COVID-19 Stressors and Health Behaviors: A Multilevel Longitudinal Study across 86 Countries

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Abstract

Anxiety associated with the COVID-19 pandemic and home confinement has been associated with adverse health behaviors, such as unhealthy eating, smoking, and drinking. However, most studies have been limited by regional sampling, which precludes the examination of behavioral consequences associated with the pandemic at a global level. Further, few studies operationalized pandemic-related stressors to enable the investigation of the impact of different types of stressors on health outcomes. This study examined the association between perceived risk of COVID-19 infection and economic burden of COVID-19 with health-promoting and health-damaging behaviors using data from the PsyCorona Study: an international, longitudinal online study of psychological and behavioral correlates of COVID-19. Analyses utilized data from 7,402 participants from 86 countries across three waves of assessment between May 16 and June 13, 2020. Participants completed self-report measures of COVID-19 infection risk, COVID-19-related economic burden, physical exercise, diet quality, cigarette smoking, sleep quality, and binge drinking. Multilevel structural equation modeling analyses showed that across three time points, perceived economic burden was associated with reduced diet quality and sleep quality, as well as increased smoking. Diet quality and sleep quality were lowest among respondents who perceived high COVID-19 infection risk combined with high economic burden. Neither binge drinking nor exercise were associated with perceived COVID-19 infection risk, economic burden, or their interaction. Findings point to the value of developing interventions to address COVID-related stressors, which have an impact on health behaviors that, in turn, may influence vulnerability to COVID-19 and other health outcomes.

Key Words: COVID-19; health behaviors; infection risk; economic burden

The COVID-19 pandemic has caused profound adverse health, economic, and psychological consequences. To contain the spread of the pandemic, many countries have imposed lockdowns, limiting citizens' participation in regular social and physical activities. Though essential to slow the rate of infection, lockdowns have been found to be positively associated with negative mental health consequences, such as depression and anxiety.[1,2] Furthermore, such measures are likely to impact health-related behaviors: restricted mobility decreases physical activity, and heightened psychological distress increases the propensity to engage in unhealthy eating, smoking, and binge drinking [3,4]. These unhealthy behaviors are risk factors for non-communicable diseases, including obesity, diabetes, and cardiovascular diseases,[5-7] which in turn increase the risk of contracting COVID-19 and greater disease severity and may eventually lead to increased mortality.[8,9]

To date, results are mixed across extant cross-sectional studies looking at the relationship between stress related to COVID-19 and unhealthy behaviors. In the United States, pandemic-related psychological distress was positively associated with alcohol use, with women being significantly more likely to consume greater amounts of alcohol on a typical evening and during their recent heaviest drinking occasion.[10] In Vietnam, fear of COVID-19 was associated with greater alcohol consumption and smoking among college students.[11] In contrast, a study based in Spain reported less alcohol consumption and better dietary behaviors during the COVID-19 lockdown.[12] In China, pandemic-related home isolation was associated with improvements in dietary behaviors and sleep quality, even though time spent being sedentary increased during lockdown compared to pre-lockdown.[13] These varying associations could in part be attributed to regional variations in lockdown policies, which affect ease of access to health-relevant resources such as exercise facilities, and outdoor dining options.

Even though these studies provide some insight into the potential impact of the pandemic on health behaviors, several caveats can be identified. First, the majority of the studies are regionally focused and do not explore global trends. One exception is a study involving over 1000 adults in Asia, Europe, and Africa, which documented a decrease in physical activity and binge drinking and an increase in unhealthy food consumption during COVID-19 home confinement.[14] The analyses however did not control for potential confounding variables, such as gender, age, and education that may have explained the changes in these health behaviors. Though most individuals likely experienced heightened anxiety about contracting COVID-19, the degree of anxiety and perceived risk may also vary globally depending on access to protective measures, as well as perceived effectiveness of the government and/or the community in curbing the pandemic.

Further, few studies have operationalized stressors related to the pandemic. Two critical stressors faced by many individuals during the pandemic include infection risk and economic burden. During the ongoing pandemic, many individuals experience varying degrees of financial impact, with millions facing unemployment and loss of income and housing, which may adversely impact health-related behaviors and outcomes. It remains to be examined whether perceived risk of infection and economic burden may differentially impact health behaviors and whether these stressors may interact to predict engagement in specific health behaviors. Importantly, these effects should be assessed while controlling for sociodemographic characteristics, which are known to impact health behaviors, such as binge drinking, smoking, and healthy eating.[15-18]

In this study, we utilized data from a multinational, longitudinal online study on psychological and behavioral correlates of COVID-19 to examine the association between perceived risk of infection and economic burden with several health-promoting (exercise, diet quality, sleep quality) and health-damaging (binge drinking, smoking) behaviors. We

hypothesized that perceived risk of infection and economic burden would be associated with reduced engagement in healthier behaviors. Specifically, we predicted that higher levels of perceived infection risk and economic burden would each independently be associated with less exercise, poorer diet, and worse sleep quality, as well as more binge drinking and smoking, independent of the effects of demographic factors. Additionally, we expected the interaction between perceived infection risk and economic burden would be a particularly strong predictor of health-damaging behaviors. Recruitment of a large international sample enabled us to observe the association between pandemic-related stressors and health behaviors on a global scale.

Method

Participants and Procedure

The sample consisted of adult participants (aged 18 and above) of an online, longitudinal study as part of the PsyCorona project (https://psycorona.org/), a multinational research project examining behavioral and psychological responses to the COVID-19 pandemic. Research participants initially completed a baseline cross-sectional survey, and a subset of participants signed up for a longitudinal study involving follow-up surveys over the course of the pandemic.[19-21] Our analysis focused on a self-selected cohort of participants (N = 7, 402) who completed Wave 7, 9, and 11 of assessments (administered in two-week intervals) between May 16 and June 13 of 2020. Each assessment lasted approximately 10 minutes. The surveys were translated into 30 languages and distributed by members of the research team (consisting of over 100 behavioral scientists) in their respective countries using social media campaigns, press releases, and social and academic networks.

This study complies with ethical regulations for research on human subjects. All participants gave informed consent, as approved by the Institutional Review Board at New

York University Abu Dhabi (HRPP-2020-42) and the Ethics Committee of Psychology at Groningen University (PSY-1920-S-0390).

Measures

Perceived Stressors: COVID-19 Infection Risk and Economic Burden

Perceived stress was measured by the item: "How likely is it that the following will happen to you in the next few months?" *(1) COVID-19 infection risk* -- "you will get infected with coronavirus", *and (2) Economic burden* – "your personal situation will get worse due to economic consequences of coronavirus." Responses were based on a Likert-type scale of 1 (*very unlikely*) to 8 (*already happened*).

Health Behaviors

Five health-related behaviors were measured with single-item questions:

(1) *Physical Exercise* was measured with the question: "During the past week, how many days did you do 20 minutes of vigorous (sweating and puffing) or 30 minutes of moderate (increasing your heart rate but not vigorous) physical activity?" (adapted from the Brief Physical Activity Assessment Tool).[22] Participants responded using a range of 0 to 7 days.

(2) *Diet quality* was assessed with the question: "During the past week, how healthy was your overall diet? Consider how many sweets you have been eating as well as how many portions of fruit and/or vegetables you ate each day" (adapted from National Health and Nutrition Examination Survey Questionnaire). [23] Participants were asked to provide a rating on a 1 (*poor*) to 5 (*excellent*) scale.

(3) *Sleep quality* was measured with the question: "During the past week, how would you rate your sleep quality overall?" (adapted from Pittsburgh Sleep Quality Index).[24] Participants were asked to provide a rating on a 1 (*poor*) to 5 (*excellent*) scale.

(4) *Binge drinking* was measured with the item: "During the past week, how many days did you have more than 4 drinks in a day?" (adapted from a screening test for unhealthy alcohol use recommended by the National Institute on Alcohol Abuse and Alcoholism).[25] Participants responded using a range of 0 to 7 days.

(5) *Smoking* was assessed with the item: "During the past week, how many cigarettes did you smoke each day?", with an open response option (adapted from National Health and Nutrition Examination Survey Questionnaire).[23] This variable was transformed into four categories: 0 cigarettes per day coded as non-smoker, 1-10 cigarettes per day coded as light smoker, 11-19 cigarettes per day coded as moderate smoker, >=20 cigarettes per day coded as heavy smoker, following the criteria of the Government of Canada [26]. After a visual inspection of the dataset, plots, and measures of dispersion, we excluded outliers, particularly those who reported smoking more than 75 cigarettes per day (n = 37, n = 24, and n = 28, in waves 7, 9, and 11, respectively).

Sociodemographic Characteristics

Participants provided information about age, categorized on a scale from 1 (*18 - 24 years old*) to 7 (*75+ years old*); education, categorized on a scale from 1 (*elementary*) to 6 (*doctorate*); and gender, categorized as 1 (*female*), 2 (*male*), and 3 (*other*). For the purpose of our analyses, gender was re-coded into a binary variable (0 = female, 1 = male, whereas "other" was excluded from analyses).

Statistical Analyses

Demographic information was assessed using SAS. M*plus* 8.4 was used to conduct multilevel structural equation modeling (MSEM) bivariate correlations and regression. Data from Waves 7, 9, and 11 (time points; level 1) were nested within the participants (level 2). All health behavior outcomes had sufficient variance across the two levels (ICCs > .68), so

MSEM was employed to estimate the structural relationships at both levels (i.e., within and between persons). Acknowledging that participants were nested within geographical region (i.e., North America, Europe, Asia, Africa, Oceania, Caribbean, Central, and South America),[27] we evaluated the intraclass correlations (ICCs) of each of the health behaviors by adding region as a level 3 variable (time points within participants within region). We evaluated region as opposed to country as a level 3 variable because of limited samples from some countries (e.g., $n < 10$), which precluded sufficient data for analyses of country as a higher order variable. However, because all ICCs were at or below .05, we did not include region as a level 3 variable in the final MSEM analyses.[28]

Because the current research interest was to evaluate the effects of COVID-19 stressors on health behaviors across individuals, all results reported are at the between-person level and over three time periods. As part of preliminary analyses, we conducted MSEM bivariate correlational analyses to examine the association between demographic factors and COVID-19 related stressors, as well as each of the health behaviors. Next, we conducted MSEM regression with random intercepts and fixed slopes to examine the role of perceived infection risk, economic burden, and their interaction as predictors of each of the health behaviors. All MSEM regression analyses included age, gender, and education as between-person covariates. Analyses were conducted using full-information maximum likelihood estimation, which provides standard errors that are robust to data non-normality and non-independence.[29]

Results

Sample Characteristics and Preliminary Analyses

The sample consisted of 7,402 participants from 86 countries. Table 1 provides a detailed breakdown of demographic information in this sample. Sixty-seven percent (n = 4959) of the participants were female. Regionally, more than one-half of the sample was

based in Europe (60.9%), followed by North America (14.8%) and Asia (6.7%). There was a relatively even distribution of individuals across age groups: 63.1% were between 18 and 54 years. More than half (56.2%) had at least a college degree. A list of all countries included in this study is provided in S1, under Supplementary Materials. Table 2 presents the descriptive statistics of COVID-19 stressors and health behavior outcomes across the whole sample.

We next examined demographic factors (age, gender, and education) as potential correlates of the two COVID-19 stressors and each of the health behaviors (see Table 3). Older age predicted significantly lower perceived COVID infection risk and economic burden, better diet and sleep quality, and more cigarettes smoked in the past week, all *p*s < .001. Being male was associated with lower perceived infection risk, better perceived diet and sleep quality, and more smoking and binge drinking, all *p*s < .01. Higher education levels were associated with significantly greater perceived COVID infection risk, better diet quality, more days spent engaging in moderate to vigorous exercise, and fewer cigarettes smoked, all *p*s < .01.

Perceived Infection Risk, Economic Burden, and Their Interaction as Predictors of Each Health Behavior and Outcome

Between-person results of the multilevel structural equation modeling analyses are presented in Table 4. Post hoc power analyses were conducted to determine achieved power for each parameter coefficient in the five models. Power analysis was conducted using Monte Carlo simulation with 500 replications using Robust Maximum Likelihood (MLR) estimation in M*plus*. The analyses indicated adequate power (> 80%) to detect the majority of effects, with the exception of physical exercise, binge drinking, and select parameter estimates for smoking. Within-person results are reported in S2, under Supplementary Materials.

COVID-related infection risk and economic burden were both negatively associated with perceived diet quality during the previous week. These main effects were qualified by a

significant interaction between perceived infection risk and perceived economic burden, b = .01, SE = .01, $p < .05$. As shown in Figure 1, those who reported high economic burden (top 10%) reported lower diet quality regardless of levels of perceived infection risk, b = 0.008, SE = 0.02, $p = .693$, whereas those perceiving low economic burden (bottom 10%) reported better diet quality if their perceived infection risk was also low, b = -0.057, SE = 0.02, $p = .002$.

COVID-related infection risk and perceived economic burden were both negatively associated with sleep quality during the previous week. These main effects were qualified by a significant interaction, b = .67, SE = .01, $p < .001$. As shown in Figure 2, those who reported high economic burden (top 10%) reported decreased sleep quality regardless of levels of perceived infection risk, b = -0.02, SE = 0.02, $p = .325$, whereas people perceiving low economic burden (bottom 10%) reported better sleep quality if their perceived infection risk was also low, b = -0.111, SE = 0.02, $p < .001$.

Perceived economic burden was positively associated with the number of cigarettes smoked. COVID-related infection risk was not associated with the number of cigarettes smoked in the previous week. There was no significant interaction between infection risk and economic burden in predicting the number of cigarettes smoked.

No relationship was observed between perceived COVID-related infection risk, economic burden or their interaction and the number of days spent binge drinking or the number of days spent exercising moderately or vigorously. Across these analyses, none of the associations at the within-person level were significant, indicating stability in participants' responses over time.

Discussion

This longitudinal study of health behaviors during the COVID-19 pandemic found that two pandemic-related stressors – perceived infection risk and perceived economic burden

– were associated with a range of health-related behaviors and outcomes. In particular, perceived economic burden related to the pandemic was found to have the most consistent negative impact across several health behavior outcomes, including diet quality, sleep quality, and cigarette smoking. Economic burden may lead to individuals engaging in unhealthy behaviors as a coping mechanism, consistent with theoretical and empirical work demonstrating an association between stress and health-damaging behaviors.[30] A recent report suggests that cash-based assistance in the form of stimulus check in the United States was linked to a robust 20% reduction in symptoms of depression and anxiety during the pandemic.[31] Therefore, economic burden might be related to unhealthy behaviors through symptoms of depression or anxiety, and when economic burden is alleviated, this may reduce unhealthy behaviors as well.

The finding that economic burden was associated with greater cigarette use is in line with previous research demonstrating a positive association between financial stress and tobacco use across households of varying incomes.[32] Notably, the association between perceived economic burden and negative health outcomes may be bi-directional: heightened economic stress may increase smoking behaviors, and greater expenditure on acquiring tobacco products may pose further economic strain.

Consistent with past research, the present study documented a negative association between COVID-19 economic burden and sleep quality.[33,34] This association may be accounted for by an increased tendency to engage in financial rumination and worry,[35] which have been found to predict worsened sleep quality and mental health outcomes.[36] Financial stress may also be linked to unemployment, which affords greater unstructured time and likely more time for smoking and drinking, and fewer resources available for healthy food consumption.[37] In the context of the COVID-19 pandemic, stress and isolation resulting from

government-imposed lockdowns and home quarantine may leave individuals more prone to engaging in unhealthy coping behaviors.

Importantly, the study found that perceived economic burden interacted with COVID-19 infection risk to predict worsened diet and sleep quality. This suggests that the main effects of perceived COVID-19-related stressors can only be meaningfully examined in the context of an interaction between the stressors. This finding highlights the need to develop interventions that address these stressors simultaneously to mitigate the negative impact of the COVID-19 pandemic on health outcomes. Specifically, economically disadvantaged populations are likely to be disproportionately impacted by the pandemic. There is therefore an urgent need to develop measures to lower their infection risk and economic burden, in order to mitigate the pandemic's long-term negative health consequences.

Contrary to our hypotheses, the study found no significant association between perceived infection risk and binge drinking, and only a trending, positive association between infection risk and smoking. It is plausible that attempts to drink or smoke may be driven more by general distress associated with the pandemic, as suggested by a study by Rodriguez and colleagues,[10] as opposed to the perception of infection risk, per se. The finding does not rule out the possibility that perceived infection risk is linked with more drinking that does not reach the threshold of a binge. The absence of a significant association between perceived infection risk and these behaviors may also reflect individual variations in response to infection risk: while some may be motivated to reduce engagement in health-damaging behaviors following awareness of high infection risk, others may engage in more of such behaviors as a coping mechanism.[30] Likewise, the lack of an association between the stressors and physical exercise may be attributable to significant individual variations in exercise habits during the pandemic, along with varying access to exercise facilities due to lockdowns.

The present study also identified a few demographic correlates of COVID-19 stressors and associated health behaviors. In particular, older individuals reported lower levels of perceived infection risk and economic burden, as well as better sleep and diet quality. The perception of lower infection risk could be due to several factors, such as the fact that older adults are less socially mobile. Compared to younger adults, they are also more likely to engage in prosocial COVID-19 protective behaviors like social distancing and mask-wearing.[19] The finding that older individuals have better sleep quality suggests they may be less psychologically impacted by the pandemic, consistent with other studies' findings that older adults experience lower levels of psychological symptoms and stress reactivity compared to younger adults, likely due to a higher degree of resilience.[38,39] Relative to females, males tend to perceive lower infection risk, in line with other research finding similar gender differences in the perception of seriousness of the COVID-19 pandemic.[40] Compared to females, males also smoke a greater number of cigarettes and spend more days binge drinking. Lastly, higher levels of education are identified consistently as a correlate of greater engagement in health-promoting behaviors and lower engagement in health-damaging behaviors. These findings point to the value of tailoring public campaigns to certain demographics such as young males, in order to reduce infection risk and likelihood of engaging in health-damaging behaviors.

This study is characterized by several strengths, such as recruitment of a large, multinational sample, a longitudinal design, and use of a multilevel analytical approach that takes into consideration potential variances accounted for by region and within-person variances across time. Limitations of the study include lack of representativeness and use of self-report measures, subject to recall and social desirability biases. Although several of the outcome measures were single-item, several of them were derived from established and validated scales. Due to limitations in survey length, some measures such as income and

general mental health were not available. We did not examine patterns of behavior change over time because each of the 86 participating countries were in a different stage of dealing with the pandemic at the time of the surveys.

Future research could examine health behaviors using multimodal and/or objective measures (e.g., food diaries to assess diet, polysomnography to assess sleep quality). Future work should control for the effects of generalized anxiety or mental health symptoms to examine the unique effects of perceived infection risk and economic burden on health behaviors. Beyond infection risk and economic burden, social isolation is an additional stressor that should be examined as a potential contributor to health outcomes. Future research could also examine coping styles that may moderate the effects of pandemic-related stressors on health behaviors. Efforts should be made to examine specific communities (e.g., lower income groups) who may be at higher risk for contracting COVID-19 due to jobs that may not support social distancing. It would be of value to examine mechanisms underlying the associations between COVID-19 related stressors and health behaviors, including decisions about vaccinations, which were not yet available at the time of the surveys.

The COVID-19 pandemic persists, with more than 305 million confirmed cases and 5.4 million deaths globally as of January 11, 2022.[41] Vaccination roll-out is moving quickly in a few countries, with marked delays in many more. Moreover, coronavirus variants are of grave concern. As such, it is critical that each country develops effective interventions tailored to the context of the local community, particularly to those who are economically disadvantaged and/or at higher infection risk, to mitigate the negative impact of the pandemic on health behaviors.

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