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Secondary Risk Theory: Validation of a Novel Model of Protection Motivation

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Protection motivation theory states individuals conduct threat and coping appraisals when deciding how to respond to perceived risks. However, that model does not adequately explain today's risk culture, where engaging in recommended behaviors may create a separate set of real or perceived secondary risks. We argue for and then demonstrate the need for a new model accounting for a secondary threat appraisal, which we call secondary risk theory. In an online experiment, 1,246 participants indicated their intention to take a vaccine after reading about the likelihood and severity of side effects. We manipulated likelihood and severity in a 2 × 2 between-subjects design and examined how well secondary risk theory predicts vaccination intention compared to protection motivation theory. Protection motivation theory performed better when the likelihood and severity of side effects were both low ($R^2 = 0.30$) versus high ($R^2 = 0.15$). In contrast, secondary risk theory performed similarly when the likelihood and severity of side effects were both low ($R^2 = 0.42$) or high ($R^2 = 0.45$). But the latter figure is a large improvement over protection motivation theory, suggesting the usefulness of secondary risk theory when individuals perceive a high secondary threat.

KEY WORDS: Protection motivation; risk response; risk tradeoffs; secondary risk theory; secondary risks

1. INTRODUCTION

Risk is commonly defined as an uncertain event that may cause damage or loss. Risk response actions are specified behaviors that may diminish or mitigate the potential damage caused by the risk. For instance, the risk of injury to a child during a vehicle collision can be lessened if drivers ensure children are buckled correctly into child safety seats. Similarly, the risks of outbreaks of diseases like measles are mostly preventable through vaccination. Risk response actions are the crux of most risk communication efforts where communicators encourage their audiences to adopt behaviors intended to reduce the initial threat (O'Keefe, 2002; Witte, Meyer, & Martell, 2001).

Protection motivation theory (PMT; Rogers, 1975) is a well-known and robust behavioral theory positing that when a threat is perceived as severe and likely to occur, individuals are motivated to attend to messaging about reducing the threat and more likely to follow a recommended action (Floyd, Prentice-Dunn, & Rogers, 2000). In general, the theory notes that increases in threat perceptions (vis-à-vis severity and vulnerability) when coupled with increased anticipatory behavior perceptions (vis-à-vis response efficacy and self-efficacy) encourage adaptive intentions to engage in risk response actions. Thus, PMT follows a problem-solution messaging format where the message first identifies a potential threat and

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then provides an advocated solution to that problem (e.g., a protective behavior; O'Keefe, 2002). This presupposes that if the message compels recipients to feel the threat is severe and likely to affect them, then they will be more likely to attend to messaging about how to protect themselves. If they perceive both the behavior to be efficacious in diminishing the threat (i.e., response efficacy) and that they can suitably complete the behavior (i.e., self-efficacy), then they will be motivated to protect themselves from the threat by means of engaging in the advocated behavior. However, this problem-solution format does not adequately explain today's risk culture, where engaging in some risk-reducing behaviors may create a separate set of problems related to real or perceived risks. This creates new communication challenges when public discourse increasingly focuses on these "secondary" risks. As Camargo and Grant (2015) wrote, "How the general population comes to trust [expert solutions to societal risks] is partially a matter of their effectiveness, but it also involves the way in which the public discourse about them is constructed" (p. 232). They identified misinformation campaigns and failed gatekeeping by news media as sources of public rejection of expert solutions. Thus, while PMT celebrates a wide following and four decades of use, from a theoretical perspective it is unable to answer the question, *"What happens when the cure itself may be perceived of as a risk?"*

PMT supposes that when all components (threat severity, threat susceptibility, response efficacy, and self-efficacy) are at high levels then individuals will be motivated to protect themselves from the threat. However, for better or worse, just about every current risk issue and proposed response is publicly contested and creates potential secondary risks. The safety seat that might protect a child during a vehicle collision may also burden parents with newfound concerns of sudden infant death syndrome, which occurs more often when babies sleep in car seats than in bassinets or cribs (Pawlowski, 2019). Similarly, the MMR vaccine that inoculates individuals against measles, mumps, and rubella bears empirically founded side effects including injection site reactions, fever, rash, headache, and muscle pain. The vaccine may also be deemed risky by those who hold and perpetuate beliefs that vaccines pose all kinds of untoward risks, despite them being debunked by science (Davies, Chapman, & Leask, 2002).

Whether a secondary risk is legitimate or not means little for behavioral outcomes. Many studies show autism is not a secondary risk of the MMR vaccine (Madsen & Vestergaard, 2004; Taylor, Swerdfeger, & Eslick, 2014), but contrary beliefs persist, ushering in new waves of individuals who earnestly believe not taking the vaccine is in their best interests. They purposefully choose to avoid what they believe is a serious risk posed by the advocated behavior. In such cases, if individuals perceive the advocated behavior is risky, it will likely diminish their intentions and behaviors to protect themselves from the primary threat. This may happen even if all components of PMT are at high levels, suggesting that model is limited to explain protection motivation in the presence of perceived secondary risks.

Building on this premise, we introduce and test secondary risk theory to explain protection motivation in cases where there may be a high secondary risk perception. The following sections present this model, adapting PMT by incorporating the concept of secondary threat appraisal. We test the proposed model using survey data from the United States and Singapore and in the contexts of four infectious diseases and their associated risk response actions. In preview of our findings, when secondary risks are reported as mild or unlikely to occur, the secondary risk theory makes a modest improvement over PMT. However, when secondary risks are reported as severe and likely, secondary risk theory performs markedly better at explaining protection motivation. This signals a greater need for communicators to address potential secondary risks when developing effective risk messaging. As public discourse may continue raising a skeptical brow toward expert risk solutions, the need for addressing secondary risks will only grow.

1.1. Protection Motivation Theory

Rogers (1975) developed PMT to explain persuasive mechanisms of fear appeals. Fear appeals can be highly effective in influencing attitudes, intentions, and behaviors (Tannenbaum et al., 2015), and are a common message strategy in health and risk communication. Public communication campaigns have used PMT as a framework for designing strategic messages about health-threatening issues, including substance abuse, breast cancer, and infectious diseases (Cismaru, Deshpande, Thurmeier, Lavack, & Agrey, 2010; Lwin, Stanaland, & Chan, 2010; Prentice-Dunn, Floyd, & Flournoy, 2001). As a body of empirical work has shown, the theory substantially explains individual attitude and behavior change regarding fear-inducing problems (Floyd et al., 2000) to the extent that more recent research has applied PMT to other domains, such as mobile-health (e.g., Guo, Han, Zhang, Dang, & Chen, 2015), proenvironmental behaviors (e.g., Keshavarz & Karami, 2016), and cybersecurity (e.g., Tsai et al., 2016).

The basis of PMT is drive theory, which premises that individuals are driven to diminish undesirable affective states evoked by fear-inducing messages (Sternthal & Craig, 1974). Individuals can satisfy that drive by following a recommended behavioral response, which is likely to be reinforced and sustained if it is effective in reducing unpleasant emotions (Leventhal, 1970). However, when fear arousal is too great, or a recommended response is perceived as ineffective, individuals will engage in maladaptive coping strategies such as defensive denial (Janis & Feshbach, 1953).

Rogers (1975, 1983) further developed this conceptual framework by elucidating the cognitive processes mediating behavioral change. The subjective expectations and evaluations that individuals form about a recommended behavior stem from thoughts and feelings they have about the threat and the behavioral response (Milne, Sheeran, & Orbell, 2000; Rogers, 1975). When confronted with fear-arousing information, individuals engage in two mediating cognitive processes. In the first cognitive process, individuals evaluate a threat in terms of its magnitude, or *perceived severity*, of harm and their personal likelihood of being harmed, or *perceived susceptibility*. This process results in a threat appraisal. In theory, the effects of perceived threat severity and susceptibility are multiplicative, where both must be high for the threat to motivate behavior. The second cognitive process involves perceptions of the recommended response's effectiveness in mitigating the harm posed by the threat, or *response efficacy*, and beliefs about personal ability, or *self-efficacy*, to implement the recommended response. This process results in a coping appraisal. As with threat appraisal, the elements are, in theory, multiplicative.

Either threat appraisal or coping appraisal alone will not result in protection motivation. Individuals who perceive a severe and likely threat are unlikely to pursue a response they believe is either ineffective or too difficult to perform. These perceptions may result in maladaptive behaviors, such as dismissal or denial, as individuals lack confidence to respond to the threat directly (Rippetoe & Rogers, 1987). Similarly, individuals who believe a response is effective and easy to perform are unlikely to pursue it if they regard the threat as mild or unlikely to affect them. Thus, PMT is a multiplicative model in which protection motivation will diminish if any one of the four components are lacking. Fig. 1 provides a visual illustration of PMT, and Table I includes the common variables and definitions of the core PMT concepts based on the meta-analysis by Floyd et al. (2000).

Table I. Concepts that Comprise Protection Motivation Theory

Concept	Definition
Threat severity	The degree of harm from the threatening event
Threat susceptibility	The likelihood that one will experience harm from the threatening event
Response efficacy	The perceived effectiveness of the recommended behavior in removing or preventing possible harm
Self-efficacy	The perceived ability to successfully enact the recommended behavior

Many researchers have proposed elaborated PMT models that maintain the primary four components and add new components to suit contextual needs. For instance, in the field of cybersecurity, Martens, De Wolf, and De Marez (2019) found subjective normative beliefs to be an important predictor of individual intentions to protect against cybercrimes. The inclusion of other individual-level attributes, like subjective knowledge, habit, moral obligation, and perceived mutuality, also explain protective behavioral intentions in the contexts of cybersecurity and water shortages (Lee, 2011; Mankad, Greenhill, Tucker, & Tapsuwan, 2013; Tsai et al., 2016). Though, these individual-level factors marginally predicted the domain-specific behavioral intentions and might not explain other kinds of risk response actions. For instance, habit does not apply to new risk behaviors and moral obligation and perceived mutuality seem most relevant to collective risks and actions.

Other researchers have incorporated the concept of *response costs* within coping-appraisal models where coping appraisal equates to "response efficacy + self-efficacy—response costs." Response costs are synonymous with *barriers*, where response costs are "any costs (e.g., monetary, personal, time, effort) associated with taking the adaptive coping response" (Floyd et al., 2000, p. 411). This blanket concept is a carte blanche signifier of any potential barrier, and researchers have used response costs to denote factors internal to the individual's decision-making (e.g., fear of needles as a barrier to vaccination) or

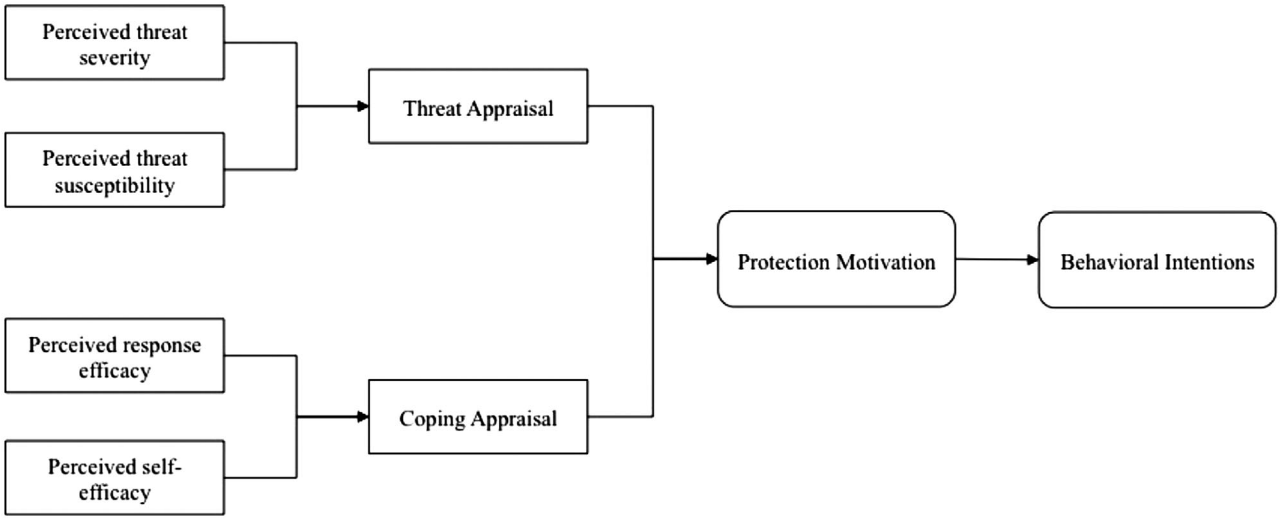

Fig 1. Protection motivation theory.

external to decision-making processes (e.g., availability of the vaccine itself). Scholars have noted that high response efficacy and self-efficacy increase the likelihood of adaptive behavioral intentions, while high response costs decrease this likelihood (Floyd et al., 2000; Weinstein, 1993). Our model isolates the influence of secondary threat severity and susceptibility, which are related to response costs and conceptually different from the efficacy beliefs central to PMT. Although there are many other kinds of response costs that can affect protection motivation, secondary threat appraisal plays a direct role in contexts where responsive behaviors create real or perceived secondary risks. It is from this premise we argue secondary risks should not be treated simply as a subset of response costs, but as additional core concepts in predicting protection motivation.

Still other works have integrated PMT with other behavioral theories to address complimentary and competing limitations and enhance the overall explanatory or predictive power. Within the health domain, Prentice-Dunn, McMath, and Cramer (2009) found motivations to avoid ultraviolet radiation exposure were different among individuals in different stages of change, and Van der Velde and Van der Pligt (1991) used conflict theory to show an adaptive coping style facilitated AIDS-prevention intentions. Within the cybersecurity literature, the combination of self-determination theory and PMT better predicted behavioral intentions than PMT alone (Menard, Bott, & Crossler, 2017), and perceived certainty and severity of informal sanctions motivated intentions to comply with cybersecurity practices (Johnston, Warkertin, & Siponen, 2015). Within environmental studies, the theory of reasoned action was examined in tandem with PMT to predict proenvironmental behaviors (Kim, Jeong, & Hwang, 2013). Although these studies offer new explanations of behavioral intentions, none considered the perceived novel risks related to engaging in protective behaviors. Stages of change, conflict theory, self-determination theory, and the theory of reasoned action emphasize individual differences and do not directly address the perceived risks that may arise in communication about recommended or desired protective behaviors.

Although the elaborations of PMT include a host of general- and domain-specific concepts, none includes secondary risk perceptions. Secondary risk perceptions are direct subjective expected outcomes of engaging in protective behavior, and we think they are essential for explaining decision-making in many risk contexts. Further elaboration of PMT should include secondary risk perceptions to explain more completely what happens when people learn about or experience secondary risks of advocated behaviors. By developing a new model centered on these perceptions, we can fill this notable research gap.

1.2. Secondary Risk Theory

In this section, we lay out the rationales for proposing a new model, eventually developing conceptual arguments. But to begin, we make the case with the example of the measles vaccine. Individuals may regard measles as threatening and the vaccine as both efficacious and easy to get. According to PMT, those individuals would get vaccinated because both the threat appraisal and coping appraisal support strong protection motivation. However, it is possible those individuals believe the vaccine has risky side effects, which might dominate their overall appraisal of the vaccine. If that were the case, those individuals would have lower protection motivation and tend to avoid the vaccine. And it is obvious, at least for those individuals, that PMT fails to explain behavioral outcomes. This would lead to a kind of Type I error (or alpha error) by overpredicting vaccination intention among those individuals.

The framework of secondary risk theory is predicated on individual subjective expectations of a threat and response to that threat. It retains the concepts of threat appraisal and coping appraisal to explain protection motivation and incorporates the concept of *secondary threat appraisal* to explain why individuals would choose to avoid engaging in a health protective behavior. This addition represents as a third and distinct cognitive process in the model. According to this extended framework, when individuals make risk decisions, they base their actions not only on evaluations of the potential harms of the threat and efficacy of their response, but also on the potential new harms associated with the response itself. As with threat appraisal from PMT, secondary threat appraisal reflects individuals' perceptions of the severity and likelihood of experiencing harm as anticipated consequences of their actions.

One of the few definitions of secondary risks comes from the field of project management, defining them as "risks that arise as a direct result of implementing a risk response" (Project Management Institute, 2013, p. 343). Risk assessors and project managers may anticipate and appraise secondary risks. In conceptual terms, suppose *Response R* is proposed to address *Risk A*, and in adopting that response *Risk A* is reduced in its potential harms and becomes *Risk a*. However, if *Response R* introduces a secondary risk, *Risk S*, it becomes important to evaluate if *Risk a* + *Risk S* < *Risk A* (Hillson, 1999, p. 4). From a strictly rational perspective, *Risk S* is acceptable only if the overall risk is reduced. Cummings (2013) adapted that conceptualization of secondary risk to explain intention to use nanoparticle sunscreen as protection against skin cancer. He found there was higher secondary threat appraisal and lower intention to use nanoparticle sunscreen when messages emphasized potential health risks of nanoparticles. We extend that proof of concept to argue that secondary threat appraisals affect protection motivation for many individuals and in different risk contexts. This leads to our first hypothesis:

Hypothesis 1: Health protection intention is negatively related to (i) the perceived severity of the secondary risk and (ii) perceived susceptibility to the secondary risk.

Secondary threat appraisal involves mental accounting like what occurs when individuals make primary threat appraisals. This involves considering the magnitude of harm associated with engaging in a behavior, or *perceived secondary threat severity*, and the likelihood of being harmed by that behavior, or *perceived secondary threat susceptibility*. These components are multiplicative, where there is a reduction in protection motivation when both are at high levels. If the perceived harm of the secondary risk is either mild or unlikely to occur, then the secondary threat appraisal is unlikely to reduce protection motivation. When the perceived harm is both severe and likely, then individuals will be less motivated to engage in the behavior, even if they believe it is effective at mitigating a noxious primary risk. Thus, we predict the following moderation effect:

Hypothesis 2: The effect of perceived severity of the secondary risk on health protection intention will be more negative when perceived susceptibility is high.

This conditional effect of secondary threat appraisal is the key point where secondary risk theory departs from PMT. When individuals have a high primary threat appraisal, high coping appraisal, and low secondary threat appraisal, a protective behavior has nothing but benefits and protection motivation will be high. In such cases, the traditional PMT ought to be adequate for explaining intention to engage in the behavior. Similarly, when individuals have either a low primary threat appraisal or a low coping appraisal, protection motivation will be low regardless of their level of secondary threat appraisal. This is because secondary risk appraisal enters the mental accounting when individuals are considering engaging in a protective behavior. When individuals have high primary threat appraisal, high coping appraisal, and high secondary threat appraisal, protection

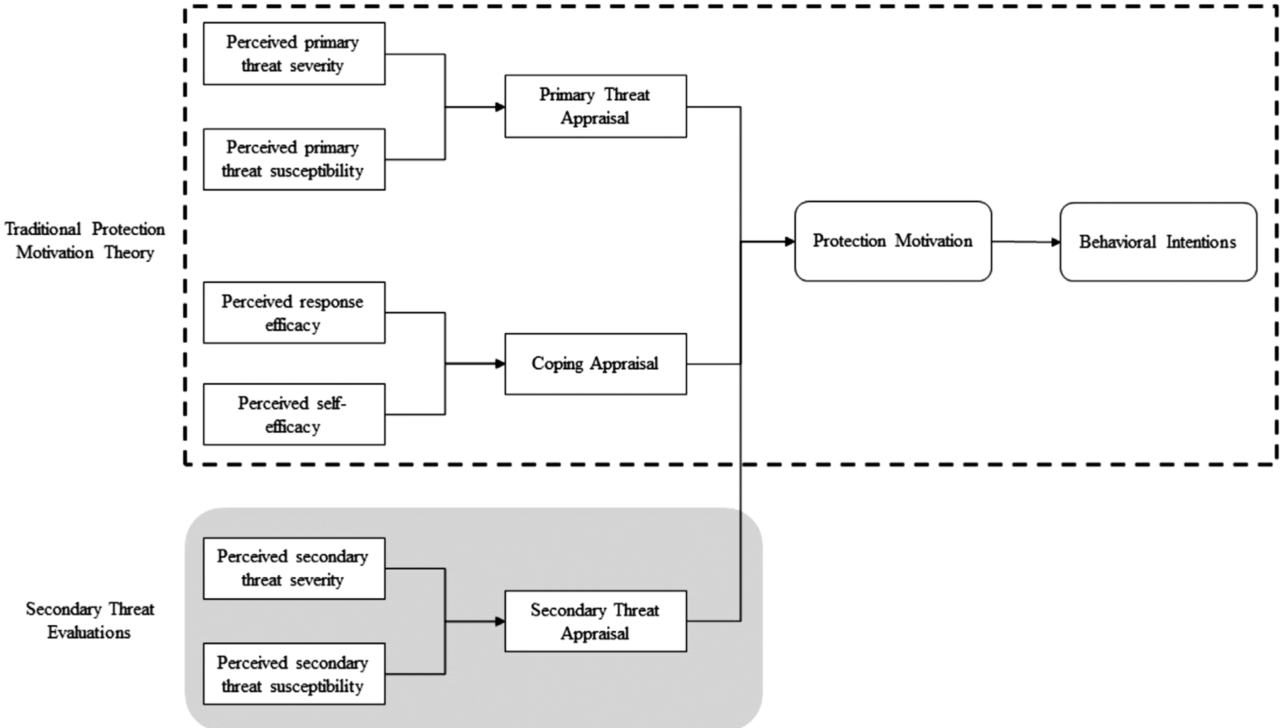

Fig 2. Secondary risk theory.

motivation will be much lower than what PMT would predict. In those cases, where some individuals may perceive the behavior to pose a new risk, secondary risk theory is necessary to accurately predict adoption of the protective behavior and should handily outperform PMT. Therefore, we expect secondary risk theory will generally do a better job than PMT at explaining health protection intention. This is an obvious thing to predict because adding more explanatory factors necessarily explains more variance. However, we also believe secondary risk theory will perform especially well in some situations, which is a prediction worth testing:

Hypothesis 3: When risk messages present severe and likely secondary risks of health protection behaviors, secondary risk theory will explain a large amount of variance in behavioral intention over PMT.

This is the central argument we presently test, which stems from observations that most any protective behavior, even those deemed by scientific evidence to be the most preferred safe risk mitigation options, are perceived and communicated by some as risky. Figs. 2 and 3 visually illustrate secondary risk theory and the anticipated effects of primary and secondary risk perceptions on protection motivation.

2. METHOD

2.1. Design

We conducted an online messaging experiment that manipulated the reported likelihood and severity of a secondary risk, in this case, experiencing vaccine side effects. We used a 2 (low vs. high vaccine risk severity) × 2 (low vs. high vaccine risk susceptibility) between-subjects factorial design. Participants read about the vaccine for one of four different diseases (dengue fever, chikungunya, bacterial meningitis, and cholera) assigned randomly. We used multiple disease messages to better generalize the model across the domain of vaccinations and perceived vaccination risks.

2.2. Sample

We analyzed online survey data from 1,246 participants. We sampled from Qualtrics-brokered

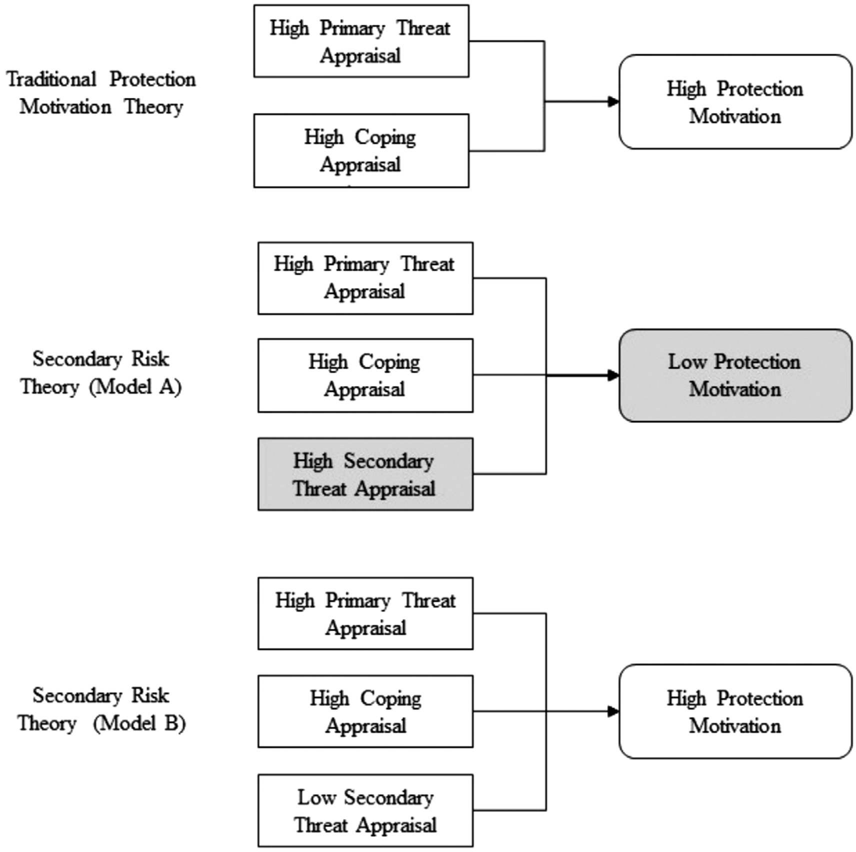

Fig 3. Secondary risk theory conditions and outcomes.

online panels in the United States (n = 691) and Singapore (n = 555). Participants in the United States ranged in age from 21 to 89 years ($M = 49.57$, $SD = 15.13$) and were 52% female. They had a median education level of "some college," which includes an associate degree, and a median household income of USD$50,000 to USD$75,000 before taxes. Participants in Singapore ranged in age from 21 to 81 years ($M = 47.25$, $SD = 14.56$) and were 50% female. They had a median education level of "Diploma" (comparable to an associate degree in the United States) and a median household income of SGD$50,000 to SGD$75,000 (about USD$38,000–USD$57,000) before taxes.

The final sample size was after deleting participants we determined were inattentive based on three criteria. First, we calculated the average error score on six reverse-coded items with a corresponding antonymous item (e.g., "The vaccine works in preventing [disease]" and "The vaccine is ineffective in preventing [disease]"). We scored each pair such that strongly agreeing or strongly disagreeing with both resulted in a score of 4, the maximum amount of error. Agreeing or disagreeing with one and somewhat agreeing or disagreeing, respectively, with the other resulted in a score of 1. We deleted cases with an average score of 1 or greater across the six pairs. Other researchers have used a similar approach using reverse-coded items to detect invalid cases (e.g., Jozsa & Morgan, 2017). Second, we estimated the within-subject variance on all seven-point Likert scales and deleted cases with zero variance, whom we suspected of straight-lining. Third, we deleted cases who completed the study in under one minute. This was an arbitrary cutoff, but it seemed highly unlikely an attentive respondent could complete the study that quickly.

2.3. Stimulus Materials

Our stimulus materials emulated the layout of online news articles and contained a byline "by the Associated Press (Health)" to induce perceptions of credibility. Each stimulus had four text sections

Table II. Experimental Manipulations of Dengue Fever Vaccine Risk Severity and Susceptibility

		Perceived Secondary Risk Severity	
		High Severity	*Low Severity*
Perceived secondary risk susceptibility	***High susceptibility***	While the vaccine is effective in preventing the effects of dengue fever, the vaccine itself poses some risks. Most patients reported common side effects including fever, injection site pain, muscle pain, bruising, swelling, severe headache, and a feeling of weakness throughout the body. There have also been reports of intense migraines, infections to the upper respiratory tract, cough, runny nose, neck pain, and skin eruptions. Cases of intense itching rashes, shortness of breath, and swelling of the face, tongue, and throat are also common. Other frequent reports include dizziness and fainting, sometimes accompanied with falling during or shortly after receiving the injection. Dr. Travis Sloan from Centers for Disease Control and Prevention said that this vaccine "poses frequent and severe risks to users."	While the vaccine is effective in preventing the effects of dengue fever, it has similar potential side effects to other vaccines. Like all vaccines, most patients reported common mild side effects including short-lasting injection site pain and slight bruising. There have also been reports of discomfort caused by getting vaccinated. Dr. Travis Sloan from Centers for Disease Control and Prevention said that this vaccine "poses frequent but mild risks to users."
	Low susceptibility	While the vaccine is effective in preventing the effects of dengue fever, the vaccine itself poses some risks. A small group of patients reported common side effects including fever, injection site pain, muscle pain, bruising, swelling, severe headache, and a feeling of weakness throughout the body. Typically, reports are very rare that intense migraines, infections to the upper respiratory tract, cough, runny nose, neck pain, and skin eruptions are caused by getting vaccinated. Cases of intense itching rashes, shortness of breath, and swelling of the face, tongue, and throat are also less common. Other less frequent reports include dizziness and fainting, sometimes accompanied with falling during or shortly after receiving the injection. Dr. Travis Sloan from Centers for Disease Control and Prevention said that this vaccine "poses infrequent yet severe risks to users."	While the vaccine is effective in preventing the effects of dengue fever, it has similar potential side effects to other vaccines. Like all vaccines, a small group of patients reported common mild side effects including short-lasting injection site pain and slight bruising. Typically, reports are very rare that any discomfort is caused by getting vaccinated. Dr. Travis Sloan from Centers for Disease Control and Prevention said that this vaccine "poses infrequent and mild risks to users."

that described the primary risk severity, primary risk susceptibility, response measure, and secondary risks. We maintained most diction across all stimulus materials except for the descriptions of different disease conditions and secondary risk severity and susceptibility levels (see Table II for dengue fever vaccine example). The Flesch–Kincaid grade level score of our stimulus text ranged between 9.6 and 12.1. Our experimental manipulations were additionally emphasized on using headlines, bold typeface, and colored text to reduce participant inattention.

2.4. Procedure

In February 2018, Qualtrics randomly selected and invited adult citizens and permanent residents in the United States and Singapore from their online panels to take part in the study. After giving informed consent, participants viewed a randomly assigned experimental stimulus and then answered survey questions to report their primary threat appraisal, coping appraisal, and secondary threat appraisal. Participants who completed the study were compensated by Qualtrics through its incentive system.

2.5. Measures

We modeled the PMT and secondary risk theory to predict vaccination intention. All measurement items used a seven-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*).

We measured primary risk severity with four items and primary risk susceptibility with three items adapted from Cummings (2013) and Kwong and Lam (2008). Participants indicated their level of agreement that the disease symptoms are severe and likely to afflict them. Higher scores reflected higher perceived primary risk severity ($M = 5.90$, $SD = 1.05$) and susceptibility ($M = 3.83$, $SD = 1.10$).

Perceived response efficacy was a three-item measure adapted from Witte, Cameron, McKeon, and Berkowitz (1996). Participants indicated their level of agreement that the vaccine is effective at preventing the disease. Higher scores reflected higher perceived response efficacy ($M = 5.24$, $SD = 1.02$). Perceived self-efficacy was measured with three items asking participants to indicate their level of agreement that they can easily get the vaccine. Higher scores reflected higher self-efficacy ($M = 5.56$, $SD = 0.94$).

We measured secondary risk severity with four items and secondary risk susceptibility with two items adapted from Cummings (2013). Participants indicated their level of agreement that vaccine side effects are severe and likely to afflict them. Higher scores reflected higher perceived secondary risk severity ($M = 3.61$, $SD = 1.36$) and higher perceived secondary risk susceptibility ($M = 4.80$, $SD = 1.08$), respectively. Behavioral intention was a single-item measure adapted from Ruiter, Verplanken, De Cremer, and Kok (2004). Higher scores reflected a stronger intention to get vaccinated ($M = 3.83$, $SD = 1.50$).

2.6. Manipulation Checks

Although the manipulations were straightforward and have good face validity, we were able to use our measures of perceived secondary risk severity and susceptibility to evaluate if the treatments had the intended psychological effects. For this analysis, we computed composite variables as item averages and compared between-treatment means using Wald tests in Mplus version 8.1. Supporting our manipulation of secondary risk severity, when the stimulus reported high severity, perceived severity was higher ($M = 4.20$, $SD = 1.21$) than when the stimulus reported low severity ($M = 3.01$, $SD = 1.25$; Wald $\chi^2 = 294.02$, $p < 0.001$). Supporting our manipulation of secondary risk susceptibility, when the stimulus reported high susceptibility, perceived susceptibility was higher ($M = 4.93$, $SD = 1.06$) than when the stimulus reported low susceptibility ($M = 4.65$, $SD = 1.08$; Wald $\chi^2 = 21.35$, $p < 0.001$). Both tests had one degree of freedom.

2.7. Model Testing

Next, we used Mplus to conduct structural equation modeling. We began by estimating a measurement model, which is equivalent to confirmatory factor analysis, and evaluated measurement invariance among experimental conditions using reporting criteria from Putnick and Bornstein (2016). Measurement invariance indicates to what extent the measurement of latent constructs varies among subsamples. In the present case, the experimental conditions defined the subsamples. Gupta (2014) discussed the rationales behind evaluating measurement invariance in experimental designs. Namely, since Hypothesis 3 concerns between-group differences in the structural model, it was necessary to ensure the latent constructs were equivalent among the four groups.

We used Mplus version 8.1 to conduct tests of configural, metric, and scalar invariance. The configural model is the least constrained and tests whether the overall measurement model fits across the four groups. The metric model extends this to hold the factor loadings constant across the groups. If the metric model has good fit, it means the composition of latent factors hold for each group. At the very least, metric invariance is needed to compare the structural model between groups. Finally, the scalar model is the most constrained and holds the item intercepts constant across the groups. If the scalar model has good fit, it allows comparisons of mean structure among groups. For further review of these levels of measurement invariance, see Lee (2018). According to Putnick and Bornstein (2016), if the more constrained model results in a change in Comparative Fit Index (CFI) less than 0.02 and change in Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean-square Residual (SRMR) both less than 0.03, there is support for the more constrained model. We found support for all three levels of invariance among the four experimental

Table III. Measurement Invariance and Structural Equivalence

	Fit Statistics for Measurement and Structural Models				
Measurement/Structural Model	χ^2	*df*	CFI	RMSEA [90% CI]	SRMR
Baseline (measurement)	1,211.89	618	0.959	0.056 [0.051, 0.025]	0.061
Configural invariance (measurement)	1,103.92	540	0.961	0.058 [0.053, 0.063]	0.054
Metric invariance (measurement)	1,146.47	579	0.961	0.056 [0.051, 0.061]	0.058
Scalar invariance (measurement)	1,211.89	618	0.959	0.056 [0.051, 0.060]	0.061
Equality constraints (structural)	1,465.06	694	0.949	0.060 [0.055, 0.064]	0.060
Free estimation (structural)	1,412.93	676	0.951	0.059 [0.055, 0.063]	0.058

Table IV. Measurement Model

Latent Construct Item Wording	AVE	CR	λ
Primary risk severity	0.74	0.92	
[Disease] causes serious illness			0.87
Health effects of [disease] are severe			0.87
Effects of [disease] would affect my usual activities			0.91
[Disease] has considerable negative consequences			0.80
Primary risk susceptibility	0.57	0.74	
I am at risk of getting [disease]			0.75
I am less likely than other people to get [disease]			0.57
I am safe from getting [disease]			0.90
Response efficacy	0.74	0.92	
The vaccine works in preventing [disease]			0.89
If I get the vaccine, I am less likely to get [disease]			0.88
The vaccine is ineffective in preventing [disease]			0.82
Self-efficacy	0.63	0.82	
I am able to get vaccinated			0.83
The vaccine is easy to get			0.77
I can choose if I want to be vaccinated			0.78
Secondary risk severity	0.70	0.89	
The vaccine causes serious illness			0.76
Health effects of the vaccine are severe			0.86
Effects of the vaccine would affect my usual activities			0.84
The vaccine has considerable negative consequences			0.89
Secondary risk susceptibility	0.67	0.85	
If I receive the vaccine, I am at risk of getting its side effects			0.91
If I receive the vaccine, I am safe from getting its side effects			0.71

Note: AVE, average variance extracted; CR, composite reliability; λ, standardized factor loading.

conditions (see Table III). Given the requirements of the current analysis, we estimated models with metric measurement invariance. Table IV summarizes the measurement model from the pooled sample, including item wording and factor loadings, average variance extracted, and composite reliability.

Next, we compared structural paths among the experimental groups. We did this with a chi-square difference test comparing two models: (1) a structural model constraining the main effects of the secondary risk theory to be equal across groups and (2) a model freely estimating the main effects of the secondary risk theory within each group. Comparing among experimental conditions, the test was significant, χ^2 (18) = 52.13, $p < 0.001$. This suggests the structural paths were different among conditions (see Table III).

Finally, we estimated four structural models for each group. The first model included only the main effects from PMT: primary risk severity, primary risk susceptibility, response-efficacy, and self-efficacy. The second model added the two-way interactions composing primary threat appraisal and coping appraisal. Table V shows the standardized path estimates from these first two models. The third model included all the main effects from secondary risk theory: the four main effects from PMT plus secondary risk severity and secondary risk susceptibility. The fourth model

Table V. Protection Motivation Theory Predicting Vaccination Intention

Predictor	Low Severity, Low Susceptibility		Low Severity, High Susceptibility		High Severity, Low Susceptibility		High Severity, High Susceptibility	
Primary risk severity	-0.21^{**}	-0.17^{*}	-0.14^{*}	-0.16^{*}	-0.01	0.00	-0.20^{**}	-0.20^{**}
Primary risk susceptibility	0.29^{***}	0.27^{***}	0.45^{***}	0.43^{***}	0.35^{***}	0.35^{***}	0.25^{***}	0.24^{**}
Response efficacy	0.54^{***}	0.52^{***}	0.26^{**}	0.24^{*}	0.28^{**}	0.26^{**}	0.38^{***}	0.35^{***}
Self-efficacy	-0.02	0.00	0.10	0.15	0.03	0.05	-0.09	-0.07
Primary threat appraisal		0.09		0.10		0.00		0.00
Coping appraisal		0.10		0.11^{*}		0.09		0.11
R^2	0.30	0.30	0.28	0.31	0.20	0.21	0.14	0.15

Note; For each experimental condition, the left column shows main effects and the right column adds interaction effects.
$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Table VI. Secondary Risk Theory Predicting Vaccination Intention

Predictor	Low Severity, Low Susceptibility		Low Severity, High Susceptibility		High Severity, Low Susceptibility		High Severity, High Susceptibility	
Primary risk severity	-0.13	-0.06	-0.08	-0.08	0.16^{**}	0.17^{*}	0.07	0.10
Primary risk susceptibility	0.32^{***}	0.29^{***}	0.47^{***}	0.45^{***}	0.33^{***}	0.33^{***}	0.29^{***}	0.30^{***}
Response efficacy	0.59^{***}	0.54^{***}	0.34^{***}	0.31^{**}	0.14	0.11	0.34^{***}	0.30^{***}
Self-efficacy	0.06	0.10	0.19^{*}	0.24^{*}	0.10	0.14^{*}	0.04	0.09
Secondary risk severity	0.25^{**}	0.27^{**}	0.12	0.15	-0.16^{*}	-0.12	-0.05	0.05
Secondary risk susceptibility	-0.30^{***}	-0.35^{***}	-0.38^{***}	-0.40^{***}	-0.39^{***}	-0.43^{***}	-0.60^{***}	-0.67^{***}
Primary threat appraisal		0.13		0.06		-0.04		-0.06
Coping appraisal		0.10		0.09		0.13^{*}		0.14^{*}
Secondary threat appraisal		-0.09		-0.08		-0.06		-0.15^{**}
R^2	0.38	0.42	0.38	0.41	0.37	0.41	0.40	0.45

Note: All estimates are standardized. For each experimental condition, the left column shows main effects and the right column adds interaction effects.
$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

added the two-way interactions composing the two interactions from PMT plus secondary threat appraisal. Table VI shows the standardized path estimates from the latter two models.

3. RESULTS

3.1. Protection Motivation Theory

Among the four conditions, primary risk susceptibility and response efficacy were consistent positive predictors of vaccination intention. Unexpectedly, primary risk severity was a negative predictor of vaccination intention in three of the four conditions, which contradicts PMT. It was unrelated to vaccination intention when the secondary risk was presented as being severe but unlikely. Self-efficacy was unrelated to vaccination intention, but there was a significant effect of coping appraisal, which contained the interaction of response efficacy and self-efficacy. That interaction shows the positive effect of response efficacy is stronger when self-efficacy is high (see Fig. 4). This is consistent with PMT. Finally, there was no effect of primary threat appraisal.

This model explained between 14% and 30% of the variance in vaccination intention. Explained variance was the highest when the secondary risk was presented as being mild. When it was presented as being severe, the explained variance was lower, especially when the secondary risk was also presented as likely to occur.

3.2. Secondary Risk Theory

Among the four conditions, primary risk susceptibility was a consistent positive predictor of vaccination intention. Response efficacy was a positive predictor except when the secondary risk was presented as severe but unlikely. Interestingly, in that condition, primary risk severity was a positive predictor. Primary risk severity was unrelated to vaccination intention in the other conditions. We

Fig 4. Interaction of response efficacy ($M \pm 1SD$) and self-efficacy ($M \pm 1SD$) in PMT for group 2 (low severity, high susceptibility).

Fig 5. Interaction of response efficacy ($M \pm 1SD$) and self-efficacy ($M \pm 1SD$) in secondary risk theory for group 3 (high severity, low susceptibility).

point this out because the results no longer contradict PMT. When the secondary risk was presented as mild but likely, self-efficacy was positively related to vaccination intention. In both conditions when the secondary risk was presented as severe, there was a significant effect of coping appraisal. As before, the interactions show the positive effect of response efficacy is stronger when self-efficacy is high (see Figs. 5 and 6). Again, there was no effect of primary threat appraisal.

Hypothesis 1a. Secondary risk severity was significantly related to vaccination intention in two conditions. Contrary to Hypothesis 1a, it was a positive predictor when the secondary risk was presented as mild and unlikely. Consistent with Hypothesis 1a, it was a negative predictor when the secondary risk was presented as severe but unlikely. The former finding is surprising because it suggests the perceived severity of side effects increases the likelihood of seeking the vaccine.

Hypothesis 1b. In contrast, secondary risk susceptibility was a consistent negative predictor of vaccination intention, which supports Hypothesis 1b. That effect appeared strongest when the secondary risk was presented as severe and likely to occur.

Hypothesis 2. There was partial support of Hypothesis 2. In three of the four conditions, the interaction of secondary risk severity and secondary risk susceptibility was not significant. However, when the secondary risk was presented as severe and likely to occur, the interaction was significant. That interaction shows the negative effect of secondary risk susceptibility is stronger when secondary risk severity is high (see Fig. 7). What that figure also shows is vaccination intention is the highest when the secondary risk severity is high, and susceptibility is low. This may be due to a tolerance or presumed inherency of vaccine side effects, which would explain the surprising effect of secondary risk severity we noted earlier.

Fig 6. Interaction of response efficacy ($M \pm 1SD$) and self-efficacy ($M \pm 1SD$) in secondary risk theory for group 4 (high severity, high susceptibility).

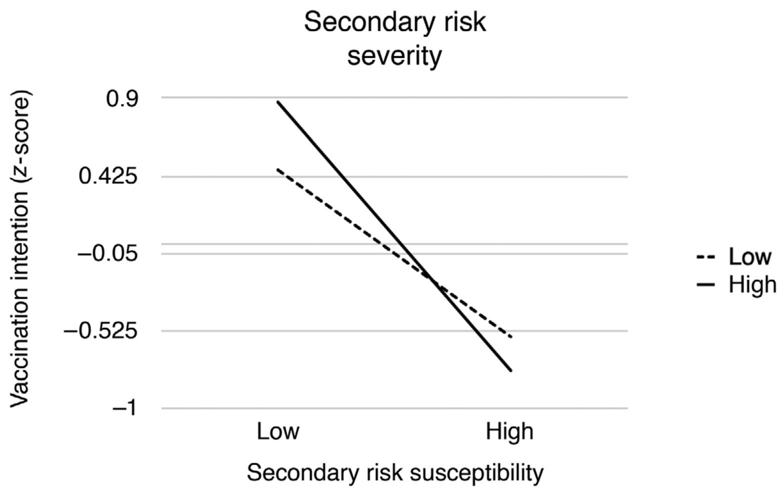

Fig 7. Interaction of secondary risk susceptibility ($M \pm 1SD$) and secondary risk severity ($M \pm 1SD$) in secondary risk theory for group 4 (high severity, high susceptibility).

Hypothesis 3. This model explained between 41% and 45% of the variance in vaccination intention. Explained variance was the highest when the secondary risk was presented as being severe and likely to occur. In that condition, secondary risk theory explained an additional 30% of the variance in vaccination intention beyond PMT. This roughly tripled the explained variance and supports Hypothesis 3. When the secondary risk was presented as severe but unlikely, secondary risk theory explained an additional 20% of variance. It explained additional variance in the remaining two conditions, but to a lesser extent.

3.3. *Post Hoc* Analysis by Disease and Country

The main goal of this study was to test the explanatory power of secondary risk theory given different levels of reported secondary severity and susceptibility. By pooling the analysis across diseases and countries, we assumed differences between countries and diseases would not affect our conclusions. But that assumption may be incorrect. Therefore, we conducted an additional analysis looking at differences among the four diseases crossed with the two countries. The full analysis of secondary risk theory involves three latent factor interactions, which is computationally intensive. Since this analysis is ancillary to the focus of this study, we conducted a simpler analysis looking only at main effects.

Following our earlier analyses, we first evaluated measurement invariance. The measurement model with metric invariance had acceptable fit, χ^2 (1,171) = 1,933.44, CFI = 0.948, RMSEA = 0.065 [90% CI: 0.059, 0.070], SRMR = 0.074. Next, we conducted a chi-square difference test to see if the structural paths differed among the eight groups. This test was significant, χ^2 (42) = 117.59, $p < 0.001$, suggesting

Table VII. Main Effects by Disease and Country

	Dengue		Chikungunya		Meningitis		Cholera	
Predictor	US	SG	US	SG	US	SG	US	SG
Primary risk severity	−0.04	0.12	0.08	0.05	-0.17^{*}	−0.09	0.06	−0.05
Primary risk susceptibility	0.54^{***}	0.14	0.40^{***}	0.07	0.38^{***}	−0.10	0.47^{***}	0.44^{***}
Response efficacy	0.28^{**}	0.25	0.26	0.24	0.18	0.21	0.32^{**}	0.58^{***}
Self-efficacy	0.16^{*}	0.16	0.00	0.23	0.17	0.29	0.16	0.20
Secondary risk severity	-0.22^{**}	0.02	0.08	−0.13	−0.07	−0.07	0.03	0.26^{*}
Secondary risk susceptibility	-0.33^{***}	-0.62^{***}	-0.34^{**}	-0.22^{*}	-0.39^{***}	−0.23	-0.40^{***}	-0.34^{**}
R^2	0.64	0.43	0.29	0.29	0.47	0.34	0.42	0.43

Note: All estimates are standardized. US, United States; SG, Singapore.
$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

the structural paths are different among the groups. Finally, we estimated the main effects model for all eight groups. Table VII shows the standardized path estimates. Here, we briefly note some apparent differences among the groups.

First, secondary risk theory did a relatively poor job predicting intention to take the chikungunya vaccine, with 29% explained variance in both countries. In the United States, primary risk susceptibility was a consistent positive predictor and secondary risk susceptibility was a consistent negative predictor of vaccination intention. In Singapore, the most consistent predictor was secondary risk susceptibility, which had a negative relationship with vaccination intention except for the meningitis vaccine. Other differences were less pronounced. It is worth noting the group sizes ranged from 131 to 177, which reduces the generalizability of these disease- and country-specific findings.

4. DISCUSSION

While the traditional PMT model has been lauded for its parsimony and is widely used by researchers (Weinstein, 1993), it is incomplete without considering the secondary risk perceptions that, in many contexts, may influence the adoption of risk response actions. This is a serious cause for concern as practitioners who employ PMT as a means (1) to understand public risk responses or (2) to base risk communication campaigns and interventions may be acting on partial insights about the subjective expected utility of the advocated behavior. This incomplete evaluation focuses on the initial threat evaluation and may generate unintentionally inflated predictions of behavioral intention.

The focus of PMT on the initial threat evaluation leaves a conceptual void, which secondary risk theory fills. In doing so, it explains more completely the subjective expected utility associated with individual motivation for self-protection. For instance, PMT notes that individuals seek vaccines when they expect there to be a utility to them to prevent disease. Secondary risk theory encapsulates a broader subjective expected utility, which accommodates cases where individuals believe a vaccine is effective against the disease but has nasty side effects. Even if they can easily take the vaccine, they may still choose to avoid it due to anticipated secondary risks. In such instances, secondary risk theory is useful because it incorporates all the explanatory power of PMT regarding expected utility plus a mechanism to capture an important source of expected disutility. Thus, secondary risk theory provides a more granular and robust accounting of threat and response and we believe it is better suited than PMT for scholars and campaigners to predict and promote protection motivation.

As our analyses show, secondary risk theory explains more of the observed variance than PMT in intentions to adopt protective behavior (see Tables IV and V). This is unsurprising because more variables explain more variance. However, unlike some prior PMT elaborations, the addition of secondary threat appraisal in secondary risk theory succinctly and directly captures an influential risk-related evaluation absent from PMT. Not only do our analyses show secondary risk theory outperforms PMT regardless of how risk messages describe a secondary risk, but secondary risk theory performs especially well when the level of the secondary threat may compete with that of the primary threat. The knowledge that secondary risk theory performs better than PMT across experimental conditions provides some empirical validation for its proposed future use, but perhaps more important are its theoretical contributions and potential for wide use.

Researchers and practitioners who already employ PMT would benefit from adopting secondary risk theory. Doing so could help them better understand public risk perceptions and attitudes toward different risk response actions. As individuals ought to vary in their cognitive appraisals of secondary threats related to virtually any risk-reducing behavior, employing secondary risk theory will improve audience analysis and inform subsequent risk communication messaging strategies. It is possible that PMT-based campaigns would put considerable efforts into promoting risk response actions only to see their target audience reject the target behavior because of the inherent, portrayed, or imagined secondary risks associated with the behavior. Secondary risk theory thus provides campaigners with a more comprehensive and adaptable framework. This framework can support their strategic planning of targeted interventions with a more informed perspective on behaviors they promote.

We wish to highlight that our study tested secondary risk theory using a messaging experiment. Media messages are often how individuals come to learn about risk response actions, but there are other ways to study secondary risk theory. For one, future studies might inquire about secondary risk perceptions related to personal experience or interpersonal communication. It may also be worthwhile to study state and trait predispositions influencing perceptions and responses to secondary risks. Finally, it would be informative to understand the mental accounting that occurs when individuals balance the expected utility and disutility of engaging in risk response actions. In other words, at what level does a secondary threat appraisal overpower the influence of the primary threat appraisal and coping appraisal? Such future lines of inquiry may strengthen secondary risk theory as a social behavioral theory.

Related to our last point above, we anticipate secondary risk theory will provide a framework for evaluating potential "risk–risk tradeoffs." Such risk–risk tradeoffs are anticipatory evaluations derived from the understanding that actions have consequences and that, although a problem may have many solutions, each solution may carry with it some consequence. To rearrange our earlier formulation, such a tradeoff might consider if $Risk\ S <$ Risk A – $Risk\ a$, where the tradeoff is fair if the reduction in primary risk is larger than the secondary risk it creates. As Graham and Weiner (1997) noted, risk assessors and risk managers should evaluate and communicate about risk–risk tradeoffs: "Public communication about risk-risk tradeoffs is critical in relation to many public health issues. Such communication is essential because it provides information that can allow individuals and society to better reduce overall health risks, to focus resources on risks of higher magnitude and to employ disease control strategies only when their health benefits appear to outweigh their health costs" (Roche, 2002, pp. 482–483). Secondary risk theory provides a framework that can better account for such risk–risk tradeoffs in individual decision-making. We feel that secondary risk theory may also improve public risk communication and, ultimately, public health by better addressing how members of the public make risk decisions in instances where they might consider the novel risks posed by the recommended actions under consideration.

Finally, in everyday situations individuals confront threats and must evaluate how best to respond to them. In doing so, they cognitively appraise the novel harms associated with actions they consider in response to an initial threat. This process becomes challenging as society continues to produce uncertain and often contradictory risk reports, and public discourse seems to be increasingly challenged by misinformation regarding notably viable and beneficial risk mitigating behaviors. In this sociopsychological space, secondary risk theory provides the next best-step in improving behavioral prediction of protection motivation and better theorizes how individual risk decisions are influenced by one's assessment of the consequences of their actions.

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