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Meta-Analysis of the Relationship Between Risk Perception and Health Behavior: The Example of Vaccination

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Background: Risk perceptions are central to many health behavior theories. However, the relationship between risk perceptions and behavior, muddied by instances of inappropriate assessment and analysis, often looks weak. ***Method:*** A meta-analysis of eligible studies assessing the bivariate association between adult vaccination and perceived likelihood, susceptibility, or severity was conducted. ***Results:*** Thirty-four studies met inclusion criteria (N = 15,988). Risk likelihood (pooled r = .26), susceptibility (pooled r = .24), and severity (pooled r = .16) significantly predicted vaccination behavior. The risk perception–behavior relationship was larger for studies that were prospective, had higher quality risk measures, or had unskewed risk or behavior measures. ***Conclusions:*** The consistent relationships between risk perceptions and behavior, larger than suggested by prior meta-analyses, suggest that risk perceptions are rightly placed as core concepts in theories of health behavior.

Keywords: perceived likelihood, perceived severity, perceived susceptibility, vaccination, influenza

Risk perceptions (i.e., beliefs about potential harm) are components of most theories of health behavior, but the strength of the relationships between these perceptions and behavior is unclear. Obtaining a better understanding of the size of these relationships can inform health behavior theory and guide intervention development. This article describes a meta-analysis of the associations between risk perceptions and behavior for one particular health-protective action: vaccination against infectious disease. Because we are aware of no experimental studies that have examined how manipulating perceived risk affects vaccination, all the data used in the meta-analysis are correlational (i.e., cross-sectional and longitudinal).

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Reasons for Uncertainty of the Risk Perception–Behavior Relationship

The role of risk perceptions in shaping health behaviors is a fundamental, undecided issue in health psychology. Neither theories of heath behavior nor empirical studies appear to agree about the importance of these perceptions. Risk perception is central to most health-specific behavioral theories (for reviews, see Sutton, 1987; Weinstein, 1993) including the health belief model (Rosenstock, 1974), protection motivation theory (Rogers, 1975), and the extended parallel process model (Witte, 1992). Similarly, the self-regulation model (Leventhal, Meyer, & Nerenz, 1980) includes several constructs important to risk perception (Cameron, 2003). Many general behavioral theories are frequently applied to health behaviors (e.g., the theory of reasoned action, Fishbein & Ajzen, 1975; the theory of planned behavior, Ajzen, 1985; subjective expected utility theory, Ronis, 1992). These general theories posit that the likelihood and magnitude of potential outcomes (including non-health costs and benefits) shape behavior, but studies testing these theories assess the anticipated likelihood and magnitude of potential health-specific harms (i.e., risk perceptions) only if participants in pilot studies mention them.

Although the majority of empirical studies find positive associations between risk perceptions and behaviors, as many theories suggest, individual studies report all types of relationships: positive, negative, and none. In meta-analyses, the effect sizes found for risk perceptions tend to be significant but small. For example, in a review of 17 studies based on the health belief model,

Harrison, Mullen, and Green (1992) reported an effect size *r* of .15 (.10−.20, $p < .01$) for the relationship of perceived likelihood to health behavior and of .08 (.01−.19, $p < .01$) for the relationship of perceived illness severity to health behavior, where the range in parentheses indicate the range of effect sizes across five categories of health behaviors and several different research designs. Floyd, Prentice-Dunn, and Rogers (2000), reviewing studies related to protection motivation theory, reported an effect size *r* of .20 for 25 studies measuring perceived likelihood and .19 for 21 studies measuring perceived severity, both significant at $p < .001$. However, nearly half of the studies in this meta-analysis used intentions as the outcome variable, not behavior. In another meta-analysis guided by protection motivation theory (Milne, Sheeran, & Orbell, 2000), the effect size *r* for 8 studies using cross-sectional/retrospective designs was .13 (*ns*) for perceived likelihood and .10 (*ns*) for perceived severity. For 5 studies using prospective designs, these authors reported an effect size *r* of .12 ($p < .01$) for perceived likelihood and stated that the effect for perceived severity was not significant. McCaul, Branstetter, Schroeder, and Glasgow (1996) conducted a meta-analysis of mammography screening and reported an effect size *r* of .16 ($p < .001$) for the 19 studies examining the perceived likelihood−behavior relationship. Janz and Becker (1984) reported that 30 out of 37 studies based on the health belief model found significant effects for perceived likelihood. They also reported significant effects for perceived severity for 24 out of 30 studies. Looking at such data, some researchers (e.g., Leventhal, Kelly, & Leventhal, 1999) have argued that risk perceptions may have little impact on health behavior.

Risk Perception Dimensions

Before discussing the methodological issues that may have produced these relatively small effect sizes, we need to distinguish among three types of risk perceptions as shown in Table 1. Health hazards have many dimensions, but in describing the threat presented by a hazard, nearly all theories focus on only two: the likelihood of harm if no action is taken and the severity of harm if no action is taken. The term *likelihood* is used interchangeably in this literature with *probability*, *susceptibility* and *vulnerability*. However, in this meta-analysis, we make a distinction between two logically distinct, though overlapping, concepts: likelihood of harm and susceptibility to illness. We define the first concept, likelihood, as one's probability of being harmed by a hazard under certain behavior conditions. It is represented by the question "What is the likelihood that you will get the flu this year if you don't get a flu shot?" The term *susceptibility* is often used interchangeably with *likelihood*, but we use it here to denote risk questions that appear to address different issues. These questions emphasize individual resistance or constitutional vulnerability, as in the questions "Do you get the flu easily?" and "Are you more likely to get the flu than other people?" Susceptibility to a disease should influence the likelihood of developing that disease, but being susceptible to an illness does not necessarily mean that the absolute probability of that illness is large. These two concepts are distinct from a third issue, "severity," or "seriousness." We define this third concept as the extent of harm a hazard would cause. It is represented by the question "How serious a disease is the flu?" Thus, our meta-analysis addresses three perceived risk dimensions: the likelihood of harm if no action is taken, susceptibility to harm if no action is taken, and the severity of harm if no action is taken.

An additional risk perception, the perceived risk if one does take some health-protective action, is also clearly relevant to health behavior. However, it reflects a combination of beliefs about both the likelihood of the risk if there is no action and the effectiveness of the precaution (Weinstein, 1993). Because beliefs about the risk given preventive action are seldom reported, we did not include this concept in our meta-analysis.

Conditioned Risk Questions

The empirical literature linking risk perceptions with behavior is compromised by methodological problems, some so severe that many studies need to be eliminated from meta-analyses (Brewer, Weinstein, Cuite, & Herrington, 2004; Weinstein & Nicolich, 1993; Weinstein, Rothman, & Nicolich, 1998). A major problem in testing whether risk perception motivates action is the failure to condition the risk question on not taking action. For example, if one is interested in testing the idea that a high perceived likelihood of getting influenza motivates influenza vaccination, one needs to know a person's perception of what the probability would be if he or she does not get vaccinated. In a prospective study, when people are simply asked about their (unconditioned) probability of getting the flu, some may say that their risk is low because they never seem to get the flu. Yet, others may say that their risk is low

Table 1
Three Dimensions of Perceived Risk

Dimension	Description	Example
Perceived likelihood	The probability that one will be harmed by the hazard	Imagine that the flu shot this year is unavailable and you are therefore unable to get the shot this fall. Given that you have had no shot, what would say is the likelihood that you would get the flu this winter? (Chapman & Coups, 2006) If I don't get immunized, there is a high chance of me getting flu [or pneumonia]. (Madhavan, Rosenbluth, Amonkar, Fernandes, & Borker, 2003)
Perceived susceptibility	An individual's constitutional vulnerability to a hazard	I get sick more easily than other people my age. (Nexoe, Kragstrup, & Sogaard, 1999)
Perceived severity	The extent of harm a hazard would cause	Influenza can cause death. (Nichol, Lofgren, & Gapinski, 1992) If I had influenza, I would not be able to manage daily activities. (Zimmerman et al., 2003)

because they plan to get vaccinated, so their answer anticipates the effect of the vaccination on their risk. The risk perceptions described by the second group are the expected consequence of vaccination, not what they think their risk would be if they did not get vaccinated. Consequently, survey responses sometimes underestimate what people who plan to act think their risk would be without action. As a result, the observed perceived risk−behavior association will underestimate the true association between perceived risk without behavior and the behavior itself. The latter is the quantity that should be examined.

A second serious methodological problem is the use of unconditional risk questions in cross-sectional studies. Such studies compare the perceptions of people who have been vaccinated with the perceptions of people who have not. But the risk perceptions of the former group—in response to an unconditioned question such as, "What is your likelihood of getting the flu?"—will reflect their awareness of having received a vaccination (Brewer et al., 2004). If the vaccine is seen to be highly effective, the same theories that predict a positive association between risk likelihood and subsequent action would predict a negative association in cross-sectional data (i.e., that people who have received the vaccine think their likelihood is lower than those who have not received the vaccine). This negative association would not mean that low risk likelihood motivates vaccination! Unconditioned risk questions in cross-sectional analyses will underestimate the relationship between risk perceptions and behavior. (Because nearly all the studies that were excluded from this meta-analysis for using unconditioned risk questions also had other problems, we were unable to test this supposition.)

Whether or not risk questions need to be conditioned on not taking a precaution depends on whether it is expected to change one's risk. Vaccination mainly changes likelihood. In contrast, mammography can change severity (by diagnosing breast cancer at an earlier stage), but it does not reduce the likelihood of disease. Consequently, perceived likelihood of the infectious disease (but not perceived severity) needs to be conditioned on not being vaccinated. Perceived severity of breast cancer (but not perceived likelihood) needs to be conditioned on not receiving a mammogram. Perceived susceptibility, as we are using the term, refers to beliefs about a general constitutional resistance that is independent of particular preventive actions, rather than a temporary state, so it does not need to be conditioned on no vaccination. (We located no studies in our search of the literature that conditioned perceived susceptibility on engaging in a health behavior.)

The meta-analyses carried out by Harrison et al. (1992) and Floyd et al. (2000) and the cross-sectional studies examined by Milne et al. (2000) included studies that should have used conditional questions to measure risk likelihood. The authors do not reveal which studies included in these reviews did or did not use conditional risk likelihood questions. Consequently, it is likely that they underestimated the risk likelihood−behavior relationship.

Other Risk Question Problems

Risk questions often have other weaknesses. One problem is that the risk question's referent is ambiguous or that it refers to people in general ("How serious is the flu?") rather than to the respondent ("How serious would it be if you got the flu?"). Social−cognitive theories of individual health behavior are constructed in terms of a person's beliefs about himself or herself, not a broader population category. Responses to a question referring specifically to the respondent are more likely to be associated with the respondent's own behavior. Time frame is often missing from risk likelihood questions (i.e., "What is the chance that you will get the flu?" rather than "What is the chance that you will get the flu this year?"). This can result in added noise in responses if different respondents think about different time frames. Susceptibility questions sometimes refer to illness in general ("I get sick more often than other people") rather than to the specific illness under consideration ("I don't seem to have much resistance to the flu"). More specific questions are more likely to be associated with the specific vaccination behavior under study.

In selecting studies for this meta-analysis, we excluded findings about risk likelihood if a cross-sectional study did not use a likelihood question conditioned on not being vaccinated because the finding is uninterpretable. (However, if the likelihood question referred to people in general—e.g., "A lot of people get the flu each year"—we did not require it to be conditioned because doing so would be unlikely to change response.) The other methodological issues mentioned earlier were incorporated into a study quality score rather than serving as exclusion criteria. Even with this restriction, risk perception measures in the literature take many forms, some of which more faithfully represent the concepts than others. Examples of the range of questions encountered in this review and included in this meta-analysis are shown in Table 1.

Risk Perceptions and Different Health Behaviors

The importance of risk perceptions to health behavior undoubtedly varies across behaviors. Risk perceptions are probably more important for behaviors, such as sunscreen use, that are intended to reduce a specific health threat and are probably less important for behaviors, such as exercise and diet, that have a wide range of health and nonhealth consequences. Risk perceptions are probably more important when people make individual decisions about a behavior with relatively diffuse external influences, as in sunscreen use, than when strong external influences are present, as with physician recommendations for cancer screening tests. When it is easy to carry out the health behavior, there is likely to be a stronger association between perceptions and behavior than when it is difficult to carry out the behavior.

We selected adult vaccination against infectious disease as the focal health behavior for the current meta-analysis. It is a discrete behavior used to decrease the risk of a specific health threat. Strengthening the possible effect of risk perceptions on this behavior, vaccination behavior is relatively easy to carry out. Weakening the risk perception−vaccination relationship, vaccination behavior sometimes reflects physician practice (the physician both recommends the vaccine and delivers it during a single patient visit) rather than the independent initiative of the recipient.

This meta-analysis was designed to test the hypotheses that higher perceived illness likelihood, perceived illness susceptibility, and perceived illness severity are associated with greater vaccination behavior and to determine the strength of any associations that were found. In addition, we looked at several factors that might modify the strength of the associations, including both substantive issues (type of illness, population vaccinated) and methodological issues (study quality, ceiling or floor effects on variables). The

results of this meta-analysis will help us to understand better the role that risk perception should play in theories of health behavior.

Method

Study Selection

To identify articles to include in the meta-analysis, we used a two-stage screening process. In the first stage, we identified articles and papers that examined the risk perception and vaccination behavior of adults. We excluded childhood vaccination from the present analysis because it represents a surrogate decision (parent judging risks and deciding about vaccination on behalf of the child). We searched PsycINFO and MEDLINE for articles published between the beginning of the databases and August 2004 whose title, abstract, or keywords included reference to both vaccination (i.e., vaccin* or immuniz* or innoculat* or shot) and perceived risk (perceived risk or risk perception* or perception of *risk or perceived likelihood or perceived susceptibility or perceived severity or attitude). We also searched the reference sections of the articles we obtained and circulated requests for unpublished studies among colleagues and on relevant electronic mailing lists.

In the second stage, we determined whether the studies satisfied our inclusion criteria. Studies included needed to assess one of three measures of perceived risk: perceived illness likelihood, perceived illness susceptibility, and perceived illness severity. Studies were excluded if they used only risk measures that conflated multiple risk constructs (e.g., likelihood and severity). Cross-sectional studies that examined perceived likelihood were required to condition the belief on not having been vaccinated (e.g., "How likely is it that you will get the flu given that you have not yet been vaccinated?"). Measures of susceptibility were acceptable only if they clearly assessed an individual's resistance to disease (e.g., "I get sick more easily than other people my age."). Simply mentioning the word *susceptibility* was not sufficient for a risk item to represent this construct. The criteria that applied to perceived severity were somewhat more relaxed and, in practice, many measures were included that might also be considered knowledge (e.g., "Influenza can cause death.").

We required that the vaccination measure assess an actual behavior (not just a behavioral intention); vaccination measured by self-report was acceptable. Articles in any language were accepted. Studies that only reported multivariate relationships were excluded because such statistics may understate the true relation of perceived risk to vaccination behavior. Studies were excluded from the meta-analysis if they did not report adequate statistical information to allow calculation of a bivariate effect size. When possible, study authors were contacted to obtain needed statistical information.

Of the 48 articles we excluded, the vast majority merely reviewed others' data or did not report a quantitative assessment of the risk perception−vaccination relationship ($n = 36$). The others reported the relationship of risk perception to vaccination in a way that precluded calculating a standardized effect size ($n = 2$), multivariate but not bivariate risk perception−vaccination relationships ($n = 2$), unacceptable risk perception measures ($n = 4$), or risk measures whose appropriateness could not be assessed ($n = 1$).

Study Coding

Each risk measure was assigned a quality score. All risk measures received one point for each of the following good practices: The perceived risk question(s) concerned the individual's own risk, the topic of the perceived risk question(s) matched the outcome, the perceived risk measure was a composite of more than one perceived risk question (and, thus, was more likely to be a reliable measure), and categories of the response scale were not combined for analysis (a strategy that would reduce variability in the predictor variable). Likelihood measures received an additional point for each of the following good practices: The underlying question(s) was conditioned on not having been vaccinated (for prospective studies), and the perceived risk question(s) specified the time frame for the illness. Based on a median split of the quality scores, risk measures were categorized as low or high quality.

For each study, we also coded sample size, whether the study was cross-sectional or prospective, the illness that the vaccine would protect against (i.e., influenza or other illness), skew of responses (i.e., whether more than 80% of respondents used a single perceived risk response category), vaccination rate (high or low, based on a median split), and population (i.e., whether respondents were healthy adults, medical personnel such as doctors or nurses, or sick or high-risk persons). Coding of studies was performed by one of three judges using a standardized coding protocol and checked for accuracy by a second. Instances not covered by the protocol were discussed by the three judges to establish a standard policy that was then incorporated into the coding protocol. Calculation of effect sizes was performed by two judges independently. In the few cases in which judges' assessments differed, they conferred with one another to resolve the discrepancy.

Data Analyses

For each study, up to three effect sizes (rs) were calculated, one for each of the perceived risk measures reported. The effect sizes were converted to Fisher's zs (to allow us to combine the effect sizes properly). For each risk dimension, the zs were pooled across studies to create a single summary z, which was converted back into r (Rosenthal, 1994; Wolf, 1986). The single summary r for each of the three risk measures was tested for its difference from zero by t test. Variability among effect sizes might reflect important differences among subgroups. To investigate this possibility, the effect sizes were examined for heterogeneity by calculating the Q statistic. If Q was significant, we then examined six potential moderators of the risk perception−behavior relationship: design, quality score, illness, population, recruitment rate, and vaccination rate.

Results

Thirty-four studies fulfilled our inclusion criteria. The included studies and their characteristics are summarized in Table A1 of the Appendix. The total number of subjects in the studies was 15,988 with a median of 374 per study and a range of 72 to 1,530. The studies were conducted between 1979 and 2004 ($mdn = 1997$). There were 28 cross-sectional studies and 6 prospective studies. Twenty-five studies concerned influenza vaccination and the remaining studies concerned vaccination against hepatitis, pneumonia, or Lyme disease. Recruitment rates ranged from 25% to 99% ($mdn = 63\%$) and vaccination rates ranged from 6% to 86% ($mdn = 51\%$). Populations studied included healthy adults (9 studies), medical personnel (7 studies), and sick or high-risk populations such as older adults (18 studies).

Perceived Likelihood

The relationship of perceived likelihood to vaccination was examined in 12 studies with 6,958 participants and effect sizes ranging from −.12 to −.45 (see Figure 1). The pooled effect was moderate in size ($r = .26$) and significantly different from zero, $t(6957) = 22.29$, $p < .001$. Those perceiving a higher likelihood of getting the illness were more likely to be vaccinated. The pooled effect showed heterogeneity of variance ($Q = 155.29$, $p < .001$), suggesting the presence of one or more moderators.

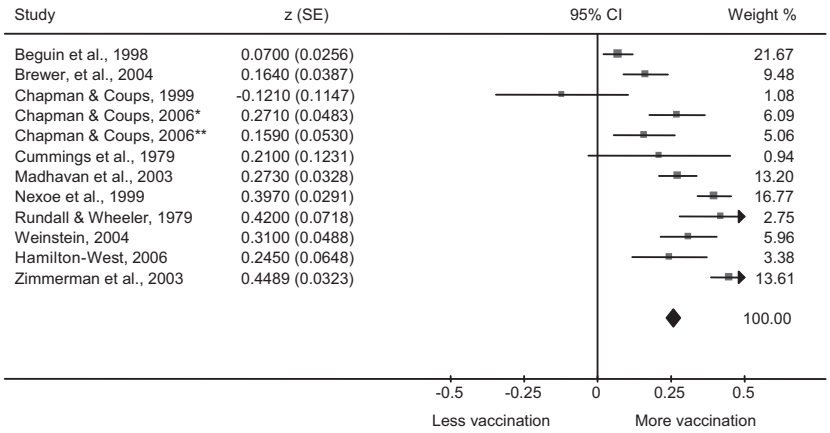

Figure 1. Perceived likelihood. Because our meta-analysis transformed the asymmetrical effect size *r* to the symmetrical effect size *z*, the figure shows the latter to more accurately depict confidence intervals (CIs). A positive *z* indicates that vaccination was more prevalent among participants reporting higher perceived likelihood. *Healthy adult sample. **Medical personnel sample.

Additional analyses showed significance for the five moderators we examined. Prospective studies yielded a pooled effect size (r = .29) larger than that for cross-sectional studies (r = .24), $t(6956) = 3.56$, $p < .001$. Higher quality risk measures yielded a pooled effect size larger (r = .28) than did lower quality risk measures (r = .23), $t(6956) = 3.14$, $p < .01$. Studies of influenza vaccination yielded a larger pooled effect size than studies of other illnesses (r = .27 vs. .22), $t(6956) = 3.36$, $p < .001$. Studies with extreme vaccination rates yielded a smaller pooled effect size than did those with vaccination rates closer to 50% (r = .22 vs. .28), $t(6591) = 3.67$, $p < .001$. The pooled effect size was small for medical personnel (r = .07), moderate in size for healthy adults (r = .23) and large for sick and high-risk populations (r = .42), and all differed from one another (ts > 7.72, ps < .001). The effect sizes for all subgroups created by the moderators were significantly different from zero (ps < .001). Extremity of response distribution was not examined as a moderator because no likelihood studies had extreme response distributions.

Perceived Susceptibility

The relationship of perceived susceptibility to vaccination was examined in 5 studies with 2,543 participants and effect sizes that ranged from .15 to .36 (see Figure 2). The pooled effect size was moderate in size (r = .24) and significantly different from zero, $t(2542) = 12.53$, $p < .001$. Those who perceived themselves to be more susceptible to an illness were more likely to be vaccinated against it. The pooled effect showed heterogeneity of variance (Q = 16.99, $p < .01$), suggesting the presence of moderators. Because of the small number of studies that assessed susceptibility, however, it was not possible to examine moderators.

Perceived Severity

The relationship of perceived severity to vaccination was examined in 32 studies with 13,945 participants and effect sizes that ranged from −.18 to .39 (see Figure 3). The pooled effect size was small to moderate in size (r = .16) and significantly different from zero, $t(13944) = 19.43$, $p < .001$. Those who perceived the severity of illness to be higher were more likely to be vaccinated. The pooled effect showed heterogeneity of variance (Q = 297.52, $p < .001$), suggesting the presence of moderators.

The effects of all six moderators proved to be statistically significant. Prospective studies yielded a pooled effect size (r = .23) larger than was yielded by cross-sectional studies (r = .15), $t(13943) = 7.60$, $p < .001$. Higher quality risk measures yielded a

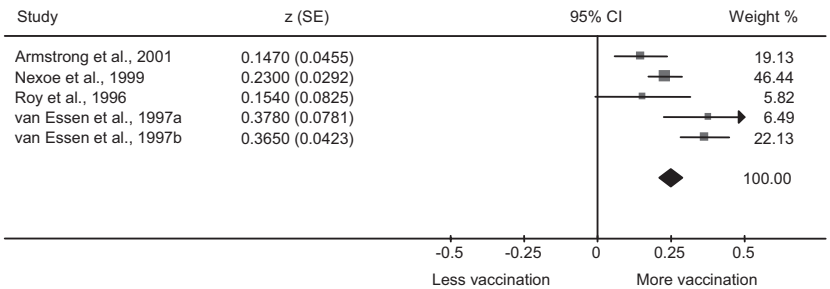

Figure 2. Perceived susceptibility. Because our meta-analysis transformed the asymmetrical effect size *r* to the symmetrical effect size *z*, the figure shows the latter to more accurately depict confidence intervals (CIs). A positive *z* indicates that vaccination was more prevalent among participants reporting higher perceived susceptibility.

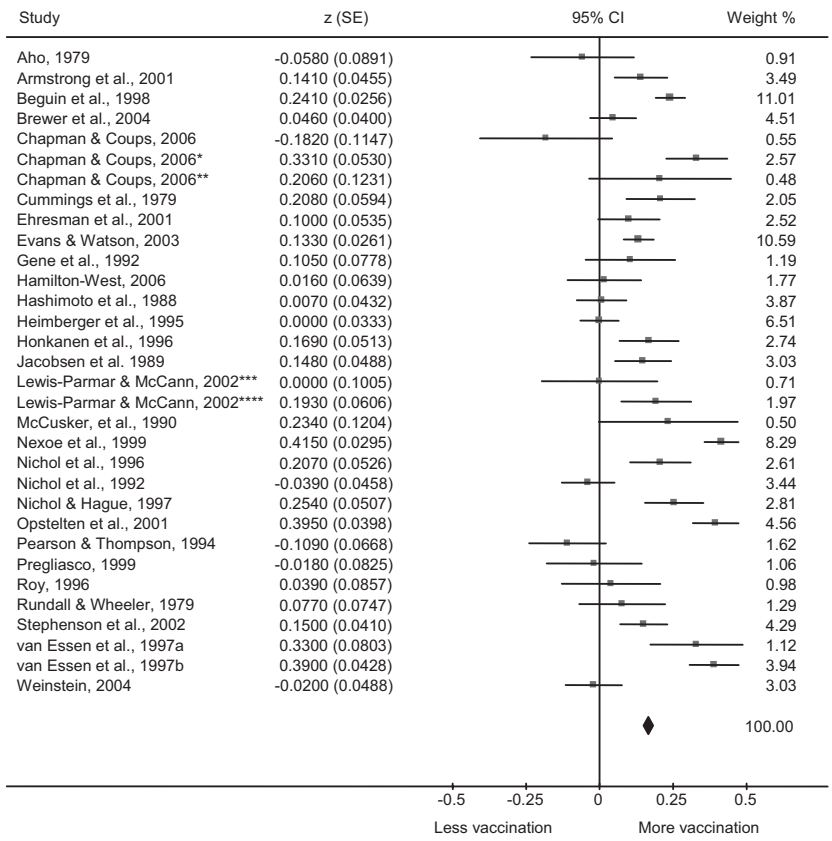

Figure 3. Perceived severity. Because our meta-analysis transformed the asymmetrical effect size *r* to the symmetrical effect size *z*, the figure shows the latter to more accurately depict confidence intervals (CIs). A positive *z* indicates that vaccination was more prevalent among participants reporting higher perceived severity. *Healthy adult sample. **Medical personnel sample. ***High risk adult sample (diabetics). ****High risk adult sample (>75 years old).

pooled effect size larger ($r = .20$) than for lower quality risk measures ($r = .11$), $t(13943) = 7.39$, $p < .001$. Studies of influenza vaccination yielded a larger pooled effect size than studies of other illnesses ($r = .18$ vs. .07), $t(13943) = 9.83$, $p < .001$. Studies with extreme vaccination rates yielded a smaller pooled effect size than those with vaccination rates closer to 50% ($r = .12$ vs. .18), $t(13578) = 4.28$, $p < .001$. Studies with skewed risk response distributions yielded a smaller pooled effect size than those with more moderate distributions ($r = .12$ vs. .19), $t(13213) = 5.86$, $p < .001$. Pooled effect sizes were smaller for medical personnel ($r = .14$) and healthy adults ($r = .11$) than for sick and high-risk populations ($r = .20$, ts > 4.18, ps $< .001$). Effect sizes for all subgroups were significantly different from zero ($p < .001$).

Relationships Among Moderator Variables

In the studies that assessed likelihood, no moderator variables were correlated with one another. Among the studies that assessed severity, however, several moderator variables were related to one another. First, quality of severity measures was related to study design: All 6 of the prospective studies that assessed severity used high-quality risk measures, compared with only 12 of the 26 cross-sectional studies ($\phi = .42$, $p = .02$). Second, population was also related to study design, $\chi^2(2, N = 32) = 7.07$, $p = .02$.[1] Of the 8 studies of healthy adults, 4 used prospective design, compared with only 1 of the 7 studies of clinicians and 1 of the 17 studies of high-risk adults. Finally, population was related to extremity of risk responses, $\chi^2(2, N = 32) = 7.22$, $p = .03$. Of the 7 studies of clinicians, 5 showed extreme risk responses, compared with only 1 of 8 studies of healthy adults and 3 of 14 studies of high-risk adults. (Three additional studies of high-risk adults could not be coded for extremity of risk response because they did not report the relevant data.) Because several moderators were themselves related, one cannot interpret their effects on the perceived severity–vaccination relationship as if the influence of other influential moderators has been controlled for.

Discussion

Risk perceptions are central to many of the theories used to explain health behaviors but are less important to or ignored

[1] The chi-square analyses should be viewed as descriptive, as the expected values in several cells are less than 5.

altogether by others. The empirical literature, muddied by frequent inappropriate assessment and analysis, looks inconsistent. However, we found a high degree of consistency and a strength of association between risk perceptions and behavior that is larger than had been suggested by prior meta-analyses. The present meta-analysis revealed that all three risk perception measures were related to vaccination behavior. The magnitudes of the associations with behavior were similar for perceived risk likelihood ($r = .26$) and susceptibility ($r = .24$) but somewhat smaller for severity ($r = .16$). The smaller effect size for perceived risk severity may reflect the larger variation of types of questions used to assess this construct, although lower predictive validity for perceived severity has been reported previously in the literature (e.g., Harrison et al., 1992).

A number of factors moderated the relationship of perceived risk likelihood and severity to vaccination behavior. Of note, the few prospective studies located yielded larger effect sizes than did cross-sectional studies. This moderation effect was especially large for risk severity measures, with the prospective studies yielding a pooled effect half again as large as that from the cross-sectional studies. To some extent, this may have been due to the fact that prospective studies tended to use higher quality severity measures. The moderating effect of prospective versus cross-sectional design is still present, however, for risk likelihood relationships, where design type is not confounded with risk measure quality.

Prospective studies are the preferred design because they assess risk perception before the respondent engages (or does not engage) in the health behavior. Consequently, prospective designs increase the plausibility that the risk perception motivates the behavior, rather than the reported risk perception being constructed to justify a behavior that has already taken place. The post hoc justification that can occur in cross-sectional studies (e.g., "I must be the sort of person who is at high risk because I just got vaccinated") might artificially inflate the size of the risk perception−health behavior relationship, but the fact that effect sizes were no greater in cross-sectional than prospective studies (and indeed were smaller) suggests that this is not the case. It should be recognized, however, that if a behavior is repeated, as in annual influenza vaccination, perceptions may change over time to become consistent with past action, so the direction of causation can be unclear even in a prospective design. For this reason, first-time vaccination against an illness (as represented by the studies of hepatitis, pneumonia, and Lyme disease vaccination) may be the best indicator of the strength of causation (Weinstein, 2004), and these effects were smaller than those with influenza.

Another moderator revealed by the present analysis is quality of the risk measure. Likelihood and severity measures that scored lower on our quality scale showed weaker associations with vaccination behavior. Poor quality measures may fail to capture the intended construct. If the measure assesses something other than the intended likelihood or severity or is statistically unreliable, it is not surprising for it to be unrelated to vaccination.

Studies of influenza vaccination yielded larger effect sizes than did studies of other types of vaccination. This may be because the non-flu category consisted of a mix of vaccine types (hepatitis, pneumonia, and Lyme disease) that resulted in additional noise across studies in risk and behavior measures, resulting in smaller effect sizes. It may also be due to the relative familiarity, accessibility, low cost, and habitual uptake of flu shots relative to these other types of shots. Another possibility is that the hepatitis and Lyme disease vaccines require a series of three vaccinations and this additional hurdle may attenuate the risk perception−vaccination relationship.

Studies of medical personnel yielded a smaller effect size than studies of sick and/or high-risk adults. The effect size for healthy adults was in between these two groups for risk likelihood and equivalent to medical personnel for risk severity. Why would effect sizes be smaller for medical personnel? This result may indicate that perceived risk to self is less of a motivator for health care providers than it is for patients. Providers may be primarily motivated by concerns specific to their job role, such as a desire not to spread infection to patients. Alternatively, the smaller effect sizes may be related to some clinicians having been required by their employers to be vaccinated (e.g., against the flu and hepatitis B) or to receiving these services at their worksite. These two factors could undermine the influence of perceived risk by eliminating the volitional aspect of the behavior for some or by making vaccination so simple for others that the remaining unvaccinated persons reflect an unusual subset.

The distributions of both the risk measure and the behavior measure were both associated with effect size, an indication that perceived risk may have greater importance than suggested by the effect sizes we report. When an extreme percentage of respondents used a single risk response category or when an extreme percentage of respondents was in a single behavior category (vaccinated or not), effect sizes were smaller. If an outcome is dichotomous and rare, an effect can appear to be quite small when reported as a correlation coefficient (or effect size r) even though it is a clinically important effect that would be large when reported as an odds ratio (Rutledge & Loh, 2004). The implication is that the meta-analysis may slightly understate the meaningfulness of the relation of perceived risk to vaccination.

Only five studies of susceptibility were included in the present analysis. As a consequence, although we could detect that susceptibility is reliably associated with vaccination behavior, we could not explore moderators of this relationship. Susceptibility appears to be an under-studied aspect of risk perception. Research is needed to determine whether this construct improves the prediction of health behaviors beyond that provided by perceptions of risk likelihood. Several other perceived risk measures, such as perceived disease prevalence and believing oneself to be a member of a high risk group, have also received relatively little attention in the research literature (Brewer & Hallman, 2006).

In summary, the occasional study showing no relationship between perceived risk and vaccination, or a small negative relationship, can be viewed as part of a larger distribution of effect sizes around a positive and significant mean effect size. We find strong evidence that perceived likelihood, susceptibility, and severity are reliably associated with vaccination and that the relationships are at least small to moderate in size. When one considers the methodological weaknesses that suppress the size of this relationship, the effect may be more accurately characterized as moderate, with major applied implications. Many of these findings rely on data from cross-sectional studies, but larger effects are found in longitudinal studies giving us confidence in our conclusion. However, experiments that manipulate risk perception are needed to provide a more definitive confirmation of the causal relationship between risk perception and preventive action. Additional research is also

needed to determine whether the relationship between risk perception and health behavior varies cross-culturally.

To illustrate the applied importance of an effect size that corresponds to a small portion of the total variance in behavior, we converted a correlation of .28 (corresponding to the value found for high-quality studies of risk likelihood) to a contingency table. We assumed a vaccination rate of 50% and an equal distribution between high and low perceived risk, both parameters close to the median found in our meta-analysis. In this situation, the correlation of .28 corresponds to a vaccination rate of 36% in the low perceived risk group and 64% in the high perceived risk group. Assuming that the observed correlations represent the causal impact of risk perceptions, it appears that raising risk perceptions from low to high would have a major effect on vaccination behavior. The present meta-analysis demonstrates that hazard-specific risk perceptions are predictors of vaccination behavior. This finding supports the inclusion of risk perceptions in health behavior-specific theories such as protection motivation theory (Rogers, 1975) and the extended parallel process model (Witte, 1992). It also suggests that the more general behavioral theories, such as the theory of planned behavior (Ajzen, 1985), may improve their ability to predict health behavior if they too incorporate these constructs.

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Appendix

Notes on the Calculation of Effect Sizes

The general analytic approach followed that suggested by Rosenthal (1994) and Wolf (1986). An effect size (*r*) was calculated for each bivariate risk perception-vaccination behavior relationship reported in a study. We report only on linear effects because no studies reported tests of curvilinear effects, and hardly any examined interactions. A sizeable number of studies reported contingency tables from which we were able to directly calculate *r*. The most common situation was a 2 × 2 table (low or high perceived risk, by vaccinated or not) from which we calculated a phi coefficient. In other cases, we transformed the statistic reported (e.g., *t*) to *r*. If multiple relationships involving the same risk construct (e.g., two likelihood measures) were reported in the same study, these were combined by averaging the *r*s after a Fisher *z* transformation. If multiple relationships for different risk constructs (e.g., likelihood and severity) were reported in the same study, these were included separately in the meta-analysis. In cases in which a study reported results separately for substantially different populations (such as healthy adults and infirm adults), effect sizes were calculated separately for each population and were treated as being from separate studies.

Table A1
Studies Included in Meta-Analysis

Study	Design	Illness	Vaccination Rate (%)	Population	*r*	*N*	Quality score	>80% in same response category
			Perceived likelihood					
Beguin et al., 1998	c	f	32	m	.07	1,530	2	n
Brewer et al., 2004	p	o	6	h	.16	702	7	n
Chapman and Coups, 1999	c	f		h	−.12	79	5	n
Chapman and Coups, 2006[a]	p	f	47	h	.27	428	6	n
Chapman and Coups, 2006[b]	p	f	67	m	.16	428	6	n
Cummings et al., 1979	p	f		h	.21	286	3	n
Hamilton-West, 2006	c	o	34	h	.25	241	7	n
Madhavan et al., 2003	c	o	20	h	.27	931	5	n
Rundall and Wheeler, 1979	c	o	73	s	.36	197	3	n
Nexoe et al., 1999	p	f	37	s	.40	1,182	4	n
Weinstein, 2004	p	f	28	h	.30	423	7	n
Zimmerman et al., 2003	c	f	79	s	.45	959	3	n
			Perceived susceptibility					
Armstrong et al., 2001	c	f	63	s	.15	486	3	n
Roy et al., 1996	c	f	48	s	.15	150	2	y
van Essen et al., 1997a	c	f	66	s	.36	167	3	n
van Essen et al., 1997b	c	f	86	s	.35	561	3	n
Nexoe et al., 1999	p	f	37	s	.23	1,179	2	n
			Perceived severity					
Aho, 1979	c	f	54	s	−.06	129	3	n
Armstrong et al., 2001	c	f	63	s	.14	486	2	y
Beguin et al., 1998	c	f	32	m	.24	1,530	3	y
Brewer et al., 2004	p	o	6	h	.05	627	2	n
Chapman and Coups, 1999	c	f		h	−.18	79	3	n
Chapman and Coups, 2006[a]	p	f	47	h	.32	428	3	n
Chapman and Coups, 2006[b]	p	f	67	m	.20	428	3	n
Cummings et al., 1979	p	f		h	.21	286	2	n
Ehresmann et al., 2001	c	o	59	s	.10	353	1	
Evans and Watson, 2003	c	f	51	s	.13	1,468	1	n
Gene et al., 1992	c	f	51	s	.02	168	1	n
Hamilton-West, 2006	c	o	34	h	.02	248	4	n
Hashimoto et al., 1988	c	o	57	m	.01	538	1	y
Heimberger et al., 1995	c	f	16	m	.00	904	1	y
Honkanen et al., 1996	c	f	51	h	.17	383	1	y
Jacobson et al., 1989	c	o	61	m	.15	423	1	y
Lewis-Parmar and McCann, 2002[c]	c	f	67	s	.00	102	1	
Lewis-Parmar and McCann, 2002[d]	c	f	70	s	.19	275	1	
McCusker et al., 1990	c	o	24	h	.23	72	2	n
Nexoe et al., 1999	p	f	37	s	.39	1,151	3	n
Nichol et al., 1992	c	f	47	s	−.04	480	2	y
Nichol et al., 1996	c	o	74	s	.20	364	2	n
Nichol and Hague, 1997	c	f	61	m	.25	392	2	y
Opstelten et al., 2001	c	f	75	s	.38	634	2	n
Pearson and Thompson, 1994	c	f	71	s	−.11	227	0	n
Pregliasco et al., 1999	c	f	26	s	−.02	150	1	n
Roy et al., 1996	c	f	47	s	.04	139	1	y
Rundall and Wheeler, 1979	c	o	72	s	.08	182	2	n
Stephenson et al., 2002	c	f	14	m	.15	597	2	n
van Essen et al., 1997a	c	f	66	s	.32	158	1	n
van Essen et al., 1997b	c	f	86	s	.37	549	1	n
Weinstein, 2004	p	f		h	−.02	423	4	n

Note. c = cross-sectional design, p = prospective design. f = vaccination against influenza, o = vaccination against other illness. h = healthy adults, m = medical personnel, s = sick or high risk persons. n = no; y = yes.
[a] Healthy adult sample.
[b] Medical personnel sample.
[c] High risk adult sample (diabetics).
[d] High risk adult sample (>75 years old).