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A Serial Cross-Sectional Study Investigating Unrealistic Optimism, Risk Perception and Protective Behavior during the COVID-19 Pandemic

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Abstract. Protective behavior is crucial during crisis conditions, especially amid the Coronavirus Disease (COVID-19) pandemic. This study aimed to examine whether (1) unrealistic optimism significantly correlates with risk perception; (2) risk perception significantly affects protective behavior; (3) risk perception mediates the relationship between unrealistic optimism and protective behavior; and (4) whether these factors (unrealistic optimism, risk perception, protective behavior) shift from the early phase to the middle phase of the COVID-19 pandemic in an Indonesian context. The study employed a cross-sectional quantitative method, involving 549 respondents (with a mean age of 26.02) obtained through nonprobability (accidental) sampling. The study was divided into two time windows: Study 1 during the early period of the COVID-19 pandemic and Study 2 when the pandemic had been ongoing for over a year. The results confirmed a relationship between unrealistic optimism and protective behavior, as well as between risk perception and protective behavior. However, risk perception did not mediate the relationship between unrealistic optimism and protective behavior. There was a shift in the levels of unrealistic optimism, risk perception, and protective behavior over time, particularly between Study 1 and Study 2. Respondents exhibited higher levels of unrealistic optimism in Study 1 compared to Study 2. Risk perception among respondents increased with the prolonged duration of the pandemic, while the level of protective behavior decreased as the pandemic persisted.

Keywords: bias optimism; COVID-19 pandemic; protective behavior; risk perception; unrealistic optimism

The Coronavirus Disease (COVID-19) pandemic has brought major changes in terms of impacts that have ended and those that are still affected today with the post-pandemic period underway. The pandemic has caused a financial crisis, a decline in the healthcare system, and a decrease in labor market development, as well as learning loss in the education system (Aristovnik et al., 2020; Hanushek & Woessmann, 2020; International Labour Organization [ILO], 2021; Wang et al., 2021; WHO, 2020;

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World Bank, 2020). When the WHO issued a pandemic declaration in 2020 (WHO, 2020), all sectors and lifelines had to adapt to changes. Collectively, behavioral changes related to individual and social interactions were strongly encouraged back then to prevent the spread of the COVID-19 virus and tackle the pandemic (Betsch, 2020; Cucchiarini et al., 2021; Michie & West, 2021).

Early in the pandemic, many Indonesian citizens were reluctant to follow COVID-19 policies, as documented in local and global studies. Yanti et al. (2020) found that 59% of subjects had positive attitudes towards social distancing, but the rest had various attitudes. Tejamaya et al. (2021) showed that respondents had moderate anxiety levels during the first phase of the pandemic, indicating a tolerance for risk. Husna (2021) explained that some individuals had a denial attitude towards the pandemic due to social learning processes and individual factors. Nanda et al. (2021) also found that despite a high perceived threat of the outbreak, subjects had a low perceived vulnerability during the early stage of the pandemic.

In the wake of the COVID-19 pandemic, individuals are expected to exhibit health-protective behavior, which includes actions taken to maintain or enhance one's health, regardless of their current health status or the effectiveness of the behavior (D. M. Harris & Guten, 1979). This behavior is crucial in preventing the spread of the virus, as highlighted by Zickfeld et al. (2020). Research conducted by Wise et al. (2020) in the US revealed that while the frequency of protective behavior increased, some individuals had a low-risk perception and did not engage in such behavior. Lüdecke (2020) also found variations in the implementation of protective behavior among the German population, with low levels of education and younger age associated with lower levels of behavior. Females, on the other hand, were found to have higher levels of protective behavior. Similar results were found in Norway, as reported by Zickfeld et al. (2020), where protective behavior was influenced by demographic factors and the perception of the pandemic as a serious issue.

In Indonesia, several studies have revealed the underestimation of health-protective behavior. The ignorance displayed by the general public is rooted in the Indonesian government's handling of the early pandemic situation (Djalante et al., 2020). Research has shown that the public demanded greater transparency from the government in presenting data, but instead, the government exhibited hesitance, skepticism, and denial in assessing the worst-case scenarios during the initial stages of the pandemic. This led to a lack of protective behavior among the public. Studies by Nanda et al. (2021) and Prawira et al. (2022) have highlighted that individuals in Indonesia had a low level of perceived vulnerability during the early stages of the pandemic due to a lack of intention to follow government rules. Furthermore, research by Irawan (2021) and Chavarría et al. (2021) has revealed that protective behavior in Indonesia, including social distancing and reducing the use of public transportation, is related to beliefs in conspiracy theories, existing prevention methods, and changes in travel behavior. Additionally, it was found that protective behavior in Aceh Province, Indonesia, is highly correlated with individual knowledge of COVID-19 and mildly correlated with socioeconomic factors, which are shaped by knowledge itself.

The influence of risk perception on the implementation of health-protective behaviors has been well documented in numerous studies (Betsch, 2020; Branstrom et al., 2006; Dryhurst et al., 2020; Lunn

et al., 2020; Park et al., 2021; Sheeran et al., 2014; Wise et al., 2020). According to the literature, risk perception plays a significant role in shaping an individual's protective behavior or risk avoidance behavior during various crises, including pandemics (Betsch, 2020; Branstrom et al., 2006; Lunn et al., 2020; Sheeran et al., 2014; Trumbo et al., 2016; Wise et al., 2020). Risk perception is defined as an individual's subjective judgment of their vulnerability to harm or danger, which is often assessed by calculating the probability of negative events (Sheeran et al., 2014).

A meta-analysis conducted by Brewer et al. (2007) found a consistent correlation between risk perception and health behavior. Similarly, Ferrer and Klein (2015) identified risk perception as a key factor in many theories of health behavior change. Given the significant role of risk perception in shaping behavior, it is reasonable to focus on this factor as the primary target in the development of behavior change interventions.

In the global context, recent studies have indicated a low risk perception among the public in many countries, particularly during the early phase of the COVID-19 pandemic. For instance, a study conducted by Betsch (2020) in Germany found a very low level of protection behavior and risk perception during the first two waves of March 2020. This study highlighted that the elderly were a specific group with a low risk perception of the possibility of COVID-19 infection. Similarly, Wise et al. (2020) in the US context described an escalating trend of risk perception towards COVID-19 spread during the early weeks of the pandemic, but respondents had simplified the possibility of being infected by the virus. As a result, some respondents engaged in poor protective behavior practices in their daily activities.

Dryhurst et al. (2020) conducted a study across 10 countries, including South Korea, Japan, Australia, the US, Mexico, Italy, Sweden, Spain, Germany, and the UK, during March-April 2020 and found that the UK and Spain had the highest risk perception. Sex played a significant demographic role, as the study showed that males had lower risk perception than females. Additionally, several factors were found to be correlated with risk perception, such as psychological factors, socio-cultural factors, knowledge, and experience with the virus itself. The study also revealed that low risk perception in Spain, the UK, Japan, Mexico, and the USA correlated with high collective efficacy beliefs. However, there were different characteristics among countries, as conservative perspectives were associated with low-risk perception in the UK and the USA, but with high-risk perception in South Korea and Mexico.

According to Trumbo et al. (2016), the measurement of risk perception encompasses two distinct domains, namely the affective and cognitive dimensions. The assessment is based on a psychometric model and is measured through an inventory, which includes indicators such as feelings of anxiety, fear, and depression in response to the possibility of a major hurricane occurring. Cognitive risk perception is measured using indicators that assess an individual's beliefs about the likelihood of severe losses, high mortality, significant financial losses, and potential threats to future generations resulting from a hurricane. Jang et al. (2020) further explored the measurement of risk perception through affective and cognitive dimensions during the MERS and MERS-CoV periods. The study revealed that over the MERS period, affective risk perception decreased, whereas cognitive risk

perception did not. Additionally, affective risk perception was associated with demographic factors such as age, gender, and economic status. Women and individuals with low economic status tended to have higher affective risk perception, while the elderly had higher affective risk perception but lower cognitive risk perception than younger individuals.

A number of studies have investigated the connection between an individual's perception of risk and the adoption of protective behavior, and have found that a psychological attribute known as "unrealistic optimism" or "optimism bias" is a significant factor in this relationship (Borschmann et al., 2012; Branstrom & Brandberg, 2010; Branstrom et al., 2006; Cho et al., 2013; Clarke et al., 1997; Hevey et al., 2009; Kuper-Smith et al., 2021; Radcliffe & Klein, 2002; A. Weinstein & Lejoyeux, 2010). The perceptions and evaluations that an individual holds regarding the likelihood of contracting and spreading COVID-19 can influence their willingness to change their behavior (Kuper-Smith et al., 2021). Unrealistic optimism is defined as the belief that one's own future will be more positive than that of their peers (A. J. L. Harris & Hahn, 2011). N. D. Weinstein (1986) also noted that many people tend to overestimate their chances of avoiding disease or poor health, with this optimism bias present across all ages, genders, educational and employment backgrounds.

Kuper-Smith et al. (2021) analyzed unrealistic optimism and risk perception during the initial stage of the COVID-19 pandemic in the UK, the USA, and Germany. The results indicated that individuals exhibited unrealistic optimism regarding their likelihood of contracting the virus compared to others, but not for experiencing severe symptoms if infected. Their study of the early phase of the COVID-19 Pandemic for 3 months (March-May 2020) also revealed that the optimism bias of subjects in the three countries did not change over time. Another study by Druic et al. (2020) in Italy and Romania during COVID-19, optimism bias was influenced by age, with higher levels in elderly subjects. Socio-demographic factors affected optimism bias differently, with no sex difference.

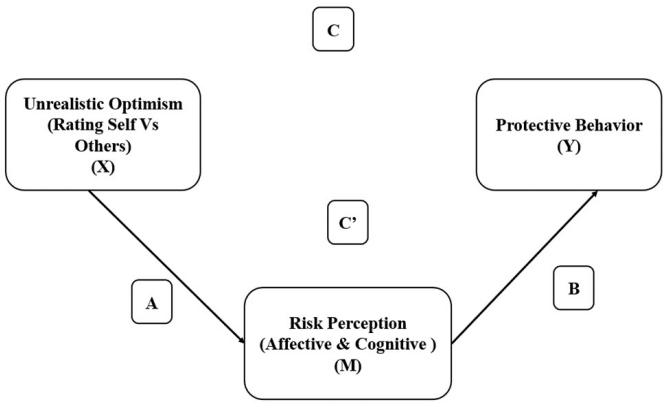
There are several aspects of unrealistic optimism that are the baseline for the indicators measuring how high a person's optimism bias is according to (Kuper-Smith et al., 2021). The first aspect is the likelihood of contracting the virus, where the individual evaluates the ratio of their own risk to that of others in the same age group and living in the same area. The second aspect is the prediction of transmission to family members, neighbors, and coworkers, as well as during daily activities such as travel, leisure, and commuting. The third aspect is the individual's assessment of the severity of symptoms they may experience if they become infected with the virus.

In regard to risk perception, Park et al. (2021) explained mediated pathways based on their study. The study showed that optimism bias impacts preventive health behaviors and intentions through both risk perception and responses. Optimism bias has a negative correlation with risk perception, while perceived risk has a positive correlation with affective responses and risk responses, which in turn have a positive correlation with subject intentions and behaviors to prevent harmful health outcomes.

Furthermore, it is known that in Indonesia the death rate due to the COVID-19 virus during the pandemic reached high numbers. At the end of 2021, there were 139,682 deaths (data from the Ministry of Health of the Republic of Indonesia https://infeksiemerging.kemkes.go.id/. Moreover, until early 2023 the confirmed deaths due to the COVID-19 virus in Indonesia were 160,772 deaths (data

from https://covid19.go.id/id). Examining Indonesia's protective behavior during COVID-19 and its connection to risk perception and unrealistic optimism is crucial. Individually, recognizing one's risk perception and optimism bias can be a vital protective measure, particularly in understanding protective behavior or risk avoidance measures. Janz (1984) explained through the health belief model (HBM) that the perception of risk is an important key in the development of preventive behavior. Through social learning theory, Rosenstock et al. (1988) also highlighted individual risk perception, especially perceived susceptibility and severity in relation to preventive health behaviors. This study aims to explore the relationship between unrealistic optimism, risk perception, and protective behavior during the COVID-19 pandemic in Indonesia. Specifically, it examines if optimism is related to risk perception, if risk perception affects protective behavior, and if optimism affects behavior through risk perception. It also looks at how these factors change throughout the pandemic.

Figure 1
Theoretical Framework



Methods

Study Design

This study used a serial cross-sectional method, which is divided into two-time windows; study 1 (July to August 2020) during the early year of the COVID-19 pandemic and study 2 (November 2021) when the pandemic had been running for more than 1 year. This study was reviewed and approved by the researcher's Institutional Review Board with approval ethical clearance number B-1583.1/Un.02/L3/TU.00/06/2020.

Participants

The participants who filled out the questionnaires in this study were 549 in total (370 participants, 244 female, 126 male, mean age 28.39 in study 1, and 179 participants, 119 female, 60 male, mean age 21.12 in study 2).

Data Collection

Data collection was administered online. Before filling out the questionnaires, participants agreed to participate by signing informed consent forms electronically. In sum, 549 participants filled out the questionnaires and gave valid responses which were included in the data analysis.

Survey Instruments

Participants were asked about their judgments on the likelihood of contracting and spreading COVID-19, their perception of risk and vulnerability, and their preventive behaviors during the initial period of the pandemic (Study 1) and 1 year after it occurred (Study 2). Additionally, they were asked about their general knowledge of COVID-19 symptoms, changes in their activities and financial, social, mental, and physical health, and employment status due to the pandemic. The survey also included questions about demographic data such as age, sex, employment status, and educational background.

Unrealistic Optimism

In measuring participants' unrealistic optimism, we refer to conceptualization from Kuper-Smith et al. (2021) through their preprint data published in 2020, where they developed an unrealistic optimism scale based on the bias optimism theory from Shepperd et al. (2015). This study modified Kuper-Smith's unrealistic optimism scale and carried out the back translation process, validation test, tryout, and reliability test. The scale assesses the probability of contracting the COVID-19 virus, the likelihood of transmitting it to others when infected, and the severity of symptoms if infected. To measure unrealistic optimism, we used a comparative indirect approach where participants were asked to compare these three dimensions in their own situation and in the situation of an average person of the same age and living in their environment during several future time periods (2 weeks, 2 months, 1 year, and a lifetime). The items included questions such as 'What do you think is the probability that you will be infected with the new coronavirus in the next 2 weeks?' and 'If you were infected with the new coronavirus, how severe would your symptoms be?. Items were measured on a 4-point scale which refers to the percentage rating of 0-100% (1 or 0-25% = not high, 2 or 26-50% = quite high, 3 or 51-75% = high, 4 or 76-100% = very high). Reliability for this scale was examined using Cronbach's Alpha and this unrealistic optimism scale has a value of 0.922.

Risk Perception

Items to measure participants' risk perception were modified from the cognitive-affective risk perception scale by Jang et al. (2020) and Trumbo et al. (2016) with modifications for the context of the COVID-19 Pandemic. Participants were asked about their levels of anxiety, fear, horror, depression,

and frustration concerning the possibility of contracting COVID-19 during the pandemic. They were also asked about their estimation of the potential losses in terms of government and society, fatalities, and long-term effects on future generations due to the pandemic. Examples of affective risk perception items included 'How worried are you about contracting COVID-19?' and 'How depressed do you feel about the possibility of contracting COVID-19?', while examples of cognitive risk perception items included 'In your opinion, how much has the government and society lost due to the COVID-19 pandemic?' and 'How dangerous do you think the long-term effects of the COVID-19 pandemic are for future generations. Risk perception items were measured on a 4-point scale (1 = not at all, 4 = very). This scale reliability has Cronbach's Alpha value at 0.832.

Protective Behavior

Participants in this study were also measured in the context of their protective behavior during the COVID-19 pandemic. The protective behavior instrument used includes a number of modified items from the studies of Wong and Sam (2010), Wise et al. (2020), (D. M. Harris & Guten, 1979), Weber et al. (2002), and based on WHO recommendations (WHO, 2020) regarding behavior protection during the COVID-19 pandemic. When measuring protective behavior, various aspects such as health and safety, recreation, ethics, social interaction, economy, and daily habits to prevent the spread of COVID-19 should be considered. Examples of these components include avoiding malls/entertainment venues, practicing cough/sneeze etiquette, refraining from direct interaction with others, avoiding physical contact, wearing a cloth mask outside, and exercising more regularly. Items are measured using a 4-point scale (1 = not at all, 4 = very). This scale reliability has Cronbach's Alpha value at 0. 900.

Knowledge on the COVID-19 Virus and The Impact of COVID-19 Pandemic on Crucial Aspects in Life

Participants were assessed for their knowledge and understanding of the COVID-19 virus's characteristics, transmission, and the pandemic's overall impact on their daily lives. They were asked to identify virus symptoms and assess the pandemic's influence on finances, work/education, health, mental well-being, routines, and social relationships.

Statistical Analysis

Characteristics of respondents and item scores were computed in descriptive statistics. The three scales used in this study were also assessed in terms of their consistent reliability using Cronbach Alpha (α). All three scales have high internal consistency as α value ≥ 0.8 which was reported above. The relationships between variables (mediating role and individual relationship between each variable) and covariates (age, sex, employment status, last education level, self-report health status) in this study were analyzed using multiple linear regression. The regression was performed to test whether (1) unrealistic optimism is significantly correlated to risk perception; (2) risk perception significantly affects protective behavior (3) risk perception mediates the relationship between unrealistic optimism and protective behavior. Furthermore, independent sample t-test analysis was also performed to examine whether they (unrealistic optimism, risk perception, protective behavior) were shifted from the early phase to the middle phase of the COVID-19 Pandemic in Indonesian context.

Results

The table below presents a summary of the research respondents in Study 1 (n= 370) and Study 2 (n = 179) in terms of their age, sex, employment status, highest level of education, province of origin, and perception of general health conditions. The demographic characteristics of the two groups appear to differ significantly. The average age of participants in Study 1 (mean = 28.39, sd = 7.75) was higher than that of Study 2 (mean = 21.1, sd = 4.4). In terms of employment status, a majority of respondents in Study 1 were employed (59%), whereas the majority of respondents in Study 2 were students (83.8%). This difference is also evident in the distribution of educational attainment, with Study 1 having a higher proportion of bachelor/master graduates (73.24%) than Study 2, which had a higher proportion of Senior High School graduates (70.39%).

Although study respondents 1 and 2 exhibit distinct characteristics, they are not believed to differ significantly in terms of sex. As depicted in Table 1, the samples in both time periods were predominantly female (approximately 66% for both studies). Furthermore, the participants' province of origin indicates that the majority hailed from DIY and Central Java Provinces. Nevertheless, findings from study 1 revealed a balanced distribution of participants from DIY and Central Java, while study 2 showed a pronounced dominance by participants from DIY.

Table 1
Respondents Characteristics (N = 549), Study 1 & Study 2

Variables		
Age***, *n* (%)	Study 1 (n = 370)	Study 2 (n = 179)
17-25	125 (33.78)	158 (88.27)
26-40	215 (58.11)	20 (11.17)
41-60	30 (8.11)	1 (0.56)
>60	0 (0)	0 (0)
Mean ś Standard deviation	28.39 ś 7.75	21.1 ś 4.40
Sex, n (%)		
Female	255 (66)	119 (66.48)
Male	126 (34)	60 (33.52)
Employment Status***, n (%)		
Employees	218 (59)	23 (12.85)
Unemployed	52 (14)	6 (3.35)
Retirees	2 (0.5)	0 (0)
College student	98 (26.5)	150 (83.8)
Last Education Level***, n (%)		
Doctoral Degree	7 (2)	0 (0)
Master's Degree & Undergraduate	271 (73.24)	52 (29.05)
Senior High School	90 (24.32)	126 (70.39)
Junior High School & Elementary School	2 (0.54)	1 (0.56)
Province of Origin, %		
DI Yogyakarta	98 (26.49)	90 (50.28)

Table 1 (Continued)

Respondents Characteristics (N = 549), Study 1 & Study 2		
Central Java	96 (25.95)	44 (24.58)
East Java 62 (16.76)	15 (8.38)	
West Java 38 (10.27)	14 (7.82)	
Banten 15 (4.05)	2 (1.12)	
DKI Jakarta 9 (2.43)	4 (2.23)	
(The rest of several provinces: South Sulawesi, South Sumatera, Lampung, West Nusa Tenggara, Aceh, Bali, Gorontalo, Jambi, West Kalimantan, East Kalimantan, North Kalimantan, Riau Island, Riau, South Papua, West Sulawesi. Central Sulawesi, North Sumatra)	52 (14.05)	10 (5.59)
Self-Report Health Status***, %		
Excellent	116 (31.44)	41 (22.91)
Very Good	201 (54.47)	88 (49.16)
Good	49 (13.28)	42 (23.46)
Fair	2 (0.54)	7 (3.91)
Poor	1 (0.27)	1 (0.56)

Upon initial examination, the variations in the properties of the two samples across these two distinct time periods are indeed noteworthy. However, the researcher maintains that the comparison between these two groups remains pertinent, as they both fall within the purview of the same research objectives and utilize similar methodologies. To mitigate the potential impact of extraneous factors on this comparison, the researcher performed a test for the homogeneity of variances, ensuring that the variances in the two measurement groups were equivalent and could be assessed against one another.

Table 2 below shows the descriptive statistic for variable measurement in Study 1, while Table 3 describes the Study 2 scale. Generally, respondents in Study 1 considered themselves (15.11 $\pm$ 5.52) to be less likely to contract the COVID-19 virus or infect it compared to other people of the same age (16.81 $\pm$ 5.84) and living in the same area. The difference in mean scores in the context of rating oneself and rating others is statistically significant with a difference in mean = 1.700, $p < 0.05$ (0.000). This proves the existence of unrealistic optimism. The same pattern was also found in study 2, where respondents felt they had a lower probability (13.66 $\pm$ 5.10) than other people of their age and living in the same city (15.22 $\pm$ 5.22) in the context of being infected or infecting others with the COVID-19 virus. The mean difference in study 2 was 1.564, $p < 0.05$ (0.000). Respondents also reported how optimistic they were regarding the level of severity (6.26 $\pm$ 2.50) in case they were infected with the COVID-19 virus.

Overall, in both Study 1 and Study 2, respondents had differences in their perception of risk during the COVID-19 pandemic. Respondents had a higher cognitive risk assessment (14.14 $\pm$ 1.66 in study 1, 14.16 $\pm$ 1.71 in study 2) than their affective risk assessment (10.85 $\pm$ 2.91 in study 1, 9.57 $\pm$ 3.28 in study 2). Respondents in this case have higher risk perceptions related to losses due to the pandemic, fatalities, financial difficulties, and long-term effects, compared to their risk perceptions related to the

affective side, such as how anxious, scared, and depressed they were due to the COVID-19 pandemic.

In the context of protective behavior, respondents reported that they sufficiently implemented preventive behavior related to safety during the COVID-19 pandemic (6.26 ± 1.14 in study 1, 6.08 ± 1.30 in study 2), reduced recreational activities (5.95 ± 1.63 in study 1, 5.12 ± 1.69 in study 2), highly applied ethics related to preventing the spread of the virus (6.95 ± 1.10 in study 1, 6.88 ± 1.29 in study 2). However, on the other hand, not all respondents limited their daily social interactions (15.22 ± 3.16 in Study 1, 13.32 ± 3.46 in Study 2). Only some of them had made preparations related to stocking food and medicine during the pandemic (7.06 ± 2.36 in study 1, 6.70 ± 2.02 in study 2), and not all of them carried out healthy daily habits that supported health during the pandemic (17.40 ± 3.09 in study 1, 16.08 ± 3.60 in study 2). The majority of respondents in Study 1 and Study 2 also had fairly good knowledge regarding the symptoms of being infected with the COVID-19 virus (7.82 ± 1.40 in Study 1, 7.23 ± 1.29 in Study 2).

Table 2
Descriptive Statistics for Variables Measurement in Study 1

Measures	Number of Items	N	Mean ± Standard Deviation (Range)	Reliability
Unrealistic Optimism[a]				0.922
Rating for Self (being Infected or infecting Other people)	8	370	15.11 ś 5.52 (1.0-4.0)	
Rating for Others (being infected or Infecting other people)	8	370	16.81 ś 5.84 (1.0-4.0)	
Perceived severity if Infected	8	370	6.26 ś 2.50 (1.0-4.0)	
Risk Perception[b]				0.832
Affective Dimension	4	370	10.85 ± 2.91 (1.0-4.0)	
Cognitive Dimension	4	370	14.14 ± 1.66 (1.0-4.0)	
Protective Behavior[c]				0.900
Health & Safety	2	370	6.26 ± 1.14 (1.0-4.0)	
Recreation	2	370	5.95 ± 1.63 (1.0-4.0)	
Ethics	2	370	6.95 ± 1.10 (1.0-4.0)	
Social Interaction	5	370	15.22 ± 3.16 (1.0-4.0)	
Economics	3	370	7.06 ± 2.36 (1.0-4.0)	
Daily Habits	6	370	17.40 ± 3.09 (1.0-4.0)	
Knowledge on COVID-19 Virus[d]	10	370	7.82 ś 1.40 (0.0-1.0)	

[a]Scale: 1 or 0-25% = not high, 2 or 26-50% = quite high, 3 or 51-75% = high, 4 or 76-100% = very high. Two dimensions within this scale has significantly different mean statistically (t (370) = -10.64, p < 0.001).

[b]Scale: 1 = not at all, 4 = very.

[c]Scale: 1 = not at all, 4 = very.

[d]Scale: yes/no (1 = yes favorable and no unfavorable).

Table 3
Descriptive Statistics for Variables Measurement in Study 2

Measures	Number of Items	N	Mean ± Standard Deviation (Range)	Reliability
Unrealistic Optimism[a]				0.922
Rating for Self (being infected or infecting other people)	8	179	13.66 ± 5.10 (1.0-4.0)	
Rating for Others (being infected or infecting other people)	8	179	15.22 ± 5.22 (1.0-4.0)	
Perceived Severity If Infected	3	179	5.32 ± 2.34 (1.0-4.0)	
Risk Perception[b]				0.832
Affective Dimension	4	179	9.57 ± 3.28 (1.0-4.0)	
Cognitive Dimension	4	179	14.16 ± 1.71 (1.0-4.0)	
Protective Behavior[c]				0.900
Health & Safety	2	179	6.08 ± 1.30 (1.0-4.0)	
Recreation	2	179	5.12 ś 1.69 (1.0-4.0)	
Ethics	2	179	6.88 ś 1.29 (1.0-4.0)	
Social Interaction	5	179	13.32 ś 3.46 (1.0-4.0)	
Economics	3	179	6.70 ś 2.02 (1.0-4.0)	
Daily Habits	6	179	16.08 ś 3.60 (1.0-4.0)	
Knowledge on COVID-19 Virus[d]	10	179	7.23 ś 1.29 (0.0-1.0)	

[a]Scale: 1 or 0-25% = not high, 2 or 26-50% = quite high, 3 or 51-75% = high, 4 or 76-100% = very high. Two dimensions within this scale has significantly different mean statistically (t (370) = -10.64, p < 0.001).

[b]Scale: 1 = not at all, 4 = very.

[c]Scale: 1 = not at all, 4 = very.

[d]Scale: yes/no (1 = yes favorable and no unfavorable).

Table 4, 5, 6 showed the results from multiple regression analysis particularly for study 1, while Table 7, 8, 9 reveals the results for study 2. In detecting the role of the mediator variable, we created three models based on the conceptual framework that was created above (see Figure 1). The first path is the regression equation for unrealistic optimism (x) on protective behavior (y) which produces the "c coefficient". This path is expected to be significant (p < 0.05). Then the second path is the regression equation for unrealistic optimism (x) on risk perception (m) which produces the "a coefficient", which is expected to be significant (p <0.05). The third path is the regression equation of unrealistic optimism (x) and risk perception (m) on protective behavior (y). This third regression analysis produces two predictor estimation values of x and m. The prediction of m with respect to y produces the "b coefficient", while the prediction of x with respect to y produces the "c′ coefficient". The b is expected to be significant (p < 0.05), while the c is expected to be not significant (p > 0.05).

In Table 4 it can be seen the c coefficient = 0.205 (βc = 0.285), with tc = 5.694 (p <0.05), thus, unrealistic optimism (x) significantly influenced protective behavior (y) (or c ≠0). It means the first

criterion was fulfilled. Furthermore, Table 5 shows the a coefficient = 0.116 (βa = 0.374), with a value of ta = 7.747 (p <0.05) Thus unrealistic optimism (x) significantly affected risk perception (m) (or a≠0), hence the second criterion was fulfilled. Table 6 reveals that the b coefficient is 0.604 (βb=0.260) and the c' coefficient is 0.135 (βc'=0.187). The value of tb=4.975 (p <0.05), while the value of tc'=3.584 (p (0.000) <0.05 means significant). Thus, the third criterion was not fulfilled. In this third analysis, b path is expected to be significant (p<0.05), while c' path is expected to be not significant (p>0.05). However, the results of the regression analysis showed that both b path and c path are significant, so it can be concluded that x (unrealistic optimism) affects y (protective behavior) without the mediating role of m (risk perception).

In the context of study 2, regression analysis also provided almost similar results regarding the mediator model. Table 7 shows that the c coefficient = 0.225 (βc = 0.263), with tc = 3.267 (p <0.05), thus, unrealistic optimism (x) in study 2 also significantly influenced protective behavior (y) (or c ≠0). It means the first criterion was fulfilled. For the second criterion, it can be concluded as well that criterion (unrealistic optimism significantly influenced risk perception, or a≠0) was met. Table 8 revealed the a coefficient = 0.101 (βa = 0.263), with a value of ta = 3.787 (p <0.05). Moving to the result for the third model (mediator model), Table 9 highlighted a similar pattern to what we have in study 1. The third criterion was not met. It can be seen from the table that b coefficient is 0.746 (βb=0.321) and the c' coefficient is 0.150 (βc'=0.175). The value of tb= 4.484 (p <0.05), while the value of tc'= 2.445 (p (0.015) <0.05, it means significant). In this third analysis, b path is expected to be significant (p<0.05), while c' path is expected to be not significant (p>0.05). However, the results of the regression analysis showed that both b path and c path are significant, so it can be concluded that in study 2 x (unrealistic optimism) affects y (protective behavior) without the mediating role of m (risk perception). However, from the regression analysis, it was also proven that there is a correlation between m (risk perception) and y (risk avoidance behavior) both in study 1 and study 2.

Table 4
Multiple Regression Analysis Results for Study 1 (c coefficient)

Variable	Dependent Variable: Protective Behavior 95% Confidence Interval				
	Beta	Standard Error	β	t	p
Unrealistic Optimism	0.205	0.036	0.285	5.694	0.000

Note. *p < 0.05

Table 5
Multiple Regression Analysis Results for Study 1 (a coefficient)

Variable	Dependent Variable: Risk Perception 95% Confidence Interval				
	Beta	Standard Error	β	t	p
Unrealistic Optimism	0.116	0.027	0.274	3.787	0.000

Note. *p < 0.05

Table 6
Multiple Regression Analysis Results for Study 1 (b & c' coefficient)

Variable	Dependent Variable: Protective Behavior 95% Confidence Interval				
	Beta	Standard Error	β	t	p
Unrealistic Optimism[c']	0.135	0.038	0.187	3.584	0.000
Risk perception[b]	0.604	0.122	0.260	4.975	0.000

b coefficient; expected significant $p < 0.05$

c' coefficient; expected not significant $p > 0.05$ (as for mediating role)

Table 7
Multiple Regression Analysis Results for Study 2 (c coefficient)

Variable	Dependent Variable: Protective Behavior 95% Confidence Interval				
	Beta	Standard Error	β	t	p
Unrealistic Optimism	0.225	0.062	0.263	3.267	0.000

Note. *$p < 0.05$

Table 8
Multiple Regression Analysis Results for Study 2 (a coefficient)

Variable	Dependent Variable: Risk Perception 95% Confidence Interval				
hline	Beta	Standard Error	β	t	p
Unrealistic Optimism	0.101	0.027	0.274	3.787	0.000

Note. *$p < 0.05$

Table 9
Multiple Regression Analysis Results for Study 2 (b & c' coefficient)

Variable	Dependent Variable: Protective Behavior 95% Confidence Interval				
	Beta	Standard Error	β	t	p
Unrealistic Optimism[c']	0.150	0.061	0.175	2.445	0.015
Risk perceptionb	0.746	0.166	0.321	4.484	0.000

b coefficient; expected significant $p < 0.05$

c' coefficient; expected not significant $p > 0.05$ (as for mediating role)

The analysis of homogeneity of variances revealed that there is no significant difference in the variance of the outcome variable between the two studies conducted. However, the Unrealistic Optimism and Risk Perception variables showed violations of this principle. In order to conduct a comparison of the two variables based on the study phase, the researcher applied the Welsch formula to correct the *t*-value.

Table 10
Homogeneity of Variances in Study 1 and Study 2

	F	df	df2	p
Mix_Protective_Behavior_Study_1_2	0.0112	1	547	0.916
Mix_Risk_Perception_Study_1_2	117.3381	1	547	<.001***
Mix_Unrealistic_Optimism_1_2	3.8948	1	547	0.049*

*p-value suggests a violation of the assumption of equal variances

The researchers conducted an Independent Sample t-test to compare the means of the three research variables (Protective Behavior, Risk Perception, and Unrealistic Optimism) between the early and post-pandemic time periods. The results revealed substantial and highly significant differences between Study 1 and Study 2. Participants showed a significant decrease in Protective Behavior ($t(547) = 5.5$, $p < .001$, Cohen's $d = .501$) and Unrealistic Optimism (Welsch's $t(394) = 3.80$, $p < .001$, Cohen's d = .338) over the course of the pandemic. However, Risk Perception increased significantly two years after the start of the pandemic (Welsch's $t(229) = -14.51$, $p<.001$, Cohen's $d = -1.442$).

Table 11
Independent Sample T-Test in Study 1 and Study 2

		Statistic	df	p		Effect Size
Mix_Protective_Behavior_Study_1_2***	Student's t	5.50	547	< .001	Cohen's d	0.501
Mix_Risk_Perception_Study_1_2***	Welch's t	-14.51	229	< .001	Cohen's d	-1.442
Mix_Unrealistic_Optimism_1_2***	Welch's t	3.80	394	< .001	Cohen's d	0.338

Note. H_a $\lambda 1 \neq \lambda 2$

Discussion

During the ongoing COVID-19 pandemic, prevention and treatment measures are crucial at both individual and government levels. The spread of the virus and its high mortality rate necessitate the need for protective behavior, which is essential for societies and countries to overcome the pandemic. Unrealistic optimism can impact an individual's risk perception and subsequently affect their protective behavior. The study examined the relationship between unrealistic optimism, risk perception, and protective behavior, with risk perception acting as a mediator between the two. This study found a connection between unrealistic optimism and risk perception in both Study 1 (early pandemic) and Study 2 (long-lasting pandemic). Those with high optimism bias had low risk perception. Previous research has explored the impact of unrealistic optimism on risk perception in various situations.

The study by N. D. Weinstein et al. (2005) showed that smokers' risk perception in assessing their likelihood of experiencing lung cancer was influenced by their unrealistic optimism. Another study by Oljaca et al. (2020) explained that unrealistic optimism correlated with risk perception during the COVID-19 pandemic. Clarke et al. (2000) explored the perceptions of elderly populations towards cancer (breast and prostate cancer) and emphasized the correlation between unrealistic optimism and risk perception in the Health Belief Model (HBM) for cancer screening assessments, cure rate, and severity of cancer. The study findings suggest that unrealistic optimism affects the perception of health risks, with a focus on the COVID-19 health context.

The findings of this study (both in Study 1 and Study 2) demonstrated that risk perception was positively correlated with protective behavior against the transmission of the COVID-19 virus

during a pandemic. However, the results of the regression analysis in the mediator model revealed that risk perception did not act as a mediator between unrealistic optimism and protective behavior. This suggests that both unrealistic optimism and risk perception independently influenced protective behavior. Additionally, the results imply that unrealistic optimism was correlated with protective behavior even in the absence of risk perception as a mediator. It is worth noting that in both studies, there was an increase in risk perception over time, accompanied by a decrease in optimism bias and protective behavior scores. Nevertheless, the relationships between optimism bias - risk perception, and risk perception - protective behavior remained positive.

These results differ from the previous study by Park et al. (2021) which has confirmed that risk perception acted as a mediator in the relationship between optimism bias and preventive behavior engagement during the COVID-19 Pandemic in the US population. The disparity between risk perception and optimism bias is believed to be significantly influenced by one's intentions, as indicated by research conducted by Branstrom et al. (2006). Although an individual may possess the ability to assess risks objectively, those who have not made a conscious decision to engage in specific behaviors, such as adhering to protective measures recommended by the media or government, tend to exhibit a low level of optimism bias. Conversely, individuals who have made a more definitive commitment to such behaviors generally display the opposite phenomenon (N. D. Weinstein & Lyon, 1999).

Indonesians, according to a study conducted by Tejamaya et al. (2021), have generally perceived COVID-19 as a serious or extremely serious issue since the start of the pandemic. Nevertheless, most of them do not seem to be concerned about the virus. This observation indicates that the Indonesian population possesses a relatively high level of risk tolerance, which may lead to increased participation in risk-taking behaviors, particularly those related to health issues (Grable et al., 2009).

On the other hand, several previous studies have examined and proven that unrealistic optimism can be strongly correlated with protective or risky behavior. Shukla et al. (2021) highlighted that high optimism bias in the Indian population during the COVID-19 pandemic caused them to engage in high-risk behavior. Another study by Clarke et al. (1997) has also described that optimism bias was correlated with preventive behavior in the context of suntanning and sun protection in adolescent and young adult populations. Previous studies by Fragkaki et al. (2021) in the context of the COVID-19 pandemic have also confirmed how a high optimism bias will make individuals have low behavioral changes.

The study results showed that in both studies conducted at different times (Study 1 at the beginning of the pandemic and Study 2 in the middle to end of the pandemic), most respondents had an optimistic bias. They believed that others were more likely to contract and transmit the COVID-19 virus than themselves. In Study 1, conducted during the early months of the pandemic, respondents had higher levels of unrealistic optimism compared to Study 2, conducted over a year later. Interestingly, respondents in Study 1 were less optimistic about the severity of contracting the virus, while those in Study 2 were more optimistic, even though the death rate had increased over time.

The findings indicate that there is evidence to suggest that humans have a propensity to be

optimistic about themselves when compared to others. In a variety of circumstances and settings, many individuals tend to believe that they are more likely to encounter positive outcomes than unfavorable ones (Bottemanne & Schmidt, 2020; Fragkaki et al., 2021). The progressive relaxation of Indonesia's Community Activity Restrictions (PPKM) policy from mid-August 2021 (Setiaji, 2021) is believed to convey a message that the COVID-19 pandemic threat is subsiding. This has engendered a misguided sense of hope among those who have experienced it (Kulesza et al., 2023). The rise in optimism bias observed in study 2 may additionally be impacted by this factor as well.

Study 2 showed that respondents' risk perception increased over time, from the early to the mid-pandemic stage. This suggests that awareness of infection risks and the comprehensiveness of their risk perceptions also increased. The link between the perception of risk and personal experience with COVID-19 illness is closely related (Dryhurst et al., 2020). With ongoing exposure to the virus and its associated risks, individuals become increasingly aware of their vulnerability to infection, leading to a decrease in optimism bias, as shown in study 2. This heightened awareness is expected to result in a rise in perceptions of risk as people become more familiar with the virus and its potential consequences.

In study 2, there was a decrease in protective behavior compared to study 1. This may be due to the fact that data collection in study 2 was not conducted during the high COVID-19 case period, including the delta wave, which was the peak of virus spread in Indonesia. Therefore, it is likely that respondents did not implement strict protective behavior during that time. In addition to the factors mentioned, pandemic fatigue plays a significant role in shaping protective behaviors (Petherick et al., 2021; Savadori & Lauriola, 2022). As the pandemic continues to persist, individuals may experience a sense of fatigue that reduces their adherence to public health guidelines (Du et al., 2022). This non-compliance can then result in a domino effect, leading to a perception of relaxed social norms surrounding the pandemic (Franzen & Wohner, 2021). Ultimately, this may lead to a decrease in protective behaviors, despite an increase in risk perception.

This study has limitations. First, there's an imbalance in the number of respondents, including gender demographics. Respondents don't represent all islands/provinces in Indonesia, limiting generalization. Second, the measurement used an online self-report questionnaire, which could have a social desirability bias and an unrepresentative sample.

Conclusion

The presented study confirmed that there was a relationship between unrealistic optimism and protective behavior, risk perception and protective behavior, but risk perception does not mediate the relationship between unrealistic optimism and protective behavior. There was a shift in the level of unrealistic optimism, risk perception, and protective behavior over time, specifically between study 1 (the early period of the pandemic) and study 2 (when the pandemic had lasted more than one year). Respondents' unrealistic optimism at the beginning of the pandemic was at a higher level than when the pandemic had been running for more than one year. The risk perception of respondents has increased along with the longer duration of the pandemic. Meanwhile, the level of protective behavior

of respondents has decreased along with the longer the pandemic lasts.

Recommendation

This study has significant theoretical and practical implications related to epidemiology and pandemic response. Given the crucial role of protective behavior, it is imperative that future research focuses on interventions that anticipate the influence of optimism bias in the event of a new pandemic. Additionally, the discrepancy between the relationship between risk perception and optimism bias in studies I and II suggests that rational thinking does not always align with an optimistic attitude that can lead to a reduction in protective behavior. Therefore, it is also important for future research to investigate other factors that may moderate the relationship between optimism bias and risk perception.

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Authors' Contributions

SH and DA designed the study. SH & DA collected the data. SH analyzed the data and wrote the manuscript. SH & DA reviewed the manuscript statistical analysis process. DA wrote manuscript revision and performed additional data analysis.

Conflict of Interest

The authors declare no conflicts of interest during conducting and publishing of this presented study.

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