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

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

Countries

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91 **Abstract**

92 Anxiety associated with the COVID-19 pandemic and home confinement has been
93 associated with adverse health behaviors, such as unhealthy eating, smoking, and drinking.
94 However, most studies have been limited by regional sampling, which precludes the
95 examination of behavioral consequences associated with the pandemic at a global level.
96 Further, few studies operationalized pandemic-related stressors to enable the investigation of
97 the impact of different types of stressors on health outcomes. This study examined the
98 association between perceived risk of COVID-19 infection and economic burden of COVID-
99 19 with health-promoting and health-damaging behaviors using data from the PsyCorona
100 Study: an international, longitudinal online study of psychological and behavioral correlates
101 of COVID-19. Analyses utilized data from 7,402 participants from 86 countries across three
102 waves of assessment between May 16 and June 13, 2020. Participants completed self-report
103 measures of COVID-19 infection risk, COVID-19-related economic burden, physical
104 exercise, diet quality, cigarette smoking, sleep quality, and binge drinking. Multilevel
105 structural equation modeling analyses showed that across three time points, perceived
106 economic burden was associated with reduced diet quality and sleep quality, as well as
107 increased smoking. Diet quality and sleep quality were lowest among respondents who
108 perceived high COVID-19 infection risk combined with high economic burden. Neither binge
109 drinking nor exercise were associated with perceived COVID-19 infection risk, economic
110 burden, or their interaction. Findings point to the value of developing interventions to address
111 COVID-related stressors, which have an impact on health behaviors that, in turn, may
112 influence vulnerability to COVID-19 and other health outcomes.

113

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

COVID-19 STRESSORS AND HEALTH BEHAVIORS

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

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

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

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

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

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

173 Method

174 Participants and Procedure

175 The sample consisted of adult participants (aged 18 and above) of an online,
176 longitudinal study as part of the PsyCorona project (<https://psycorona.org/>), a multinational
177 research project examining behavioral and psychological responses to the COVID-19
178 pandemic. Research participants initially completed a baseline cross-sectional survey, and a
179 subset of participants signed up for a longitudinal study involving follow-up surveys over the
180 course of the pandemic.¹⁹⁻²¹ Our analysis focused on a self-selected cohort of participants (N
181 = 7, 402) who completed Wave 7, 9, and 11 of assessments (administered in two-week
182 intervals) between May 16 and June 13 of 2020. Each assessment lasted approximately 10
183 minutes. The surveys were translated into 30 languages and distributed by members of the
184 research team (consisting of over 100 behavioral scientists) in their respective countries using
185 social media campaigns, press releases, and social and academic networks.

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

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

190 **Measures**191 ***Perceived Stressors: COVID-19 Infection Risk and Economic Burden***

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

197 ***Health Behaviors***

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

199 (1) *Physical Exercise* was measured with the question: “During the past week, how
200 many days did you do 20 minutes of vigorous (sweating and puffing) or 30
201 minutes of moderate (increasing your heart rate but not vigorous) physical
202 activity?” (adapted from the Brief Physical Activity Assessment Tool).²²

203 Participants responded using a range of 0 to 7 days.

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

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

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

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

227 *Sociodemographic Characteristics*

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

233 **Statistical Analyses**

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

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

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

258 Results

259 Sample Characteristics and Preliminary Analyses

260 The sample consisted of 7,402 participants from 86 countries. Table 1 provides a
261 detailed breakdown of demographic information in this sample. Sixty-seven percent ($n =$
262 4959) of the participants were female. Regionally, more than one-half of the sample was

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

268 We next examined demographic factors (age, gender, and education) as potential
269 correlates of the two COVID-19 stressors and each of the health behaviors (see Table 3).
270 Older age predicted significantly lower perceived COVID infection risk and economic
271 burden, better diet and sleep quality, and more cigarettes smoked in the past week, all ps
272 $< .001$. Being male was associated with lower perceived infection risk, better perceived diet
273 and sleep quality, and more smoking and binge drinking, all $ps < .01$. Higher education levels
274 were associated with significantly greater perceived COVID infection risk, better diet quality,
275 more days spent engaging in moderate to vigorous exercise, and fewer cigarettes smoked, all
276 $ps < .01$.

277 **Perceived Infection Risk, Economic Burden, and Their Interaction as Predictors of** 278 **Each Health Behavior and Outcome**

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

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

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288 significant interaction between perceived infection risk and perceived economic burden, b
289 = .01, $SE = .01$, $p < .05$. As shown in Figure 1, those who reported high economic burden
290 (top 10%) reported lower diet quality regardless of levels of perceived infection risk, $b =$
291 0.008, $SE = 0.02$, $p = .693$, whereas those perceiving low economic burden (bottom 10%)
292 reported better diet quality if their perceived infection risk was also low, $b = -0.057$, $SE =$
293 0.02, $p = .002$.

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

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

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

310 Discussion

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

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

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

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

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

339 Importantly, the study found that perceived economic burden interacted with COVID-
340 19 infection risk to predict worsened diet and sleep quality. This suggests that the main
341 effects of perceived COVID-19-related stressors can only be meaningfully examined in the
342 context of an interaction between the stressors. This finding highlights the need to develop
343 interventions that address these stressors simultaneously to mitigate the negative impact of
344 the COVID-19 pandemic on health outcomes. Specifically, economically disadvantaged
345 populations are likely to be disproportionately impacted by the pandemic. There is therefore
346 an urgent need to develop measures to lower their infection risk and economic burden, in
347 order to mitigate the pandemic's long-term negative health consequences.

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

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

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

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

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

402 The COVID-19 pandemic persists, with more than 305 million confirmed cases and
403 5.4 million deaths globally as of January 11, 2022.⁴¹ Vaccination roll-out is moving quickly
404 in a few countries, with marked delays in many more. Moreover, coronavirus variants are of
405 grave concern. As such, it is critical that each country develops effective interventions
406 tailored to the context of the local community, particularly to those who are economically
407 disadvantaged and/or at higher infection risk, to mitigate the negative impact of the pandemic
408 on health behaviors.

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