. We say that risk perceptions "appear" to lead to vaccination because these are correlational findings. A longitudinal design allowed us to infer

[2]Note that it is possible to have between-vaccination-group differences in risk perception at both Times 1 and 2 without having a difference in slopes. It is also possible to have a difference in slopes but the same risk perception at Time 1 or Time 2 (but not at both times).

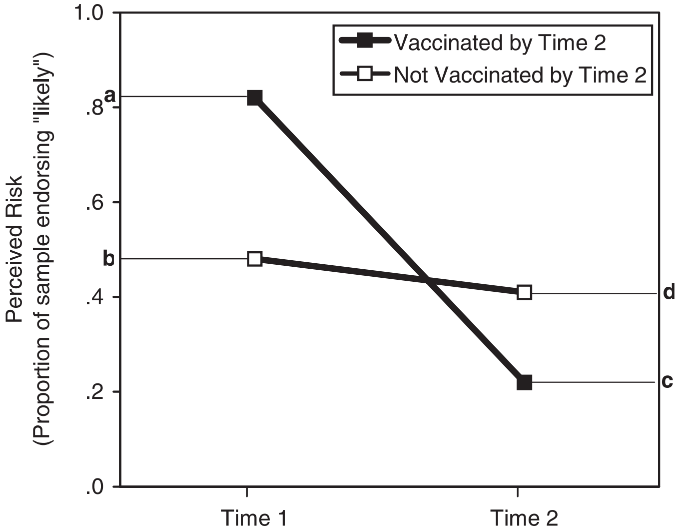

FIGURE 2 Study participants' perceived risk for Lyme disease and its relation to vaccination behavior. Figure 2 stratifies by vaccination behavior (that occurred anytime between Time 1 and Time 2) to show risk perception differences at the start of that time period and at the end. The behavior motivation hypothesis is supported by the fact that people who got vaccinated had higher risk perceptions at Time 1 than those who did not get vaccinated (a > b). The accuracy hypothesis is supported by the fact that people vaccinated had lower perceived risk at Time 2 than those who were not vaccinated (c < d). The risk reappraisal hypothesis is supported by the fact that the decline in risk perception among those who became vaccinated (a – c) is greater than the decline for those who were not vaccinated (b – d).

a likely causal direction, but not to eliminate third-variable explanations. The best one can do with correlational data is determine whether the observed relations are consistent with the causal model.

The relations between risk perceptions and behavior are of interest to many health researchers. Members of the public often misinterpret their risk of health problems (violating the accuracy hypothesis) and correcting these misinterpretations is seen (because of researchers' belief in the behavior motivation hypothesis) as a way to encourage healthy behavior. However, researchers often mistake their cross-sectional tests of the accuracy hypothesis as being tests of the behavior motivation hypothesis. As we have shown, these tests are completely different and may even have opposite signs (7,8). In this study, confusing these two hypotheses would lead researchers to conclude that high perceptions of risk *discourage* vaccination and to invent explanations for this finding, perhaps suggesting that people who feel at risk continue risky behavior in a vain attempt to convince themselves that they are not really at risk.

The accuracy hypothesis is testable in cross-sectional designs. It can be useful for identifying information deficits and the need for public or patient education, but it is theoretically less interesting than the other two hypotheses primarily because it is a descriptive statement without implications for causal processes. Researchers should take great care to decide which hypothesis is of interest to them and then to match their analyses to the hypothesis.

This study uses a primary prevention behavior (i.e., vaccination against Lyme disease) to illustrate hypotheses about the relation between risk perceptions and a risk behavior. Analogous hypotheses can be formulated for other risk-related variables that might affect behavior, such as worry and perceived illness severity. For example, one can ask whether elderly people are appropriately worried about influenza, whether those who worry more are more likely to have an annual flu shot, and whether those who get a shot worry less. Similarly, the points made here are not restricted to either new behaviors or to behaviors that need to be taken only once to reduce risk. They apply to other primary prevention behaviors, to screening, and to treatment (i.e., to secondary and tertiary prevention).

In testing the behavior motivation hypothesis, researchers examine whether or not risk perceptions change behavior. However, care is needed when controlling for initial behavior. The initial behavior must match the behavioral context of the risk perception question. Consider, for example, a study conducted in the early fall among people who have not yet been vaccinated against the virus expected in the coming influenza season. The appropriate risk questions would refer to their risk of getting the flu if they do not get vaccinated that year, so the behavioral "baseline" is one of no vaccination *that year.* Because all respondents fit this category of not being vaccinated, there will be no need to control for initial behavior when the relation between the risk perception and subsequent vaccination behavior is examined.

Furthermore, in this context one *should not* control for the vaccination behavior of prior years. This past behavior does not correspond to the risk question. In fact, by controlling for vaccination behavior in prior years, one is also partialing out the effects of prior risk perceptions on vaccination behavior in prior years, statistically removing the effects of the independent variable one wishes to test.

We caution that the hypothesized signs of the correlations and path coefficients in Figure 1 would be reversed for behaviors believed to increase rather than reduce objective risk. Higher perceived risk for Lyme disease should cause one to be less likely to go into wooded areas (a reduction in risk-increasing behavior), but more likely to wear protective clothing (an increase in risk-decreasing behavior). Also, the reappraisal hypothesis would be expected to hold only if the risk behavior is believed to have the potential for reducing risk (or whatever construct is predicted to motivate action). This is not always the case. A chest x-ray will detect lung cancer (and may improve survival rates) but will do nothing to reduce the chances of getting the disease. Thus, higher perceived risk for lung cancer could prompt a person to be screened, but screening would not be expected to reduce perceived risk.

Several aspects of this study have the potential to affect the generalizability of the findings. Our sample was selected at random from counties with high rates of Lyme disease. Tests of these hypotheses may yield different results in locations with lower levels of the disease. Furthermore, although the sample was representative of homeowners in the areas we studied, it overrepresented White and well-educated participants relative to the general population.

As we argued, the complex relations between perceived risk and behavior require care in the formulation of risk questions, the choice of study design, and the selection of statistical procedures. Too often, these issues are overlooked or misunderstood. Experimental tests of predicted relations are much simpler to interpret, but they are surprisingly rare in health behavior research. Given the frequency of errors in the interpretation of correlational data, literature reviews must be especially vigilant. If they include studies using invalid tests, their conclusions about the strength of risk perception/risk behavior relations will be equally invalid.

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