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# Risk preferences, preventive behaviour, and the probability of a loss: Empirical evidence from the COVID-19 pandemic

Adriaan Kalwij

*Utrecht University School of Economics, Department of Economics, Utrecht University, Kriekenpitplein 21-22, 3584EC, Utrecht, the Netherlands*

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ABSTACT

*Rationale:* A theoretical model of optimal choice under risk, in which an individual chooses the level of prevention to avoid a loss, has the ambiguous prediction that a higher risk-taking preference increases the probability of a loss.

*Objective:* To empirically investigate the prediction in the case of COVID-19 with individual-level survey data.

*Data:* Survey data from the Understanding America Study (UAS). The UAS Coronavirus Tracking Survey followed 8628 respondents from March 2020 until July 2021 (29 survey waves) and data was gathered on having contracted COVID-19, vaccination, and preventive behaviour. Separate UAS modules gathered data on individuals' risk preferences; twice before and once during the COVID-19 pandemic. UAS also gathered data on pre-pandemic health and socio-economic status. Combining these data, and dropping missing observations, provided longitudinal data for 4335 respondents (96,370 observations) of whom 530 contracted COVID-19.

*Results:* In support of the theoretical prediction, the empirical findings show that a one-standard deviation higher risk-taking preference is associated with about a one-third higher probability of contracting COVID-19 within two weeks. Furthermore, the findings show that individuals' risk-taking preference is negatively associated with the preventive behaviour of social distancing and not associated with getting vaccinated. There is, however, no support for preventive behaviour being associated with the probability of contracting COVID-19. The exception is for being vaccinated, which is negatively associated with the probability of contracting COVID-19. The findings, therefore, do not support that the positive association of the risk-taking preference with the probability of contracting COVID-19 is mediated through observed preventive behaviour.

*Conclusions:* The findings support the importance of individuals' risk-taking behaviour for contracting COVID-19 and, more generally, the importance of loss prevention as a risk management tool for individuals.

## 1. Introduction

Individuals' risk of contracting the coronavirus disease 2019 (COVID-19) was global and imminent at the onset of the COVID-19 pandemic (https://www.who.int). This setting provides an opportunity to empirically analyse the importance of individuals' risk-taking behaviour for the probability of a loss (i.e., contracting COVID-19). Individuals' risk preferences are fundamental building blocks in models of human behaviour (Okasha, 2011; Schildberg-Hörisch, 2018) and based on a theoretical model of optimal choice under risk (Peter, 2021) we hypothesize that, compared to individuals with a low risk-taking preference, individuals with a high risk-taking preference are less likely to take preventive measures to avoid a loss and, therefore, have a higher probability of contracting COVID-19.

In support of the hypotheses are previous findings of a negative association between the preference for risk taking and COVID-19 prevention by avoiding crowds (Müller and Rau, 2021), and of relatively low COVID-19 incidence rates among individuals who wear face masks or adhere to social distancing rules (Rader et al., 2021). Preventive behaviour is, however, likely to be incompletely observed, and individuals could exhibit compensatory risk-taking behaviour (Peltzman, 1975) such as less social distancing when wearing a face mask (Luckman et al., 2021; Yan et al., 2021). Hence, while previous findings suggest that individuals' risk-taking behaviour matters for the probability of contracting COVID-19, they do not show the importance of individuals' risk-taking preference for this probability. This study presents empirical evidence in support of the latter. That is, we find empirical support for a meaningful positive association between an individuals' risk-taking preference and the probability of contracting COVID-19. For the empirical analysis, a sample of 4335 respondents was available from the

*E-mail address:* a.s.kalwij@uu.nl.

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Understanding America Study (UAS, https://uasdata.usc.edu), forming an unbalanced panel of 96,370 observations, recorded between April 2020 and July 2021. Further, the role of preventive behaviour in the positive association between an individuals' preference for risk taking and the probability of contracting COVID-19 is substantiated with empirical support for negative associations between the risk-taking preference and the probabilities of taking up preventive measures related to social distancing. Finally, the positive association of the risk-taking preference with the probability of contracting COVID-19 remains after having controlled for observed preventive behaviour such as wearing a face mask, social distancing, and being vaccinated. Contributing more widely, the empirical evidence supports the importance of loss prevention as a risk management tool for individuals (Eeckhoudt et al., 2012; Ehrlich and Becker, 1972; Peter, 2021).

The previous literature has provided theoretical and empirical support for a positive association between the preference for risk taking and the probability of a loss. The seminal work of Ehrlich and Becker (1972) introduced loss prevention – named self-protection – as an individual's preventive behaviour to reduce the probability of a loss. Their study sparked a stream of theoretical work that shows, among other things, which assumptions enable theoretical models of optimal choice under risk to predict that a lower risk-taking preference increases preventive investments and reduces the probability of a loss (Briys and Schlesinger, 1990; Courbage and Rey, 2006; Crainich et al., 2019; Dionne and Eeckhoudt, 1985; Eeckhoudt and Gollier, 2005; Eeckhoudt et al., 2017; Julien et al., 1999; Peter, 2021). Such insights are important for interpreting, for example, risk-taking preference as positively associated with a wide range of risky behaviours such as stock trading, an unhealthy diet, smoking, or self-employment (Barsky et al., 1997; Dohmen et al., 2011; Galizzi and Miraldo, 2017; Kimball et al., 2008; Schildberg-Hörisch, 2018). Empirical evidence on the ambiguous theoretical prediction of a positive association between the preference for risk taking and the probability of a loss is, however, sparse (Peter, 2021). Arguably, this is because individuals' investments towards preventing a loss often also reduce the size of the loss – referred to as self-insurance (Ehrlich and Becker, 1972) – which leaves us with an ambiguous interpretation of empirical findings on how risk preferences are associated with preventive behaviour to avoid a loss, or with the probability of a loss, for many life outcomes (Ehrlich and Becker, 1972). Still, empirical evidence shows, for example, that an individual's risk-taking preference is negatively associated with the treatment of contaminated water to reduce incidences of diarrhoea and parasitic diseases (Tsaneva, 2013), and with adherence to diabetes medication regimes to avoid related health problems (Simon-Tuval et al., 2018). Empirical support for how risk-taking preference is associated with both preventive behaviour and the probability of a loss was found in the context of the HIV pandemic: for Senegalese sex workers, a higher level of risk aversion is positively associated with preventive behaviour and negatively associated with the incidence of HIV infection (Lépine and Treibich, 2020). These theoretical and empirical findings generally imply that self-protection can be an important risk management tool for individuals, next to self-insurance and market insurance (Eeckhoudt et al., 2012; Ehrlich and Becker, 1972). Nevertheless, the theoretical literature has also acknowledged the need for more empirical work to better understand individuals' risk-taking behaviour in relation to experiencing a loss (Peter, 2021).

The COVID-19 pandemic provides a setting that is, arguably, well suited for empirically analysing the association between individuals' risk preferences and the probability of a loss (i.e., contracting COVID-19). First, at the onset of the pandemic the COVID-19 risk was global and imminent. This study, therefore, assumes that the population at risk when the pandemic started is the whole population. The analysis is of the probability of contracting COVID-19 for the first time and accounts for a decrease over time in the population at risk by conditioning the sample on not having had COVID-19. Second, before the pandemic the risk of COVID-19 per se was unknown to individuals. It is therefore assumed that individuals did not anticipate the COVID-19 pandemic. This assumption is necessary to control in the empirical analysis for a possible effect of having had COVID-19 on risk preferences, which were measured about one year into the pandemic. Previous studies provide support for such an effect that can cause a simultaneity bias in the association between risk preferences and the probability of contracting COVID-19 (Angrisani et al., 2020; Decker and Schmit, 2016; Hammitt et al., 2009). The analysis controls for simultaneity bias by employing an instrumental variables estimator with the pre-pandemic risk-taking preference as an instrument for the risk-taking preference measured during the pandemic. Third, individuals can reduce the probability of contracting COVID-19 through preventive behaviour such as wearing face masks, social distancing, or vaccination against COVID-19. Although the severity of COVID-19 varies across individuals, and in the worst case they can die from it (Banerjee et al., 2020), it is not affected by preventive behaviour such as social distancing. Vaccination, however, has been shown not only to reduce the probability of contracting COVID-19 but also to reduce the severity of the disease (Barda et al., 2021; Chemaitelly et al., 2021; Lopez et al., 2021). Hence, an individual can have a self-protection motive (to avoid contracting COVID-19) and a self-insurance motive (to reduce the severity of COVID-19) for getting vaccinated. The empirical analysis addresses this issue by controlling for having been vaccinated. Further, there is some evidence suggesting that wearing face masks could reduce the severity of COVID-19 (Courtney and Bax, 2021; Gandhi et al., 2020) and that having had COVID-19 can be protective (Hall et al., 2021). The latter issue does not affect our analysis of the probability of contracting COVID-19 conditional on not having had COVID-19.

Finally, there are relatively high incidences of COVID-19 among obese and low educated individuals (Hawkins et al., 2020; Kwok et al., 2020), and risk preferences are correlated with, for example, health and SES (Dohmen et al., 2011; Finley et al., 2022). These findings suggest that confounding factors can account for risk preferences' associations with preventive behaviour and the probability of contracting COVID-19. We show the importance of controlling for a wide range of pre-pandemic characteristics related to health and SES in the empirical analysis. Nevertheless, no causal inferences are drawn because not all confounding factors can be controlled for.

## 2. Methods

### 2.1. The data: Understanding America Study (UAS)

The empirical analysis is based on individual level survey data from the Understanding America Study (UAS). UAS is a probability-based internet panel comprising about 9000 respondents (age 18+) who are representative of the U.S. population (Alattar et al., 2018; https://uasdata.usc.edu). The UAS oversamples Native Americans and residents of Los Angeles County and survey weights are available. All this study's data is self-reported, and all its computations are own computations.

#### 2.1.1. UAS Coronavirus Tracking Survey

The UAS Coronavirus Tracking Survey was launched in March 2020 (Kapteyn et al., 2020). After the first survey in March, it was continued biweekly from April 2020 until February 2021 and four-weekly from mid-February 2021 until July 2021 (Supplementary Material Table S1). The survey was fielded 29 times. Information was gathered on, among other things, having contracted COVID-19 and preventive behaviour. The survey participation rate, on average, is 80% per wave and the response sample has 179,662 observations of 8628 individuals (Supplementary Material Table S1).

Whether a respondent contracted COVID-19 is determined with information from each wave on having had a COVID-19 diagnosis and on having tested positive for COVID-19 (see Supplementary Material S1 for the survey questions). A binary variable 'have had COVID-19' was constructed that is equal to 1 if the respondent answered, in any of the surveys up to and including the current one, positively to the survey question as having been diagnosed by a healthcare professional as infected, or probably infected, with COVID-19, or positively to the survey question as having tested positive for COVID-19 (and equal to 0 otherwise). For respondents who did not have had COVID-19 in the current survey, a binary variable 'contracted COVID-19' was constructed that is equal to 1 if the respondent contracted COVID-19 between a current survey wave and the next one (and equal to 0 otherwise).

Preventive behaviour in the seven days preceding the interview was elicited in each survey wave (see Supplementary Material S1 for the survey questions). Based on this information we constructed the binary variables 'washed hands', 'wore face mask', 'avoided restaurants', 'avoided public places' (public spaces, gatherings, or crowds), 'stayed at home' (except for essential activities or exercise), and 'no visits' (of friends, neighbours, or relatives). Information for the latter two variables is not available in the first wave of the survey.

Further, as from wave 21 (December 2020) onwards information is available on the preventive behaviour of being vaccinated against COVID-19 (see Supplementary Material S1 for the survey question). The binary variable 'have been vaccinated' is equal to 1 if the respondent answered to be vaccinated for the coronavirus, and equal to 0 otherwise. This refers to having received at least one dose of the vaccine. For respondents who were not vaccinated, a binary variable 'got vaccinated' was constructed that is equal to 1 if the respondent got vaccinated between a current survey wave and the next one (and equal to 0 otherwise).

#### *2.1.2. UAS risk preferences survey modules*

Individuals' risk preferences were elicited in UAS surveys using a question about general risk preferences with answer categories on a 0–10 Likert scale (Falk et al., 2018; Finley et al., 2022; see Supplementary Material S1 for the survey question). The extant literature supports using such a question to elicit individuals' risk preferences (Arslan et al., 2020; Bonsang and Dohmen, 2015; Charness et al., 2019; Falk et al., 2016; Kapteyn and Teppa, 2011; Verschoor et al., 2016).

Risk preferences were elicited for the first time in November or December of 2018, the second time in June or July of 2019, and the third time in December 2020 or January/February 2021. The survey participation rate is 76% for the 2018 survey, 74% for the 2019 survey, and 80% for the 2020/21 survey. There is about 0.6% item non-response on the risk preference question across these three surveys. If a respondent's risk preferences are available for both the 2018 and 2019 survey, we used the 2018 observation. For 6064 respondents, risk preferences are available for either the 2018 survey (82%) or the 2019 survey (18%). We refer to these as pre-pandemic risk preferences. Of these respondents, 81% provided an answer to the risk preference question in the 2020/21 survey (4887 respondents), which we label as *mid-pandemic risk preferences*.

#### *2.1.3. Pre-pandemic characteristics*

The pre-pandemic demographic characteristics included for the analysis are gender, age (in full years) and age squared, state of residence, children present, race, and marital status. This information is available from the 2018 and 2019 UAS surveys on risk preferences (UAS surveys 164 and 193, https://uasdata.usc.edu). We recoded the data on race: the category Native Americans includes American Indians, Alaskan Natives, and Pacific Islander Americans. The other categories are White (non-Hispanic), White Hispanic, Black only, Asian only, and mixed race. Data on marital status is collapsed into a binary variable 'married,' which is equal to 1 if the respondent is either married or cohabiting (and 0 otherwise). Further, a binary variable indicating children under 18 in the household is constructed based on information giving household members' age and position in the household.

The pre-pandemic socioeconomic status (SES) characteristics refer to educational attainment and labour market status. Information on these characteristics is also available from the 2018 and 2019 UAS surveys on risk preferences. The level of education is categorized in at most a high school diploma, some college, or at least a college degree. Labour market status is summarized with two binary variables for currently working and for retired from work. Hence, the reference category is not working nor retired from work.

Information on respondents' pre-pandemic health-related characteristics is available from the UAS Comprehensive File (https://uasdata.usc.edu). These characteristics are self-assessed health (categories: fair or poor, good, very good, and excellent), body mass index (BMI; categorized in normal or underweight if BMI$<$25, overweight if 25 $\leq$ BMI$<$30, and obese if BMI$\geq$30), health behaviour (ever smoked, alcohol consumption, vigorous sport participation), height, having a lung condition, having diabetes, and having a severe health condition (cancer or cardiovascular diseases).

Item non-response on each of these pre-pandemic variables is at most 4%, conditional on having risk preferences information.

#### *2.1.4. Data selection*

About 0.5% of the observations were removed from the data of the Coronavirus Tracking Survey because of item non-response on the questions related to having had COVID-19 or being vaccinated against COVID-19 (Supplementary Material Table S2). Supplementing these data with the data on risk preferences, and removing respondents with missing information on these preferences, reduced the sample to 119,698 observations of 4658 respondents (Supplementary Material Table S2). The null hypothesis of no correlation between being removed from the sample and having contracted COVID-19, conditional on survey wave, was not rejected (p-value = 0.869), which is in favour of exogenous sample selection. The resulting sample is only used for Fig. 1. Respondents, on average, were in 26 of the 29 waves, and 635 respondents had had COVID-19 (measured until mid-July 2021).

Next, for the estimation sample respondents' observations when they have had COVID-19 or when they were not in a next wave were excluded (Supplementary Material Table S2). That is, the sample includes respondents' observations when they did not have had COVID-19 and were at risk of contracting COVID-19 for the first time. Therefore, Wave 28 is the last wave of the estimation sample and information from Wave 29 was only used for constructing the variables 'contracted COVID-19' and 'got vaccinated'. Information on having contracted COVID-19 between a current survey wave and the next one conditional on not having had COVID-19 is available for 4580 respondents (108,543 observations) of whom 627 contracted COVID-19. Finally, we dropped observations with missing values on any of the variables used for the empirical analysis. This includes dropping observations from the first wave of the survey (March 2020) because the preventive measures 'stayed at home' and 'no visits' were not elicited in that wave (Section 2.1.1). The estimation sample has information for 4335 respondents (96,370 observations) of whom 530 contracted COVID-19 for the first time between a current survey wave and the next one. Seventeen respondents contracted COVID-19 when there were vaccinated.

For the respondents included in the estimation sample, the distribution of pre-pandemic and mid-pandemic risk preferences, their rank correlation and Cronbach's αs, are in Supplementary Material Table S3. Summary statistics of the pre-pandemic variables are in Supplementary Material Table S4. Supplementary Material Table S5 shows associations of the difference between mid-pandemic and pre-pandemic risk preferences with having had COVID-19 and with pre-pandemic characteristics. Supplementary Material Table S6 shows information on the uptake of preventive measures by survey wave.

### *2.2. Empirical models and estimators*

This section presents the empirical models for estimating the associations of the preference for risk taking with the probability of contracting COVID-19 and with the probabilities of taking up preventive

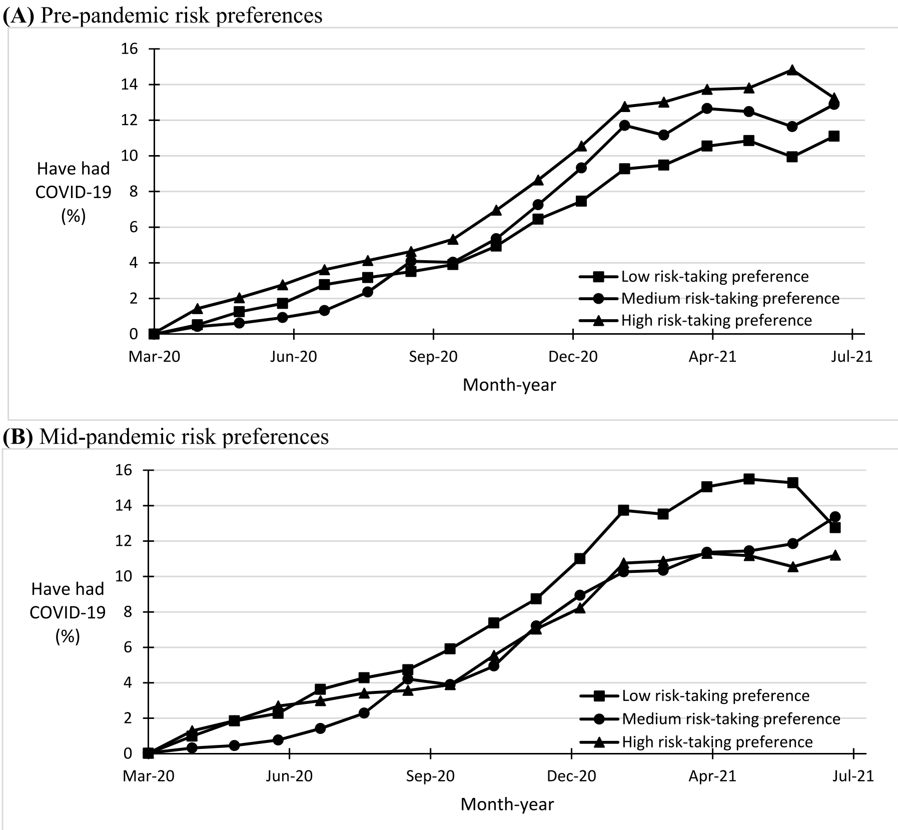


**Fig. 1.** The percentage of individuals who have had COVID-19 over time and by their risk-taking preference. *Notes.* Data: respondents' observations, including when they had had COVID-19 (Section 2.1.4). For this figure, risk preferences – measured on a Likert 0–10 scale – are categorized in low (0–4), medium (5–6), and high (7–10) preference for risk taking (see Supplementary Material Table S3 for the distribution of risk preferences). Survey weights were used. For the three risk-categories combined, 12.5% of respondents have had COVID-19 in June/July 2021.

measures. The probabilities are conditional on not having had COVID-19. Next to the risk-taking preference, all models control for survey wave fixed effects. Most models include a vector of pre-pandemic demographic, health, and SES characteristics, denoted by $X$ (see Section 2.1.3 and Supplementary Material Table S4). For this presentation, the index $i$ refers to an individual and the index $t$ refers to the survey wave of the UAS Coronavirus Tracking Survey.

#### 2.2.1. *Risk preferences and the probabilities of contracting COVID-19 and of taking up preventive measures*

The association of the risk-taking preference $R$ with the probability of contracting COVID-19 conditional on not having had COVID-19, is estimated with the linear probability model (Wooldridge, 2010)

$$P(COVID_{it+1} = 1 | COVID_{it} = 0, R_i, \boldsymbol{X}_i) = \gamma_t + \beta_1 R_i + \boldsymbol{X}_i \boldsymbol{\beta}_2, \qquad (1)$$

where the variable *COVID* is equal to 1 if an individual had had COVID-19, and 0 otherwise, and $R$ is the mid-pandemic risk-taking preference. The regressions control for wave-specific fixed effects $\gamma$, with the second survey wave as a reference (the first wave is excluded from the sample; Section 2.1.4), which also accounts for the switch from biweekly to four-weekly surveys in February 2021 (Supplementary Material Table S1). The coefficient $\beta_1$ is therefore interpreted as the association between the risk-taking preference $R$ and the probability of contracting COVID-19 within two weeks.

Estimates of the associations between the risk-taking preference $R$ and the probability of taking up a preventive measure $M$, conditional on not having had COVID-19, are obtained by estimating the linear probability model

$$P(M_{it} = 1 | COVID_{it} = 0, R_i, \boldsymbol{X}_i) = \alpha_t + \alpha_1 R_i + \boldsymbol{X}_i \boldsymbol{\alpha}_2, \qquad (2)$$

where $\alpha$ is a wave-specific fixed effect. The condition $COVID_{it} = 0$ reflects that the model of Equation (2) is estimated on the same sample that is used for estimating the model of Equation (1). The preventive measures considered are 'got vaccinated, 'washed hands', 'wore face mask', 'avoided restaurants', 'avoided public places', 'stayed at home', and 'no visits' (Section 2.1.1). The coefficient $\alpha_1$ is interpreted as the association between the risk-taking preference and the probability of taking up the preventive measure in the last seven days, except for 'got vaccinated'. For the latter, the coefficient $\alpha_1$ is interpreted as the association between the risk-taking preference and the probability of getting vaccinated within two weeks.

#### 2.2.2. *Estimators and test statistics*

The linear probability models based on Equations (1) and (2) are estimated with a least squares (LS) estimator and with an instrumental variables (IV) estimator (Wooldridge, 2010). For the estimations, individual-specific random effects and random error terms are included in the regression models. For the LS estimations, $R$ is either the pre-pandemic risk-taking preference or the mid-pandemic risk-taking preference. For the IV estimations, $R$ is the mid-pandemic risk-taking preference and the instrument for $R$ is the pre-pandemic risk-taking preference. When using IV, it is assumed that pre-pandemic risk preferences are only associated with the probability of contracting COVID-19 through their association with mid-pandemic risk preferences. The IV estimator eliminates a possible simultaneity bias in the association that stems from an effect of having contracted COVID-19 on mid-pandemic risk preferences (Angrisani et al., 2020; Wooldridge, 2010). While IV is, arguably, not needed for estimating the model of Equation (2) (preventive behaviour), the IV estimator can also remove possible measurement error bias insofar as such error is uncorrelated over time (Beauchamp et al., 2017; Bound et al., 2001).

Standard errors are clustered at the individual level (robust standard errors) to control for heteroskedasticity and serial correlation. An $F$-test statistic is reported for the null hypothesis that the pre-pandemic risk-taking preference is correlated with the mid-pandemic risk-taking preference (Angrist and Pischke, 2009; Montiel Olea and Pflueger, 2013). A rejection of the null hypothesis when the *F*-statistic is a sufficiently high is empirical evidence in favour of instrument relevance, hence of not having a weak instrument (Montiel Olea and Pflueger, 2013). Furthermore, *p*-values are reported of an endogeneity test (Wooldridge, 2010). A rejection of the null hypothesis is empirical evidence in favour of the presence of a simultaneity bias when using a LS estimator and, therefore, of the need for employing an IV estimator.

## 3. Results

This section presents empirical estimates of the associations of the preference for risk taking with the probability of contracting COVID-19 (Equation (1)) and with the probabilities of taking up preventive measures (Equation (2)). For interpreting estimation results, a statistical finding that is significant at the 0.5% level is plausibly replicable (Benjamin et al., 2018) and treated as empirical evidence against the null hypothesis. A statistical finding with a significance level between 0.5% and 5% is considered suggestive empirical evidence against the null hypothesis.

### 3.1. The percentages of having had COVID-19 and of contracted COVID-19 b y risk-taking preference

The percentage of individuals having had COVID-19 reached about 12.5% in July 2021 (Fig. 1's notes). Further, Fig. 1A shows a positive relationship between the risk-taking preference and having had COVID-19. The null hypothesis that pre-pandemic risk preferences and having had COVID-19 are independent is rejected (*p*-value = 0.003). Individuals could have adjusted their risk preferences during the pandemic, arguably because of the ubiquity of COVID-19 (Mussio et al., 2023). Fig. 1B shows, therefore, the same relationship as Fig. 1A using mid-pandemic instead of pre-pandemic risk preferences. A pertinent feature in Fig. 1B is the relatively high percentage of individuals with a low mid-pandemic risk-taking preference having had COVID-19. The null hypothesis that mid-pandemic risk preferences and having had COVID-19 are independent is, however, not rejected (*p*-value = 0.389), which suggests there is no relationship between risk preferences and having had COVID-19.

The slopes of the curves in Fig. 1 are determined by the percentages of individuals who contracted COVID-19 between a current survey wave and the next one, conditional on not having had COVID-19. These percentages are shown in Fig. 2 for three survey periods; disaggregated by month would yield too small samples for reliable inferences. In accordance with Fig. 1A and 2A shows a positive association between pre-pandemic risk preferences and contracted COVID-19. The null hypothesis that pre-pandemic risk preferences and contracted COVID-19 are independent is rejected (*p*-value = 0.003). Also, in line with Figs. 1B and 2B shows no association between mid-pandemic risk preferences and contracted COVID-19. The null hypothesis that mid-pandemic risk preferences and contracted COVID-19 are independent is not rejected (*p*-value = 0.916).

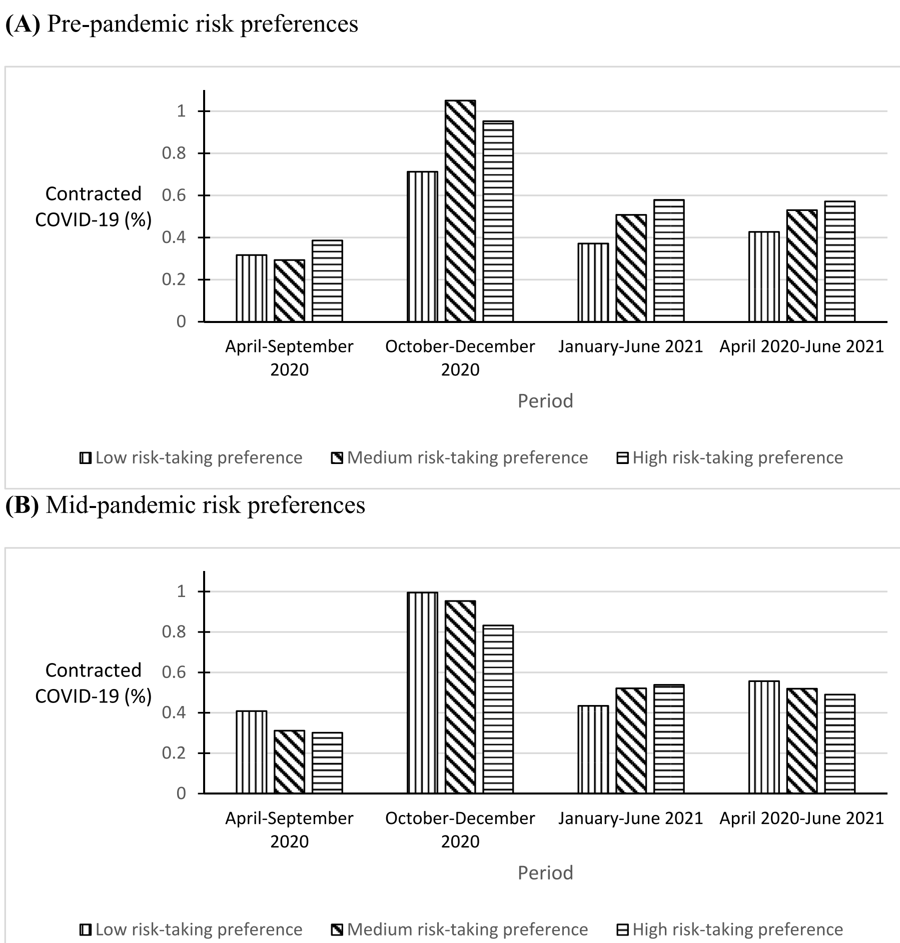


**Fig. 2.** The percentage of individuals who contracted COVID-19 within two weeks, conditional on not having had COVID-19, by period and their risk-taking preference. *Notes.* Data: estimation sample (Section 2.1.4). For this figure, risk preferences – measured on a Likert 0–10 scale – are categorized in low (0–4), medium (5–6), and high (7–10) preference for risk taking. For the three risk-categories combined, on average 0.55% of respondents contracted COVID-19 within two weeks.

The risk preferences depicted in Figs. 1B and 2B were elicited about one year into the pandemic when respondents can already have contracted COVID-19. For our estimation sample, 396 respondents contracted COVID-19 before, and 134 respondents after, mid-pandemic risk preferences were elicited. If had contracted COVID-19 affects the preference for risk taking as previous studies suggest (Angrisani et al., 2020; Decker and Schmit, 2016; Hammitt et al., 2009), this could explain the striking differences between the patterns in Fig. 1A and B and between the patterns in Fig. 2A and B. That is, the pattern in Fig. 1B or 2 B can be dominated by respondents reporting a low risk-taking preference because they had had COVID-19. Such an effect would give rise to a simultaneity bias when analysing risk preferences' association with the probability of contracting COVID-19 (Wooldridge, 2010).

While an association based on the pre-pandemic risk preferences (Fig. 2A) is free of simultaneity bias because these preferences were elicited before the pandemic, it does not account for possible changes in individuals' risk preferences because of an increase in background risk during the COVID-19 pandemic (Mussio et al., 2023; Supplementary Material Table S5). A regression analysis using mid-pandemic risk preferences can allow for such changes and at the same time control for a possible simultaneity bias by using an IV estimator (Section 2.2). A statistical test is carried out for whether controlling for such a simultaneity bias is needed (see Section 2.2.2).

### 3.2. Risk preferences and the probability of contracting COVID-19

Table 1 presents the estimation results of the model of Equation (1). Without instrumenting (mid-pandemic) risk preferences, hence when using a LS estimator, the empirical evidence agrees with Fig. 2B and does not support an association between risk preferences and the probability of contracting COVID-19 (specification LS1). In accordance with Fig. 2A there is suggestive evidence in favour of a positive association of the pre-pandemic preference for risk taking with the probability of contracting COVID-19 (specification LS2). Allowing for a change in risk preferences during the pandemic, hence using mid-pandemic risk preferences, and controlling for possible simultaneity bias by employing an IV estimator, provides suggestive evidence in favour of a positive association of risk-taking preference with the probability of contracting COVID-19 (specification IV1). The latter association is substantially strengthened when pre-pandemic characteristics to control for possible confounding factors are included (specification IV2).

The estimated association of 0.086 (specification IV2) is also meaningful: a one-standard deviation higher risk-taking preference (2.16 points on a 0–10 scale) is associated with a 0.19 percentage points higher probability of contracting COVID-19. The average probability of contracting COVID-19 is 0.55% (Fig. 2's notes), which implies that a one-standard deviation higher risk-taking preference is on average associated with about a one-third (34%) increase in the probability of contracting COVID-19 within two weeks.

Further, the model of Equation (1) estimated with specifications IV3 – IV4 allows that the association between the risk-taking preference and the probability of contracting COVID-19 can vary between unvaccinated and vaccinated individuals because of a self-insurance motive stemming from vaccination reducing the severity of the disease. While the results for these specifications show the importance of vaccination for reducing the probability of contracting COVID-19, they also show that the association between the risk-taking preference and the probability of contracting COVID-19 is not affected by having been vaccinated.

Finally, the results at the bottom of the table support controlling for a possible simultaneity bias by using an IV estimator. For all specifications estimated with IV, the F-statistic is high enough to reject the null hypothesis of the pre-pandemic risk-taking preference being a weak instrument ('Instrument relevance'; Angrist and Pischke, 2009; Montiel Olea and Pflueger, 2013) and the null hypothesis of exogeneity of the mid-pandemic risk-taking preference is rejected ('Endogeneity test'; Wooldridge, 2010).

### 3.3. Risk preferences and preventive behaviour

Arguably, the preference for risk taking is associated with the probability of contracting COVID-19 through its association with preventive behaviour. To substantiate this argument, we analysed the association between the risk-taking preference and the probability of taking up a preventive measure by estimating the regression model of Equation (2) with LS. The preventive measures we considered were whether in the seven days preceding the survey interview respondents had washed their hands, wore a face mask, avoided restaurants or public places, stayed at home, and neither visited nor received visits from

**Table 1**
The association between the preference for risk taking and the probability of contracting COVID-19 (in %).

| Specification | LS1 | LS2 | IV1 | IV2 | IV3 | IV4 |
|---|---|---|---|---|---|---|
| | Coeff.<br>(S.E.)<br>[p-value] | Coeff.<br>(S.E.)<br>[p-value] | Coeff.<br>(S.E.)<br>[p-value] | Coeff.<br>(S.E.)<br>[p-value] | Coeff.<br>(S.E.)<br>[p-value] | Coeff.<br>(S.E.)<br>[p-value] |
| Risk-taking preference | −0.047<br>(0.028)<br>[0.090] | 0.044<br>(0.026)<br>[0.093] | 0.063<br>(0.028)<br>[0.022] | 0.086<br>(0.030)<br>[0.002] | 0.086<br>(0.030)<br>[0.004] | 0.086<br>(0.031)<br>[0.006] |
| Vaccinated | | | | | −0.522<br>(0.121)<br>[<0.001] | −0.577<br>(0.245)<br>[0.245] |
| Risk-taking preference × vaccinated | | | | | | 0.010<br>(0.043)<br>[0.595] |
| $H_0$: no association with pre-pandemic variables[a], *p*-value | | | | <0.001 | <0.001 | <0.001 |
| Instrument relevance, *F*-statistic | | | 1664 | 1444 | 1443 | 1061 |
| Endogeneity test, *p*-value | | | <0.001 | <0.001 | <0.001 | 0.002 |
| $R^2$ | 0.003 | 0.003 | 0.003 | 0.005 | 0.005 | 0.005 |
| Number of respondents | 4335 | 4335 | 4335 | 4335 | 4335 | 4335 |
| Number of observations | 96,370 | 96,370 | 96,370 | 96,370 | 96,370 | 96,370 |

*Notes.* Data: estimation sample (Section 2.1.4; Fig. 2). Coeff. = coefficient; S.E. = standard error. Estimates of the model of Equation (1). The associations refer to percentage points changes in the probability of contracting COVID-19. On average, 0.55% of the respondents contracted COVID-19 within two weeks, conditional on not having had COVID-19. The sample standard deviation of the risk-taking preference is 2.16 points. Specification LS1 uses mid-pandemic risk preferences (RP) and specification LS2 uses pre-pandemic RP. Both specifications are estimated with LS. Specifications IV1-IV4: IV estimates with pre-pandemic RP as an instrument for mid-pandemic RP. The full set of estimation results for specification IV2, including the first-stage results are in Supplementary Material Table S7.

[a] Demographics, health characteristics and socioeconomic status (Section 2.1.3 and Supplementary Material Table S4). All specifications control for survey wave fixed effects.

friends, relatives, or neighbours (‘no visits’). Also considered is whether the respondent got vaccinated in between two waves. Fig. 3 shows the average uptake of these preventive measures during the pandemic.

The empirical evidence does not support that the probabilities of washing hands, of wearing face masks, and of getting vaccinated are associated with the risk-taking preference (Table 2). The evidence does support that a higher risk-taking preference is associated with a lower probability of social distancing as measured by either having avoided public places and restaurants, having stayed at home, or not having visited or received visits from friends, relatives, or neighbours (‘no visiting’). For instance, a one-standard deviation higher risk-taking preference is associated with a 1.7 percentage points lower probability of ‘no visiting’ and with a 2.4 percentage points lower probability of avoiding restaurants in the seven days preceding the survey interview.

Finally, the model of Equation (2) was also estimated with an IV estimator that used the pre-pandemic risk-taking preference as an instrument for the mid-pandemic risk-taking preference. The null hypothesis of exogeneity of mid-pandemic risk-taking preference was, however, not rejected for each preventive measure (see Panel B of Supplementary Material Table S9) and the LS results are, therefore, reported in Table 2.

### 3.4. The probability of contracting COVID-19, risk preferences, and preventive behaviour

The results of Tables 1 and 2 suggest that part of the association between risk preferences and the probability of having contracted COVID-19 can be mediated through observed preventive behaviour. For the mediation analysis, a vector of preventive measures is added to the model of Equation (1). The preventive measures included are ‘washed hands’, ‘wore face mask’, ‘avoided restaurants’, ‘avoided public places’, ‘stayed at home’, ‘no visits’, and ‘had been vaccinated’ (Fig. 3; Supplementary Material Table S6).

There is no discernible difference in the estimated association of risk preferences with the probability of contracting COVID-19 between Table 1 (specification IV2) and Table 3 (specification IV5). Hence, there is no support for mediation of the association between risk preferences and the probability of contracting COVID-19 through observed preventive behaviour. One reason for this finding is that there is no empirical support for associations between observed preventive behaviour, excluding had been vaccinated, and the probability of contracting COVID-19 (Table 3). The hypothesis of no joint associations with preventive behaviour, excluding had been vaccinated, is not rejected for specifications IV5 and LS5; the *p*-values are 0.593 and 0.435, respectively. Another reason is that while being vaccinated is associated with the probability of contracting COVID-19, there is no empirical support for an association between risk preferences and getting vaccinated (Table 2).

Furthermore, the null hypothesis of no associations of the probability of contracting COVID-19 with interactions between the risk-taking preference and each preventive measure was not rejected ($p$-value = 0.944; not reported in a Table). Hence, there was no evidence to support that the association of the risk-taking preference with the probability of contracting COVID-19 is influences by taking up a preventive measure.

### 3.5. Full sets of estimation results

Various pre-pandemic individual characteristics have been included in the empirical models of Tables 1–3 to control for possible confounding factors. While the associations of these characteristics with the probability of contracting COVID-19, and the probabilities of taking up preventive measures are of interest, they deserve more thorough investigation than this study can provide. The latter associations are, therefore, not discussed in the main text and Supplementary Material Tables S7, S8 and S10 show these.

Furthermore, Supplementary Material Tables S7, S9 and S10 show LS estimates of associations of either the pre-pandemic or the mid-pandemic risk-taking preference with, respectively, the probability of contracting COVID-19, the probability of taking up preventive measures and the probability of contracting COVID-19 when observed preventive measures are controlled for.

### 3.6. Robustness checks

The finding of no empirical support for an association of the risk-taking preference with the probability of getting vaccinated (Table 2) is, arguably, an unexpected finding. We have, therefore, further investigated the associations of the risk-taking preference with the probability of getting vaccinated and with the probability of being vaccinated using all observations, i.e., also observations when respondents had had COVID-19 (Supplementary Material Table S11). In line with the results of Table 2, the analysis provides no empirical support for such associations. Possible reasons for this finding are that vaccination has been politicized in the US (Albrecht, 2022) or that respondents are concerned about the side effects of the vaccine (Crainich et al., 2019).

A further issue is that preventive behaviour can change after being vaccinated, resulting in changes in the associations between the risk-taking preference and the probability of taking up a preventive

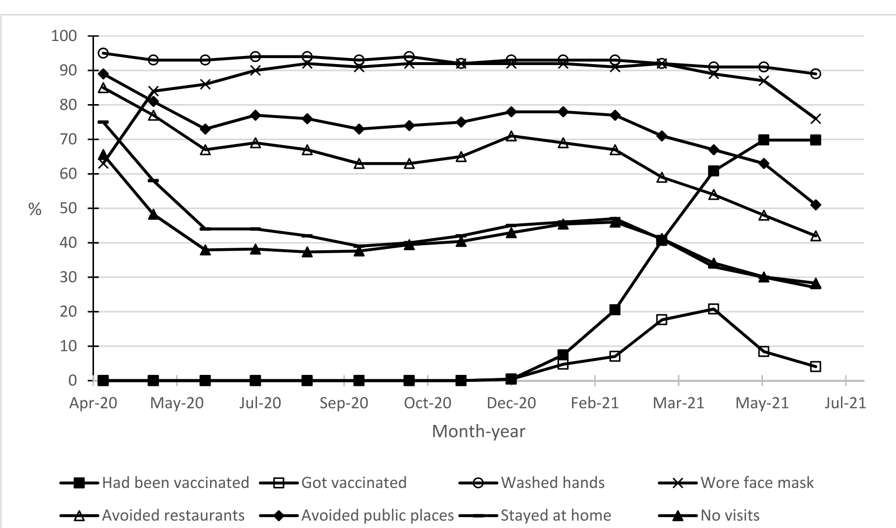


**Fig. 3.** Preventive behaviour over time. *Notes.* Data: estimation sample (Section 2.1.4). Shown are the percentages of individuals who had taken up a preventive measure in the seven days preceding the survey interview, conditional on not having had COVID-19. The exceptions are that ‘got vaccinated’ refers to the time in between two waves and that ‘had been vaccinated’ refers to the percentage of respondents that were vaccinated (cumulative over time). Respondents could get vaccinated from December 2020 onward. Supplementary Material Table S6 shows the (raw) associations of preventive behaviour with the probability of contracting COVID-19.

**Table 2**
Associations between the preference for risk taking and the probability of taking up a preventive measure.

| Preventive behaviour | Washing hands | Wearing a face mask | Avoiding restaurants | Avoiding public places | Staying at home | No visiting | Getting vaccinated[a] |
|---|---|---|---|---|---|---|---|
| Coefficient | −0.109 | −0.337 | −1.118 | −1.142 | −1.081 | −0.765 | −0.070 |
| (Standard error) | (0.146) | (0.158) | (0.226) | (0.209) | (0.224) | (0.233) | (0.099) |
| [*p*-value] | [0.455] | [0.033] | [<0.001] | [<0.001] | [<0.001] | [0.001] | [0.484] |
| $H_0$: No associations with pre-pandemic variables[b], *p*-value | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| $R^2$ | 0.027 | 0.123 | 0.106 | 0.091 | 0.147 | 0.061 | 0.127 |
| NR | 4335 | 4335 | 4335 | 4335 | 4335 | 4335 | 3900 |
| *N* | 96,370 | 96,370 | 96,370 | 96,370 | 96,370 | 96,370 | 20,789 |
| Percentage | 93.700 | 87.880 | 67.170 | 75.600 | 41.011 | 46.820 | 11.730 |

*Notes.* Data: estimation sample (Section 2.1.4; Fig. 3). The associations refer to percentage points changes in the probabilities of taking up preventive measures. NR = number of respondents; N = number of observations. The sample standard deviation of the risk-taking preference is 2.16 points. For each preventive measure, the model of Equation (2) was estimated with LS. The full set of estimation results are in Supplementary Material Table S8. For all models, the null hypothesis of exogeneity of the mid-pandemic risk-taking preference is not rejected (Panel B of Supplementary Material Table S9).

[a] For survey waves 20–28. Respondents could get vaccinated from December 2020 onward.

[b] Demographic, health, and SES characteristics (Section 2.1.3 and Supplementary Material Table S4). All specifications control for survey wave fixed effects.

**Table 3**
Associations of the preference for risk taking and preventive behaviour with the probability of contracting COVID-19.

| | IV5 | LS5 |
|---|---|---|
| | Coeff. (S.E.) [p-value] | Coeff. (S.E.) [p-value] |
| Risk-taking preference | 0.086 | |
| | (0.030) | |
| | [0.005] | |
| Vaccinated | −0.523 | −0.567 |
| | (0.121) | (0.122) |
| | [<0.001] | [<0.001] |
| Washed hands | 0.092 | 0.090 |
| | (0.117) | (0.135) |
| | [0.434] | [0.505] |
| Worn face mask | 0.058 | −0.040 |
| | (0.093) | (0.101) |
| | [0.533] | [0.695] |
| Avoided restaurants | −0.037 | −0.029 |
| | (0.072) | (0.076) |
| | [0.611] | [0.702] |
| Avoided public places | −0.025 | −0.003 |
| | (0.082) | (0.085) |
| | [0.756] | [0.967] |
| Stayed at home | −0.059 | −0.028 |
| | (0.062) | (0.066) |
| | [0.338] | [0.665] |
| No visits | 0.090 | 0.144 |
| | (0.060) | (0.065) |
| | [0.131] | [0.026] |
| $H_0$: No associations with demographics, health characteristics and socioeconomic status, *p*-value | <0.001 | <0.001 |
| $H_0$: No associations with preventive behaviour (excluding being vaccinated), *p*-value | 0.593 | 0.435 |
| $R^2$ | 0.005 | 0.005 |
| Number of respondents | 4335 | 4335 |
| Number of observations | 96,370 | 96,370 |

*Notes.* Data: estimation sample (Section 2.1.4). The associations refer to percentage points changes in the probability of contracting COVID-19. IV5: IV estimates of the model of Equation (1) extended with preventive measures. LS5: LS estimates of the model without controlling for risk preferences. The full sets of results are in Supplementary Material Table S10.

measure (Table 2). We found no empirical support for such changes (Supplementary Material Table S12).

Finally, the analysis is carried out using linear probability models. While these are suited for estimating (average) marginal effects, our assessment of how a one-standard deviation higher risk-taking preference is associated with the probability of contracting COVID-19 can be affected by the linearity assumption. Our main conclusion based on the findings of Table 1 did not change, however, when using probit models instead of linear probability models (Supplementary Material Table S13).

## 4. Discussion

In the risk-taking literature it is often hypothesized that individuals' preference for risk taking is positively related to the probability of a loss (Ehrlich and Becker, 1972; Peter, 2021). Although theoretical studies on models of optimal choice under risk have extensively investigated the assumptions under which a higher preference for risk taking predicts an increase in the probability of a loss, empirical evidence on the prediction for adverse life events is sparse. The latter is, arguably, because investments individuals make to prevent a loss (self-protection) often also reduce the size of the loss (self-insurance), which leaves the interpretation of empirical findings on how risk preferences are associated with the probability of a loss for many life outcomes ambiguous (Ehrlich and Becker, 1972). Arguably, the COVID-19 pandemic provides an opportunity to empirically investigate the association of individuals' risk preferences with the probability of a loss (i.e., contracting COVID-19), as well as with preventive behaviour to avoid such a loss such as wearing a face mask or getting vaccinated.

This study's empirical findings support the hypothesis that individuals' risk-taking preference is positively associated with the probability of contracting COVID-19 and negatively associated with the preventive behaviour of social distancing. These findings are also meaningful: For example, a one-standard deviation higher risk-taking preference is associated with about a one-third higher probability of contracting COVID-19. Furthermore, the latter positive association remained when having controlled for observed preventive behaviour, which suggests an important role for unobserved preventive behaviour.

For the wider literature on optimal choice under risk this study's empirical findings support the ambiguous theoretical prediction that a higher risk-taking preference increases the probability of a loss. The latter suggests that preventive behaviour to reduce a possible loss risk (e.g., self-protection) can be an important risk management tool for individuals to reduce the expected adverse effects of a loss, alongside self-insurances such as precautionary savings and market insurances such as health insurance, to face, for example, financial and health risks (Eeckhoudt et al., 2012; Ehrlich and Becker, 1972).

This study is not without limitations. For instance, the findings are robust to the inclusion of a wide range of possible confounding factors related to health and SES. In fact, this inclusion strengthens the association of the risk-taking preference with the probability of contracting COVID-19 which suggests that the estimated association can be a lower bound of the effect of the risk-taking preference on the probability of contracting COVID-19. Nevertheless, we cannot draw causal inferences because not all possible confounding factors were controlled for in the empirical analysis. To overcome this limitation in future research will be challenging because it would require an exogenous change in risk preferences. This limitation also applies to an interpretation of our finding of no empirical support for associations of observed preventive behaviour with the probability of contracting COVID-19. If, for example, individuals with a relatively high (unobserved) risk of contracting COVID-19 are more likely to take up prevention measures, the estimated associations of observed preventive measures with the probability of contracting COVID-19 are attenuated toward zero.

Further, this study's definition of contracting COVID-19 is conditional on respondents having tested for COVID-19 or having consulted a healthcare professional at the appropriate time. This condition can be associated with risk preferences. Such an association is not empirically supported (Müller and Rau, 2021), but more empirical evidence is needed on how risk preferences are associated with preventive testing or consulting a healthcare professional.

Also, several of the preventive measures analysed in this study were mandatory for some time during the survey period. Arguably, without mandatory COVID-19 measures, individual behaviour would have played a more important role in containing the coronavirus. Further research could shed light on the extent to which the association between risk preferences and COVID-19 is influenced by the mandatory nature of preventive measures.

Finally, this study can be replicated for other countries. For many countries survey data on behaviour before and during the pandemic is available, such as for Europe in the Survey of Health, Ageing and Retirement in Europe (Bonsang and Dohmen, 2015; Mendoza-Jiménez et al., 2021). Investigating whether this study's findings hold for other populations would be a valuable research avenue that could provide further insight into the importance of risk preferences in loss prevention.

## 5. Conclusion

This study's main empirical finding of a meaningful positive association of individuals' risk-taking preference with the probability of contracting COVID-19 supports the ambiguous prediction of a theoretical model of optimal choice under risk that a higher risk-taking preference increases the probability of a loss. This study, therefore, contributes to the literature on the determinants of contracting COVID-19 and to the wider literature on loss prevention as a risk management tool for individuals.

## Ethical review

This study has been approved by the Ethics Committee of the Faculty of Law, Economics and Governance at Utrecht University. Informed consent was obtained from all participants and/or their legal guardians, and all methods were carried out in accordance with the relevant guidelines and regulations.

## Author contributions

It is a single-authored paper.

## Declaration of competing interest

The author declares to have no conflicting interests relevant to the research presented in this article

## Data availability

All data are available through the Understanding America Study's website (https://uasdata.usc.edu).

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2023.116169.

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