The Impact of COVID-19 Probability and Cost Estimates on Worry and Health Behavior
Compliance in Young Adults

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Abstract

The novel coronavirus COVID-19 pandemic is associated with elevated rates of anxiety and relatively lower compliance with public health guidelines in younger adults. To develop strategies for reducing anxiety and increasing adherence with health guidelines, it is important to understand the factors that contribute to anxiety and health compliance in the context of COVID-19. Earlier research has shown that greater perceived probability of negative events and their costs are associated with increased anxiety and compliance with health behaviors, but it is unclear what role they play in a novel pandemic surrounded by uncertainty. In the present study we measured 1) perceived probability as the self-reported probability of being infected and experiencing serious symptoms due to COVID-19 and 2) perceived cost as financial, real-world, physical, social and emotional consequences of being infected with COVID-19. Worry was assessed using the Penn State Worry Questionnaire (PWSQ) and health compliance was measured as endorsement of the World Health Organization (WHO) health directives for COVID-19. Our results showed that greater perceived costs of contracting the COVID-19 virus were associated with greater worry and compliance with health behaviors, even when controlling for probability estimates. Interestingly, neither self-reported worry nor its interaction with cost estimates was associated with increased engagement in health behaviors. Our results provide important insight into decision making mechanisms involved in both increased anxiety and health compliance in COVID-19 and have implications for developing psychoeducational and psychotherapeutic strategies to target both domains.

Keywords: COVID-19, decision-making, probability, cost, worry, health

Declarations

Funding

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Conflicts of interest/Competing interests

The authors declare that they have no conflicts of interest.

Ethics Approval

This investigation was approved by the Stony Brook University Institutional Review Board and was performed in accordance with the ethical standards as delineated by in the 1964 Declaration of Helsinki and its later amendments.

Informed Consent

All participants provided informed consent prior to engaging in any procedural tasks.

Availability of data and material

Data used for this project is available online at Open Science Framework (OSF; <https://osf.io/cgzsd/>).

Code availability

Not applicable

Authors' contributions

Mohanty supervised the project. Jin, Larsen, and Mohanty conceived of the experiment and compiled the materials for the experimental design. Mohanty, Luhmann, and Jin advised on theoretical background and analysis considerations. Larsen collected the data. Jin and Imbriano analyzed the data. Imbriano, Mohanty, and An wrote the manuscript with support from Jin and Larsen. All authors helped shape the manuscript and provided essential feedback to finalize the completed manuscript.

Introduction

The novel coronavirus COVID-19 pandemic poses a major public health threat in our current global community (Spring/Summer, 2020). The negative effects of this pandemic are experienced at the individual (e.g., insecurity and emotional isolation) and community (e.g., economic loss, school closures) level, and these effects translate into mental health consequences, such as anxiety and worry as well as noncompliance with public health directives, such as social distancing, and hand washing (Pfefferbaum & North, 2020). The United Nations has described the coronavirus pandemic as having “the seeds of a major mental health crisis” (United Nations Sustainable Development Group, 2020), with evidence of increased anxiety and depression in the general population (Vindegard & Benros, 2020; Torales, O’Higgins, Castaldelli-Maia, & Ventriglio, 2020; Serafini et al., 2020), especially for young adults (National Center for Health Statistics [NCHS], 2020). For effective prevention and treatment of anxiety, including screening, psychoeducation and psychological therapy, it is important to understand factors that contribute to anxiety related to the COVID-19 pandemic in young adults.

Additionally, while the present public health response to the COVID -19 pandemic relies primarily on behavioral directives, noncompliance to these directives has been noted due to a variety of reasons (Blendon et al., 2006; Wright, Sonin, Driscoll, & Wilson, 2020; Briscese, Lacetera, Macis, & Tonin, 2020), especially in younger adults (Canning, Karra, Dayalu, Guo, & Bloom, 2020). For effective messaging and psychoeducation, it is important to understand the decision-making mechanisms that contribute to compliance with COVID-19-related public health directives critical to effective containment of viral spreading in young adults. Hence, in the present study, we focused on two key aspects of decision making: perceived probability of experiencing negative events and the perceived cost (consequences) of these negative events.

Specifically, we examined whether perceived probability and costs of developing COVID-19 influences levels of worry and compliance to health recommendations in young adults.

There is considerable evidence suggesting that anxiety can be driven by decision making biases that involve exaggerated estimates of the probability of negative events, and exaggerated estimates of the cost (i.e., consequences) associated with the negative events (Carr, 1974; Beck, 1976; Foa & Kozack, 1986). Overestimation of feared consequences has been demonstrated as a common transdiagnostic feature of anxious pathology (Beck, Emory, & Greenberg, 1985). Prior research has shown that inflation of perceived risk related to acute stressors is related to increased state anxiety, whereas inflation of perceived risk of encountering negative situations more generally is related to increased trait anxiety (Butler & Mathews, 1987). Clinical populations with generalized anxiety disorder also perceive negative events as being more probable (for review, Aue & Okon-Singer, 2015; Butler & Mathews, 1983). Additionally, Berenbaum and colleagues (2007) showed that greater self-reported worry was associated with higher perceived probability of negative outcomes as well as more severe cost estimates of these negative outcomes in a sample of college students. However, anxiety disorders or symptoms are not uniformly characterized by overestimation of probabilities and costs of negative or feared outcomes. Instead, anxiety may exhibit specific relationships with probability and costs (Nelson, Deacon, Lickel, & Sy, 2010; Nelson, Lickel, Sy, Dixon, & Deacon, 2010). Considering the higher rates of anxiety in the younger adult populations (NCHS, 2020), it is important to assess perceived probability and costs of COVID-19 infection to examine if they contribute uniquely to worry severity in young adults during the pandemic.

While the COVID-19 pandemic is characterized by novelty and uncertainty, it is clear that health-related decisions such as socially distancing oneself, washing hands frequently, not

touching one's face, and avoiding non-essential travel will be effective in reducing the spread of COVID-19 (National Center for Immunization and Respiratory Diseases [NCIRD], 2020).

However, while factual information about health threats and methods of risk-reduction is necessary, it is often not sufficient for compliance. Research in decision making shows that effective human behavior is guided by accurate assessments of the probability with which negative events will occur and the cost associated with those negative events (Crandall, Solomon, & Kellaway, 1955; Edwards, 1953, 1962; Irwin, 1953; Marks, 1951; Morlock & Hertz, 1964). Indeed, most decision-oriented theories of health behavior propose that the judgments of the probability of future harm are key to whether preventive action is taken (Conner & Norman, 2005; Ferrer & Klein, 2015). For example, prior investigations have shown that adherence to vaccine protocols was significantly predicted by estimated probabilities of getting infected with influenza as well as costs associated with influenza (Brewer et al., 2007). Additionally, evidence suggests that self-reported judgements of how vulnerable someone feels regarding their health can have more of an impact on subsequent behavior than judgements based on statistical evidence (Ferrer & Klein, 2015; Weinstein et al., 2007; Janssen, van Osch, de Vries, & Lechner, 2011). Since younger adults tend to show lower compliance to COVID-19-related health directives (Nivette et al., 2020; Canning et al., 2020), perceived probability and estimates of COVID-19 infection may offer clues about this non-compliance.

Finally, more recent models of health-related risk perception and decision-making have differentiated more *deliberative* components of decision-making from the more *affective* components (Ferrer & Klein, 2015; Gerrard, Gibbons, Houlihan, Stock, & Pomery, 2008; Loewenstein, Weber, Hsee, & Welch, 2001; Slovic, Finucane, Peters, & MacGregor, 2004). Worry or anxiety about a threat is considered to be an affective analogue to deliberative risk

perceptions (Loewenstein et al., 2001). Additionally, it has been proposed that more complex interplay between deliberative and affective factors can influence health-related behaviors (Ferrer & Klein, 2015). For example, when deliberative and affective perceptions converge, the potential for action is the greatest (Ferrer & Klein, 2015). This suggests the need to examine the contribution of anxiety and its interaction with cost/probability estimates with COVID-19 health behavior compliance in young adults.

In sum, prior research on health behaviors has demonstrated the importance of probability and cost estimates in increased anxiety and compliance with health recommendations. However, these factors have not yet been examined in the context of an ongoing pandemic such as COVID-19. Additionally, this is particularly important to assess in young adults who can be powerful vectors for disease transmission as they are more likely to be asymptomatic carriers of COVID-19 (Moghadas et al., 2020; Poletti et al., 2020; Furuse et al., 2020) and show increased anxiety and decreased health compliance. Hence, in the present study we aimed to examine the differential association of perceived probability and cost of COVID-19 related outcomes with anxiety as well as compliance with health-related behaviors in a sample of college students in the New York metro area. Perceived probability was measured as the self-reported probability of being infected by COVID-19 and experiencing serious symptoms due to COVID-19 while perceived cost was measured as financial, real-world, social and emotional consequences of being infected with COVID-19. We predicted that greater perceived probability and costs of contracting COVID-19 would be associated with greater worry. Furthermore, we hypothesized that greater perceived probability and costs of contracting COVID-19, greater worry, and their interaction would be associated with greater compliance with health directives for reducing the spread of COVID-19.

Methods

Data were collected from 261 (156 female, 105 male) undergraduate students (M age = 19.93 years) at Stony Brook University who participated in this experiment for partial course credit. Participants were excluded from analyses for completing the questionnaires in less than 10 minutes ($N= 21$) due to suspected inattentiveness, leaving a final sample of 240 participants. Participant demographics for the final sample can be seen in Table 1. The average time to complete the study for the final sample of participants was 27.3 minutes. Participants consented to participation prior to engaging in any procedural tasks. This investigation was approved by the Stony Brook University Institutional Review Board.

Measures

Data collection. Questionnaires were administered via Qualtrics survey software. Order of questionnaire administration was randomized with the exception of demographic questions, which were presented first. Following completion of the survey, participants were automatically directed to a debriefing form. Data for this manuscript was obtained from a subset of questionnaires given for a larger study which included 12 total questionnaires (for description of other data that were collected, see Larsen, Donaldson & Mohanty, 2020).

COVID-19 Health Behavior Questions. Health behavior adherence was assessed based on recommendations appearing on the website of the World Health Organization (World Health Organization, 2020) during the first week of April, 2020. A total of 8 items were administered pertaining to changes in frequency of the following health behaviors: handwashing; use of hand sanitizer; social distancing; avoiding touching eyes, nose and mouth; covering mouth and nose with bent elbow or a tissue when coughing or sneezing; disinfecting or washing surfaces that are frequently touched. All questions were framed in terms of the respondent's behavior in the past

week. Responses ranged on a 4-point scale from *Not at all* to *Very much increased*. The set of health behavior questions displayed acceptable internal consistency (Cronbach's $\alpha = .71$), supporting the use of a total score as a unitary index.

COVID-19 Perceived Probability. Participants rated their perceived probability of various COVID-19 related scenarios and outcomes. For example, items included “*I think my chances of getting infected with COVID-19 are*” and “*I think my chances of becoming seriously ill due to COVID-19 are*”. Participants responded to each of these items on a 7-point scale with scores ranging from 1 (*Almost zero*) to 7 (*Almost certain*). Wording of the probability estimate items and scales were adapted from prior research investigating the perception of influenza risks (Weinstein et al., 2007).

COVID-19 Perceived Cost. Projected consequences of COVID-19 infection were measured using a novel, 30-item measure. Five domains of projected illness costs were assessed, including perceived physical symptom consequences (“*If I get infected with COVID-19, I will have breathing problems*”; responses ranged from 1-*Not distressing* to 5-*Severely distressing*); daily functioning consequences (“*If I get infected with COVID-19, it will impact my ability to do my work*”; responses ranged from 1-*Not at all* to 5-*Severely*); emotional/mood consequences (“*If I get infected with COVID-19, I will feel irritable*”; responses ranged from 1-*None* to 5-*Severe*); social consequences (“*If I get infected with COVID-19, I will impact people by making them worry*”; responses ranged from 1-*Not at all* to 5-*Severely*); and financial/livelihood consequences (“*If I get infected with COVID-19, I will suffer financially*”; responses ranged from 1-*Not at all* to 5-*Severely*). The 30-item inventory displayed excellent internal consistency (Cronbach's $\alpha = .95$).

Penn State Worry Questionnaire (PSWQ). The PSWQ (Meyer, Miller, Metzger, & Borkovec, 1990) is a 16-item measure that assesses for self-reported symptoms of worry by asking participants to rate on a 1 (“*Not at all typical of me*”) to 5 (“*Very typical of me*”) scale how characteristic various worry related statements are for them (for e.g., “*My worries overwhelm me.*”). The PSWQ has demonstrated high reliability ($r = .93$) as a measure of worry.

Results

First, we sought to examine whether greater probability of contracting COVID-19 and the perceived costs were related to worry. All correlations were corrected for multiple comparisons at 0.05 level of significance and were assessed as significant if they exceeded the $p < 0.007$ threshold for corrected significance. Correlational analyses showed that greater perceived probability of contracting COVID-19, $r(238) = 0.211$, $p = .001$, experiencing more serious COVID-19 symptoms, $r(238) = 0.244$, $p < .001$, and greater perceived negative costs, $r(238) = 0.339$, $p < .001$, were associated with greater severity of worry symptoms.

Next, we conducted regression analyses to examine the differential relationship of COVID-19-related probability and cost estimates with worry. Regression analyses conducted with the probability of infection, probability of becoming seriously ill, and the total perceived costs of COVID-19 were associated with worry severity, $R^2 = 0.147$, *Adjusted R squared* = 0.136, $F(3, 236) = 13.541$, $p < .001$. There was a positive relationship between total perceived costs, $\beta = .278$, $t(236) = 4.368$, $p < .001$ and worry, but no relationship with probability of becoming seriously ill, $\beta = .124$, $t(236) = 1.883$, $p = .061$ nor the probability of infection, $\beta = .107$, $t(236) = 1.656$, $p = .099$, after controlling for the other two predictors. Hence, higher perceived costs of COVID-19 infection, but not probability of being infected or becoming seriously ill, were associated with more severe worry.

Second, we examined whether greater perceived probability of contracting COVID-19 and related costs were associated with greater compliance with health behaviors shown to prevent the spread of COVID-19. Correlational analyses showed that perceived probability of contracting COVID-19 was not related to health behavior engagement, $r(238) = 0.108$, $p = .096$, nor was the perceived probability of becoming seriously ill due to COVID-19, $r(238) = 0.048$, $p = .455$. However, beliefs about the costs of contracting COVID-19 were positively associated with engagement in health behaviors, $r(238) = 0.199$, $p = .002$, such that the greater one's estimation of the negative costs of COVID-19, the more likely respondents were to endorse an increased engagement with preventative health behaviors.

We then sought to determine the unique contributions of probability and cost estimates to health behaviors. Regression analyses conducted with the probability of infection, probability of becoming seriously ill, and the total perceived costs of COVID-19 explaining health behavior scores, $R^2 = 0.045$, *Adjusted R squared* = 0.033, $F(3, 236) = 3.70$, $p = .012$, demonstrated a positive relationship between total perceived costs, $\beta = .193$, $t(236) = 2.863$, $p = .005$ and health behaviors, which did not exist for probability of infection, $\beta = .077$, $t(236) = 1.124$, $p = .262$, or probability of becoming seriously ill, $\beta = -.035$, $t(236) = -.506$, $p = .613$. Thus, the aggregate costs of COVID-19 infection are associated with increased engagement in health behaviors, even after controlling for the probability of infection and probability of becoming seriously ill.

Finally, because in addition to probability/cost estimates, anxiety and their interaction may have independent effects on adherence to health behaviors we conducted regression analyses to examine if they accounted for additional variance in COVID-19 health related behaviors. Hierarchical regression analyses conducted with the perceived costs of COVID-19, anxiety and their interaction predicting health behavior scores, $R^2 = 0.045$, *Adjusted R squared* =

0.033, $F(3, 236) = 3.70$, $p = .012$, showed that neither anxiety nor the interaction term accounted for significant additional variance in COVID-19 related health behaviors.

Discussion

Almost a third of Americans have reported increased anxiety during the peak of the COVID-19 pandemic, with nearly 50% of young adults reporting anxiety increases (National Center for Health Statistics [NCHS], 2020). While public health agencies have recommended several non-pharmacological health behaviors that are effective in reducing transmission rates and risk of illness (National Center for Immunization and Respiratory Diseases [NCIRD], 2020), behavioral responses to COVID-19 have been mixed with evidence of non-compliance, especially in young adults (National Center for Health Statistics [NCHS], 2020). Our study sought to understand the factors that contribute to this increased anxiety and decreased compliance with health directives in young adults. Our results showed that higher perceived probability of COVID-19 infection was associated with increased worry severity; however, negative consequences or costs one would incur from contracting the virus were uniquely associated with increased worry and engagement in preventive health behaviors. However, greater self-reported worry or its interaction with cost estimates was not related to increased engagement in health behaviors.

Worry can serve to be more harmful than helpful in the case of the COVID-19 pandemic; hence, global health advocates may want to consider integrating worry assessment and reduction when educating the public on current challenges they may be facing. Our findings suggest that an important contributing factor to increases in worry is the perception that one might incur several negative costs or consequences as a result of contracting COVID-19. Targeting catastrophizing has been an integral part of cognitive-behavioral interventions for worry (Leahy, 2006) and

maybe effective in reducing worry at the time of the current pandemic. It is important to note that in interventions such as cognitive restructuring for worry, possible negative consequences or costs of outcomes are not invalidated or minimized. Rather, the focus of treatment is shifted to agency in actions that would productively decrease an individual's risk of the feared outcome, for example the health behaviors recommended for COVID-19. Also, particularly relevant for young adult populations, it may be important to examine how social media and news consumption contributes to increased cost estimates because recent work from Gao and colleagues (2020) shows that social media use during the COVID-19 outbreak in China was related to increased anxiety and depression symptoms.

A great deal of research has focused on understanding the psychological determinants of health behaviors (e.g. Conner & Norman, 2017). Models of health behavior include a number of common determinants including intentions, self-efficacy, treatment outcome expectancies, perceived risk or susceptibility and perceived severity, that contribute differentially to different health problems (Conner & Norman, 2017). According to the predominant health belief model (Clark, Davila, Regis, & Kraus, 2020), the importance of probability and cost estimates relies on the fact that when the disease threat is viewed as low probability and its consequences mild, there is a low motivation to engage in health behavior change and individuals ignore health directives (Clark et al., 2020). Our results show that it is not perceived probability but perceived costs of contracting COVID-19 illness that predicts health compliance. The relatively low importance of perceived probability in case of COVID-19 pandemic may be because pandemics tend to be low probability but high consequence events, perhaps giving individuals less opportunity to factor probability estimates in their decision making. Furthermore, the novelty of this pandemic with constantly changing information maybe reducing reliance on probability

estimates in a situation where the emotional, social, financial and physical consequences are being experienced. Finally, our results diverge from another study that found an association between probability estimates and health behavior (de Bruin & Bennett, 2020) however, this study did not measure cost estimates allowing participants to separate the two in their responses and did not focus specifically on younger adults who tend to underestimate risk of diseases (Green, Grant, Hill, Brizzolara, & Belmont, 2003; Mongiello, Freudenberg, Jones, & Spark, 2016). Given the importance of cost estimates in the present study, it is important to consider perceived costs in psychoeducation and messaging for encouraging health-related behaviors in young adults.

This investigation was limited by the availability of COVID-19-related assessment measures at the time of data collection. However, the scales used above demonstrated internal consistency. Additionally, at the time of data collection and approval, wearing masks was not unanimously regarded as an accepted practice for mitigating viral spread in the United States so we were unable to collect data related to that aspect of prevention. However, future iterations of this paradigm will include mask-related questions. Additionally, the population of this study was composed of college-age students enrolled in a New York Metro area university from April 21, 2020 to May 8, 2020. Therefore, the results should be interpreted with respect to the specificity of this group, as the geographic and temporal specificity of data collection is germane to the investigation of the trajectory of COVID-19 related beliefs. Particularly relevant is that towards the beginning of the COVID-19 outbreak, younger individuals were considered to be less vulnerable than older populations to severe health outcomes (Maragakis, 2020). The results presented here, while not nationally representative, do offer important insights into mental health and compliance with health behaviors in a population demographic that have become of greater

interest as we learn more about asymptomatic viral spreading. To expand on the current results, future studies may seek to investigate other factors that contribute to positive health behavior engagement such as consistent exposure to accurate and comprehensible scientific information and guidance.

Table 1: Participant demographics

	Mean	SD	N	%
Gender	—	—	—	—
Female	—	—	150	62.5
Male	—	—	90	37.5
Race	—	—	—	—
White/Caucasian	—	—	73	30.4
Hispanic/Latino	—	—	37	15.4
Black	—	—	18	7.5
Asian/Pacific	—	—	101	42.1
Islander				
Other	—	—	11	4.6
Age (years)	19.9	2.4	—	—

Figure 1. Scatterplots displaying correlations between A. perceived probability of contracting COVID-19 and Penn State Worry Questionnaire (PSWQ) scores B. perceived probability of serious illness due to COVID-19 and PSWQ scores C. perceived consequences of COVID-19 and PSWQ scores and D. consequences of COVID-19 and health behavior engagement.

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