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People underestimate the probability of contracting the coronavirus from friends

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This article reveals a social perception that may contribute to the spread of the novel coronavirus (SARS-CoV-2). Across five studies—including two large-scale samples of Americans and Canadians ($N = 3395$)—we show that people consistently underestimate the risk of contracting the coronavirus from close others (i.e., friends) compared to other groups (e.g., colleagues or strangers). We show that informing people of their (unconscious) preference to believe that friends are less of a threat than strangers can effectively attenuate this tendency. Together, these results provide evidence that people's beliefs about the probability of contracting the coronavirus from their friends are lower than from strangers, which can affect their physical distancing intentions.

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Introduction

The coronavirus pandemic has dramatically changed people's lives: Since January 2020 the coronavirus has spread globally (Poon and Peiris, 2020) and has caused a substantial death toll (August 2021, US data: 618,137; see John Hopkins institute[1] for current statistics). While not all consequences are known, the virus seems to affect the respiratory and cardiovascular system (e.g., Soumya et al., 2021) partly causing long-term consequences (e.g., del Rio et al., 2020) that are still being understood.

The primary way by which the coronavirus spreads is through droplets and aerosols produced in people's respiratory systems (Wölfel et al., 2020). COVID-19 predominantly spreads through close contact with infected people (Böhmer Merle et al., 2020; Burke et al., 2020; Ghinai et al., 2020). As a result, research has shown that intimate gatherings and living in the same household are primary ways of spreading COVID-19 (Böhmer Merle et al., 2020; Burke et al., 2020; Ghinai et al., 2020; Metlay et al., 2021).

Public health officials have advocated for physical distancing that comprises of two primary strategies. The first strategy involves keeping a distance between oneself and others of six feet (~2 m; Chu et al., 2020; Greenstone and Nigam, 2020; Zhang et al., 2020). The second strategy involves suggesting that people should avoid unnecessary contact with individuals who live outside their households.

In this article, we examine a process that affects people's adoption of physical distancing, that is, how people make assessments about the threat of various people in their social network having COVID-19, and thus their likelihood of contracting the virus from them. Based on previous research examining the links between familiarity and trust in the context of the general assessment of threats (Duncan et al., 2009), and for diseases more specifically (Faulkner et al., 2004), we propose that people will (a) systematically underestimate the threat of close others regarding having and spreading the coronavirus and, as a result, (b) fail to intend to obey physical distancing rules. Five studies support these hypotheses and in doing so, identify a key issue related to confining the spread of the coronavirus.

Theory

Physical distancing—staying at least six feet away from other people and obeying "stay-at-home" practices—is an effective method for attenuating the consequences of the coronavirus pandemic (Chu et al., 2020; Flaxman et al., 2020; Greenstone and Nigam, 2020). Nearly all countries globally have advised their citizens to engage in physical distancing (Anderson et al., 2020; Sen-Crowe et al., 2020). Even now, more than a year after the COVID-19 pandemic started, leaders are advising citizens to engage in physical distancing where possible, especially as new, and increasingly contagious variants continue to emerge (CNBC, 2021). Insight into what predicts physical distancing is nascent. Emerging research has found that person-level variables such as political orientation (Painter et al., 2020) and values (Oosterhoff and Palmer, 2020) play a role in compliance with distancing recommendations.

Another underexplored factor that may lead people to defer practicing physical distancing is their perception of risk. In a longitudinal study, Siegrist and Bearth (2021) found that perceptions of risk were central to the acceptance of public health measures during COVID-19.

Notably, risk comprises the threat that others pose, people's own vulnerability, and the consequences of that behavior. In terms of the coronavirus: being in contact with somebody who has the coronavirus, contracting the virus, and suffering from the coronavirus all predict people's perceptions of the risk that COVID-19 poses to their health. Typically, the risk that research mostly focused on is how likely people think they are to *contract* the virus (e.g., Weinstein, 1982; Wölfel et al., 2020).

Prior research has examined the antecedents of contracting diseases including individual differences, like health conditions (Meischke et al., 2000), and general beliefs about susceptibility to infectious diseases (Duncan et al., 2009). In research on the "behavioral immune system," Schaller and Park (Schaller and Park, 2011) describe multiple factors that increase people's perceived vulnerability to diseases. In this research, people who feel vulnerable to contracting infections favor contact with more familiar rather than less familiar people (Faulkner et al., 2004). Moreover, high levels of repetition decrease perceived risk (Lu et al., 2015), unfamiliar objects are assessed as riskier (Covello et al., 2001; Slovic, 1987; Song and Schwartz, 2009), and people underestimate risk-related factors associated with members of their own group (Campbell and Stewart, 1992), such as their friends. Finally, levels of trust are central to affecting people's risk judgments—such that when people trust someone else more, they are less likely to perceive that person as a risk to their physical health (Earle et al., 2010). Accordingly, we propose that people will judge close others to be less likely to spread the coronavirus and will report lower intentions to engage in physical distancing with these individuals.

H1: The perceived probability of contracting the coronavirus from socially close others will be lower than from more socially distant others.

As we have already argued above, risk perceptions can be "shaped by powerful cognitive biases […] that might lead non-rational judgments and decisions" (Slovic, 2020; p. 359). Risk perceptions during COVID-19 could therefore drive behavioral intentions towards behaviors that might increase the probability of contracting COVID-19. Specifically, greater perceptions of the probability of contracting the coronavirus should increase people's intention to physically distance themselves from others. Accordingly, we propose the following hypotheses:

H2: Physical distancing intentions will be less pronounced for socially close (vs. distant) others.

H3: The perceived probability of contracting the coronavirus will mediate the extent to which people intend to physically distance from socially close (vs. distant) others.

We test these hypotheses in five studies ($N = 3{,}395$) with participants recruited through representative panels including participants from Amazon's Mechanical Turk, which is typically more representative of the general population than college samples (Paolacci et al., 2010). In all studies, we obtained informed consent from all subjects. See Table 1 for demographics across studies.

Summary of studies

Studies 1A ($N = 754$) and 1B ($N = 840$) examine whether and how people judge the relative probability of contracting the coronavirus from various social ties (Study A: US; Study B: Canada). Study 2 replicates these results in a scenario-based study ($N = 296$) and provides a more controlled test of our core hypothesis (H1). Study 3 ($N = 301$) examines whether people differently assess the probability of contracting the coronavirus from friends compared to strangers using a within-subjects design (H1). Study 4 ($N = 402$) examines the same hypothesis (H1) using a between-subjects design, disentangles the different components of risk (i.e., threat, vulnerability, and consequence), and examines the consequences of risk perceptions on behavioral intentions to participate in a common social event (H2, H3). This study also tests the underlying mechanisms and rules out alternative explanations (e.g., different expectations for friends vs. a stranger). Study 5 ($N = 802$) tests potential intervention strategies and uses a behavioral task to assess people's inclinations for physical distancing.

Table 1 Demographics across all studies.

Study	N	M_{age}	SD_{age}	Percent female	Percent political orientation left/democrat[a]	Date of study
S1A	754	44.3	16.7	51.3	23.7	05/2021
S1B	840	42.6	17.4	62.1	30.6	05/2021
S2	296	34.3	10.3	32.1	32.8	07/2020
S3	301	43.2	13.5	48.5	58.5	07/2021
S4	402	41.0	12.5	49.0	52.0	09/2021
S5	802	38.5	12.8	46.8	31.5	05/2020
WA1	120	37.3	12.2	38.3	47.5	04/2020
WA2	400	37.2	11.9	45.0	41.8	04/2020
WA3	196	38.3	12.3	45.9	52.6	04/2020

[a]In the large-scale surveys (S1A, S1B), the question was "Overall, what would be the best description of your political views", 0 = "*very left-leaning*" to 10 = "*very right-leaning*". Values 0–4 were counted left-leaning. In all other studies, participants could identify as Democrats.

Together, these studies show that people estimate the probability of contracting the coronavirus from close others to be lower than from distant others. The effect is robust even when holding constant several factors that significantly affect the probability of transmitting the coronavirus, such as knowledge about physical distancing, vaccination status, wearing masks, time of interaction, and physical distance. These studies also reveal that the probability of contracting the coronavirus explains people's intentions, such as their intention to attend a dinner.

Study 1: large-scale survey evidence from the US and Canada

Study 1 was designed with the objective of providing initial field evidence on people's perceptions of the relative likelihood of contracting the coronavirus from different groups of people, and, particularly, from close (vs. distant) others (H1). To do so, we used two large-scale surveys (Sample A: US; Sample B: Canada).

Procedure. Sample A (754 US Americans, $M_{Age} = 44.3$, $SD_{age} = 16.7$, Percent female = 51.3) was recruited using the professional survey company "Qualtrics." Sample B (840 Canadians, $M_{Age} = 44.3$, $SD_{age} = 16.7$, Percent female = 51.3) was recruited using an online survey recruitment provider "Lucid." Respondents first completed an attention check that asked them to type a specific number into a field. Moreover, respondents reported whether they had tested positive for COVID-19. We excluded participants who had tested positive for COVID, as they would be unlikely to contract the COVID-19 in the future, as well as having possible bias in case they had contracted the coronavirus from a specific group of persons (i.e., family members).

Measures. Both studies used nearly identical measures. All respondents were asked to assess the relative likelihood of contracting coronavirus from a friend, a family member, a stranger, a work colleague, and an acquaintance as compared to any other person: "Compared to any other person, how high would you estimate the likelihood to be infected with the coronavirus from ____?" The scale ranged from 0 = "Far below average" over 50 = "Average" to 100 = "Far above average."

Respondents then completed several questions that were used as control variables including "Currently, how many hours per week (Monday to Sunday) do you spend on paid work?", the two-factor COVID-19 threat scale (*14*; "On March 11th, 2020, the World Health Organization (WHO) officially declared the COVID-19, a viral disease that has swept the globe, a pandemic. "How much of a threat, if any, is the coronavirus outbreak for each of the following," sample item factor 1: "Your personal health"; sample item factor 2: "American values and traditions"), whether they stayed at home ("During the days of the coronavirus (COVID-19) pandemic, I have been…" "…staying at home as much as practically possible," "…visiting friends, family, or colleagues outside my home", ranging from 0 = "Strongly disagree" to 10 = "Strongly agree"), and whether participants knew anybody who tested positive (1 = "no", 2 = "no").

At the end of the survey, respondents were asked several demographic questions (age, gender, region [Midwest, Northeast, South, West]). The demographic variables slightly differed across Sample A and Sample B (see Open Science Framework for the full list of items[2]). Our questions were part of a larger multi-topic study administered at the beginning of May 2020.

Results. Across Samples A and B, we used a linear mixed model and included several, conceptually relevant control variables (i.e., threat scales, staying at home practices, age, gender, region, knowledge of somebody tested positive, working hours) to examine people's relative perceptions of contracting COVID from friends, family, acquaintances, colleagues, and strangers.

In Sample A, people rated the relative likelihood of contracting coronavirus from a friend to be lowest, and from a stranger to be highest ($M_{Friend} = 42.37$, $M_{Family} = 45.95$, $M_{Colleague} = 42.48$, $M_{Acquaintance} = 43.27$, $M_{Stranger} = 49.65$). In Sample B, once again, people rated the relative likelihood of contracting the coronavirus from a friend to be lowest, and from a stranger to be the highest ($M_{Friend} = 37.27$, $M_{Family} = 41.77$, $M_{Colleague} = 38.58$, $M_{Acquaintance} = 39.06$, $M_{Stranger} = 49.07$). See Fig. 1 for point estimates. These effects held even when including all covariates. See supplementary appendix for between-group contrasts, as well as moderation analyses that further explore people's low estimated relative likelihood of contracting the COVID-19 from their colleagues.

Discussion. Study 1 showed that people judge the relative likelihood of contracting the coronavirus to be highest from strangers (distant others) and to be lowest from friends (close others; H1). Interestingly, the group of people that were identified as the second most likely group to contract the coronavirus were members of one's family. This result could be driven by the fact that people most likely lived together with a family member—which should increase the likelihood of contracting the virus from this group given the higher frequency of contact.

One limitation of these studies concerns the (relative) assessment used in these studies, asking respondents to indicate the likelihood of contracting COVID-19 against another average person. Respondents could have interpreted the question as asking about any stranger (i.e., multiple other strangers), and if they had been in contact with more strangers than friends, this could have inflated respondents' assessment of the threat of

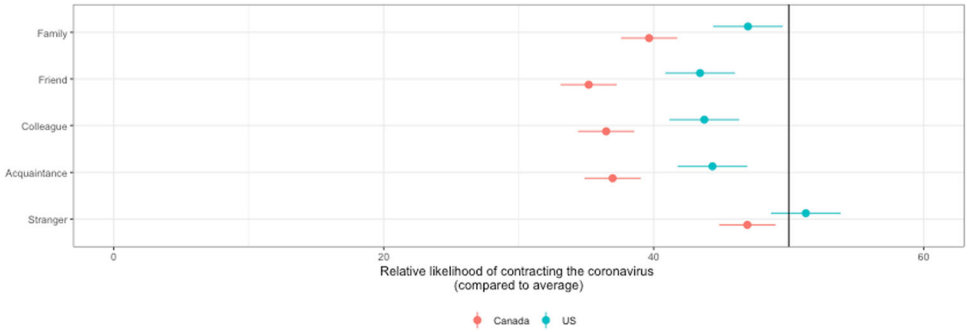

Fig. 1 Relative likelihood of contracting the coronavirus. The relative likelihood of contracting the coronavirus from various social ties compared to an average person (Study 1A, B). Note: Vertical line indicates average person.

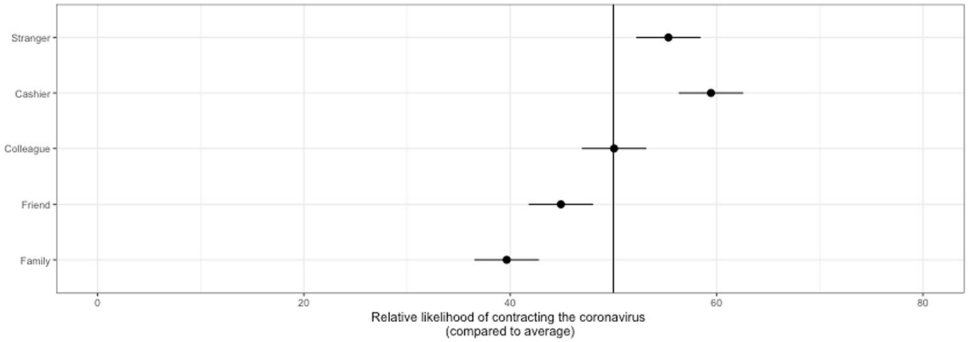

Fig. 2 The effect of conditions on the relative likelihood of contracting the coronavirus (Study 2). Note: Vertical line indicates average person.

people from that group. Moreover, participants might have misunderstood the question as asking for their own likelihood of contracting the coronavirus compared to an average person, and not assessing the different persons against an average person.

Study 2: supermarket study

Study 2 tackled the limitations of Study 1. This study had the objective of testing whether people assign a different likelihood of contracting the coronavirus to different groups of people in a setting that holds constant the frequency of exposure to people from each group. Thus, this study attenuates the limitation of Study 1 that respondents could have interpreted the question in terms of any (and not one single, specific) stranger.

Study 2 used a scenario-based experiment that asked respondents to imagine talking to a friend, family member, stranger, work colleague, and cashier (in random order) while shopping. This design allowed us to test H1 in a cleaner way by holding constant exposure to members of each group.

Procedure. Respondents (296 participants from Amazon Mechanical Turk, $M_{Age} = 34.3$, $SD_{age} = 10.3$, Percent female = 23.1) imagined that they went shopping at the supermarket and talked to several groups of people. Specifically, respondents imagined encountering a friend, a family member, a stranger, a work colleague, and the cashier of the supermarket: "*Imagine you went shopping this week and you met several persons, a friend, a family member, the cashier in the supermarket, a stranger, and a work colleague.*"

Measures. Next, respondents rated the relative likelihood of contracting the coronavirus from each of the people mentioned against any other person: "Compared to any other person, how high would you estimate the likelihood to be infected with the coronavirus from each of these persons?" The scale ranged from 0 = "Far below average" over 50 = "Average" to 100 = "Far above average."

Respondents also indicated the amount of time they would expect talking with each of those groups of people "How much time would you spend talking with each of these persons? (Please indicate in minutes)" on a scale ranging from 0 to 60 min. Respondents then answered several demographic questions.

Test of manipulation. We conducted a posttest of the manipulation of perceived closeness asking a sample of MTurkers how close they perceived each of the persons in the scenario (57 MTurkers, $M_{Age} = 38.5$, $SD_{age} = 10.8$, Percent female = 49.1) asking "How close do you feel to each of the persons described in the scenario?" ranging from 1 = "Not close at all" to 11 = "Very close." As expected, a linear mixed model showed that respondents felt closest to the family member and the friend and felt least close with the stranger and the cashier ($M_{Friend} = 8.44$, $M_{Family} = 9.44$, $M_{Colleague} = 6.28$, $M_{Stranger} = 2.37$, $M_{Cashier} = 3.23$; see supplementary appendix for a test of significance). The only non-significant contrast was between the cashier and the stranger, thus supporting the effectiveness of our manipulation of perceived closeness.

Results. Consistent with Study 1, people rated the relative likelihood of contracting the coronavirus from close others (i.e., the friend or family member) to be lowest (i.e., significantly lower than the average person, which was 50), while the relative likelihood of contracting the coronavirus from the cashier was evaluated to be the highest (significantly greater than the average person) ($M_{Friend} = 44.91$, $M_{Family} = 39.66$, $M_{Colleague} = 50.06$, $M_{Stranger} = 55.33$, $M_{Cashier} = 59.45$; H1). See Fig. 2 for point estimates and supplementary appendix for contrasts and differences from the average person. These effects were robust when

controlling for the time that people expected to interact with members from each group (see supplementary appendix).

Discussion. This study showed that people estimated the relative likelihood of contracting the coronavirus to be greatest for the cashier and the stranger, while they assigned the lowest probability to their friends and family members. Compared to Study 1, this Study 2 used a concrete scenario to hold constant exposure to group members. The results were largely consistent with those of Study 1. These results also demonstrate that people do not assume family members are more likely to spread the coronavirus when encountering them in the same setting (instead of at home). Thus, Study 2 largely supports the hypothesis that people judge the probability of contracting the coronavirus from close (vs. distant) others to be lower (H1).

Nevertheless, the key limitation of this study—as in Study 1—was the measure of the relative likelihood of contracting the coronavirus against an average. Again, this measure could have been misunderstood by participants such that they could have compared themselves with an average person.

Study 3: supermarket replication

This study had the objective of testing whether people judged the probability of contracting the coronavirus to be greater for strangers (vs. friends) (H1) using a between-subjects experimental design. This study and all measures were preregistered on aspredicted.org (preregistration number "70230", registered July 8, 2021[3]).

Procedure. Participants (301 MTurkers, $M_{Age} = 43.2$, $SD_{age} = 13.5$, Percent female = 48.5) imagined that they were shopping and that they had talked to a stranger as well as a friend. Participants imagined that they were starting to cough and suspected that they had contracted the coronavirus. We asked participants to imagine a friend that they had not seen in the past weeks and therefore could not know whether s/he followed the recommendations of the Centers for Disease Control and Prevention (CDC). Moreover, we asked participants to imagine that neither wore a mask and that they talked for 15 min at 1 m to make sure that they could potentially have been contracted the Coronavirus COVID-19 ("*Imagine you went shopping four days ago. On this day in the supermarket, you met only two persons: A stranger and a friend that you had not seen for 2–3 weeks. You don't know if any of the two, the stranger or the friend, has already been vaccinated or had contracted COVID-19. You talked with each, the friend, and the stranger, for about 15 min. You are not aware whether the friend or the stranger have followed best practices from the Center for Disease Control in the US (CDC[4]). In these conversations, you were standing close, at a distance of 1 m. Neither the stranger, friend, or yourself were wearing masks. After this visit to the supermarket, you had been primarily at home, and not seen anybody. Imagine, you now start coughing and think that you have been infected with the coronavirus.*").

Measures. Next, we asked a series of questions about who was most likely to have spread the coronavirus ("Assume you would have been infected with the coronavirus. Who would you think had infected you with the coronavirus?", 1 = "friend", 2 = "stranger").

They also responded to several questions on various risk components assigned and the probability they would have assigned to the stranger and the friend (likelihood of contraction: "I will contract COVID-19 after interacting with [your friend/the stranger] in the supermarket", becoming symptomatic: "I will become symptomatic for COVID-19 after interacting with [your friend/the stranger] in the supermarket", suffering consequences: "Assuming I have contracted COVID-19 after interacting with [your friend/the stranger], I will experience the worst symptoms possible", overall threat: "Interacting with [your friend/the stranger] in the supermarket is a threat to my personal health", all ranging from 1 = "Strongly Disagree" to 10 = "Strongly Agree"). These measures allowed us to collect initial data about which components of risk systematically vary between close (vs. distant) others and would contribute to the perception of threat. Participants then answered several demographic questions including age and gender.

Test of manipulation. We conducted a posttest of perceived closeness with fifty-five participants from MTurk ($M_{Age} = 38.3$, $SD_{age} = 11.6$, Percent female = 36.4) and using the same question as in the pretest from Study 2. A linear mixed model showed that the friend was perceived to be closer than the stranger ($M_{Friend} = 8.02$, $M_{Stranger} = 3.05$, $b = 5.15$, $SE = 0.42$, $t = 12.3$, $p < 0.0001$). Thus, the manipulation of perceived closeness worked as intended.

Results. Respondents indicated who they believed they had contracted the disease from (binary response: "friend" vs. "stranger"). Respondents were more likely to identify the stranger as the person infecting them with COVID-19 (exact binomial test: $P_{Friend} = 23\%$, $P_{Stranger} = 77\%$; $p < 0.001$). The results for the risk measures are reported in the supplementary appendix.

Discussion. Study 3 showed that—holding constant exposure time, mask-wearing, the (lack of) knowledge about the person's current vaccination status, and their prior coronavirus infections—that people are significantly more likely to assume that a distant (vs. close) person (i.e., a stranger vs. a friend) infected them with the coronavirus (H1).

One limitation of Study 3 is that this study used, as the previous studies, a within-subjects design, which could be subject to order effects or survey fatigue. Thus, the next studies will use between-subjects designs.

Study 4: invitation to join the dinner table

Study 4 had the objective of not only testing whether people judge the probability of infection to be lower for friends (vs. stranger; H1), but also whether this judgment increases people's intention to physically distance from that person. Specifically, this study uses a between-subject design to examine whether the overall increased perception of risk for strangers (vs. close friends) would lower people's intention to decline an invitation for dinner (H2, H3).

Procedure. Four hundred and two MTurkers ($M_{Age} = 41.0$, $SD_{age} = 12.5$, Percent female = 49.0) imagined that they were going for dinner. At the beginning of the study, we asked participants to indicate the name of a good friend. Importantly, they were advised to only choose a person that they had not heard or seen during the past 2 weeks ("*Please name the first name and the first letter of the last name (Example: Peter F.) of a close friend. Important: Please choose a close friend that you have not talked to about the coronavirus in the past 3 weeks, do not know whether the friend follow social distancing and mask recommendations, and are not aware of whether the friend got vaccinated.*") This was done to guarantee that people did not know whether the person engaged in social distancing.

In the friend condition, participants imagined that they were invited by the friend that they had named. In the stranger condition, participants imagined being invited by a stranger:

"*Imagine you are going for dinner at an indoor restaurant. When ordering, [your good friend "name of friend"/a stranger] is approaching you and starts talking to you. You exchange some phrases. Neither [your good friend "name of friend"/a stranger] nor you wear masks. You talk at a distance of about 3 feet (~1 m). The conversation seems interesting. You don't know if ["name of friend"/the stranger] has been vaccinated. ["name of friend"/The stranger] invites you to join her/his table for dinner.*"

Measures. We asked several measures that should identify which risk component would contribute to considering the stranger a greater threat than the friend. This allows us to identify whether people assess the probability of contracting the coronavirus from friends to be lower than for strangers, as they judge the former to be less likely to be infected with the virus or to be less likely to infect them with the virus. Thus, relative to Study 3, we also measured whether the person was infected with the virus. Specifically, we asked: "[Your friend/The stranger] is likely to have COVID-19", contraction: "Assuming [your friend/the stranger] had COVID-19: I will contract COVID-19 after interacting with [your friend/the stranger] at the dinner", becoming symptomatic: "Assuming you contracted COVID-19: I will become symptomatic for COVID-19 after the dinner with [your friend/the stranger]", suffering consequences: "Assuming I have contracted COVID-19: I will experience the worst symptoms possible" as well as the overall risk of the person they evaluated: "Interacting with [your friend/the stranger] at the dinner is a risk to my personal health", ranging from 1 = "Strongly Disagree" to 10 = "Strongly Agree").

We asked for the intention to join the dinner ("How likely are you to join the table of [name of the friend/the stranger]", ranging from 1 = "Not likely at all" to 10 = "Very likely."

Next, we assessed a host of alternative explanations that could also determine whether people would join the table of the friend (stranger), namely, whether respondents imagined fearing to offend the other person when declining the invitation ("Please assess the following questions and statements on how much you would offend if declining to attend the dinner. To what extent do you think would feel…" "Offended", "Judged", "Insulted", "Hurt", ranging from 1 = "Not at all" to 7 = "Very"; $\alpha = 0.95$).

We also asked the extent to which respondents missed the imagined person ("I miss having interactions with [name of the friend/stranger]", "I miss the pleasure of the company of [name of the friend/stranger]", "I miss having [name of the friend/stranger] around"; $\alpha = 0.99$), their fear of missing out on something when not joining for dinner ("I would feel regretful of missing the dinner", "I would feel sad if I was not capable of participating in this dinner due to constraints of other things", "I believe I am falling behind compared with others when I don't join [name of the friend/stranger] for the dinner", "I would feel anxious when I don't join [name of the friend/stranger] for the dinner", "I feel anxious because I know something important or fun must happen when I would miss the dinner with [name of the friend/stranger]"; $\alpha = 0.93$), and their interest in joining the other table ("This dinner would be entertaining", "I am inclined to join the dinner because of the other person", "I would be interested in joining the dinner", "The food is the enticement to join the dinner", "This is my kind of dinner", "This dinner would be interesting"; $\alpha = 0.93$). All items were assessed using a scale ranging from 1 = "Do not agree at all" to 7 = "Completely agree."

Finally, we asked whether they assumed that the person followed social distancing and mask-wearing recommendations "In the scenario, to what extent did you think/assume is following guidelines for social distancing and mask-wearing?", ranging from 1 = "Not at all" to 7 = "Completely". Then, participants answered demographic questions.

Test of manipulation. Ninety-one MTurkers participated in a posttest of perceived closeness ($M_{Age} = 39.1$, $SD_{age} = 13.2$, Percent female = 46.2) that asked the same question as in the pretest of Study 2. A t-test showed that the friend was perceived to be closer than the stranger ($M_{Friend} = 9.16$, $SD = 1.51$, $M_{Stranger} = 3.76$, $SD = 2.90$; $t(89) = 11.10$, $p < 0.001$, $d = 2.33$). Thus, the manipulation of perceived closeness was successful.

Results. Table 2 summarized the results across the measures of all components of risk as well as alternative explanations that could explain the difference between friends and strangers, and that likely affected their intentions to join for dinner.

Risk components. Overall, people thought that the friend (vs. stranger) was less likely to be infected with the coronavirus, but, assuming they were infected, they judged their probability of contracting the virus equally. A follow-up regression analysis with probability of contracting the coronavirus as the dependent variable and conditions, as well as infection status of the person as independent variables revealed that the increased probability of the stranger to have the coronavirus fully explained the difference in the probability of contracting the coronavirus from that person ($B_{Infected} = 0.65$, $SE = 0.05$, $t(399) = 14.28$, $p < 0.001$; $B_{Friend} = -0.002$, $SE = 0.20$, $t(399) = -0.01$, $p = 0.99$). Interestingly, respondents assumed that, given they would get symptoms, those symptoms would be more severe for strangers than friends ($B_{Symptoms} = 0.56$, $SE = 0.04$, $t(399) = 12.85$, $p < 0.001$; $B_{Friend} = -0.53$, $SE = 0.21$, $t(399) = -2.55$, $p = 0.01$).

Table 2 Results across all measures (Study 4).

Measure	M_{Friend}	SD	$M_{Stranger}$	SD	$t(400)^a$	p	d
Probability person being infected	4.02	2.17	4.59	51.3	2.62	0.009	0.26
Risk contracting virus (given infection)	4.73	2.43	5.11	2.47	1.52	0.13	0.15
Risk becoming symptomatic (given contraction)	5.56	2.38	5.91	2.42	1.43	0.15	0.14
Risk severity of symptoms (given symptoms)	3.78	2.36	4.50	2.57	2.92	0.004	0.29
Overall risk	5.53	2.62	6.78	2.67	4.76	<0.001	0.48
Intention to join dinner	8.05	2.84	3.89	2.93	14.47	<0.001	1.44
General interest in dinner	5.21	1.20	3.50	1.50	12.69	<0.001	1.27
Extent to which person is missed	5.83	1.18	2.50	1.66	23.21	<0.001	2.32
Fear of missing out on something	4.01	1.54	2.51	1.53	9.80	<0.001	0.98
Fear of offending person	3.80	1.90	3.62	1.59	1.01	0.31	0.10
Social distancing	3.51	1.81	2.41	1.61	6.45	<0.001	0.64

[a]The degrees of freedom were 400 for all analyses.

Table 3 Regressions predicting the risk of the person (Study 4).

	No controls				With controls			
	B	SE	*t*	*p*	*B*	SE	*t*	*p*
Risk_PersonPositive	0.37	0.06	6.18	<0.001	0.33	0.06	5.65	<0.001
Risk_Contraction	0.28	0.05	5.39	<0.001	0.26	0.05	5.22	<0.001
Risk_Symptoms	0.18	0.05	3.56	<0.001	0.16	0.05	3.25	0.002
Risk_Consequence	0.13	0.05	2.55	0.02	0.14	0.05	2.81	0.01
Age					0.01	0.01	1.64	0.11
Gender[Female]					−0.06	0.19	−0.3	0.77
DemocraticPolitic.Orient.					0.05	0.11	0.47	0.64
Contracted[Yes]					−0.37	0.28	−1.35	0.18
Contracted[No]					−1.01	0.44	−2.32	0.03
KnowInfected[Yes]					−0.09	0.2	−0.44	0.67
KnowInfected[No]					−0.45	0.73	−0.62	0.54
Vaccinated[Yes]					0.61	0.17	3.57	<0.001
LeaveHome					−0.18	0.06	−3.13	0.002
FollowMasking					−0.09	0.03	−3.11	0.003
FollowDistancing					−0.17	0.06	−3.09	0.003
Constant	1.52	−0.28	5.5	<0.001	1.99	0.85	2.34	0.02
R^2	0.48				0.55			
Adjusted R^2	0.47				0.54			
Residual SE	1.97 (df = 397)				1.85 (df = 386)			
F	90.28 (df = 4; 397); $p < 0.001$				32.09 (df = 15; 286); $p < 0.001$			

Predicting overall risk. We examined what predicted the overall risk that the other person posed. The regressions showed that the probability that the person was infected with the virus ($B = 0.37$, $p < 0.001$) and the likelihood of contracting the virus from that person ($B = 0.28$, $p < 0.001$) determined respondents' risk judgments of that person. The effect of getting symptoms ($B = 0.18$, $p < 0.001$), or even the worst possible symptoms ($B = 0.13$, $p = 0.02$) was weaker. See Table 3 for the results of the regressions, with and without adjusting for controls.

Alternative explanations. Respondents stated they were more likely to join their friend at dinner than the stranger. Moreover, respondents indicated that they were generally more interested in a dinner with a friend than a stranger, missed the friend more than the stranger, felt that they would miss out more when not joining with a friend, and assumed that their friend was more likely to follow social distancing rules. We controlled for those alternative explanations in the regression analysis (Table 3) and in following mediation analysis.

Mediation analysis. We examined whether differences in perceived threat of the persons explained why people were more inclined to join their friend (vs. the stranger) for dinner using a mediation model with bootstrapped estimates. We used conditions as independent variable, perceived threat as mediators, and the intention to join dinner as dependent variable. The indirect effect via perceived threat ($b = 0.18$, $CI_{95\%} = [0.10; 0.27]$, $SE = 0.04$) was significant. The direct effect of condition (friend vs. colleague) on intention to join dinner remained significant ($b = 0.99$, $CI_{95\%} = [0.85; 1.14]$, $SE = 0.07$, $t = 13.45$, $p < 0.001$).

Next, we included all alternative explanations as potential mediators. The indirect effect via perceived threat remained significant ($b = 0.12$, $CI_{95\%} = [0.06; 0.19]$, $SE = 0.03$). Moreover, the indirect effects of general interest in the dinner ($b = 0.47$, $CI_{95\%} = [0.34; 0.60]$, $SE = 0.07$), and expectations of following social distancing ($b = 0.06$, $CI_{95\%} = [0.01; 0.11]$, $SE = 0.02$) were significant. Neither the indirect effect via fear of missing out ($b = -0.004$, $CI_{95\%} = [-0.10; 0.09]$, $SE = 0.05$), nor offending the other person ($b = 0.005$, $CI_{95\%} = [-0.01; 0.02]$, $SE = 0.01$), nor missing the person ($b = 0.14$, $CI_{95\%} = [-0.06; 0.35]$, $SE = 0.10$) were significant. While the alternative explanations captured a significant part of the variance of conditions on intention to join for dinner, the direct effect remained significant ($b_{Friend} = 0.39$, $CI_{95\%} = [0.21; 0.57]$, $SE = 0.09$, $t = 4.20$, $p < 0.001$), suggesting that people still felt strangers were more of a threat, regardless of these other factors that could have otherwise explained the relationship.

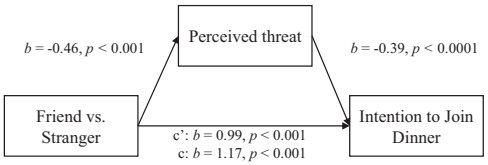

Fig. 3 The mediational paths of condition on intention to join dinner without controls (Study 4).

Together, the mediations demonstrate that the perceived threat remained a significant predictor of the effect of close (vs. distant) others on intentions to join the dinner (H3). See Figs. 3 and 4 for individual paths of the mediation model.

Discussion. This study showed that people assess the threat of friends (vs. a stranger) to be lower, which eventually also affects their intention to have dinner with that person—holding constant several things like the time they interacted before the invitation, mask-wearing, and the unawareness of the other person's vaccination status.

This result held even when controlling for alternative explanations, such as a greater fear of offending the friend (vs. the stranger) when imagining rejecting the invitation, or the generally greater interest in having dinner with that person.

Study 5: park interaction

This final study had the objective of testing physical distancing using a dependent variable designed to gauge respondents' intentions to engage in physical distancing. In this study, we used a social distancing task whereby respondents could indicate how

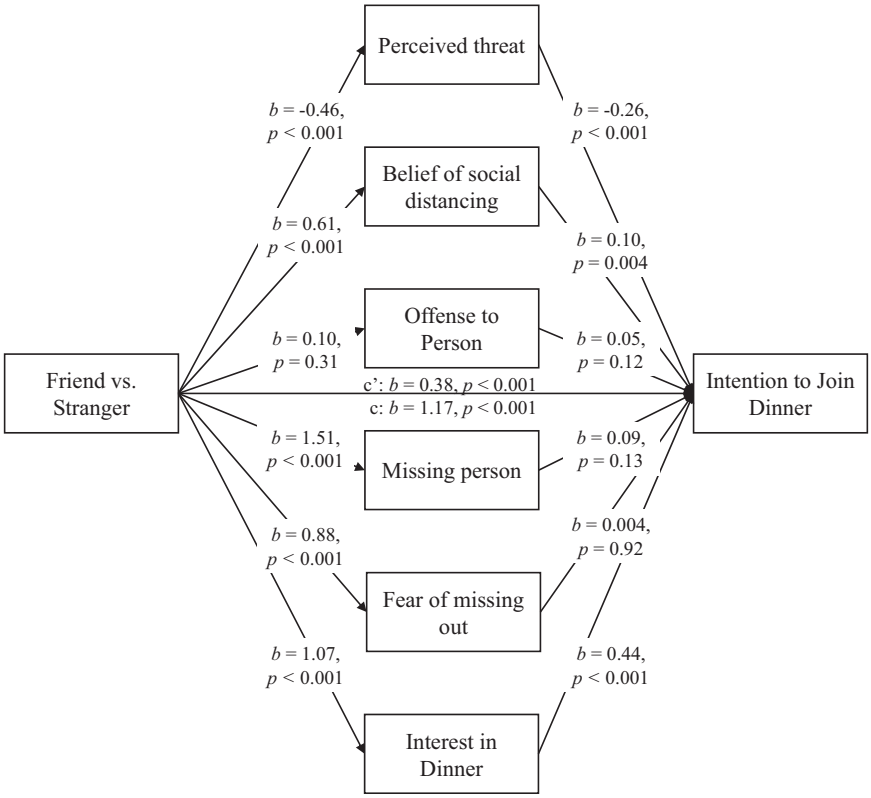

Fig. 4 The mediational paths of condition on intention to join dinner with controls (Study 4).

much distance they would intend to keep between themselves and another person. This task has several advantages: First, while the task measures intentions, it is an intuitive task that does not use a rating scale. Thus, this task is arguably closer to measuring actual behavior. Second, the nature of the task makes it less likely to suffer from experimenter effects than self-reported measures because there are not clearly better or worse distances to place oneself in the task.

Procedure. Participants were recruited from MTurk and assigned to four conditions (colleague vs. friend vs. friend direct vs. friend social distancing) in this between-subjects experiment. We excluded participants who indicated that they tested positive for COVID-19 to rule out the possibility that their results were driven by the need for these participants to physically distance themselves from others. This led to a final sample of 802 participants, slightly exceeding the preregistered sample size (i.e., $N = 800$, $M_{Age} = 38.5$, $SD_{age} = 12.8$, Percent female = 46.8). This study and all measures were preregistered on aspredicted.org (preregistration number "41200", registered May 17, 2020[5]).

Participants imagined that they met a person in a park. Again, we asked participants to indicate two persons: A good friend and a distant work colleague. Importantly, participants received the instructions that both had to live in the same city to guarantee the scenario was realistic.

Next, we presented participants with the interventions. Across all conditions, participants first read the sentence: "*The new coronavirus has become a major health crisis. In the US alone, more than 1.5 mill people are infected with the virus and more than 90.000 have died.*" Again, the interventions only were provided in the "friends" conditions (but not in the colleague condition), as they should attenuate the effect of friends on risk and physical distancing intentions.

The first intervention ("friend risk") directly aimed at making people more attuned to the idea that friends pose a significant risk. The condition read as follows: "*Friends are most likely to spread COVID-19: One gets closer when speaking to friends (i.e., less than 6 feet) and talks longer than with anyone else (i.e., more than 15 min). This increases the likelihood of transmitting of COVID-19. In pandemics, friends are your enemies!*"

The second intervention ("friend distance") was included to test whether generic social distancing measures could already attenuate the bias exhibited against friends. Thus, we included a message reminding people of social distancing, which read as follows: "*Lack of physical distance makes it likely to spread COVID-19: If one is close to others (i.e., less than 6 feet) and if one talks longer (i.e., more than 15 min), more virus material is seeded. This increases the likelihood of transmitting of COVID-19. Do not get too close to anybody!*"

The time was fixed between 15 and 40 seconds to make sure all participants closely read the text of the shown intervention. The site was followed by a message again displaying the last sentence of the intervention.

Next participants imagined that they would meet the friend (vs. colleague) in the park. The exact conditions read as follows: *"Imagine you now meet [colleague's/friend's name] in the park. Imagine talking with [colleague's/friend's name] for some minutes."*

Measures. Participants then had to rate the risk of contracting coronavirus from the imagined person: "*Assess following answers and statements concerning the risk of contracting coronavirus of [colleague's/friend's name].*" Participants also rated the five items of the 10-item scale from *18* on their overall perception for risk of getting infected with the coronavirus ("I think my chances of getting infected with the coronavirus are" 1 = "Zero" to

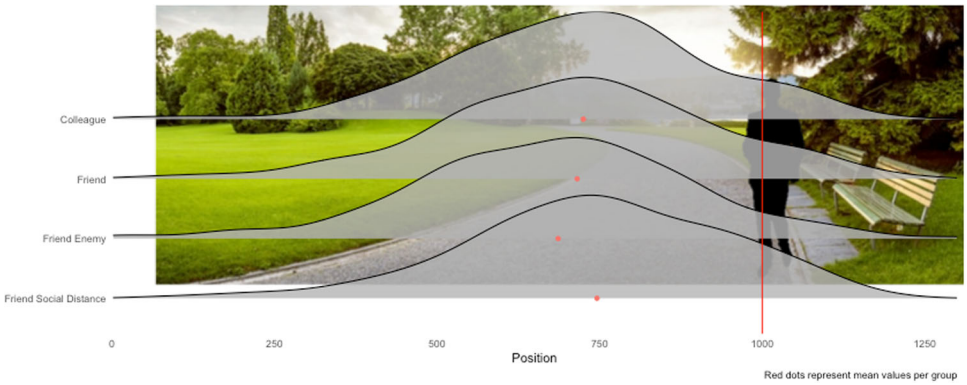

Fig. 5 The effect of condition on physical distancing intentions. Note: Red dots show median values (Study 5).

6 = "Very large"; "I am sure I will NOT get infected with the coronavirus" 1 = "Strongly disagree" to 6 = "Strongly agree"; "There is a chance, no matter how small, I could get the coronavirus" 1 = "Strongly disagree" to 6 = "Strongly agree"; "What is your gut feeling about how likely you are to get infected with the coronavirus" 1 = "Extremely unlikely" to "Extremely likely"; "I feel I am unlikely to get infected with the coronavirus" 1 = "Strongly disagree" to 6 = "Strongly agree"; $\alpha = 0.81$). Then participants had to indicate how close they would stand to the person using an online social distancing task (this study could not be conducted offline as none of the authors' universities would have allowed that study). The task displayed a scene in the park including the shadow of a person. Participants were asked to imagine that this person was their friend (vs. colleague): "*In the previous situation when you imagined meeting in the park, how close would you stand to [colleague's/friend's name]? You are the green person on the left-hand side, indicate how close you would go to on the right. To do so, drag and drop the green person. Then click 'Submit'.*" The online social distancing task is shown in the supplementary appendix. To measure the distance that people took, we used the vertical distance between both people that was automatically registered by the task (i.e., the pixels on the x-axis were registered automatically. Then, participants answered several questions about their demographics (i.e., age, gender, political orientation) and several COVID-19 related control variables, such as whether they currently leave their homes ("How often do you leave home at the moment (e.g., for shopping, the pharmacy)?", ranging 1 = "Once per month or less" to "More than twice per day").

Manipulation check. The manipulation check of closeness showed that the manipulation worked as intended. The one-way ANOVA showed that the colleague condition was perceived to be less close than all other conditions irrespective of the intervention ($F(3,798) = 111.25$, $p < 0.0001$, $\eta^2 = 0.29$; $M_{\text{Colleague}} = 3.04$, SD = 1.45, $M_{\text{Friend}} = 5.38$, SD = 1.64, $M_{\text{FriendRisk}} = 5.32$, SD = 1.66, $M_{\text{FriendDistance}} = 5.40$, SD = 1.52). All contrasts with the colleague condition were significant ($ps < 0.0001$) and none of the contrasts among the friend conditions were significant ($ps > 0.60$).

Results. Consistent with our previous studies, the one-way ANOVA ($F(3,798) = 3.71$, $p = 0.01$, $\eta^2 = 0.01$; $M_{\text{Friend}} = 3.25$, SD = 0.85, $M_{\text{Colleague}} = 3.49$, SD = 0.91, $M_{\text{FriendRisk}} = 3.52$, SD = 1.04, $M_{\text{FriendDistance}} = 3.35$, SD = 0.92) and the post-hoc contrast ($B = -0.24$, $t(798) = -2.58$, $p = 0.017$, $d = 0.26$; H1) showed that in the no-intervention conditions, people perceived interacting with their friend as less risky than interacting with their colleague.

The one-way ANOVA ($F(3,798) = 3.83$, $p = 0.01$, $\eta^2 = 0.014$; $M_{\text{Friend}} = 676.98$, SD = 209.25, $M_{\text{Colleague}} = 746.08$, SD = 199.67, $M_{\text{FriendRisk}} = 713.49$, SD = 209.04, $M_{\text{FriendDistance}} = 717.78$, SD = 194.88) also showed that respondents in the no-intervention conditions intended to keep less physical distance with the friend than with the stranger ($B = -69.09$, $t(798) = -3.37$, $p = 0.001$, $d = 0.34$; H2; see supplementary appendix for all contrasts).

The interventions successfully increased physical distancing intentions (Fig. 5). The interventions, which all aimed at increasing distance from friends, were effective. Participants assigned to those conditions intended to keep a greater physical distance than participants who were randomly assigned to the friend condition (i.e., without any intervention). The mediation analyses supported the role of perceived risk (H3) and showed that the interventions reduced this link (see supplementary appendix).

Additional mediation analyses revealed that the interventions reduced the perceived risk, which affected physical distancing intentions (see supplementary web appendix).

Discussion. This study used a task designed to measure physical distancing intentions to demonstrate the robustness of the results. Respondents intended to keep a greater distance from their colleagues (vs. friends), which was caused by increased perceptions of threat.

Second, this study also tested several interventions aimed to increase the intention to keep a greater physical distance from the friend. Communicating the risk of the friend and providing a generic physical distancing message both reduced intentions to stand close to the friend.

While experimenter's demand could have caused the responses in the previous studies, the more intuitive measure of physical distancing intentions used in this study was less obvious to participants. At the same time, despite the high face validity of this task, one limitation is that the task was not validated. Finally, also this study measured intentions and not actual behavior. Thus, the behavioral implications of this study—despite using a social distancing task—are limited.

General discussion

The coronavirus pandemic has significantly changed the way we live. In this paper, we document an effect that potentially contributes to the spread of the pandemic: People consistently assign less risk to their friends and engage in lower physical distancing

intentions as compared to other more socially distant groups—including strangers and colleagues.

Five studies support this hypothesis: Study 1, which included two large-scale surveys conducted in the US and Canada, provided initial evidence that people who were previously known to individuals—especially friends—were systematically thought to pose less risk than strangers. Study 2 used a more controlled design to corroborate these findings. Study 3 used another scenario-based study to replicate these effects in a different social setting. Study 4 replicated these findings and found that this belief that friends are less risky translated into behavioral intentions to join a friend at a dinner. This study also revealed that people primarily underestimate the probability that a friend (vs. a stranger) has the coronavirus—which fully explained their belief that the risk of contracting the coronavirus from a friend was lower than for strangers. Study 5 provided initial evidence that highlighting the fact that friends can be *more* likely to spread the coronavirus—as we interact with them more often and for a longer period—attenuated this tendency to assess friends as less risky and restored physical distancing. However, this friend-specific intervention was not more effective than a generic physical distancing reminder at promoting physical distancing intentions targeted toward friends.

The key contribution of this paper is revealing one of the mechanisms that potentially contributes to the spread of the novel coronavirus: People underestimate the risk that friends—and other close contacts—pose, even though close others are most likely to facilitate the spread of COVID-19 (*13*). Indeed, recent studies not only find that mainly close contacts such as family members, or community contacts spread the disease (Böhmer Merle et al., 2020; Burke et al., 2020; Ghinai et al., 2020), but also that social contacts play a critical role in spreading the disease (Gudbjartsson et al., 2020; Yong et al., 2020). Moreover, we provide evidence for two interventions that can attenuate this bias in our underestimation of the risk of friends (in Study 5). This study showed that both directly emphasizing that it is important to keep physical distance as well as pointing out that people often underestimate the risk of friends compared to others effectively increases the physical distance people intend to have when socializing with friends.

This paper, therefore, contributes to research on behavioral science called for by international organizations (WHO, 2020), as well as scientists (Bavel et al., 2020) by highlighting a critical area for future intervention: reducing the perception that friends are less risky and more trustworthy than strangers, colleagues, and more socially distant others. This insight, i.e., that people believe that the probability of contracting the coronavirus from friends is lower than for strangers because people assume that friends are less likely to be infected with the coronavirus than strangers (see Study 4) has direct implications for communicating the risk of such close others. Specifically, one key communication strategy could emphasize that friends pose a similar threat for spreading the coronavirus as any other person.

There are several limitations of this research that require mentioning. First, the studies primarily used participants from Amazon MTurk. While this pool of participants yields similar results as those in other samples (e.g., McCredie and Morey, 2019), samples from MTurk are specific in that participants tend to be younger and more educated than the average population (Thomas and Clifford, 2017). Even though Study 1 does not use MTurk samples, we note that there is the possibility that the results of the other studies are affected by particularities of MTurkers. The second limitation that should not go unmentioned is that throughout our studies, we relied on self-reported measures and thus self-reported risk assessments as well as physical distancing intentions instead of actual physical distancing. While using a behavioral task for gauging social distancing (in Study 5), future studies should examine actual physical distancing between friends and strangers to provide additional behavioral evidence for the results that the reported studies provided.

Data availability

All data and variables are accessible under https://osf.io/7g3ds/?view_only=27c23a42455949e091f82ffd1532b198.

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Notes

1 https://coronavirus.jhu.edu/region/united-states
2 https://osf.io/7g3ds/?view_only=27c23a42455949e091f82ffd1532b198
3 https://aspredicted.org/MKN_FHF
4 https://www.cdc.gov/coronavirus/2019-ncov/index.html
5 http://aspredicted.org/blind.php?x=5cx7qx

References

Anderson RM, Heesterbeek H, Klinkenberg D, Hollingsworth TD (2020) How will country-based mitigation measures influence the course of the COVID-19 epidemic? Lancet 395(10228):931–934

Bavel JJV, Baicker K, Boggio PS et al. (2020) Using social and behavioural science to support COVID-19 pandemic response. Nat Hum Behav, 395 (Suppl. 3), https://doi.org/10.1038/s41562-020-0884-z

Böhmer Merle M, Buchholz U, Corman V M, Hoch M et al. (2020) Investigation of a COVID-19 outbreak in Germany resulting from a single travel-associated primary case: a case series. Lancet Infect Dis, 1–9, https://doi.org/10.1016/S1473-3099(20)30314-5

Burke RM, Midgley CM, Dratch A, Fenstersheib M, Haupt T, Holshue M, Ghinai I et al. (2020) Active monitoring of persons exposed to patients with confirmed COVID-19—United States, January–February 2020.; Weekly/March 6, 2020/69(9);245–246, Accessed at: https://www.cdc.gov/mmwr/volumes/69/wr/mm6909e1.htm?s_cid=mm6909e1_

Campbell LF, Stewart AE (1992) Effects of group membership on perception of risk for AIDS. Psychol Rep 70(3_suppl):1075–1092

Chu DK, Akl EA, Duda S, Solo K, Yaacoub S et al. (2020) Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. Lancet 1–15. https://doi.org/10.1016/S0140-6736(20)31142-9

CNBC (2021) WHO says full vaccinated should wear masks and physically distance as Covid infections surge. Accessed at https://www.cnbc.com/2021/11/24/who-tells-fully-vaccinated-to-wear-masks-physically-distance-as-infections-surge.html (accessed Dec 3, 2021)

Covello VT, Peters RG, Wojtecki JG, Hyde RC (2001) Risk communication, the West Nile virus epidemic, and bioterrorism: responding to the communication challenges posed by the intentional or unintentional release of a pathogen in an urban setting. J Urban Health 78(2):382–391

del Rio C, Collins LF, Malani P (2020) Long-term Health Consequences of COVID-19. JAMA 324(17):1723–24

Duncan LA, Schaller M, Park JH (2009) Perceived vulnerability to disease: Development and validation of a 15-item self-report instrument. Pers Individ Differ 47(6):541–546

Earle TC, Siegrist M, Gutscher H (2010) Trust, risk perception and the TCC model of cooperation. In: Trust in risk management, Routledge. pp. 1–49

Faulkner J, Schaller M, Park JH, Duncan LA (2004) Evolved disease-avoidance mechanisms and contemporary xenophobic attitudes. Group Process Intergroup Behav 7:333–353

Flaxman S et al. (2020) Report 13: Estimating the number of infections and the impact of non-pharmaceutical interventions on COVID-19 in 11 European countries. Imperial College COVID-19 Response Team, Working Paper

Ghinai I, McPherson TD, Hunter JC, Kirking HL, Christiansen D et al. (2020) First known person-to-person transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in the USA. Lancet 395(10230):1137–44

Greenstone M, Nigam V (2020) Does social distancing matter? University of Chicago, Becker Friedman Institute for Economics Working Paper, (2020–26)

Gudbjartsson DF, Helgason A, Jonsson H, Magnusson OT, Melsted P et al. (2020) Spread of SARS-CoV-2 in the Icelandic Population. N Engl J Med, https://doi.org/10.1056/NEJMoa2006100

Lu X, Xie X, Liu L (2015) Inverted U-shaped model: how frequent repetition affects perceived risk. Judgm Decis Mak 10:3
McCredie MN, Morey LC (2019) Who are the turkers? A characterization of MTurk workers using the personality assessment inventory. Assessment 26(5):759–66
Meischke H, Sellers DE, Goff DC, Daya MR, Meshack A, Hand MM (2000) Factors that influence personal perceptions of the risk of an acute myocardial infarction. Behav Med 26(1):4–13
Metlay et al. (2021) Household transmission of SARS-CoV-2. JAMA Infect Dis, 4(2), https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2776908
Oosterhoff B, Palmer C (2020) Psychological correlates of news monitoring, social distancing, disinfecting, and hoarding behaviors among US adolescents during the COVID-19 pandemic. Accessed at https://doi.org/10.31234/osf.io/rpcy4 (accessed May 20, 2020)
Paolacci G, Chandler J, Ipeirotis PG (2010) Running experiments on amazon mechanical turk. Judgm Decis Mak 5(5):422–419
Painter M, Qiu T (2020) Political beliefs affect compliance with COVID-19 social distancing orders (April 8, 2020). Available at SRN: https://ssrn.com/abstract=3569098.
Poon LL, Peiris M (2020) Emergence of a novel human coronavirus threatening human health. Nat Med 26(3):317–319
Schaller M, Park JH (2011) The behavioral immune system (and why it matters). Curr Direct Psychol Sci 20(2):99–103
Sen-Crowe B, McKenney M, Elkbuli A (2020) Social distancing during the COVID-19 pandemic: staying home save lives. Am J Emerg Med 28(7):1519–1520
Siegrist M, Bearth A (2021) Worldviews, trust, and risk perceptions shape public acceptance of COVID-19 public health measures. Proc Natl Acad Sci USA 118(24):e2100411118
Slovic P (1987) Perception of risk. Science 236(4799):280–285
Slovic P (2020) Risk perception and risk analysis in a hyperpartisan and virtuously violent world. Risk Anal 40(S1):2231–39
Song H, Schwartz N (2009) If it's difficult to pronounce, it must be risky. Psychol Sci 20(2):135–138
Soumya RS, Govindan UT, Raghu KG (2021) Impact of COVID-19 on the cardiovascular system: a review of available reports. Cardiovasc Drugs Ther 35(3):411–25
Thomas KA, Clifford S (2017) Validity and mechanical turk: an assessment of exclusion methods and interactive experiments. Comput Hum Behav 77:184–97
Weinstein ND (1982) Unrealistic optimism about susceptibility to health problems. J Behav Med 4:441–460
WHO (2020) Behavioural insights are valuable to inform the planning of appropriate pandemic response measures. http://www.euro.who.int/en/media-centre/sections/statements/2020/statement-behavioural-insights-are-valuable-to-inform-the-planning-of-appropriate-pandemic-response-measures. Date accessed: May 13, 2020
Wölfel R, Corman VM, Guggemos W, Seilmaier M et al. (2020) Virological assessment of hospitalized patients with COVID-2019. Nature. 581(7809): 465–469
Yong S, Fang E, Anderson DE, Wei WE, Pang J (2020) Connecting clusters of COVID-19: an epidemiological and serological investigation. Lancet Infect Dis. 20(7):809–815
Zhang Y, Jiang B, Yuan J, Tao Y (2020) The impact of social distancing and epicenter lockdown on the COVID-19 epidemic in mainland China: a data-driven SEIQR model study. Accessed at: https://doi.org/10.1101/2020.03.04.20031187 (accessed May 20, 2020)

Competing interests
The authors declare no competing interests.

Ethical approval
The University of Lausanne Institutional Review Board approved this project. All research was performed in accordance with relevant guidelines/regulations. Research involving human research participants must have been performed in accordance with the Declaration of Helsinki.

Informed consent
Informed consent was obtained from all participants by requiring respondents to click on "I agree" during the survey.

Additional information
Supplementary information The online version contains supplementary material available at https://doi.org/10.1057/s41599-022-01052-4.

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