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The Effect of Individual Preferences on Precautionary Behaviors in Vaccine Taking, Saving, and Physical Activity

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Abstract

The COVID-19 pandemic has underscored the importance of how people react behaviorally to external threats. Precautionary behavioral responses to COVID-19 become apparent. In addition, individual risk and time preferences are related to economic behaviors under uncertainty and health-related behaviors. This study aims to determine whether and how time and risk choices influence precautionary behaviors in vaccine-taking, saving, and physical activity during the coronavirus lockdown. We conducted a cross-sectional study utilizing an online survey, which included a sample of 1016 individuals aged 18 to 60 residing and working in Shanghai. We use logistic regressions to estimate. We have three findings. First, risk-taking and future-oriented individuals are more likely to get vaccinated. Second, future-oriented ones are more inclined to exercise at home via digital media during the lockdown. Third, neither risk preference nor time preference is predictive of precautionary saving. This work aids the literature by documenting time and risk preferences influencing health-related behaviors and life well-being during the lockdown. The conclusions have practical implications from a policy perspective.

Keywords: time preference; risk preference; the willingness to take vaccines; precautionary saving; home-based exercise via digital media

1. Introduction

The COVID-19 pandemic has highlighted the significance of an individual's behavioral reaction to external threats, such as a severe infectious disease outbreak (Frías-Armenta, Corral-Frías, Corral-Verdugo, & Lucas, 2021). Roughly three years following public efforts to prevent this virus from spreading, More than 6.6 million fatalities and 658 million documented cases have been reported globally. Many precautionary behavioral responses to COVID-19 appear. For example, taking vaccines (ElBagoury et al., 2021), precautionary saving (Zhang, Lu, & Zhong, 2022), and keeping physical exercise at home (Da Silveira, da Silva Fagundes, Bizuti, Starck, Rossi, & de Resende E Silva, 2021). These responses reflect individuals' precautionary principle (Isaacs, 2021) and their aim to maintain their well-being (Corral-Verdugo, Corral-Frías, Frías-Armenta, Lucas, & Peña-Torres, 2021) in this uncertain context (Koffman, Gross, Etkind, & Selman, 2020).

These precautionary behaviors can bring observable benefits. Particularly, accepting vaccines can boost immunity and reduce the medium-term risk of severe disease (Krause et al., 2021). In addition, COVID-induced precautionary saving can increase the saving buffer when facing possible adverse changes in future income or employment prospects due to the pandemic threat (Immordino, Jappelli, Oliviero, & Zazzaro, 2022). Furthermore, physical exercise at home can maintain good health (Lavie, Ozemek, Carbone, Katzmarzyk, & Blair, 2019) to offset the adverse outcomes of certain diseases (Ozemek, Lavie, & Rognmo, 2019). It is also a therapeutic approach to combat the mental and physical repercussions of COVID-19 quarantine, such as preventing self-worth and cognitive impairment or deterioration (Jiménez-Pavón, Carbonell-Baeza, & Lavie, 2020).

Therefore, studying and tracking predictors contributing to individual heterogeneity in precautionary behaviors during the pandemic becomes essential. Risk preference refers to an individual's willingness to take on risk or uncertainty when making financial or other resource decisions. Time preference, on the other hand, deals with how individuals value present consumption or benefits compared to future consumption or benefits. They can

significantly influence precautionary behaviors, particularly in financial decision-making and saving for unforeseen events (Herberholz, 2020). However, existing literature provides limited insights into the potential impact of time and risk preferences on precautionary behaviors like vaccine-taking, saving, physical activity, or exercise during the pandemic.

This research contributes to the expanding body of empirical evidence regarding the effect of individual preferences on these precautionary behaviors and gives possible interpretations. Specifically, We carried out a cross-sectional study through an online survey, encompassing 1016 Shanghai residents aged between 18 and 60, all living and working in the city. Logistic regression is used to estimate and test hypotheses. Our results underline the following points. First, risk-taking and future-oriented people are more likely to accept vaccines. Second, future-oriented people are more likely to keep physical exercise via digital media during the lockdown period. Third, neither risk preference nor time preference predicts precautionary saving. Our results have implications for public health authorities and fitness clubs and gyms.

2. Literature Review

2.1 Time Preference, Risk Preference, and The Inclination to Receive the COVID Vaccine

The extent of the COVID-19 vaccine rollout differs among countries. (Peters, 2022), and it is compulsory to understand the factors that influence the vaccination rate (Hudson & Montelpare, 2021). Macroscopic predictors comprise financial affordability (Wouters et al., 2021), vaccine supply (Alam, Ahmed, Ali, Sarker, & Kabir, 2021), storage capacity (Sun et al., 2022), vaccine production (Feinmann, 2021), distributing capability (Mills & Salisbury, 2021), and public misperception (Mac, Muscat, Ayre, Patel, & McCaffery, 2021). Microscopic factors include socio-demographic factors, such as age (Volkman, Hokeness, Morse, Viens, & Dickie, 2021), income and dependent children (Wu et al., 2008), education (Carpiano, Polonijo, Gilbert, Cantin, & Dubé, 2019), rurality (Wagner et al., 2021), and psychological factors, such as mistrust in vaccine safety, conspiracy beliefs, susceptibility to infection (Troiano & Nardi, 2021), individual preferences (Cawley & Ruhm, 2011; Tsutsui, Benzion, Shahrabani, & Din, 2010), as well as other factors, such as health literacy (Lorini et al., 2018), cultural factors (Agarwal et al., 2021).

Authorities have made substantial efforts to mitigate and control the transmission of the COVID-19 virus and its variants (Yang et al., 2021). The collective inclination to take the COVID-19 vaccine was at a rate of 88.9% in 2020. As mentioned above, identifying psychological structures that promote or hinder vaccination is important (Gerretsen et al., 2021; Nazl□ Y□ğman, Sevindik, & Deniz Özturan, 2022). Notably, Our primary goal is to ascertain whether an individual's time and risk preferences can be used to predict their inclination to receive the COVID-19 vaccine. One reason is that these individual preferences affect health-related decisions, including vaccines (Cawley & Ruhm, 2011; Tsutsui et al., 2010). Additionally, time preference plays a role in shaping an individual's intention to get vaccinated because people would like to get immunizations in the future by bearing the present costs. The third reason is that risk averters tend to feel confused between infectious risk due to no vaccination and the side effects of the vaccines (Okamoto, Kamimura, & Komamura, 2022).

Time preference provides insights into the trade-offs people make between immediate and future outcomes and informs strategies for improving long-term decision-making, for instance, taking vaccines against diseases. The relationship between time preference and vaccine uptake is controversial in the literature. A US study reports considering future consequences is not relevant to H1N1 vaccine uptake based on a survey of 411 university students (Nan & Kim, 2014). Nevertheless, other papers reported similar findings in that time preference influences the willingness to take the vaccine. For example, in a representative German dataset (including 1778 randomly selected respondents), future-oriented people are more likely to get the flu vaccine (Nuscheler & Roeder, 2016). People with smaller time discount rates are more likely to accept HBV (Hepatitis B Virus Vaccination) vaccination (Guo, Wang, Nicholas, Maitland, & Zhu, 2020). Future-oriented French individuals tend to get the COVID-19 vaccine (Guillon & Kergall, 2021). Okamoto et al. (2022) mention that time preference can predict COVID-19 vaccine hesitancy based on the Japanese sample.

Therefore, previous studies have provided evidence of the relationship between time preference and the willingness to take the vaccine. Meanwhile, the evidence on whether time preference predicts the desire to take a vaccine against COVID-19 is limited. This study proposes to see whether time choice influences the willingness to get the COVID-19 vaccine in the Chinese sample, which seeks to expand the existing body of literature by presenting fresh empirical findings and paving the way for possible interventions to tackle vaccine hesitancy. The first hypothesis can be expressed as:

Hypothesis 1: Time preference positively correlates with the willingness to get a vaccine against COVID-19.

Risk preference reflects how much they prefer to avoid risk and opt for safer, more predictable outcomes. Does risk preference influence the acceptance of COVID-19 vaccination? In the literature, the majority of relevant papers suggest there is such a relationship. For instance, risk perception triggers preventative action for influenza, like taking vaccine (Chapman & Coups, 2006); the perception of risk increases the acceptance of an H1N1 vaccine (Ibuka, Chapman, Meyers, Li, & Galvani, 2010) and predicts the acceptance of a COVID-19 vaccine (Caserotti et al., 2021; Guillon & Kergall, 2021). Given that risk perception and preference differ (Meraner & Finger, 2019), more direct evidence is that Trueblood, Sussman, and O'Leary (2022) state monetary risk preferences correlate to a COVID-19 vaccine's take-up based on a US sample.

Hence, the evidence on whether risk preference predicts the willingness to take a vaccine against COVID-19 is limited. This research seeks to enhance the existing body of literature by introducing novel empirical evidence concerning the influence of risk preference on the willingness of Chinese participants to receive the COVID-19 vaccine, and it also aims to propose interventions aimed at reducing vaccine hesitancy and increasing vaccine acceptance. The second hypothesis can be described as follows:

Hypothesis 2: There is a positive correlation between risk preference and the inclination to receive a COVID-19 vaccine.

2.2 Time Preference, Risk Preference, and Precautionary Saving

Both saving and consumption play pivotal roles in individual financial choices, potentially impacting economic development and growth (Jin, Zhao, Song, & Zhao, 2021). In the Permanent Income model (Christiano, Eichenbaum, & Marshall, 1987), an outcome of a future decrease in income will lead to an increase in savings. Therefore, savings can optimally allocate lifetime income to consumption (Lugilde, Bande, & Riveiro, 2019). In an uncertain context, a positive extra saving is generated, called "precautionary saving." Recently, the COVID-19 pandemic threatened our future income and has caused an economic shock in a short time that is exacerbated by uncertainty concerning its length and depth (Miescu & Rossi, 2021). This cumulative uncertainty has influenced both companies and individuals. They have subsequently diminished investment, spending, and consumption (Vergara & Bonilla, 2021) because individuals often allocate their household savings to bolster their financial resilience in the face of unforeseen emergencies, such as contagious diseases (Baiardi, Magnani, & Menegatti, 2020). Hence, COVID-induced precautionary saving becomes necessary (Dossche & Zlatanos, 2021; Zhang et al., 2022).

Precautionary saving is also influenced by personal characteristics and the environment (Lugilde et al., 2019), such as current income (Menegatti, 2010), family composition (Banks, Blundell, & Brugiavini, 2001), age, gender, race, marital status, health (Deidda, 2013), education (Mishra, Uematsu, & Fannin, 2013), unemployment episodes (Lusardi, 1997). We propose investigating the relationship between psychological factors and precautionary saving in the context of the COVID-19 pandemic.

Essential preferences, such as altruism, risk preferences, reciprocity, time preference, or trust, form the groundwork of choice theories and direct human behavior (Falk & Hermle, 2018). Time preference refers to preferences over intertemporal trade-offs or the timing of rewards (Cohen, Ericson, Laibson, & White, 2020). Given the significance of time preferences in decision-making (De Marchi, Cavaliere, & Banterle, 2021), some empirical literature documented the relationship between time preference and saving behavior. For example, Saving in advance for retirement is inspired by the need to increase consumption decades in the future. Time discounting predicts such saving behavior (Finke & Huston, 2013). In addition, in Korea, when individuals are future-oriented (presented-oriented), they save more (less) by reducing (increasing) consumption, indicating that saving behavior can be well interpreted by time preference (Choi & Han, 2018). However, little is known about the association between time preference and precautionary saving during the pandemic. The third hypothesis is as follows:

Hypothesis 3: Time preference increases the probability of saving in advance.

We differ in our willingness to take risks. Important decisions about health, financial affairs, and relationships often raise the question of how much trouble an individual bears to take (Arslan et al., 2020). Particularly, in the literature, risk aversion is a sufficient condition for the existence of precautionary saving (Menegatti, 2001). In addition, Bommier and Grand (2019) report that in the context of binding borrowing constraints and income uncertainty, based on the two assumptions of preference monotonicity and a stochastically monotone income process, risk aversion is positively associated with savings. One interpretation is that when uncertainty exists, precautionary saving occurs (Vergara & Bonilla, 2021). Risk-averse individuals' uncertainty about future income is identified as impaired, diminishing their well-being. Subsequently, these people would use "precautionary

saving" to reallocate current wealth to the future, reducing their pain due to uncertainty and increasing their well-being (Eeckhoudt, Schlesinger, & Tsetlin, 2009). Given the current uncertainty stemming from the COVID-19 pandemic, this study aims to provide empirical evidence on risk preference influencing precautionary saving during the pandemic. The fourth hypothesis is as follows:

Hypothesis 4: Risk preference reduces the probability of saving in advance.

2.3 Time Preference, Risk Preference, and Home-Based Exercise via Digital Media

The existing global pandemic of COVID-19 implemented strict emergency procedures and restrictions, such as quarantines, home confinement, and the complete shutdown of cities, to prevent virus dissemination (Amatriain-Fernández, Murillo-Rodríguez, Gronwald, Machado, & Budde, 2020). These changes may cause mental and physical health problems in quarantined individuals and healthcare employees (Brooks et al., 2020). Physical exercise is an imperative intervention (Amatriain-Fernández et al., 2020) to reduce the impacts of this pandemic on physical health (Ghram et al., 2021). The advantages of keeping physical exercise during the pandemic are vast. First, physical exercise positively impacts mental disorders (Zschucke, Gaudlitz, & Ströhle, 2013) and related problems, such as frustration and boredom (Foye, Li, Birken, Parle, & Simpson, 2020). Second, physical exercises enhance one's chronic immune system (Nieman & Wentz, 2019; Peake, 2020). Routine and systematic exercises work in the prevention and complementary treatment of virus-related infections, such as COVID-19 (Halabchi, Ahmadinejad, & Selk-Ghaffari, 2020; Wu et al., 2020; Zbinden-Foncea, Francaux, Deldicque, & Hawley, 2020). In addition, it is positively associated with the cure rate and negatively associated with morbidity and mortality (Lin, Hu, Guo, & Huang, 2022). Therefore, it tends to be a crucial factor in the protection power of the immune system when facing the threat of COVID-19 (Scartoni et al., 2020; Da Silveira et al., 2021).

Since physical activity and exercise significantly influence our well-being during the pandemic (de Abreu et al., 2022), it is worthwhile to find physical exercise barriers and enablers (Granger et al., 2017). In the literature, using the COM-B model (Michie, Van Stralen, & West, 2011; Granger et al., 2017), factors that predict physical exercise are attributed to 1) capability, including physical and psychological factors, such as comorbidities, mood, confusion about physical activity, introversion, feel overwhelmed; 2) opportunity, such as time and convenience, weather, access to services, social support (Blake, Stanulewicz, & Mcgill, 2017); 3) motivation, such as fear to physical activity, personal, self-efficacy (Rodrigues, Teixeira, Neiva, Cid, & Monteiro, 2020). Therefore, identifying factors that promote physical exercise is valuable, especially in the context of the pandemic (León-Zarceño, Moreno-Tenas, Boix Vilella, García-Naveira, & Serrano-Rosa, 2021). Particularly, the third objective of the present paper is to investigate the effect of individual time preference and risk preference on physical exercise. The main reason is that personal risk and time preferences influence economic behaviors under uncertainty and health behaviors (Herberholz, 2020), such as overeating and obesity (Zhang & Rashad, 2008), adherence to physician advice on health behavior change (van Der Pol, Hennessy, & Manns, 2017), vaccination (Tsutsui, Benzion, & Shahrabani, 2012), etc.

Time preference predicts general human capital investments, of which health maintenance habits are one (Bradford, 2009). One underlying mechanism to explain is that individuals with higher discounting rates (who are present-oriented) are less inclined to spend time and effort developing healthy habits with upfront costs to have better future health (Norrgren, 2022). In addition, physical exercise is conceptualized as a habitual health behavior (Aarts, Paulussen, & Schaalma, 1997). Therefore, we expect that time preference is associated with physical exercise. Furthermore, during the COVID-19 pandemic lockdown, home confinement applies, and people are forced to stay home. Consequently, home-based physical activity has become an alternative to outdoor sports (Hammami, Harrabi, Mohr, & Krustrup, 2022). Given that physical exercise based on digital media has become prevalent in many countries (Ballin et al., 2020; Parker et al., 2021; Mutz, Müller, & Reimers, 2021), our objective is to make a contribution to the existing literature by examining the following hypothesis, which is as follows:

Hypothesis 5: time preference is positively associated with home-based physical exercise via digital media during the pandemic lockdown.

Risk preference refers to a stable psychological trait (Schildberg-Hörisch, 2018), which explains individual differences in risk appetite and their decision to participate in behaviors. These behaviors could be investing in stock markets, committing crimes, or consuming drugs, which include a trade-off between potential costs and benefits associated with risk and uncertainty (Mata, Frey, Richter, Schupp, & Hertwig, 2018). The empirical findings regarding the connection between risk preference and health-related behavior are subject to debate. On one side, risk aversion is negatively associated with unhealthy behaviors, such as smoking (Jusot & Khlat, 2013), heavy drinking (Dave & Saffer, 2008), being overweight, and not using a seat belt (Anderson & Mellor, 2008;

Ferrer & Klein, 2015). In contrast, some studies claim no evidence to support the relationship between risk preference and health behavior (Conell-Price & Jamison, 2015; van der Pol et al., 2017). More recently, the relationship between risk preference and sports and physical activity (Kalashi, Eydi, Abbasi, & Foroughi, 2022; List, List, Ramirez, & Samek, 2022) has been documented. One potential explanation for this correlation is that individuals with a higher inclination for risk-taking may emphasize the health-related benefits of strenuous exercise and less on the possibility of injury. Given the fact that digital media built a new scene for socialization and sports practice during the COVID-19 pandemic (Mazza, 2021), we aim to extend the literature by evaluating the association between risk preference and doing home-based physical exercise via digital media, which is detailed as follows:

Hypothesis 6: more risk-seeking individuals are more likely to exercise at home via digital media.

3. Method

3.1 Survey and Eligibility Criteria

This cross-sectional study took place in Shanghai following the lifting of the lockdown measures. We launched an online survey using the WJX technology platform, which provides services for distributing the survey and collecting data and has received recognition from reputable journals.

Study invitations were sent to potential participants in the pre-registered panel in Shanghai. Before participation, all survey respondents were aware of the study's purpose before signing a digital consent form. Afterward, They accessed the link to complete the questionnaire. The research proposal received approval from the Ethics Committee affiliated with the authors' institution.

Individuals between 18 and 60 who were employed and living in Shanghai during the lockdown were included for further analysis. In this survey, a total of 1325 questionnaires were gathered, and 1016 of them were deemed valid. 309 questionnaires were excluded from the study due to missing data, speedy responses, obvious fictitious entries, and inconsistencies. Hence, the questionnaire's validity rate stood at 76.68%.

All questions were translated into Chinese from the original English. Chinese-speaking researchers evaluated these questions to assess and before starting the study to determine and enhance reliability and validity.

3.2 Data Gathering and Measurement

The questionnaire collected data on 1) socio-demographic characteristics, encompassing gender, age, marital status, the presence of children under 12 years old, educational attainment, annual household income, and income stability; 2) risk preference and time preference; and 3) participants' intent to receive the COVID-19 vaccine, engagement in home-based physical activity through digital media, and precautionary saving habits.

Time preference. We choose a combination of intertemporal behaviors to measure time preference, as proposed by Finke and Huston (2013). Participants were subsequently queried about their behavior in seven areas, including wearing a seatbelt while driving, smoking, consuming wine, utilizing nutrition labels when grocery shopping, participating in vigorous physical exercise, engaging in unprotected sexual activity, and making dietary choices. Each question employs a five-point Likert scale from "never" to "always." For positive behaviors, for example, using nutrition labels when shopping for food, we coded 1 (5) for those who never (always) look at nutrition labels when purchasing food. In contrast, for negative behaviors, for instance, smoking, we coded 1 for those who smoke almost daily and 5 for those who never smoke. Therefore, this additive scale varies between 7 and 35, with a higher score indicating a higher possibility of delaying fulfillment and focusing on future goal attainment.

Risk preference. We employ a simple question to assess risk attitudes in a broad context, as Dohmen et al. (2011) proposed. The participants were requested to evaluate their inclination to engage in risky behavior: "How do you see yourself: are you generally fully prepared to take risks, or do you try to avoid them? Please tick a box on the scale, where the value 0 means 'not at all willing to take risks' and the value 10 means: 'very willing to take risks.'"

Willingness to get vaccinated. The respondent was asked, "*Do you plan to get all doses of a coronavirus vaccine when available?*" This measurement is introduced by Qin, Wang, and Ni (2021). A value of 1 is assigned to this variable when the respondent answers 'yes'; otherwise, we assign 0.

Precautionary saving. A straightforward question is given to the respondent, "After experiencing the lockdown in Shanghai, have you or your household increased the amount you save for coping with unforeseen events, such as unemployment, health, or other emergencies?" which is proposed by Immordino et al. (2022). It is set to 1 if the respondent answered 'yes'; otherwise, it is 0.

Exercising at home via digital media. We measure it with a question Mutz et al. (2021) suggested, "Please think of

the last six months: Have you used videos, online programs, or other digital media for sports activities at home?" We would assign a value of 1 to it in case respondents answered 'yes'; otherwise, it would be 0.

Socio-demographic attributes. They are control variables. We incorporate them to address endogeneity issues and prevent skewed estimates. The *Age* variable consists of five consecutive sub-groups: 24 or younger (1), 25-34 (2), 35-44 (3), 45-54 (4), and 55 or older (5). *Annual household income* is divided into five sequential sub-groups, with the following codes: "less than 20,000 (1), 20,000 – 50,000 (2), 50,001-100,000 (3), 100,001 - 200,000 (4), and 200,001 and above (5)." The *Male* variable is binary, taking a value of 1 if the respondent is male and 0 otherwise. The *Marital status* variable is set to 1 if the respondent is married and 0 otherwise. The *Higher education* variable is binary, assigned a value of 1 if the participant possesses higher education and 0 if not. The variable *Children under 12* is binary, with a value of 1 representing the presence of a child under 12 years old in the respondent's household and 0 otherwise.

Furthermore, we introduce *income risk* as a dummy variable because it influences the probability of augmenting savings and decreasing consumption (Immordino et al., 2022). It is assigned a value of 1 if the respondent selects (1), (2), or (3) from the question, "During the Shanghai lockdown, which sentences best describe your work situation? (1) I have lost my job; (2) I still have a job but expect to lose it in the next six months; (3) I still have a job but am working fewer hours than before the crisis; (4) My job position has remained stable; (5) I have found a (first or new) job; (6) I do not work and am not working before the crisis." Otherwise, it equals 0.

3.3 Econometrics Model

A logistic regression model is used to investigate the effect of time and risk preferences on willingness to get vaccinated. The advantages of logistic regression are as follows: firstly, it is unnecessary to assume either the outcome variable or the predictor variables follow a normal distribution; secondly, the associated error terms could be either normally distributed or not. Thirdly, we do not assume linear relationships between the independent and dependent variables.

The provided model below aims to explore the connection between time preference and the inclination to receive vaccination (Hypothesis 1) and the association between risk preference and the intent to receive the vaccine (Hypothesis 2):

$$\begin{aligned} Willingness\ to\ take\ COVID\ vaccines_i &= \beta_0 + \beta_1(Time\ preference_i) + \beta_2(Risk\ preference_i) + \sum_{k=7}^{k} \beta_k X_{ik} \\ &+ \epsilon_i \end{aligned} \quad (1)$$

where X_{ik} is a set of covariates for individual *i*, comprising age, gender, marital status, higher education attainment, annual household income, presence of children under 12, and income risk. ϵ_i represents the residual term.

The following model is crafted to explore the relationship between time discounting and precautionary saving (Hypothesis 3) and the association between risk preference and precautionary saving (Hypothesis 4):

$$Precautionary\ saving_i = \beta_0 + \beta_1(Time\ preference_i) + \beta_2(Risk\ preference_i) + \sum_{k=7}^{k} \beta_k X_{ik} + \epsilon_i \quad (2)$$

where X_{ik} is a set of covariates for individual *i*, as the same as in Equation (1). ϵ_i represents the residual term.

The third model aims to assess the link between time preference and engaging in home-based exercise through digital media (Hypothesis 5) and the relationship between risk preference and digital sports (Hypothesis 6):

$$\begin{aligned} Digital\ media-based\ sports\ activities_i = \beta_0 + \beta_1(Time\ preference_i) + \beta_2(Risk\ preference_i) + \\ \sum_{k=7}^{k} \beta_k X_{ik} + \epsilon_i \end{aligned} \quad (3)$$

where X_{ik} is a set of covariates for individual *i*, as the same as in Equation (1). ϵ_i represents the residual term.

4. Results

4.1 Descriptive Statistics

We eliminated observations from fast responders, those with missing responses (i.e., respondents began answering a questionnaire and then stopped for whatever reason), or outliers (309 observations), resulting in 1016 valid observations remaining. We ensure that our survey participants underwent home confinement or were subject to centralized quarantine amidst the COVID-19 lockdown in Shanghai. The means, standard deviations, minimums, maximums, skewness, and kurtosis of the variables are presented in Table 1.

From a demographical perspective, 45.4% of survey respondents were male. 91.13% of them fell in the scope of 25 and 54 years old. Only 23.3% of respondents were unmarried, and 7.7% did not receive higher education. Almost

half of them (47.6%) had children under 12. 71.2% of participants reported that they did not face income risk.

904 survey participants (89%) intend to get vaccinated, and 708 individuals (69.69%) increased their bank savings as a precautionary measure to address potential risks like unemployment, health crises, or other emergencies following the lockdown.

Figure 1 displays the distribution of time preferences, which is left-skewed. Furthermore, Figure 2 portrays the distribution of general risk preference, which is left-skewed.

Table 1. Summary statistics (N=1016)

Sample variables	Mean	Standard deviation	Min	Max
Dependent variables				
Willingness to take all vaccine doses	89%	0.313	0	1
Bank savings increased	69.6%	0.460	0	1
Doing home-based sports via digital media	74.6%	0.435	0	1
Variables of interest				
Time preference	25. 670	3.334	9	34
General risk preference	6.779	2.615	1	11
Control variables				
Male	0.454	0.498	0	1
Age	2.731	0.940	1	5
Marital status	0.767	0.423	0	1
Higher education	0.923	0.266	0	1
Annual household income	4.068	1.025	1	5
Children less than 12	0.476	0.499	0	1
Income risk	0.288	0.453	0	1
Number of observations	1016			

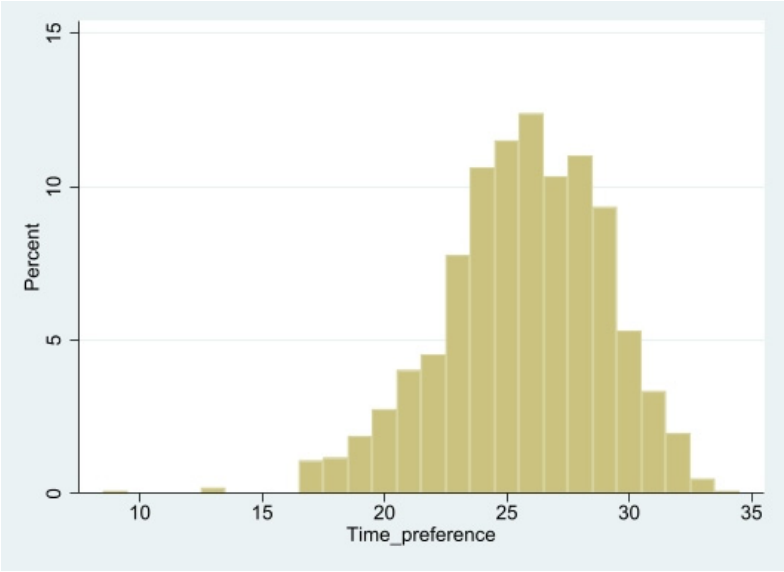

Figure 1. The distribution of time preference

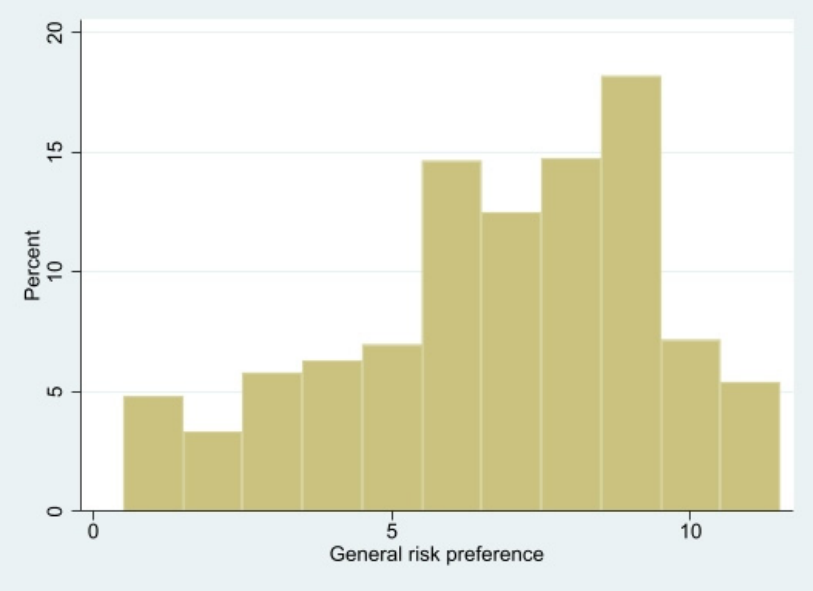

Figure 2. The distribution of general risk preference

4.2 Hypothesis testing

4.2.1 The inclination to receive COVID vaccines

We employed a binary logit regression model to explore the potential relationship between time preference, risk preferences, and willingness to receive vaccination. Table 2 portrays the estimated results. One primary variable of interest is the average marginal effect of "Time preference". Its significance suggests that time preference is positively linked to the overall willingness to vaccinate, thus corroborating Hypothesis 1. For each one-unit increase in time preference (on a scale ranging from 9 to 34), there is a 0.9% increase in the probability of vaccination.

Furthermore, another primary variable of interest is the average marginal effect of "General risk preference." The findings indicate a positive association between general risk preference and the willingness to complete all vaccine doses, thus supporting Hypothesis 2. Significantly, with every one-unit increase in general risk preference (on a scale ranging from 1 to 11), there is a 1% rise in the probability of vaccination.

The other average marginal effects in Table 2 indicate that the willingness to get vaccinated is higher for married and younger individuals, possibly reflecting that married ones tend to reduce the possibility of being infected and care about their family members' health; young aged ones are more likely to accept new vaccines and less concerned about its side effect or effectiveness.

Table 2. The average marginal effect of time preference and general risk preference on the willingness to take COVID-19 vaccines

Dependent Variables: Willingness to COVID-19 vaccines	**Logistic Regression**			
Variables	**Average Marginal Effect**	**SE**	**z-Statistic**	***p*-Value**
Time preference	0.009***	0.003	3.280	0.001
General risk preference	0.010***	0.036	2.730	0.006
Male	0.027	0.022	1.250	0.211
Age	-0.031***	0.012	-2.620	0.009
Marital status	0.104***	0.028	3.680	0.000
Higher education	0.021	0.037	0.570	0.566
Annual household income	-0.021	0.011	-1.940	0.052
Children less than 12	-0.002	0.025	-0.090	0.931
Income risk	-0.022	0.021	-1.030	0.303
Log pseudolikelihood	−330.269			
Pseudo R2	0.063			
Number of observations		1016		

Note. ** and *** denote significance at the 5% and 1% levels, respectively. Robust standard errors were utilized. No multicollinearity was identified following the VIF test.

4.2.2 Saving behavior for unforeseen events

We attempt to determine whether time and general risk preferences are related to the probability of increasing bank savings. We conducted a binary logit regression model. Table 3 presents the estimated findings, and the primary variable of interest is the average marginal effect of "Time preference" and "General risk preference". As we can see, time preference does not exhibit a statistically significant association with the augmentation of bank savings, thus failing to support Hypothesis 3. In addition, The findings suggest that general risk preference does not display a statistically significant connection with the inclination to augment bank savings, thereby failing to support Hypothesis 4.

The other average marginal effects in Table 3 indicate that precautionary saving is higher for individuals with high education attainment, income risk, and children less than 12 years old, which probably reflects that more educated ones save more for future uncertainty; income risk triggers precautionary saving for coping with no income problem when unemployed; saving more for bringing up young children.

4.2.3 Home-Based Sports Activities via Digital Media

A binary logit regression model examines whether time and general risk preferences predict physical exercise at home via digital media during the COVID-19 pandemic lockdown. Table 4 represents the estimated results. One primary variable of interest is the average marginal effect of "Time preference", which implies that time preference is positively linked to engaging in home-based sports through digital media, thus providing support for Hypothesis 5. In particular, with each one-unit rise in time preference (on a scale ranging from 9 to 34), there is a 1.2% increase in the probability of participating in home-based sports through digital media.

Table 3. The average marginal effect of time preference and general risk preference on increasing bank savings

Dependent Variables: Increasing bank savings	**Logistic Regression**			
Variables	**Average Marginal Effect**	**SE**	**z-Statistic**	***p*-Value**
Time preference	0.007	0.004	1.59	0.112
General risk preference	0.004	0.006	0.77	0.440
Male	0.037	0.030	1.22	0.221
Age	-0.013	0.017	-0.79	0.428
Marital status	0.039	0.041	0.95	0.342
Higher education	0.111**	0.055	2.01	0.044
Annual household income	-0.004	0.015	-0.32	0.748
Children less than 12	0.102***	0.034	2.97	0.003
Income risk	0.164***	0.033	4.94	0.000
Log pseudolikelihood	-594.933			
Pseudo R2	0.046			
Number of observations	1016			

Note. ** and *** denote significance at 5% and 1%, respectively. Robust standard errors were utilized. The VIF test revealed no evidence of multicollinearity.

Another primary variable of interest is the average marginal effect of "General risk preference". Results show that general risk preference does not predict implementing physical exercise via media channels at home, which does not support Hypothesis 6.

The other average marginal effects in Table 4 indicate that the probability of doing digital sports is less for aged individuals and higher for individuals with high education attainment, possibly reflecting that senior individuals hesitate to physically exercise at home according to digital media due to degenerated physical function; university graduates may have a habit of doing sports even during the period of lockdown.

Table 4. The average marginal effect of time preference and general risk preference on doing home-based sports via digital media

Dependent Variables: Doing home-based sports via digital media	**Logistic Regression**			
Variables	**Average Marginal Effect**	**SE**	**z-Statistic**	***p*-Value**
Time preference	0.012***	0.004	3.14	0.002
General risk preference	0.009	0.005	1.75	0.079
Male	-0.017	0.027	-0.61	0.541
Age	-0.073***	0.015	-4.73	0.000
Marital status	0.024	0.039	0.60	0.545
Higher education	0.141***	0.048	2.95	0.003
Annual household income	0.015	0.013	1.17	0.241
Children less than 12	0.059	0.032	1.87	0.061
Income risk	0.026	0.029	0.89	0.376
Log pseudolikelihood	-528.872			
Pseudo R2	0.081			
Number of observations	1016			

Note. ** and *** denote significance at 5% and 1%, respectively. Robust standard errors were utilized. The VIF test revealed no evidence of multicollinearity.

5. Discussion

In the present study, we inspected whether time preference and financial risk preference affect the inclination of individuals to receive vaccines and conduct indoor physical exercise through digital platforms, as well as to increase savings within the context of the zero-Covid policy. This study offers valuable insights by analyzing representative survey data gathered in Shanghai during and following the COVID-19 pandemic.

5.1 Time preference and the inclination to receive the COVID-19 vaccine

Our findings indicated that time preference positively correlates with taking COVID-19 vaccine doses. This discovery represents the initial empirical evidence connecting time preference to COVID-19 vaccine acceptance in China. In the literature, Okamoto et al. (2022) mentioned that factors associated with vaccine hesitancy include socio-demographic differences in gender, education level, and flu vaccination history (Wang, Yang, Jin, & Lin, 2021; Al-Amer et al., 2022; Truong, Bakshi, Wasim, Ahmad, & Majid, 2022), and psychological and behavioral factors, such as risk perception (Caserotti et al., 2021), fear (Willis et al., 2021), beliefs (Saied, Saied, Kabbash, & Abdo, 2021) and individual preferences (Cawley & Ruhm, 2011; Tsutsui et al., 2010). In addition, our finding is consistent with the results of previous studies. For example, Guillon and Kergall (2021) report a positive relationship between time preference and the willingness to COVID-19 vaccination based on their French sample collected by an online survey.

Similarly, a Japanese study conducted a conjoint experiment claiming that time preference predicts vaccine hesitancy (Okamoto et al., 2022). Nevertheless, there are still differences in their research. First, their findings are based on survey and experimental data from France and Japan, while we collect the survey data from China. Second, measure methods of time preference are not the same. They choose the French-validated 7-item version of Consideration of Future Consequences proposed by Demarque, Apostolidis, Chagnard, and Dany (2010) and a single self-reported question introduced by Frederick, Loewenstein, & O'donoghue (2002) while we construct an additive scale based on eight items reflecting future discounting from 8 perspectives of daily life, which is proposed by (Finke & Huston, 2013). Third, our survey participants experienced the Shanghai lockdown, while these two studies did not set such conditions during data collection.

Time preferences affect our decision-making related to health (Attema, 2012; Lawless, Drichoutis, & Nayga, 2013). One reason why future-oriented individuals tend to get vaccinated is that they believe the benefits of vaccination in the future outweigh the present concerns. The perceived benefits of vaccination are various, including reinforcing immunity and resisting virus (Reiter, Pennell, & Katz, 2020; Sherman et al., 2021) and relaxing public health restrictions due to an increased vaccine uptake rate (Okamoto et al., 2022). The present concerns comprise vaccine efficiency, ambiguity in protection level (Motta, 2021), fear of COVID-19, poor health literacy, and mistrust of authorities (Dhama et al., 2021).

5.2 General Risk Preference and the willingness for COVID vaccination

Similar to previous findings regarding the association between influenza vaccination (Tsutsui et al., 2012; Massin, Ventelou, Nebout, Verger, & Pulcini, 2015), HPV vaccination (Guo et al., 2020), and risk attitudes, our results show a positive relationship between risk preference and COVID-19 vaccination, which indicates that risk-taking individuals are more likely to get vaccinated.

The findings align with some previous research (Trueblood et al., 2022; Guillon & Kergall, 2021) regarding the connection between risk preference and the intention to take the vaccine. Even so, our sample population and risk preference measures differ from theirs. For example, they distribute their national survey among the US and French populations while we collect data from Shanghai citizens who have just experienced lockdown. Furthermore, Trueblood et al. (2022) use a choice question and ask participants how many lottery tickets last week they purchased to measure risk preference; Guillon and Kergall (2021) and Dohmen et al. (2011) use a single question to ask participants to rate their willingness to take the risk in health domain and in the general field, respectively.

For another, our findings are not consistent with other papers (Okamoto et al., 2022; Diza, Nuryakin, & Muchtar, 2022) in this concerned relationship. Notably, none report the effect of risk preference on vaccine-taking because the corresponding coefficients of risk preference in estimation are non-significant. Their results are based on Japanese online survey data and the fifth-wave Indonesian Family Life Survey data, respectively. Their measures of risk preference are different from ours. Okamoto et al. (2022) use a seven-point Likert scale proposed by Meertens and Lion (2008), while Diza et al. (2022) elicit risk aversion, which they define as one form of risk preference, through some questions answered by subjects. Therefore, national heterogeneity and different measures may contribute to this inconsistency among these studies.

Hence, explaining the underlying mechanism of why risk preference influences vaccination willingness becomes essential. Vaccination involves balancing risk-related choices: vulnerability and immunity (Binder & Nuscheler, 2017). Taking COVID-19 vaccines then seems like a potential risk that risk averters would like to avoid (Guillon & Kergall, 2021). Building on this insight and knowing risk preferences are stable during the COVID-19 pandemic (Drichoutis & Nayga, 2022), it is reasonable and essential to highlight vaccine efficacy and message its function to increase vaccine uptake of reducing the infection risk to the public in time.

5.3 Time Preference, General Risk Preference, and Precautionary Saving

Our results demonstrate that time and general risk preferences do not affect precautionary saving after experiencing the pandemic lockdown. Although, in the literature, financial risk preference is associated with a higher intention to save. While financial risk tolerance is associated with less sense of saving (DeVaney, Anong, & Whirl, 2007; Magendans, Gutteling, & Zebel, 2017), saving behavior is associated with a long-run planning horizon (Lee, Park, & Montalto, 2000; Chamon, Liu, & Prasad, 2013), our results are not in line with these mentioned findings.

Generally speaking, precautionary saving is contingent on individual characteristics related to consumption choices and savings decisions and the background in where these decisions are made (Lugilde et al., 2019). Therefore, the following reasons may contribute to this difference between previous empirical findings and our results. First, economic factors and sociological factors may be the primary factors influencing the choice of precautionary saving, such as the household's economic situation (Copur & Gutter, 2019), dependent children (Guariglia & Kim, 2003), financial socialization (Cho, Gutter, Kim, & Mauldin, 2012), education (Mishra et al., 2013; Kureishi and Wakabayashi, 2013), and income uncertainty (Baiardi et al., 2020). Second, under an uncertain environment (e.g., a lockdown caused by the pandemic), other psychological factors may contribute more to increased saving rate than individual preferences, such as self-efficacy (Lown, Kim, Gutter, & Hunt, 2015), perceived barriers to saving (Magendans et al., 2017), and being pessimistic to economy recovery throughout and after the pandemic (Zhang, Lu, Yin, & Zhao, 2021) because individuals higher in self-efficacy are more inclined to take precautions to alleviate adverse financial shocks and avoid default on their debt and bill payments after going through negative shocks (Kuhnen & Melzer, 2018). Plus, perceived barriers to saving lowers the intention to save (Magendans et al., 2017).

5.4 Time Preference, General Risk Preference, and Indoor Sports Activities by Using Digital Media

Our results show that time preference positively correlates with physical exercise at home with digital fitness apps or platforms. In contrast, general risk preference does not predict this type of physical exercise.

Our finding is partially the same as the empirical findings before 2020 because all results indicate a positive relationship between an individual's time preference and the individual's physical sports activities. For example, Kosteas (2015) reports that time preference predicts the amount of time spent in energetic physical exercise for women and men, based on the National Longitudinal Surveys of Youth 1979 (NLSY 79). A British study conducted a behavioral economic field experiment and stated that future-oriented participants did significantly more physical exercise than their present-biased counterparts (Hunter et al., 2018). More recently, also using NLSY 79, an American study conveys that time preference is positively associated with maintaining physical activity (Eberth, van der Pol, & Kemenev, 2020). In contrast, Norrgren (2022) does not find a significant relationship between time preference and physical exercise using the Swedish cohort dataset.

Nevertheless, there are still some differences between their studies and our study. First, our finding points out a positive association between time preference and fitness activities via social media platforms during the pandemic lockdown, which also constructs the primary contribution to the existing body of literature. Nevertheless, their results inform time preference matters for conventional physical exercise. Second, their research timing is before the COVID-19 outbreak. Third, all representative samples are from different countries; hence, national heterogeneity in culture, economic situations, or other perspectives may also account for the concerned relationship. Afterward, the ways to measure time preference are not the same. They all use a monetary trade-off option, but we employ a summary indicator constructed by some intertemporal behaviors proposed by Finke and Huston (2013). The latter is more effective in predicting intertemporal discounting than the former (Finke & Huston, 2013).

The possible mechanism is that future-oriented individuals are inclined to choose the healthier option to maintain their health in the long term. Subsequently, during the pandemic and lockdown, these people are more likely to keep fit and exercise at home via social media channels. Consequently, a strengthened immune system and good physical function are rewarded for mitigating infectious risk and securing general health.

5.5 Practical Implications

Based on our findings, several practical implications can be drawn. First, constructing interventions among risk-averse and present-oriented people to raise immunization uptake is essential. One intervention is to build information campaigns highlighting the infection risk of not taking the COVID-19 vaccines and how much these risks would be diminished due to vaccination. Notably, public health experts and policymakers can make an effort to train citizens' numerical capability to understand numerical information regarding side effects, and the evidence of effectiveness can prevent them from expecting too much of the risk of getting vaccinated (Caserotti et al., 2021; Garcia-Retamero, Sobkow, Petrova, Garrido, & Traczyk, 2019). The reason is that improving vaccine accessibility or awareness might not be as helpful as minimizing risk perception (Trueblood et al., 2022). Another intervention could be establishing information campaigns that underline the short-term benefits of vaccinating, such as less restriction on traveling across different administrative regions (Guillon & Kergall, 2021).

Second, to facilitate physical activity during the pandemic lockdown, interventions should aim to shift intertemporal discounting to favor long-term consequences, which could mitigate one's desire to reward presently (Hunter et al., 2018). From policy makers' perspective, particular solutions could be to train cognitive skills, such as attention, memory ability, and executive control, which can change time preference biases (O'Donoghue and Rabin, 1999; Radu, Yi, Bickel, Gross, & McClure, 2011), or to use contingency management interventions to reinforce desired behaviors (here, i.e., physical exercise at home via apps) through financial incentives, such as vouchers or other tangible rewards (Hall & Fong, 2007).

5.6 Theoretical Contributions

Scholars find that many crucial decisions are frequently made in situations of uncertainty (Guo, Chen, & Liu, 2022). The impact of COVID-19 is extensive, encompassing delays in various aspects, including the time it takes for vaccine distribution, the likelihood of fresh outbreaks, the period during which closure policies are in effect, the duration for the economy to recover post-pandemic, as well as changes in saving and spending patterns (Altig et al., 2020). We contribute to the literature by presenting evidence that risk preference and intertemporal choices predict the willingness to take the COVID-19 vaccines in China. In addition, our research extends the literature by demonstrating that these individual preferences do not influence precautionary savings. Furthermore, we add to the literature by documenting how time preference can predict doing sports at home via digital media during the pandemic lockdown.

5.7 Limitations of the Study and Directions for Future Research

We should acknowledge certain limitations of the current study. Firstly, our findings are based on a survey. The randomly picked sample from the registered panel may be less representative of Shanghai's general working population because these participants tend to have higher levels of education. Hence, people with lower levels of education may have lower coverage. Secondly, regional variations may exist since this research was carried out solely in Shanghai. Authorities' responses and policies to the pandemic and reasons for taking the vaccine, saving in advance, and exercising at home using digital apps may vary across countries and regions.

Risk and time preferences are stable amid the COVID-19 pandemic (Drichoutis & Nayga, 2022). By taking notice of these limitations, providing intertemporal and cross-national evidence on this topic would be an exciting line of future inquiry.

6. Conclusion

Economic theory states that time and risk preferences are vital in decision-making in many aspects of life (Tasoff & Zhang, 2022). They influence individuals' financial behaviors, for example, their saving rate (Mudzingiri, Muteba Mwamba, & Keyser, 2018), asset allocation (Alserda, Dellaert, Swinkels, & van der Lecq, 2019), insurance decisions (Baillon, O'Donnell, Quimbo, & van Wilgenburg, 2022), and their health behaviors, for instance, smoking (Harrison, Hofmeyr, Ross, & Swarthout, 2018), and exercise (Lopez-Guzman, Konova, & Glimcher, 2019). The COVID-19 pandemic brought external threats to public health and the global economy (Drichoutis & Nayga, 2022). People behave in advance in health and finance domains to cope with this dynamic change (Altig et al., 2020). This study was carried out using an online survey involving 1016 residents of Shanghai, which aims to investigate whether risk and time preferences influence vaccine taking, precautionary saving, and performing home-based sports via digital media.

Our results are a vital reference for public health authorities, psychological consultants, fitness clubs, and gyms. First, risk-taking and future-oriented individuals are inclined to get vaccinated, which calls for building information campaigns to underpin the infection risk of not getting vaccinated and how much this risk can be reduced after vaccination.

Second, future-oriented people are more likely to exercise at home using digital media because this action is believed to maintain physical and mental health and prevent and improve minor diseases' symptoms (Frías-Armenta et al., 2021). Interventions could be using financial incentives to support this indoor activity or altering time preference biases via cognitive skills training.

Third, neither risk nor time preference influences precautionary saving.

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The authors declare that there are no competing or potential conflicts of interest.

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