Biases in medical decision-making: a cross-medication comparison

Cantarella, M., Cantarella, S., Zaninotto, F., Riccaboni, M. and Galli, G. (2026) Biases in medical decision-making: a cross-medication comparison. Economics & Human Biology, 61. 101574. ISSN 1570-677X doi: 10.1016/j.ehb.2026.101574 Available at https://centaur.reading.ac.uk/128425/

Economics and Human Biology 61 (2026) 101574

Contents lists available at ScienceDirect

Economics and Human Biology

journal homepage: www.elsevier.com/locate/ehb

Full length article

Biases in medical decision-making: A cross-medication comparison ☆

Michele Cantarella [a], Simona Cantarella [b], Francesca Zaninotto [c], Massimo Riccaboni [d,*], Giulia Galli [c]

[a] Technical University of Denmark & IMT School for Advanced Studies Lucca, Denmark
[b] University of Reading & Kingston University, United Kingdom
[c] Kingston University, United Kingdom
[d] IMT School for Advanced Studies Lucca & Istituto Universitario di Studi Superiori, Italy

ARTICLE INFO

JEL classification:
L12
D81
D91

Keywords:
Risk-taking
Stated choice
Rationality
Numerator bias
Vaccine hesitancy

ABSTRACT

In this paper, we investigate whether cognitive biases in medical decision-making differ across types of medications when objective risks of side effects are held constant. Using data from a survey and a stated-choice experiment, we compare hypothetical medication-taking responses across four medication choices, including vaccines and therapeutic interventions, and four combinations of trials and side effects. Our main findings suggest that individuals are generally rational and prefer medications with lower risks, but responses to risk information differ systematically by medication type. In particular, individuals are more susceptible to salient side-effect information, especially for vaccines, even when overall risk levels are identical. Examining individual-level sources of variation, we find that many of these vaccine-specific distortions are substantially reduced once we account for vaccination hesitancy and illness-related anxiety, while other correlated individual characteristics also play an important role in explaining heterogeneity in medication-taking behaviour.

1. Introduction

Medical decision-making often requires individuals to evaluate the risks and benefits of different medications, even when objective risk levels are similar. These decisions are influenced not only by clinical information but also by how these risks are framed, perceived, and compared in different contexts. These considerations become particularly relevant when comparing preventive interventions, such as vaccines, with therapeutic treatments. In fact, even if vaccines are among the most cost-effective and safest public health measures for the prevention of infectious diseases, vaccine hesitancy has increased in recent decades (Bedford et al., 2018). It is easy to see why the overall desirability of preventive interventions can be affected by their uncertain and delayed benefits (Weinstein, 1988), and the varying salience of individual and collective consequences (Böhm et al., 2016; Bordalo et al., 2012; Garrouste et al., 2023).

What is less well understood is whether these same features also change how individuals respond to variation in medication risk. When reference points shift to a state of current good health, preventive interventions may frame side effects as more vivid and psychologically attributable than their individual and collective benefits (Loewenstein et al., 2001), especially when these benefits do not scale proportionally to these risks. Consistent with a large literature on loss aversion, losses that are immediate and attributable to an active decision tend to be overweighted relative to equivalent gains, increasing reliance on intuitive reasoning and heuristics under uncertainty (Kahneman et al., 1979, 1982). When it comes to side effects, these heuristics can include ratio bias, whereby individuals focus on the absolute number of side effects rather than their underlying probabilities (Denes-Raj et al., 1995), and bandwagon behaviour, whereby choices are influenced by the observed or perceived behaviour of others (Colman, 2003).

Might these biases be exacerbated for preventive interventions relative to therapeutic ones? And under which conditions would these biases disappear? As a primary research question, this paper investigates whether cognitive biases in medical decision-making systematically

☆ The authors would like to thank Bianca Sanesi for conducting exploratory analysis on our survey data. We are also grateful to the participants of Masaryk University Economic Seminars (MUES) for their useful comments and suggestions. The authors acknowledge partial support from the project "THE – Tuscany Health Ecosystem" (CUP: D63C22000400001), funded by the European Union - Next Generation EU program, in the context of the Italian National Recovery and Resilience Plan, Investment 1.5: Ecosystems of Innovation. The authors certify that they have no affiliations with or involvement in any organization or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

* Corresponding author.
E-mail addresses: micant@dtu.dk (M. Cantarella), s.cantarella@reading.ac.uk (S. Cantarella), francescazaninotto@gmail.com (F. Zaninotto), massimo.riccaboni@imtlucca.it (M. Riccaboni), g.galli@kingston.ac.uk (G. Galli).

https://doi.org/10.1016/j.ehb.2026.101574
Received 19 August 2025; Received in revised form 3 February 2026; Accepted 3 February 2026
Available online 7 February 2026

vary across types of medications and diseases when objective risk information, involving both the number of side effects and trials, is held constant. As a secondary research question, we examine the extent to which individual characteristics, such as vaccination hesitancy, infection anxiety, and other socio-demographic factors, explain these cognitive biases.

We use data from an online survey and stated-choice experiment (Bliemer and Rose, 2024) conducted in the UK in 2021, a period where COVID-19 was particularly salient. We manipulated the disease and medication by presenting four fictitious medical scenarios: COVID-19 vaccination, COVID-19 medical treatment, influenza vaccination, and high-cholesterol medical treatment, which we treated as a neutral, non-communicable baseline against the previous scenarios. Each scenario then includes four additional vignettes, each differing in the relative number of administrations (high or low) and side effects (high or low), with the ratios fixed across scenarios. Each participant then rated their likelihood of choosing each option across all 16 vignette combinations, allowing within-subject comparison of responses. We also collect several individual characteristics influencing medication taking and attitudes to risk, including vaccination hesitancy, COVID-19 anxiety, and socio-demographic and health status data.

Our results suggest that, overall, therapeutic interventions are preferred to preventive ones, although willingness to vaccinate is substantially higher for COVID-19 than for influenza. Moreover, while ordinal preferences with respect to risk are rational, as individuals tend to prefer medications with lower overall risk, aversion to side effects can distort cardinal preferences, but only for preventive treatments. In particular, vaccination decisions respond more positively to reductions in reported side effects than do other medications within comparable risk classes. Additional results suggest that differences across scenarios mostly disappear after accounting for vaccination attitudes and infection anxiety, reinforcing our main results.

Our main contribution to the literature is to provide evidence that identical medical risk information is processed differently across medications and diseases. Building on this core result, we make two additional contributions. First, we contribute to the behavioural economics and medication-hesitancy literature by documenting how biased responses to side-effect information and social uptake cues vary by medication type, with particularly strong sensitivity to side-effect risks in vaccination decisions. Second, we contribute to the emerging COVID-19 literature by showing that pandemic-related anxiety and salience are associated with higher medication-taking propensity, suggesting that COVID-19 shaped medical decision-making not only through disease-specific risk but also through broader emotional and attentional channels.

The paper is structured as follows: Section 2 provides an overview of the relevant literature. Section 3 describes our data sources and econometric approach. Section 4 presents the main results, while Section 5 concludes. The Appendix includes additional results and robustness checks.

2. Literature review

Although much of the literature on medication and vaccination preferences emphasizes the role of perceived risks and benefits in medical decisions, it remains unclear how comparable risk is processed across medical contexts. Perceptions of risk play a central role in shaping vaccine hesitancy. Overall, the literature highlights the central role of risk perception in medication decisions (Brewer et al., 2007),[1] as emphasized by most models of health decision-making, including the Health Belief Model (Rosenstock, 1974). Empirical findings suggest that vaccination decisions, whether against COVID-19 or other infectious diseases, are often a matter of weighing the risks and benefits of vaccination (Shapiro, 2016). Individuals who perceive a disease as severe and view themselves as vulnerable are generally more likely to accept vaccination, while those who perceive greater risks from the vaccine itself tend to show greater hesitancy (Brewer et al., 2007; Betsch et al., 2015). Looking at COVID-19 vaccination, studies found that the willingness to be vaccinated with a COVID-19 vaccine increased as the likelihood of severe side effects decreased (Kreps et al., 2020; Kaplan and Milstein, 2021; Schwarzinger et al., 2021).

The preventive or therapeutic nature of an intervention may affect how people respond to these perceptions of risk in medical contexts. People often use heuristics and biased reasoning, i.e., mental shortcuts that allow them to solve problems and make judgements quickly and intuitively (Kahneman et al., 1982), when faced with medical evaluations (Azarpanah et al., 2021). This line of research, which intersects with behavioural economics, has notably shown that people are more likely to rely on heuristics when they face risky and uncertain choices (Tversky and Kahneman, 1974; Loewenstein et al., 2001) or when they face losses relative to a reference point (Kahneman et al., 1979). In the context of vaccine uptake, side effects may carry greater weight in decision-making because the possibility of infection remains uncertain and the reference state is current good health. Biases and heuristics can therefore lead to stronger deviations from rational risk–benefit calculations than in other medical contexts. A related mechanism underlying these heuristics is salience bias, the tendency to over-weight information that is vivid, emotionally charged, or prominently displayed (Bordalo et al., 2012; Garrouste et al., 2023). In the context of the COVID-19 pandemic, the salience of COVID-19 may also have significantly influenced individuals' reliance on heuristics in medication decisions.

These factors can affect the context of the four medical scenarios presented to each respondent in this study. When assigning a risk of side effects to each medication in a vignette, we then rely on two additional sources of variation in information: the number of trials and the number of reported side effects. In the existing literature, these two dimensions have been closely linked to well-documented cognitive biases in risk evaluation.

Firstly, responses to variation in the number of reported side effects can reveal behaviour that is typically connected with ratio bias, also referred to as denominator neglect. When considering a vaccine, one may tend to focus on the number of side effects experienced while not paying enough attention to the total number of administrations (denominator neglect or ratio bias, Denes-Raj et al., 1995). This type of biased reasoning was well illustrated in a study where participants rated the probability of dying from different causes and concluded that the probability of dying from cancer, for example, was higher in a scenario in which cancer killed 1286 out of 10,000 people than in a scenario in which cancer killed 24.14 out of 100 people (Yamagishi, 1997). This bias illustrates how individuals may overweight numerators (e.g., the number of reported side effects) while neglecting the denominator (e.g., the total number of vaccine doses administered). In vaccination contexts, ratio bias can distort perceptions of vaccine safety, leading people to judge a vaccine as riskier simply because they hear of "more" side effects, even when those events are proportionally rare (Denes-Raj et al., 1995).

Secondly, vaccination choices are also influenced by social cues and the observed behaviour of others, and the number of trials can provide such a proxy. Thus, bandwagon effects, or social-conformity heuristics, are well-documented drivers of vaccination behaviour, where individuals update their beliefs or behaviours based on others' actions (bandwagon bias, Colman, 2003). For example, Hershey et al. (1994) showed hypothetical vaccination scenarios that differed in the proportion of people already vaccinated and found that the intention to vaccinate increased with the proportion of others vaccinated. Furthermore, the

[1] These perceptions may in turn be mediated by contextual and socio-demographic factors such as age, gender, socioeconomic status, and trust in institutions (Leng et al., 2021; Murphy et al., 2021; Klüwer et al., 2023; Welch et al., 2023).

number of trials may also affect perceived statistical uncertainty, as probabilities inferred from larger samples may be viewed as more reliable and less ambiguous (Fox and Tversky, 1995). Our manipulation of the proportion of others vaccinated directly captures these mechanisms, allowing us to examine how social information interacts with perceived medical risk.

These mechanisms are particularly relevant in vaccination contexts, where potential side effects are framed as salient and attributable losses, making deviations from proportional risk evaluation more likely. The COVID-19 pandemic provides a high-salience context to examine whether these cognitive biases differ across medications and diseases.

While a large body of literature uses discrete choice experiments to study vaccination preferences and attribute trade-offs (Diks et al., 2021; Huang et al., 2024), it remains unclear whether and how identical risk information is processed differently between vaccines and non-vaccine therapeutic interventions within a common experimental framework. Some studies found that the perception of vaccine safety influenced the decision to vaccinate against COVID-19 but not against other diseases (Antonopoulou et al., 2022; SteelFisher et al., 2023). Other studies found that cognitive biases are more evident in vaccination compared to other medical decisions (DiBonaventura and Chapman, 2008; Pomares et al., 2020). To the best of our knowledge, no studies compare COVID-19 and non-COVID-19 medication and vaccination decisions while keeping objective risk information constant across medication types.

3. Data and econometric setting

We collected data from 748 participants between June 18 and June 26, 2021, around the so-called "Freedom Day" (July 19, 2021) when the UK government lifted all COVID-19 restrictions.

The survey captures several dimensions: (i) a series of questions to collect demographic information (age, gender, education, nationality, employment, income, area of residence) and information related to the COVID-19 pandemic, (ii) a Multiple Choice General Numeracy Scale (Hill et al., 2019), (iii) the Vaccination Attitude Examination Scale (Martin and Petrie, 2017), (iv) the COVID-19 Anxiety Syndrome Scale (Nikčević and Spada, 2020), and (v) an experimental choice task. Full summary statistics are reported in Table 1, and a full description of our data source is presented in Appendix A.

Although our recruitment targeted a broad cross-section of UK residents, the resulting Prolific sample is not necessarily demographically representative of the UK population. At the time of the survey, our sampling relied on voluntary participation conditional on eligibility criteria. This limitation affects the external validity of our results. The analysis should therefore be viewed as informative about behavioural patterns across cohorts within our sample rather than as nationally generalizable evidence.

The experimental choice task consists of 16 vignettes associated with 4 fictional medication scenarios: seasonal influenza vaccination (*FluVax*, henceforth), COVID-19 vaccination (*CoVax*), cholesterol medication (*CholTreat*), and COVID-19 medication (*CoTreat*). Each participant reports their stated likelihood of taking a medication in each scenario on a 1–5 Likert scale, from "Extremely unlikely" to "Extremely likely". We use these stated preferences as our response variable y. The cholesterol vignette, being non-communicable, differs conceptually from the others in that its adoption affects only the individual respondent and not the wider community. By contrast, the communicable disease vignettes (COVID-19, influenza) embed potential social or altruistic motivations related to transmission risk and herd immunity. We explicitly take advantage of this vignette design to treat medication choices in the cholesterol scenario as a purely self-directed baseline.

Each vignette varies combinations of side effects (high and low) and trials (high and low), allowing us to study the within-variation of responses across medication classes and risk factors. This design creates a pseudo-panel where each individual provides 16 different responses across 4 medications t, 2 levels of trials j, and 2 levels of side effects k. It is important to recall that *all* 16 combinations are shown to *all* respondents so that the final panel is virtually fully balanced.[2] This within-subject design allows us to isolate differences in risk processing across medication and disease types by holding objective risk information constant within individuals.

Table 1
Summary statistics.

	(1)			
	mean	sd	min	max
Age	28.65374	9.588126	18	70
Health status	2.946524	.8163826	0	4
Gender: male	.3836898	.4866092	0	1
Children in hh.	.1764706	.3814751	0	1
Occupation: Employed	.5421687	.4985524	0	1
Occupation: Student	.2891566	.4536746	0	1
Occupation: Unemployed	.1686747	.3747152	0	1
Education: Secondary or lower	.0708556	.2567552	0	1
Education: A-levels or equivalent	.3823529	.4862873	0	1
Education: Bachelor's or equivalent	.4024064	.4907111	0	1
Education: Master's or higher	.144385	.3517149	0	1
Math score	9.340909	1.57799	2	11
C-19 income loss	.3622995	.4809863	0	1
News use	3.547523	1.230239	1	6
Social Network use	4.657754	1.355432	1	6
Web use	5.272727	.8844663	1	6
Tv use	4.390374	1.506794	1	6
COVID-19 anxiety	1.921032	1.0174	0	5
Vaccination attitude	2.800647	1.194735	0	5
Vaccinated vs. Influenza	.1925134	.3945378	0	1
Vaccinated vs. COVID-19	.2433155	.4293711	0	1
Observations	748			

A preliminary four-way fixed effects model can exploit the quasi-panel nature of this sample to estimate the following equation:

$$y_{ijkt} = \alpha_i + \beta_t + \gamma_j + \delta_k + \zeta_{jk} + \eta_{ijkt} \quad (1)$$

where α_i is the idiosyncratic effect, capturing individual-level adversity (or propensity) to get treated. γ_j and δ_k absorb the levels of trials and side effects, respectively, revealing how individuals respond to increases in trials (capturing the "bandwagon" effect) and side effects (capturing the "ratio" effect). The term ζ_{jk} denotes the interactions between side effects and trials, accounting for non-monotonic variations in the propensity to take a medication arising from each combination, giving rise to "rational" behaviour. Finally, the medication effect is captured by the parameter β_t, which indicates how likely it is on average that an individual will take up a particular medication, leaving the risk factors unchanged. Given the structure of the equation, the standard errors are clustered at the individual level.

We estimate this and our following models using linear specifications (pooled and fixed effects OLS, and mixed effects GLS). In our experiment, respondents rate the likelihood of taking each medication on a 1–5 Likert scale, providing ordinal ratings rather than a single choice among competing alternatives. This makes a linear specification more appropriate than a random-utility framework such as a multinomial or conditional logit model. While the model could in principle be estimated with an ordered logit or probit specification, several prominent studies (such as Ferrer-i Carbonell and Frijters, 2004, who focused on the estimation of life-satisfaction regressions) have shown that linear models estimated on ordinal satisfaction or Likert-type responses yield results very similar to those from ordered models. Consistent with this evidence, our modelling approach focuses on internally valid contrasts in stated preferences rather than on discrete probabilistic choices among alternatives. We might expect heterogeneous effects

[2] Only 19 survey medication-taking questions across all respondents were affected by item non-response.

to arise when individuals respond differently to variations in side effects and trials depending on the medication class. The interaction between all these variables can then reveal further information on medication-taking.

To examine whether responses to identical risk information vary systematically across medication and disease types, we enrich the baseline specification in Eq. (1) to allow for full interactions between medications and risk factors:

$$y_{ijkt} = \alpha_i + \beta_t + \gamma_j + \delta_k + \zeta_{jk} + \theta_{tj} + \kappa_{tk} + \lambda_{tkj} + \eta_{ijkt} \quad (2)$$

where θ_{tj}, κ_{tk}, and λ_{tkj} denote the full interaction set.

This saturated model will allow us to estimate variation within responses to medication, holding all else fixed. The residual variation in medication propensity would then depend on idiosyncratic factors related to the medication at hand. After holding risk factors as fixed, the two main sources of variation arise from (i) whether the medication is intended to treat a COVID-19 infection or (ii) whether the medication is a vaccine. These two intercepts will capture the average aversion to COVID-19 infection and the average aversion to vaccination, respectively, reflecting aggregate considerations about the perceived risks of illness and medication.

The validity of our estimates relies on the within-person assignment of vignette attributes, which are independent of respondents' characteristics by design. This guarantees that variation across side effects, trials, and medication types is experimentally induced, in line with the principles of stated choice experiments (Bliemer and Rose, 2024). The approach captures internally valid contrasts in stated preferences, but it does not identify causal effects in the experimental or quasi-experimental sense.

We can then estimate the differences between "vaccine medications" and "COVID-19 medications" across vignettes. In other words, after controlling for the difference in intercepts between COVID-19 and other conditions (influenza or high cholesterol), it is possible to estimate the idiosyncratic effect of vaccination on the propensity to take a medication, keeping all risk factors from the stated-choice experiment fixed. Conversely, we can estimate the COVID-19 effect if we consider the vaccination intercept as fixed. This approach can also work with only the two COVID-19 medications and the cholesterol treatment, treating the latter as a baseline scenario involving a non-communicable illness. Parallel behaviour with the seasonal influenza vaccine may provide additional robustness, but differences in aversion between influenza and cholesterol-related diseases cannot be ruled out.

The models presented so far will fully identify the effect of each medication class on the propensity to get treated. However, the individual-level predictors of medication-taking behaviour, which could also be of interest to the researcher, will be fully absorbed by the individual fixed effects. Heterogeneous effects can still be estimated with the fixed effects model, but the effect of individual-level mediators can only be evaluated with a pooled OLS or a mixed-effects model.

While our primary interest is in differences across medication and disease types, incorporating individual-level characteristics allows us to assess whether and how these differences are mediated by pre-existing attitudes and anxiety. Taking all heterogeneous effects into account, we update the model to:

$$\begin{aligned} y_{ijkt} = {} & \alpha_i + \beta_t + \gamma_j + \delta_k + \zeta_{jk} + \theta_{tj} + \kappa_{tk} + \lambda_{tkj} + \\ & (\mu + \nu_t + \xi_j + o_k + \pi_{jk} + \rho_{tj} + \sigma_{tk} + \tau_{tkj}) X_i' + \eta_{ijkt} \end{aligned} \quad (3)$$

where X_i is a generic vector of individual-level controls that can predict the propensity to get treated, which is then interacted with the full set of medication-risk-factor effects.

In our setting, each observed variable predates the choice experiment and could technically be included as part of X_i without jeopardizing identification. In our analysis, we are particularly interested in studying how vaccination attitudes and infection anxiety mediate the potential biases observed in the previous specifications.

Also, we may be interested in examining demographics, health status, occupation, education, and math skills (separately), media diet, and other plausible determinants of variation in perceived risks and benefits associated with each medication type and risk factor. These additional results are included in Appendix B.

Due to the structure of the choice experiment, the vector X_i only contains variables with variation at the individual level. The implicit assumption central to the validity of the random/mixed model is that individual characteristics are invariant, and hence α_i is independent of the unobserved, exogenous set of individual characteristics dependent on the medication & the risk factor.

However, the variation in t between the four medication classes requires further discussion. Clearly, most individual characteristics, such as demographics, will not change across t, j, and k. However, some other individual characteristics, such as prior beliefs about COVID-19 and/or vaccination, could vary between medication types and influence the outcome, calling into question the appropriateness of the mixed-effects model.

While the appropriateness of the model can be probed with a Hausman test, there are two ways in which we can directly address these sources of individual variation. Firstly, the decomposition of the 4 medications into 2×2 classes (vaccine or treatment) and illness type (COVID-19 or else) allows us to study the within-variation between classes, assuming these prior beliefs vary along these two axes.

Furthermore, the fact that we observe these beliefs comes to our support. Indeed, the survey contains a variety of questions that capture aspects of COVID-19 anxiety and vaccination attitudes, along with their interaction.[3] We can control for these beliefs by including them in the vector X_i. We can also include other proxies of these beliefs, such as actual vaccination behaviour. These controls might mediate the effect of other individual characteristics[4] but as discussed earlier, they all predate the choice experiment, so they cannot be considered endogenous in terms of our estimation.

If the results remain unchanged after the inclusion of these controls, then we can safely argue that our estimation approach is correctly accounting for the heterogeneities arising from prior medication-specific beliefs.

4. Results

4.1. Main results

Table 2 summarizes our results for our initial model from Eq. (1), testing the robustness of the model across various specifications using high-cholesterol medication as the baseline level.

In column (1), we present pooled OLS estimates for non-interacted medication-taking behaviour. Columns (2) and (3) add individual fixed and random effects, respectively. There is no significant difference between the fixed effect and pooled OLS models, as expected, since the medication-risk factor fixed effect is independent of the individual effect. This independence is due to respondents providing responses for every combination of medication and risk factor, preventing this variation from being absorbed by the individual fixed effect.

Models with individual effects indicate that roughly 66% of the variance lies at the individual level (intraclass correlation), although this does not affect the estimation of coefficients tied to vignette attributes. The random-effects specification in column (3) yields a very similar intraclass correlation.

Our results (columns 1 to 3), overall, indicate a lower average stated Likert-scale likelihood (1–5) for the seasonal influenza vaccine with reference to medication choices in both the baseline cholesterol

[3] 25 in total, 11 about COVID-19 anxiety, 2 about perceived COVID-19 infection, and 12 about vaccination attitudes.

[4] For this reason, it is better to introduce them in a stepwise fashion.

Table 2
Treatment-taking estimates, medication-risk factor F.E.

	(1) P.OLS	(2) F.E.	(3) R.E.	(4) P.OLS	(5) F.E.	(6) R.E.
SeasVax	−0.248***	−0.248***	−0.248***	−0.166***	−0.164***	−0.164***
	(0.034)	(0.034)	(0.034)	(0.042)	(0.042)	(0.042)
CoVax	−0.062	−0.061	−0.061	0.103*	0.104*	0.104*
	(0.034)	(0.034)	(0.034)	(0.042)	(0.042)	(0.042)
CoTreat	0.096**	0.096**	0.096**	0.120**	0.120**	0.120**
	(0.031)	(0.031)	(0.031)	(0.038)	(0.038)	(0.038)
High Side Effects	−0.754***	−0.755***	−0.755***	−0.669***	−0.669***	−0.669***
	(0.026)	(0.026)	(0.026)	(0.031)	(0.031)	(0.031)
High Trials	0.433***	0.432***	0.432***	0.518***	0.517***	0.517***
	(0.019)	(0.019)	(0.019)	(0.028)	(0.028)	(0.028)
High Side Effects × High Trials	0.002	0.003	0.002	−0.067*	−0.066*	−0.066*
	(0.020)	(0.020)	(0.020)	(0.031)	(0.031)	(0.031)
SeasVax × High Side Effects				−0.040	−0.042	−0.042
				(0.033)	(0.033)	(0.033)
CoVax × High Side Effects				−0.209***	−0.209***	−0.209***
				(0.035)	(0.035)	(0.035)
CoTreat × High Side Effects				−0.090**	−0.093**	−0.093**
				(0.032)	(0.032)	(0.032)
SeasVax × High Trials				−0.160***	−0.161***	−0.161***
				(0.032)	(0.032)	(0.032)
CoVax × High Trials				−0.177***	−0.175***	−0.175***
				(0.030)	(0.030)	(0.030)
CoTreat × High Trials				−0.004	−0.002	−0.002
				(0.030)	(0.030)	(0.030)
SeasVax × High Side Effects × High Trials				0.072	0.072	0.072
				(0.038)	(0.038)	(0.038)
CoVax × High Side Effects × High Trials				0.112**	0.109**	0.109**
				(0.040)	(0.040)	(0.040)
CoTreat × High Side Effects × High Trials				0.090*	0.091*	0.091*
				(0.040)	(0.040)	(0.040)
Constant	3.403***	3.403***	3.402***	3.335***	3.335***	3.334***
	(0.045)	(0.024)	(0.045)	(0.046)	(0.028)	(0.046)
Within R-squared		0.268	0.268		0.271	0.271
Between R-squared		0.000	0.000		0.000	0.000
Overall R-squared	0.106	0.107	0.107	0.107	0.108	0.108
Intraclass correlation		0.659	0.652		0.660	0.652
N	11,949	11,949	11,949	11,949	11,949	11,949

SE clustered by ID. Cholesterol treatment as base level.
* p<.05.
** p<.01.
*** p<.001.

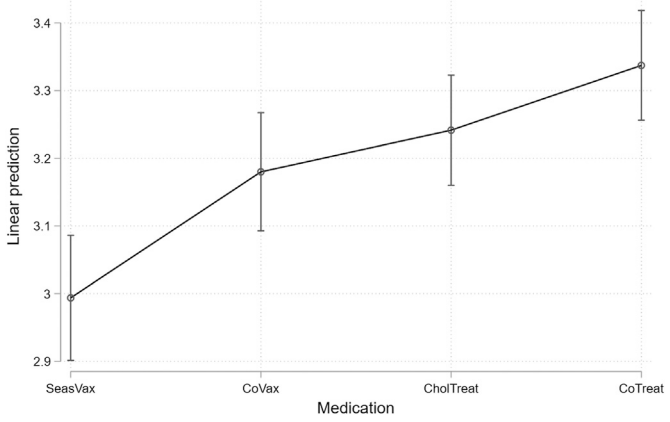

Fig. 1. Average marginal medication-taking propensities.
Notes: Predictive margins with 95% confidence interval, fitted from model (1).

vignette and all other vignettes. Although the self-reported likelihood to medicate, relative to the cholesterol baseline, is less pronounced for the two COVID-19 scenarios, individuals show a preference for COVID-19 therapeutic products over the COVID-19 vaccine.

Medication and illness-specific results, estimating intercepts for vaccination-type medication and COVID-19-type illness, vis-à-vis the cholesterol treatment baseline, are detailed in Table A.2, Appendix C. Fig. A.12 in the same Appendix shows fitted values from the final estimated model (column 2), which are identical to the results from Fig. 1.

Looking at risk factors (columns 1 to 3), higher side effects decrease the medication-taking propensity by around 0.75 Likert-scale points, while higher trials increase it by about 0.45 points, which are suggestive of "ratio bias" and "bandwagon" behaviour. But what about the combination of trials and side effects? The interaction between trials and side effects appears to yield no effects, suggesting that medication preferences, overall, are not stronger or weaker when both side effects and trials are high. In other words, respondents do not seem to respond with increased medication rates to the lower uncertainty connected with a higher number of trials and side effects.

Still, it is difficult to draw conclusions before looking at the full interaction set between all medications and risk factors. Columns (4), (5), and (6) include all interactions between medication and risk factors in the Pooled OLS, fixed, and random effects models, respectively, showing again no significant differences between models. The Random effects model also passes the Hausman test (Prob > chi2 = 0.4995). For brevity and ease of presentation, subsequent estimates are then produced using random effects only.

Given the large interaction set, interpreting coefficients from Table 2 alone is challenging. Fig. 1 plots fitted values for medication-taking conditional on the type of medication, keeping variation in risk factors (i.e., side effects and trials) as fixed. Fig. 2 visualizes medication effects

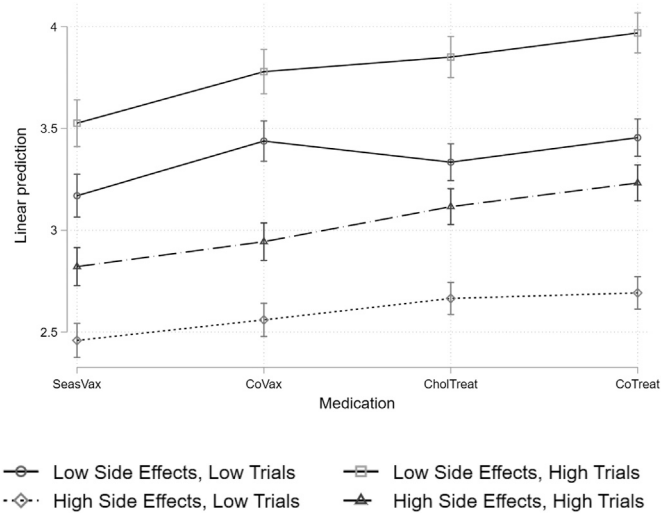

Fig. 2. Average marginal medication-taking propensities by risk profile.
Notes: Predictive margins with 95% confidence interval, fitted from model (2).

by predicting fitted values for each combination of medication, side effects, and trials.

Several patterns emerge: responses between risk classes follow a rational preference pattern, with individuals preferring medications with the lowest risk. However, significant heterogeneity appears within risk classes and between medication scenarios. In particular, individuals appear to be much more susceptible to low side effects when it comes to vaccinations (and especially COVID-19 vaccinations), as vignettes with low side effects and low trials feature higher stated medication-taking propensities for vaccine-type medications (and the COVID-19 vaccine in particular) when compared to the other medication scenarios with the same risk profile. This result can only be attributed to salience effects specific to vaccination, which may increase reliance on heuristics such as ratio bias or bandwagon bias. This effect is so strong that, within the same risk factor class (low side effects, low trials), the order of preference between the COVID-19 Vaccine and the Cholesterol medication is inverted.[5]

As a robustness check, we controlled for respondents having no prior COVID-19 infection or related symptoms, adding these variables to the vector X_i, and including interactions, predicting fitted values *as if* the entire population never contracted COVID-19 or any related symptoms. The results, shown in Appendix C, Fig. A.11, are nearly identical to those in Fig. 2, confirming that our estimates are not influenced by prior COVID-19 infections or related symptoms. A broader analysis of heterogeneity across socio-demographic characteristics is presented in Appendix B. These results show that the main medication and risk factor patterns documented above are robust across population subgroups.

4.2. The role of COVID-19 anxiety and vaccination attitude

Using the model from Eq. (3), we interact the medication and risk factor intercepts with a pair of indicators of revealed preferences concerning COVID-19 anxiety and confidence in vaccination. These results allow us to test how much the differences in responses across medication types discussed above can be attributed to infection anxiety and trust in vaccination.

We include two additional predictors to proxy for infection anxiety and vaccine confidence. The first variable, "COVID-19 Anxiety", is the sum of 11 Likert-scale questions normalized to a 0–5 scale. The second, "Vaccination Attitude", comprises 12 Likert-scale questions on trust in vaccines, also normalized to a 0–5 scale.[6] The interaction among these variables is also included to account for "hedge cases" such as, for example, individuals who would gladly take the COVID-19 vaccine but are more hesitant about influenza vaccination.

Full heterogeneous results are reported in Appendix D, Table A.6, featuring the same column disposition as in Table A.5. We repeat the same exercise from Section 4.1 and plot average predicted responses in Fig. A.14. Once we consider all interactions, there is no difference in medication-taking preferences with reference to our main model (2), as shown in the Figure. The results are virtually identical, with narrower confidence intervals. This is expected, as perceived risk preferences are independent of the assignment of the medication choices.[7]

Again, given the large set of interactions, much of the variation in responses lies at the intersection with specific cells, so the table will hardly paint a full picture of average medication-taking preferences across levels of anxiety and confidence. We estimate marginal effects by fitting the estimated parameters over the upper and lower bounds of the COVID-19 anxiety and Vaccine Confidence scales.

We further analyse the effect of anxiety and confidence by predicting outcomes at different preference levels. Fig. 3 shows predicted responses for the highest (top figure) and lowest (bottom) COVID-19 anxiety levels, holding other factors constant. The results suggest that individuals with high COVID-19 anxiety experience generalized anxiety towards any disease and that vaccination is also not a factor, aligning with findings from Nikčević et al. (2021). For those with little COVID-19 anxiety, there is no statistical difference in medication-taking for all medications except for the seasonal vaccine, as all point estimates fall within the same 95% confidence intervals. These results are unexpected but not without nuance: we would have expected individuals with high anxiety to have higher medication-taking preferences for COVID-19 illnesses, and individuals with low anxiety to only respond to vaccination. Note that, in any case, medication-taking preferences are still several points higher for individuals with high anxiety.

These results seem to suggest that much of the variation might be attributed to the perceived benefits of vaccination. In Fig. 4, we switch confidence in generic vaccination between its highest (top) and lowest (bottom) values. The results for the highest confidence level are unambiguous: general medication-taking is high across all risk-factor classes, and there is nearly no statistical difference caused by vaccine-type medications, as the only remaining differences are connected with COVID-19-type illnesses. For the lowest confidence group, the opposite is true: the only remaining differences that persist are the ones between vaccine and non-vaccine types. Furthermore, it is also interesting to note that general medication-taking is much lower for this group than it is for individuals who have high trust in generic vaccines.

We are now ready to study how these anxiety and confidence factors interact. We do so in Figs. 5 and 6, in which we plot medication-taking predictions for (i) high-confidence, high-anxiety (Fig. 5, top), (ii) low-confidence, high-anxiety (Fig. 5, bottom), (iii) high-confidence, low-anxiety (Fig. 6, top), and (iv) low-confidence, low-anxiety individuals (Fig. 6, bottom).

These results paint a nuanced picture. High-confidence, high-anxiety individuals have the highest likelihood to take any medication, and there is statistically no difference in medication-taking

[5] This change alone cannot be explained by the general variation in trials and side effects (shown in Table A.1, Appendix A), as it does not occur for any other medication, not to mention that, in our choice experiment, "low" side effects in vaccine-type medication are generally higher than the ones from the other medications.

[6] Principal component analysis yielded similar results, so we use summative scores for simplicity.

[7] As discussed earlier, this property arises from all respondents being presented with the same options. From this point of view, this exercise acts as a robustness check to our initial approach from Section 4.1.

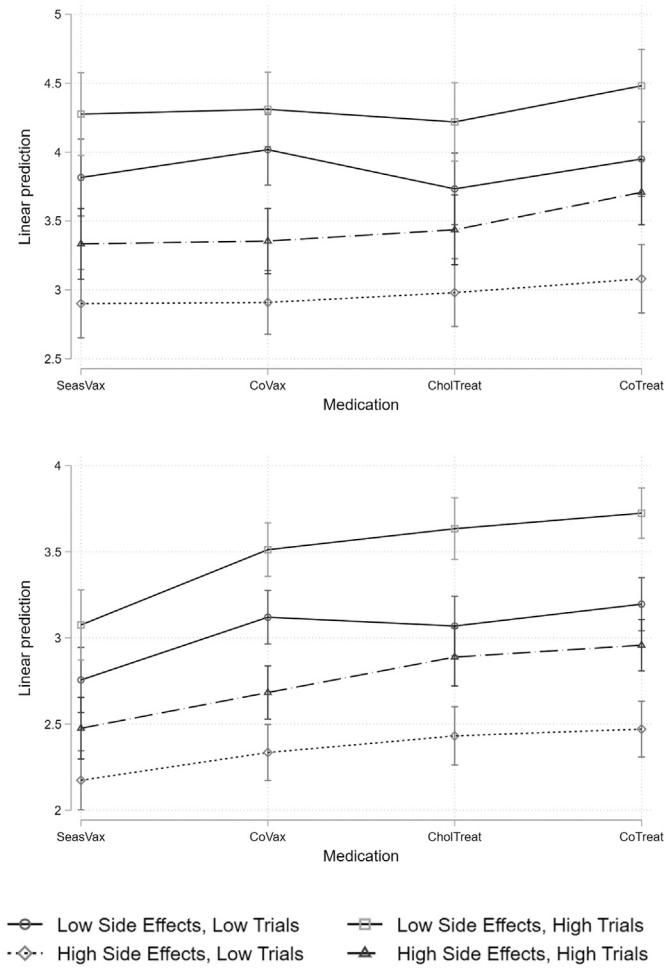

Fig. 3. Average marginal medication-taking propensities by risk profile, over COVID-19 anxiety cohorts.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: highest COVID-19 anxiety. Bottom figure: lowest COVID-19 anxiety.

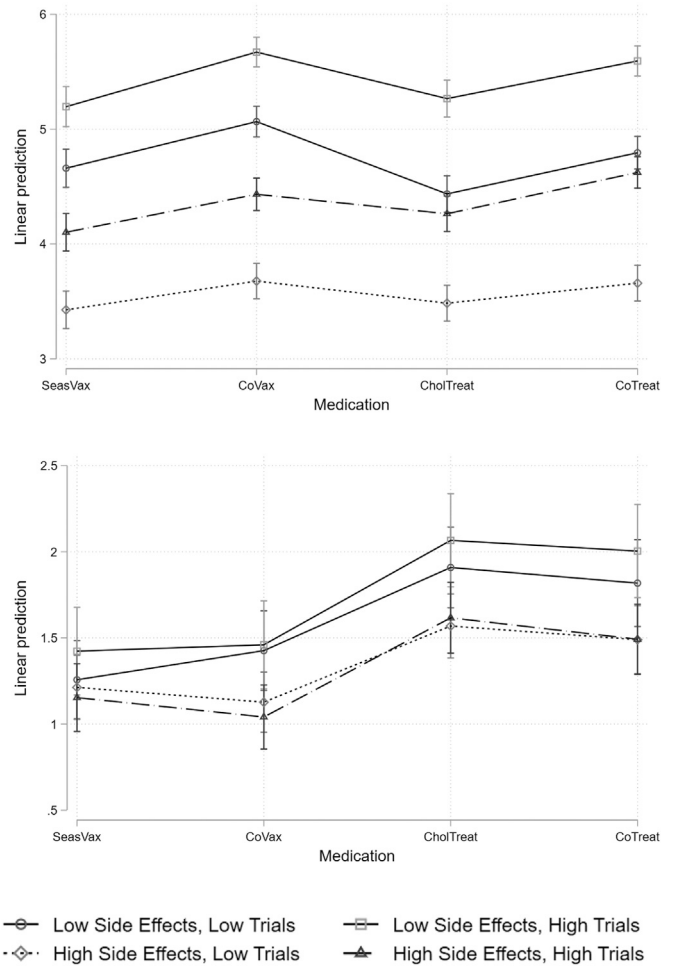

Fig. 4. Average marginal medication-taking propensities by risk profile, over vaccination attitude cohorts.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: highest vaccination attitude. Bottom figure: lowest vaccination attitude.

across scenarios, all falling within the same 95% confidence intervals. Risk factors also seem to play a much smaller role in medication-taking preferences, to the point that there is barely any statistical difference between the first three relative risk classes.

High-confidence, low-anxiety individuals also feature a comparable likelihood of medication-taking but feature higher between-scenario variation. This suggests the possibility that, for individuals with high trust in vaccines, low COVID-19 anxiety might be connected with even lower anxiety connected with other illness types. Interestingly, this is the group for which the between-risk-factor variance in medication-taking remains at its largest.

The remaining two figures offer further insights into low-confidence, high-anxiety and low-confidence, low-anxiety individuals. The former group features low medication-taking scores across all medications, with a noticeable split between risk classes, which suggests ratio bias behaviour in the form of a strong aversion to high side effects, especially for the COVID-19 vaccine. Interestingly, the low trust in vaccines also affects the scores for CoTreat, which, while higher than for the other medications, are still low enough to suggest that trust in vaccines is also connected, more generally, with trust in the healthcare system.

For the latter, we have the most striking results. Not only are the medication scores the lowest overall, but there is essentially no statistical difference between any risk factors, all falling within the same 95% confidence bands. Another interesting result is connected to the infra-medication variation, which suggests that COVID-19 is probably perceived as less dangerous than any other illness, at least for this group of individuals.

As a final check, we repeat the same exercise, controlling for individuals who have already taken the COVID-19 and Influenza vaccine, representing a subset of individuals for whom the perceived risk of illness offsets the perceived risk of vaccine-related complications. After updating the model by switching the X_i vector with the pair of vaccine-taking variables (and their interactions), we produce fitted values for the vaccine-taking and vaccine-not-taking subsamples. Full regression results are reported in Table A.4, in Appendix C.

The marginal results are reported in Appendix C Fig. A.15. We begin by looking at individuals who took the vaccine for both COVID-19 and Influenza. Between-scenario variation for the first two risk classes is fully absorbed for individuals who took both vaccines, suggesting, as expected, that (i) these individuals have enough trust in vaccination so that the perceived risk of complications is negligible and (ii) the perceived risk of illness is the same for all medications. Interestingly, preference for low trials still seems to affect the magnitude of

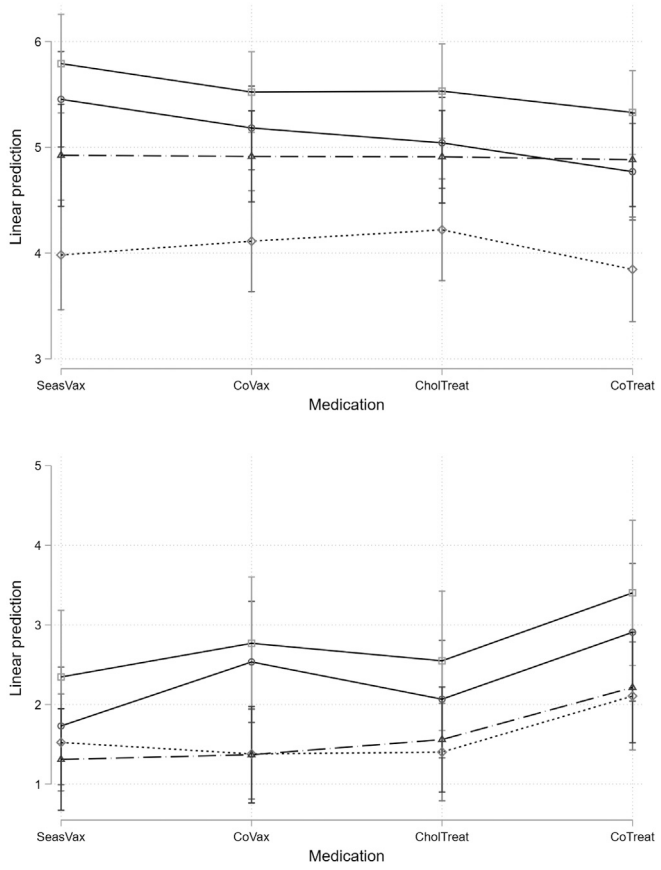

Fig. 5. Average marginal medication-taking propensities by risk profile, over Vaccination Attitude cohorts, high Vaccination Attitude.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: highest vaccination attitude & highest COVID-19 anxiety. Bottom figure: lowest vaccination attitude & highest COVID-19 anxiety.

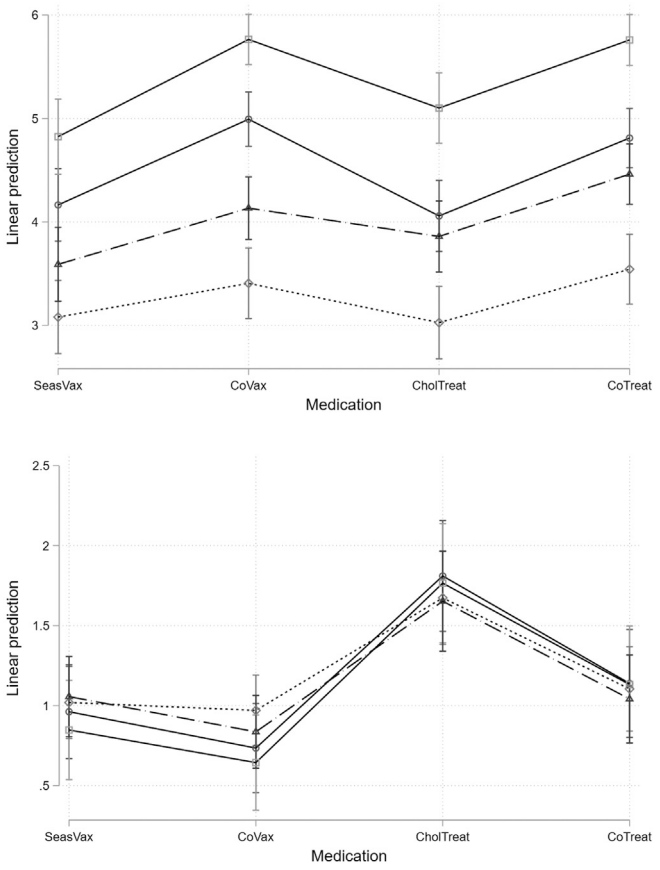

Fig. 6. Average marginal medication-taking propensities by risk profile, over Vaccination Attitude, low COVID-19 anxiety.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: highest vaccination attitude & lowest COVID-19 anxiety. Bottom figure: lowest vaccination attitude & lowest COVID-19 anxiety.

medication-taking for the last two risk classes, albeit the results are far from statistically significant at the 5% level. Note, instead, how results for the subsample who did not take any vaccine resemble our initial results from Fig. 2.

5. Discussion and conclusions

In this study, we examined how the decision to take different medications is affected by biased reasoning and other psychological and demographic factors. Using data from a survey and a stated-choice experiment, we have compared differences in medical decision-making across medication types and side-effect risks.

In general, participants in our study showed lower preference for vaccines *vis-a-vis* other types of medications. This finding likely reflects the widespread distrust towards vaccinations (Yaqub et al., 2014). One key determinant of vaccine scepticism or hesitance is the fear of side effects, as consistently found in research regarding COVID-19 and other vaccines (Betsch et al., 2012; Kreps et al., 2020; Kaplan and Milstein, 2021; Kessels et al., 2021; Schwarzinger et al., 2021).

Individuals' ordinal preferences were also overall rational, as participants were more likely to accept medications when side effects were low and the number of trials was high. However, patterns of biased reasoning varied by medication type and emerged from cardinal preferences. Participants were especially influenced by side-effect information when evaluating vaccines, showing a greater willingness to receive a vaccine only when side effects were minimal.

This heightened sensitivity may reflect contextual differences between preventive treatments and other direct forms of therapeutic intervention. More specifically, our results suggest that heuristics such as ratio bias exert a stronger influence on vaccination decisions than on other medication choices, and support a wide body of literature on loss aversion under uncertainty (Kahneman et al., 1979, 1982). For non-vaccine medications, treatment-taking responses largely reflect the relative risk information presented, with profiles featuring high trials and high side effects receiving similar evaluations to those with low trials and low side effects, consistent with their comparable overall risk. By contrast, for vaccination decisions, the difference in preferences between these risk profiles is substantially larger, indicating a disproportionate response to side-effect information.

These results suggest that decisions involving preventive medication, presumably due to the uncertainty in future infections and the attributable nature of side effects, are more likely to be affected by a higher prevalence of side effects. Furthermore, the fact that these effects were more intense for COVID-19 vaccination also suggests the presence of salience effects, suggesting side-effect information becomes more attention-grabbing and emotionally charged in the context of the pandemic, compared with other vaccinations.

Next, we examine whether the biases observed in vaccination scenarios can be explained by attitudes towards vaccination and COVID-19 anxiety, and find that, when combined, these two factors account for most of the observed biases.

More specifically, and consistently with evidence that vaccine-hesitant individuals are more likely to exhibit cognitive biases (Di-Bonaventura and Chapman, 2008; Pomares et al., 2020), our sensitivity checks show that differences in medication-taking preferences across scenarios largely disappear among individuals with high vaccination attitudes and among those who have already taken both influenza and COVID-19 vaccines, provided that reported side effects remain relatively low. Individuals with high COVID-19 anxiety are instead more likely to take any medication. This is consistent with previous evidence showing a positive association between COVID-19 anxiety and COVID-19 vaccine acceptance (Bendau et al., 2021). The fact that COVID-19 anxiety affects treatment-taking across all medications suggests that this measure captures broader illness-related anxiety rather than COVID-19–specific concerns, in line with evidence of increased health anxiety during the early phase of the pandemic (Kibbey et al., 2021; Luo et al., 2021). Conversely, individuals with low COVID-19 anxiety display uniformly low medication-taking probabilities for both vaccines and treatments, particularly for influenza vaccination.

Finally, exploratory heterogeneity analyses indicate that few socio-demographic characteristics systematically mediate medication-taking behaviour. Unemployment status is associated with lower willingness to vaccinate, consistent with reduced perceived risk of infection induced by the reduced commuting (Schwarzinger et al., 2021). Older respondents, holding health constant, are less likely to take any medication and show reduced inclination to vaccinate, which may reflect more fatalistic attitudes towards ageing and health (Sarkisian et al., 2002; Goodwin et al., 1999). Numeracy skills do not influence overall medication-taking propensity, although individuals with lower numeracy distinguish less clearly between risk profiles, consistent with prior evidence (Peters et al., 2006; Garcia-Retamero and Galesic, 2009). Other characteristics, including gender, family size, education, media usage, and income, do not seem to significantly affect medication-taking.

Taken together, these findings indicate that differences in medication-taking across vaccines and therapeutic treatments are driven not only by risk levels but also by how identical risk information is processed in preventive and high-salience contexts. In policy terms, our results suggest that, especially in high-salience settings such as the UK during the COVID-19 pandemic, public health campaigns should account for heterogeneities across illness type, medication type, and target population. Further research is needed to better understand how risk information is processed in different medical contexts, especially in settings with heightened uncertainty and salience.

However, our conclusions should be interpreted in light of two main limitations.

(1) External validity. The sample is not representative of the UK population, and our results should therefore be extrapolated to the population level with caution. In addition, the timing of the fieldwork (June 2021, immediately preceding the UK "Freedom Day") was characterized by intense media attention to COVID-19 and very limited circulation of other infectious diseases. This specific context likely shaped respondents' perceptions of medical risks and benefits, making our results particularly reflective of that historical moment. Consequently, the external validity of our findings is limited both by the composition of the Prolific sample and by the exceptional informational environment of the data-collection period.

(2) Internal validity. As our analysis is based on a stated-preference design rather than observed behaviour, hypothetical bias cannot be ruled out: respondents may overstate or understate their willingness to take a medication compared with real-world choices. Furthermore, what we interpret as ratio or bandwagon effects can also be viewed as manifestations of *salience bias*, whereby individuals over-weight highly visible or emotionally charged cues, such as side-effect information or social-proof signals, when forming judgements. These mechanisms, together with the specific salience of COVID-19 during our survey period, could amplify responses beyond what would be observed in neutral settings. Nonetheless, the internal validity of our estimates remains strong, as the fully balanced within-subject design and researcher-assigned vignette attributes ensure that observed differences across the four medical scenarios reflect systematic variation in stated preferences rather than uncontrolled confounders.

CRediT authorship contribution statement

Michele Cantarella: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Simona Cantarella:** Writing – review & editing, Conceptualization. **Francesca Zaninotto:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Methodology, Investigation, Conceptualization. **Massimo Riccaboni:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Methodology, Data curation, Conceptualization. **Giulia Galli:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Michele Cantarella reports administrative support was provided by European Union - Next Generation EU. The other authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Data

We collected data from 805 participants between June 18 and June 26, 2021, days surrounding the so-called "Freedom Day" (July 19, 2021) when the UK government lifted all COVID-19 restrictions. We aimed for a final sample size of approximately N=400 participants, similar to the group-level sample size of other studies on vaccination decisions (Vietri et al., 2012; Schwarzinger et al., 2021). We recruited double the number of participants to account for data loss and poor quality data obtained online (as recommended in Chandler et al., 2014).

The eligibility criteria were being above 18 years of age, native English speakers, and residents of the UK at the time of the survey. The language criteria were set to ensure that all participants had a similar verbal comprehension of the presented scenarios. Our study advert invited only individuals yet to receive the COVID-19 vaccination, although not all participants met this criterion (see Table 1). The survey was presented using Qualtrics, and data were collected using the Prolific platform. Participants provided informed consent on the initial screen of the online survey. The study was approved by the Kingston University Research Ethics Committee. The survey captures the following dimensions:

(i) Demographic and COVID-19-related questions. A set of basic demographic variables were collected, most of which we have included in our analysis. These are age, health status (on a 0–4 scale from "Very Bad" to "Very-Good"), gender, occupational status, education attainment, and presence of children in the household. Other variables of interest to our analysis concern the individual-specific experiences with the pandemic and the lockdown: among these, we include a simple

Table A.1
Treatments and risk factors.

Treatment	Risk profiles: / Side effects, Trials:	Low Low–High	Medium–Low Low–Low	Medium–High High–High	High High–Low
SeasVax	Side effects	33	26	780	875
	Trials	13,980,000	1,600,000	15,760,000	1,742,000
	Ratio	2.36e−06	1.62e−05	4.95e−05	5.02e−04
CoVax	Side effects	29	24	1010	1054
	Trials	17,800,000	1,570,000	18,500,000	2,100,000
	Ratio	1.63e−06	1.53e−05	5.46e−05	5.01e−04
CholTreat	Side effects	13	10	270	315
	Trials	6,102,000	599,000	5,630,000	635,500
	Ratio	2.13e−06	1.67e−05	4.80e−05	4.95e−04
CoTreat	Side effects	8	6	195	218
	Trials	3,495,000	400,000	3,940,000	435,500
	Ratio	2.29e−06	1.50e−05	4.95e−05	5.00e−04

Treatments and risk factor matrix from the stated choice experiment. Each treatment-risk factor combination constitutes an option. All options are offered to every respondent.

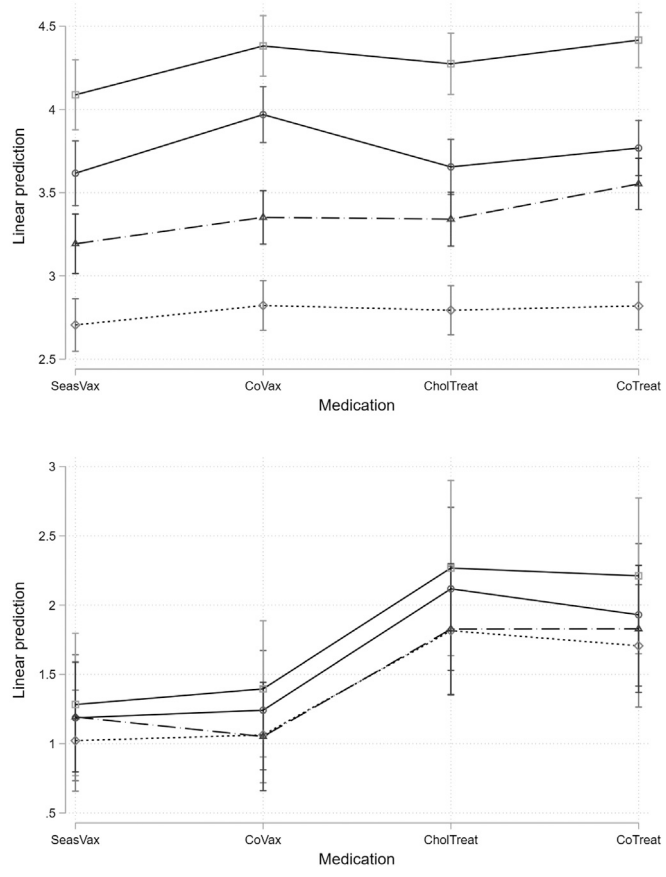

Fig. A.1. Average marginal medication-taking propensities by risk profile, over age cohorts.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: 20 years old. Bottom figure: 65 years old.

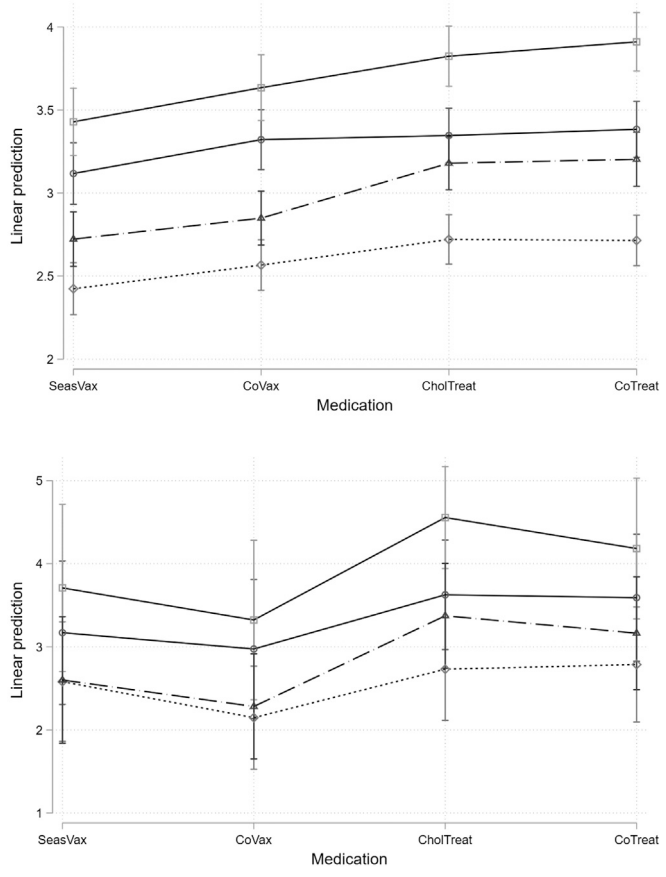

Fig. A.2. Average marginal medication-taking propensities by risk profile, over health cohorts.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: Very good health. Bottom figure: Very bad health.

dummy variable indicating whether the respondent has suffered from income losses during the pandemic, and a set of variables revealing the respondent's media diet.

(ii) Multiple Choice General Numeracy Scale (*MCGNS*, Hill et al., 2019). The scale consists of 11 items used to measure general numeracy skills. The scale is an adaptation of the General Numeracy Scale (Lipkus et al., 2001), which has been widely used to discriminate between people with high and low numeracy across a fairly large range of intellectual abilities. The MCGNS presents responses in multiple-choice format, making this scale easier to administer online and more useable for the general population sample (Hill et al., 2019). The rationale for measuring numeracy skills is that previous studies showed that individuals with high numeracy skills seem to be more resistant to the ratio and other biases, perhaps because they may be more likely to engage in rational (e.g., numerical) processing (Peters et al., 2006; Garcia-Retamero and Galesic, 2009).

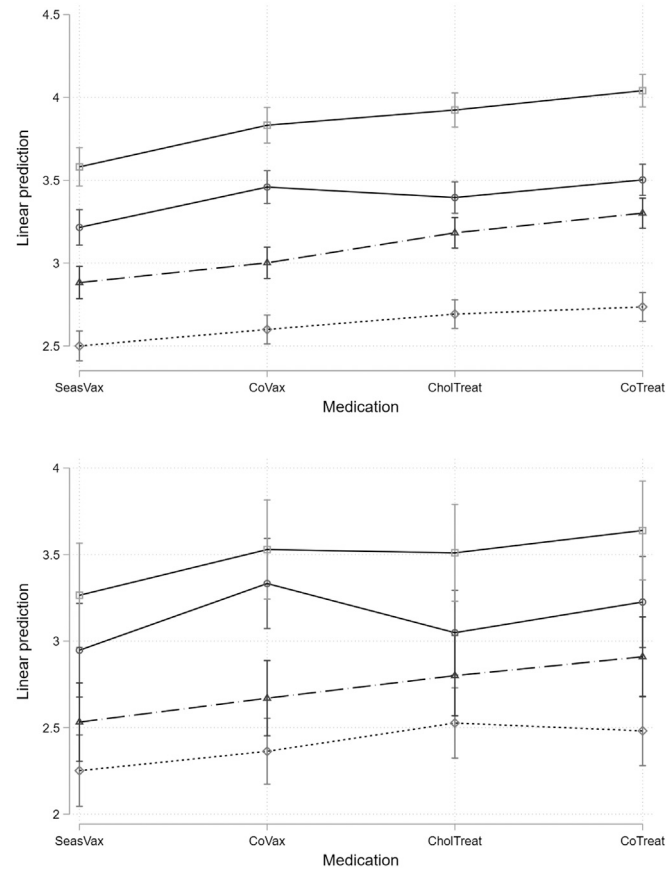

Fig. A.3. Average marginal medication-taking propensities by risk profile, over family cohorts.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: No children in the household. Bottom figure: children in the household.

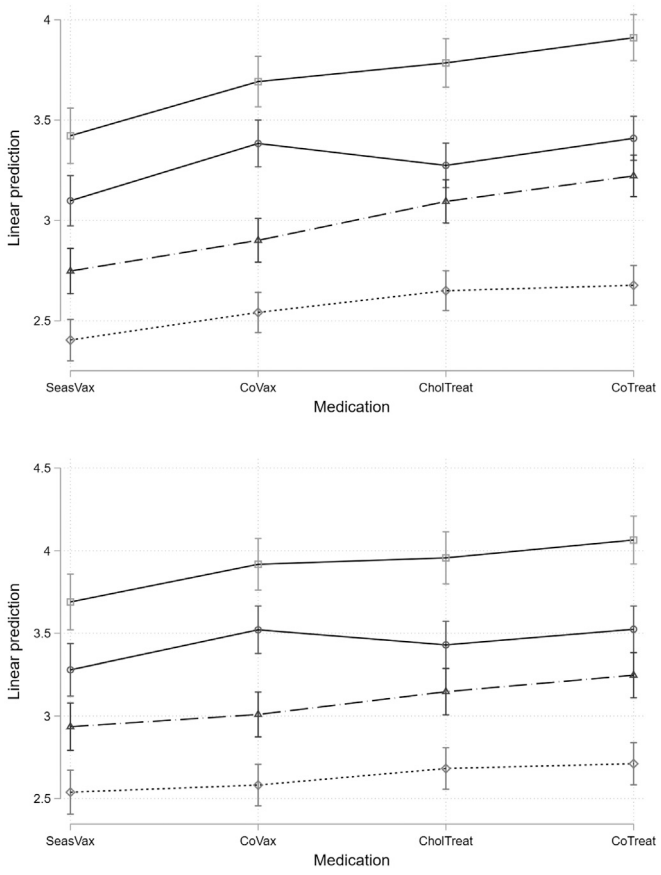

Fig. A.4. Average marginal medication-taking propensities by risk profile, over gender cohorts.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: female respondent. Bottom figure: male respondent.

(iii) Vaccination Attitude Examination Scale (*VAX*, Martin and Petrie, 2017) A 12-item scale used to measure general vaccination attitudes and identify individuals with vaccination resistance. It consists of four subscales: mistrust of vaccine benefits, worries about unforeseen future effects, concerns about commercial profiteering, and preference for natural immunity.

(iv) COVID-19 Anxiety Syndrome Scale (*C-19ASS*, Nikčević and Spada, 2020) A 9-item scale that measures the COVID-19 anxiety syndrome along two different dimensions related to the syndrome, perseverate thinking and avoidance.

(v) Experimental choice task. The experimental choice task consisted of four fictional medical scenarios, corresponding to four experimental conditions: seasonal influenza vaccination (*FluVax*, henceforth), COVID-19 vaccination (*CoVax*), cholesterol medication (*CholTreat*), and COVID-19 medication (*CoTreat*).

We used fictional yet credible scenarios to avoid any bias from pre-existing familiarity with currently available vaccinations, such as the Pfizer-BioNTech, Moderna, and Oxford-AstraZeneca COVID-19 vaccines. The structure of the scenarios was identical in the four conditions and is shown in Table A.1. Even though these are only fictional scenarios, previous research has shown that the same factors that drive hypothetical choices in survey experiments can predict comparable choices in the real world (Carlsson and Martinsson, 2003; Klüver et al., 2021; Hainmueller et al., 2015).

First, an opening sentence reported that the Medicines and Healthcare Products Regulatory Agency (MHRA) was reviewing four vaccines (Co-Vax and Flu-Vax conditions) or medications (Co-Treat or Chol-Treat conditions), already available in other countries. We avoided UK-based scenarios because participants might have been suspicious of COVID-19 vaccinations under review by the MHRA that they had not heard about before.

Each scenario next described the key mechanism of action of the product (viral vector for vaccinations and monoclonal antibodies for medications), followed by the product's efficacy, which was set to 95% in all scenarios, and a list of rare, severe side effects. The type of side effects differed between the scenarios to reflect the actual side effects reported in the literature.

Side effects and number of administrations linearly varied across the four options, resulting in four different profiles of risk of the product: (i) Low risk (0.0002%), with high denominator (administrations) and low numerator (side effects), (ii) Medium–Low risk (0.002%), with low denominator and low numerator, (iii) Medium–High risk (0.005%), with

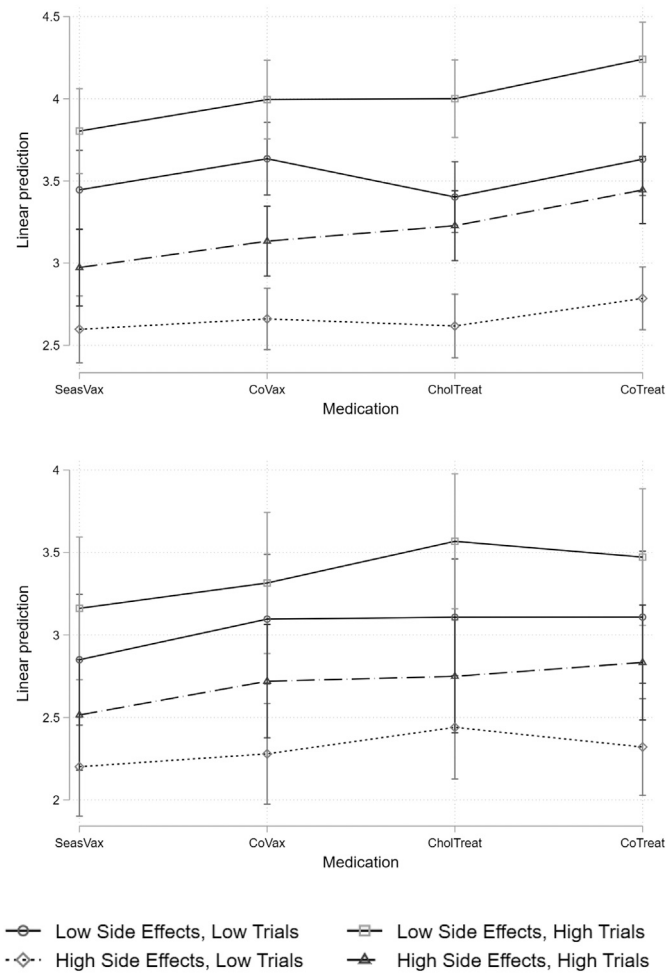

Fig. A.5. Average marginal medication-taking propensities by risk profile, over education cohorts.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: Master's or higher. Bottom figure: Secondary or lower.

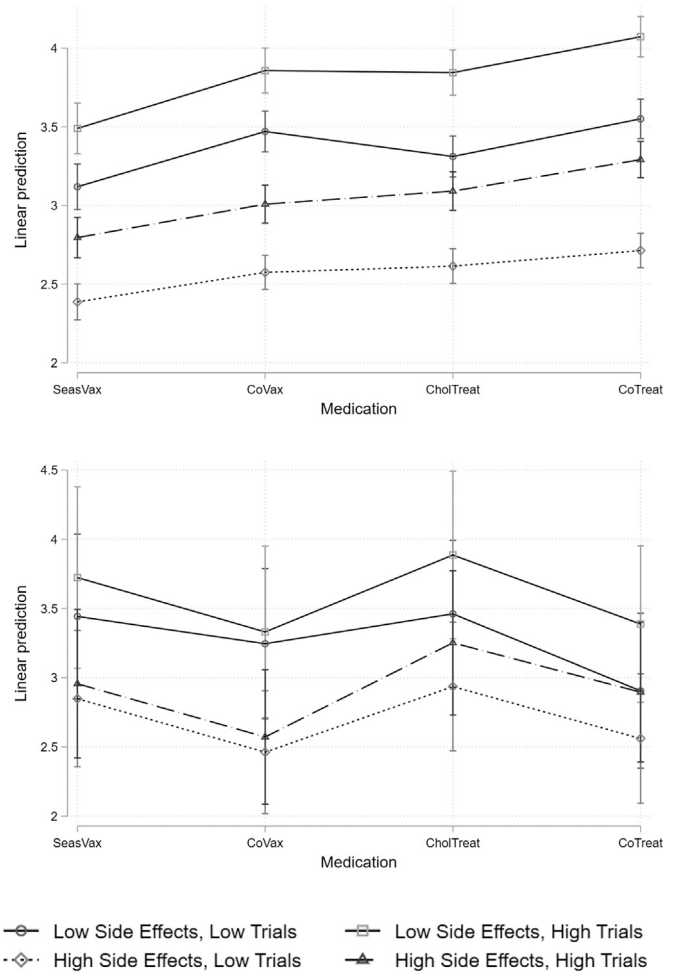

Fig. A.6. Average marginal medication-taking propensities by risk profile, over math ability cohorts.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: Highest math score. Bottom figure: Lowest math score.

high denominator and high numerator,[8] and (iv) High Risk (0.05%), with low denominator and high numerator.

The ratio was constant across the four scenarios, although the numbers varied to increase credibility, as shown in Table A.1.

Participants read the information about the number of administrations and side effects for each of the four vaccines. They were then asked to indicate their willingness to receive each vaccine in each scenario on a 5-point Likert scale, ranging from 'never' to 'very likely'.

The order of the options was randomized anew for each participant, and the scenarios were counterbalanced across subjects. The experiment employed a within-subject design, meaning all participants were exposed to all sixteen scenarios.

We hypothesized that participants using normative reasoning would prioritize their preferences based on the ratio of administrations to side effects, choosing from low to high-risk options. In contrast, participants with biased reasoning would ignore the ratio and focus solely on either the number of administrations or the side effects, depending on their specific bias.

On the one hand, participants with a bandwagon bias would focus on the number of administrations and prefer the options from the highest to the lowest denominator. On the other, participants with a ratio bias would focus on the number of side effects and prioritize the options from the lowest to the highest numerator.

Finally, the absolute, medication, and risk-profile-specific propensity to take a medication might vary depending on the idiosyncratic perceived risk of medication-taking and illness. We expect individuals who place little trust in medications to display lower medication-taking scores, while individuals who are anxious about falling ill should feature higher scores. From this point of view, the vaccination attitude and COVID-19 anxiety items can help proxy for these idiosyncratic sources of variation. We normalized both indicators on a scale from 0 to 5 for ease of interpretability. We collected data from 805 individuals. From this sample, we excluded 57 participants with one or no scenario completed (N=56) or no response in the "Have you been vaccinated for COVID-19" (N=1).

[8] Note that this corresponds to the rate of severe side effects observed after the administration of COVID-19 vaccine vaccinations as of Spring, 2021. Nature, April 2021, Why is it so hard to investigate the rare side effects of COVID vaccines?, https://www.nature.com/articles/d41586-021-00880-9, Last accessed: 24/11/2023.

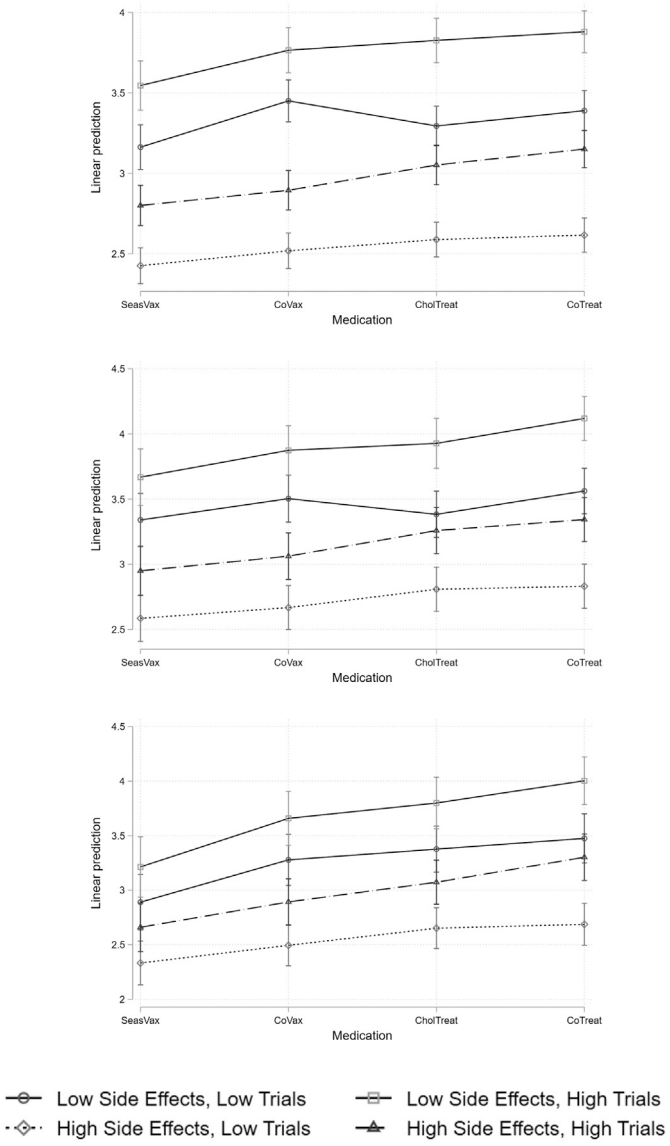

Fig. A.7. Average marginal medication-taking propensities by risk profile, over employment cohorts.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: Employed. Middle figure: Student. Bottom figure: Unemployed.

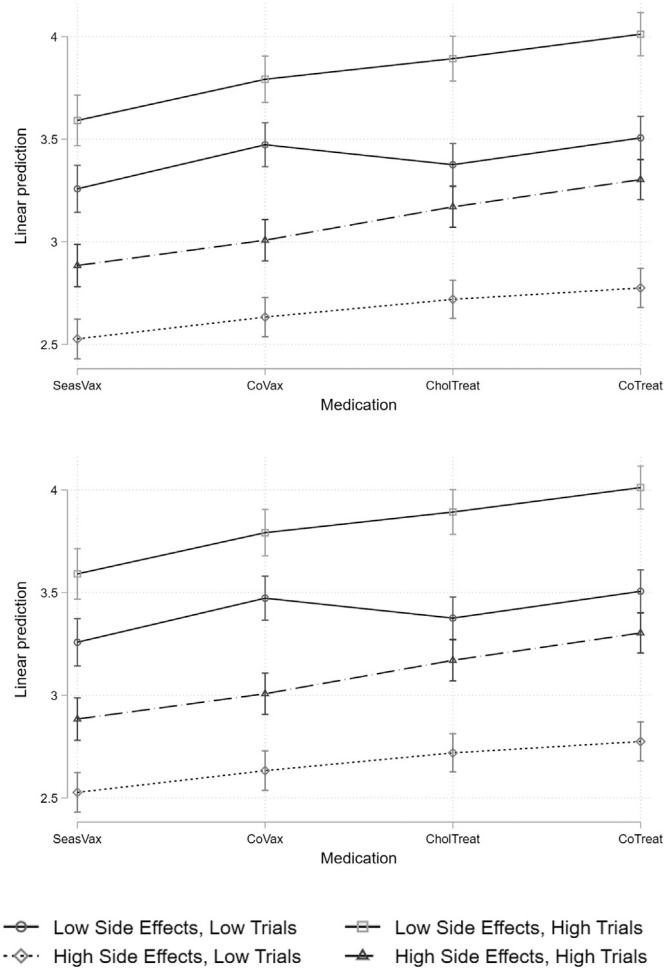

Fig. A.8. Average marginal medication-taking propensities by risk profile, over income cohorts.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: No income loss. Bottom figure: Small to significant income loss.

Appendix B. Individual-level moderators

This appendix presents additional results on heterogeneity across individual characteristics. These exploratory analyses complement the main results by assessing whether the core medication and risk-factor patterns vary across demographic and socio-economic groups.

We add a set of individual controls and their interactions with medication and risk factors to the interacted specification (2), which updates to model (3). While not strictly exogenous, these predictors predate medication-taking preferences and help indicate how specific groups respond to treatment suggestions. The results might not necessarily denote a causal channel but can indicate how specific groups of individuals respond to medication-taking suggestions, leaving the question of self-selection into these groups open.

We control for gender, age (and its squared term), education, employment status, and presence of dependent children. Health status (on a 5-point Likert scale) is included in a quadratic specification to account for non-linear responses. We also control for math ability based on the respondent's score in a set of math questions described in Appendix A. Additionally, we include controls for income losses during the pandemic and media usage (internet, social networks, television, and newspapers)[9] to capture how information exposure and responses to lockdown restrictions influence health-related attitudes and behaviours. Individual-level controls can be introduced as interactions in the fixed-effects model; however, as the individual term absorbs the base effect, we report results for the random-effects models only.

Full results are reported below in Appendix D, Table A.5. The table shows a single random effects specification equivalent to Eq. (3), including all interactions between individual variables and medication-risk factor fixed effects. Results for individual controls are in the

[9] These variables follow the scale: I do not do this activity; Once a week; 2–3 times per week; Less than 1 h per day; Between 1 and 3 h per day; More than 3 h per day.

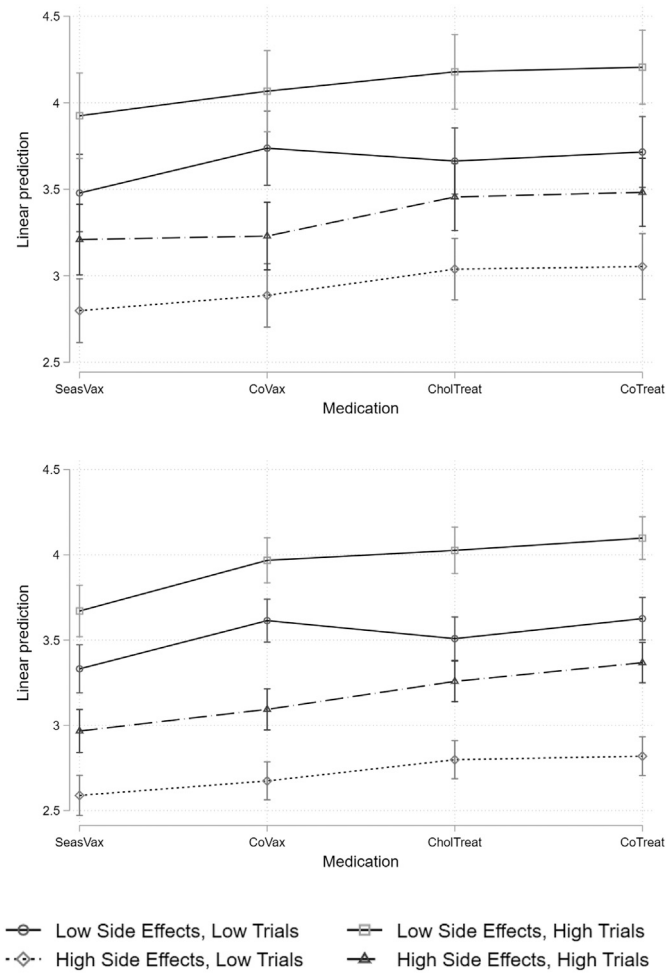

Fig. A.9. Average marginal medication-taking propensities by risk profile, over news consumption cohorts.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: Highest News Reading. Bottom figure: Highest Tv Use.

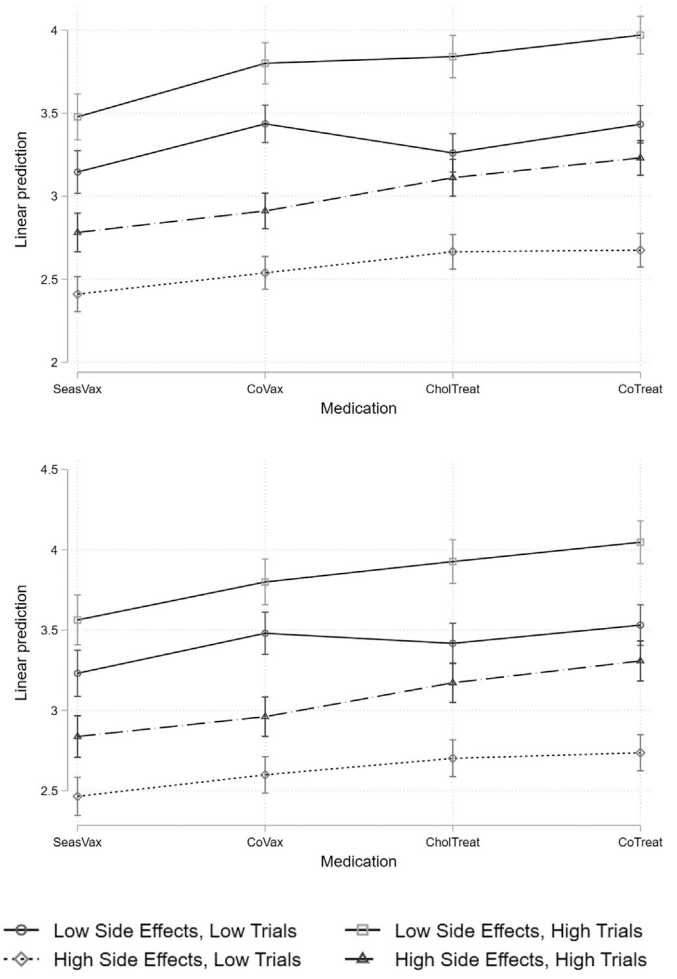

Fig. A.10. Average marginal medication-taking propensities by risk profile, over social network use cohorts.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: Highest Web Use. Bottom figure: Highest Social Network Use.

first column, while other columns display estimated coefficients for interactions with all fixed effects. Medication-taking preferences in response to each scenario and to each combination of risk factors are virtually unaffected by the inclusion of these controls. For a visual representation, see also Fig. A.13 in the Appendix, which plots the fitted values for medication-taking across medications and risk factors after including all controls. The fitted values remain unchanged from Fig. 2, indicating individual controls have little effect on the unconditional medication-taking preferences.

The results suggest few variables have a generalized and statistically significant (at the 0.1% level) effect on medication-taking. Much of the residual variation seems to be attributed to heterogeneities at the medication-risk factor level. However, the large set of interactions makes it difficult to provide a comprehensive view of our results from the table alone. Some statistically significant relationships might emerge only after taking all interactions into account.

We then produce marginal effects by fitting self-reported medication propensities over different cohorts. These marginal effects are displayed in the figures shown in this Section, and provide a more comprehensive insight into our results. To avoid clutter and to better illustrate the range of variation in the fitted values, we choose these cohorts based on the upper and lower bounds of each category, and, when the variable is continuous, we pick values corresponding to the approximate lower and upper deciles of its distribution. As all reported values are predicted from the parametric model estimated on the full sample, the figures should be interpreted as conditional fitted values (that is, smooth predictions evaluated at those representative points) rather than as estimates from separate subsamples.

We then analyse how medication-taking preferences change with individual characteristics by predicting outcomes at different levels of X_i using the estimated model parameters.

For age, Fig. A.1 shows fitted values for individuals aged 20 (top figure) and 65 (bottom). Younger respondents follow the expected pattern, with overall medication-taking preferences not different from our general results. Fitted values for older respondents are, however, much more different. Three patterns emerge: for these individuals, average medication-taking is several points lower and with higher variability; there is no difference between risk classes; and vaccine-type medications seem to feature lower propensity, which is often statistically significant at the 0.1% level notwithstanding the high standard error. These results are surprising because we would expect medication use to increase as the relative risk of illness rises with age.

This finding may be due to an age-related underestimation of illness risk or an overestimation of medication risk compared to younger peers. However, in Table A.3, in Appendix C, we regress all these controls on our COVID-19 anxiety and Vaccination attitude variables, and age does not appear to be related to either. Another possibility is that fatalistic outlooks might be more prevalent among older individuals.

The age effect might be captured by health status. In Fig. A.2, we show fitted values for individuals in very good (top figure) and very poor (bottom) health. While results for individuals in good health are nearly indistinguishable from the baseline, fitted values for individuals in bad health reveal much higher overall medication-taking scores, with almost no distinction between medications and risk profiles in a statistical sense, as their 95% confidence intervals overlap. These results suggest that the risk of illness far outweighs any concerns about medication type for individuals in poor health.

Gender-specific variation is shown in Fig. A.4, indicating slightly lower medication-taking for women, with no other significant patterns. The presence of children is associated with a generalized reduction in medication-taking, without any other notable patterns (Fig. A.3).

We now move away from the demographic variables to focus on education, occupation, and math ability. We show these results in Fig. A.5, where we show fitted values for individuals with a Master's degree or higher secondary (top figure) and lower education (bottom). Higher education levels exhibit similar patterns to the baseline, where, interestingly, the low side-effects preference, suggestive of a ratio bias, persists. For individuals with lower education, medication-taking is lower, but with almost no difference between medications. Differences between risk profiles are also far less pronounced, as the standard errors are quite high.

Fitted values conditional on math score are shown in Fig. A.6, with math score switched to its highest in the top figure and its lowest at the bottom. There is little difference from the baseline for the high-ability group, which includes the ratio bias effect. While the hierarchy between risk classes is preserved for the low-ability group, the standard errors get so large that differences between these risk classes are often statistically insignificant, with the 95% statistical confidence intervals intersecting. Medication-taking is also, on average, higher than in the general population results across all medications.

We have also treated occupation separately. In Fig. A.7, we plot medication-taking predictions conditional on occupation. We show that employed workers and students display behaviour that is not particularly different from the baseline, with students featuring only a stronger response overall. Unemployed workers, instead, feature a much more noticeable aversion to vaccine-type medications for a much steeper incline. While these results have no other remarkable qualities, the idea that the unemployed might be averse to vaccination as they are less likely to leave their homes for work is not new to the literature (Schmitz and Wübker, 2010).

Fitted values for income loss are also shown in Fig. A.8, showing no differences from the baseline, suggesting pandemic-related income shocks did not affect medication-taking preferences. Finally, we look at media usage in Figs. A.9 and A.10. Apart from an overall positive effect of TV Use and newspaper reading, and a negative one for web use, most medication-taking patterns are unchanged from our main results.

Appendix C. Additional results

See Figs. A.9–A.15 and Tables A.2–A.4.

Appendix D. Full regression results

See Tables A.5 and A.6.

Data availability

Data will be made available on request.

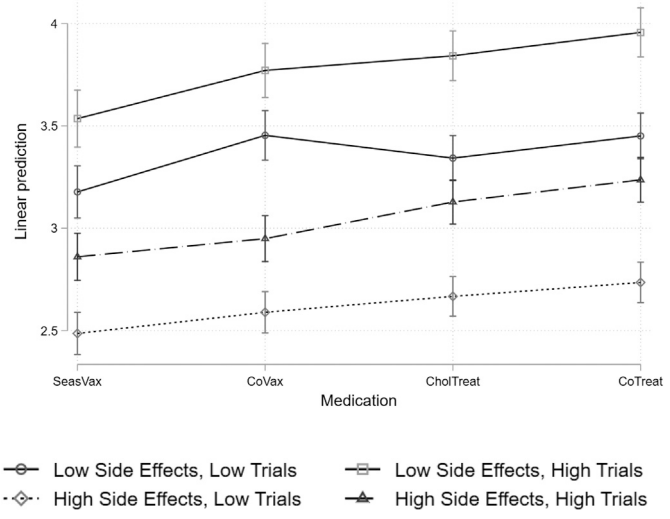

Fig. A.11. Average marginal medication-taking propensities by risk profile, net of previous COVID-19 infections.
Notes: Predictive margins with 95% confidence interval, fitted from model (3), adding COVID-19 infection or symptoms to the vector X_i and predicting fitted values for individuals who did not have any infection or symptom.

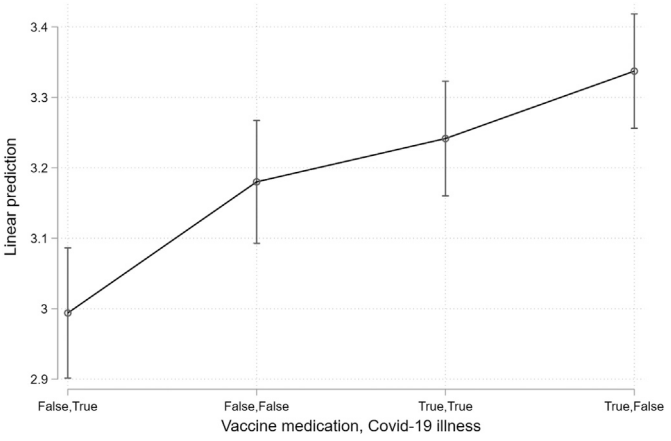

Fig. A.12. Average marginal medication-taking propensities, disaggregated by illness and medication type.
Notes: Predictive margins with 95% confidence interval, fitted from model (1), with medications replaced by 2 × 2 matrix of medication and illness types.

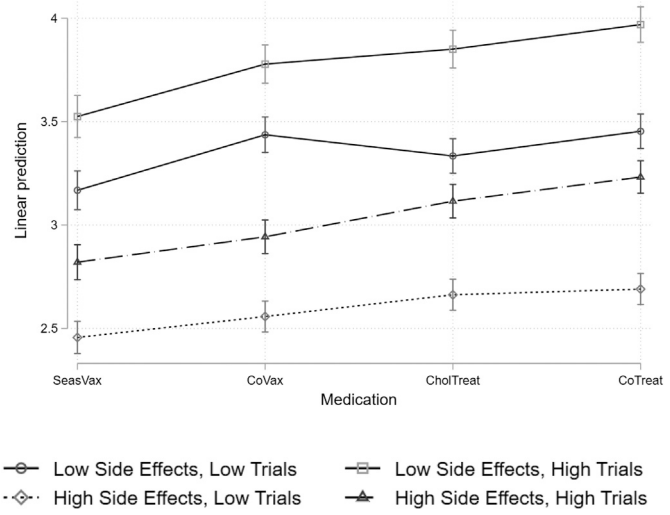

Fig. A.13. Average marginal medication-taking propensities by risk profile, net of individual characteristics.
Notes: Predictive margins with 95% confidence interval, fitted from model (3), with individual-level exogenous controls in X_i.

Table A.2
Treatment-taking estimates by treatment and illness type.

	(1) R.E.	(2) R.E.
Covid-19 illness	0.096**	0.120**
	(0.031)	(0.038)
Vaccine treatment	−0.248***	−0.164***
	(0.034)	(0.042)
Covid-19 illness × Vaccine treatment	0.090*	0.148**
	(0.036)	(0.046)
High Side Effects	−0.755***	−0.669***
	(0.026)	(0.031)
High Trials	0.432***	0.517***
	(0.019)	(0.028)
High Side Effects × High Trials	0.002	−0.066*
	(0.020)	(0.031)
Covid-19 illness × High Side Effects		−0.093**
		(0.032)
Vaccine treatment × High Side Effects		−0.042
		(0.033)
Covid-19 illness × Vaccine treatment × High Side Effects		−0.074
		(0.041)
Covid-19 illness × High Trials		−0.002
		(0.030)
Vaccine treatment × High Trials		−0.161***
		(0.032)
Covid-19 illness × Vaccine treatment × High Trials		−0.013
		(0.040)
Covid-19 illness × High Side Effects × High Trials		0.091*
		(0.040)
Vaccine treatment × High Side Effects × High Trials		0.072
		(0.038)
Covid-19 illness × Vaccine treatment × High Side Effects × High Trials		−0.055
		(0.053)
Constant	3.402***	3.334***
	(0.045)	(0.046)
Within R-squared	0.268	0.271
Between R-squared	0.000	0.000
Overall R-squared	0.107	0.108
Intraclass correlation	0.652	0.652
N	11,949	11,949

SE clustered by ID.
* p<.05.
** p<.01.
*** p<.001.

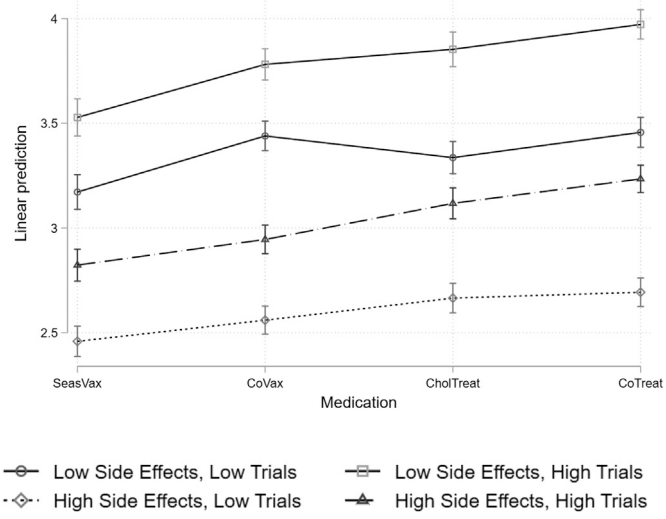

Fig. A.14. Average marginal medication-taking propensities by risk profile, net of COVID-19 anxiety and Vaccination Attitude. Notes: Predictive margins with 95% confidence interval, fitted from model (3).

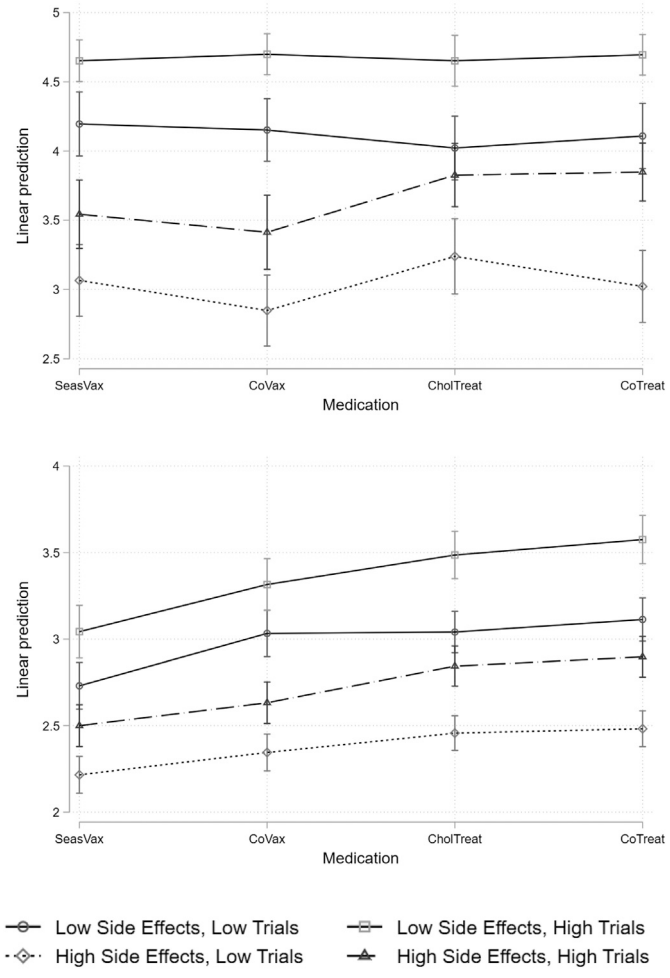

Fig. A.15. Average marginal medication-taking propensities by risk profile, over vaccination history cohorts.
Notes: Predictive margins with 95% confidence interval, fitted from model (3). Top figure: took both the COVID-19 and the Influenza vaccine. Bottom figure: took neither the COVID-19 nor the Influenza vaccine.

Table A.3
COVID-19 anxiety and Vaccine confidence, individual predictors.

	(1) OLS Vaccination attitude	(2) OLS COVID-19 anxiety
Age	−0.036	−0.017
	(0.024)	(0.028)
Age × Age	−0.000	−0.000
	(0.000)	(0.000)
Health status	0.097	−0.448*
	(0.215)	(0.194)
Health status × Health status	−0.031	0.066
	(0.039)	(0.035)
Gender: Male	0.046	−0.112
	(0.081)	(0.079)
Children in hh.	−0.471***	−0.063
	(0.119)	(0.113)
Student	0.358***	0.002
	(0.106)	(0.105)
Unemployed	0.105	−0.102
	(0.108)	(0.103)
Educ.: A-levels or equivalent	0.056	−0.142
	(0.149)	(0.163)
Educ.: Bachelor's or equivalent	0.345*	0.136
	(0.151)	(0.163)
Master's or higher	0.447**	0.127
	(0.167)	(0.175)
Math score	0.086***	−0.023
	(0.024)	(0.025)
C-19 income loss	−0.106	0.077
	(0.076)	(0.072)
News use	0.126***	0.114***
	(0.034)	(0.032)
Social Network use	0.004	0.051
	(0.031)	(0.030)
Web use	0.074	0.066
	(0.042)	(0.042)
Tv use	0.034	0.049
	(0.026)	(0.025)
Constant	1.892**	2.219**
	(0.629)	(0.678)
Adjusted R-squared	0.318	0.108
N	745	746

SE clustered by ID.
* p<.05.
** p<.01.
*** p<.001.

Table A.4
Treatment-taking estimates, vaccination behaviour.

	(1) R.E.															
Vaccine:		SeasVax	CoVax	CoTreat		SeasVax	CoVax	CoTreat		SeasVax	CoVax	CoTreat		SeasVax	CoVax	CoTreat
Side effects:					High	High	High	High					High	High	High	High
Trials:									High	High	High	High	High	High	High	High
Vaccined vs. COVID-19	0.665***	0.200	0.449***	0.229*	−0.306***	−0.208*	−0.330***	−0.114	0.180*	−0.014	−0.021	−0.016	−0.022	0.058	0.150	0.208
	(0.109)	(0.118)	(0.103)	(0.105)	(0.087)	(0.094)	(0.090)	(0.091)	(0.074)	(0.084)	(0.078)	(0.081)	(0.094)	(0.110)	(0.108)	(0.111)
Vaccined vs. Influenza	0.856***	0.607***	0.162	0.041	−0.138	−0.355***	−0.144	−0.066	0.209*	−0.168	−0.104	−0.089	−0.028	0.219	0.136	0.184
	(0.108)	(0.094)	(0.110)	(0.101)	(0.092)	(0.099)	(0.115)	(0.100)	(0.089)	(0.104)	(0.095)	(0.085)	(0.100)	(0.120)	(0.140)	(0.134)
Interaction	−0.541**	−0.323	−0.473*	−0.255	0.245	0.147	0.056	−0.077	−0.203	0.142	0.204	0.045	0.066	−0.242	−0.288	−0.122
	(0.183)	(0.191)	(0.198)	(0.168)	(0.188)	(0.232)	(0.255)	(0.206)	(0.167)	(0.194)	(0.209)	(0.183)	(0.208)	(0.255)	(0.303)	(0.271)
Constant	3.041***	−0.310***	−0.008	0.073	−0.583***	0.069	−0.104**	−0.048	0.445***	−0.133***	−0.163***	0.016	−0.058	0.030	0.063	0.012
	(0.061)	(0.054)	(0.057)	(0.050)	(0.038)	(0.036)	(0.040)	(0.037)	(0.033)	(0.039)	(0.035)	(0.037)	(0.034)	(0.042)	(0.043)	(0.046)
Within R-squared	0.294															
Between R-squared	0.164															
Overall R-squared	0.217															
Intraclass correlation	0.617															
N	11,949															

SE clustered by ID. Cholesterol treatment as base level.

* p<.05.

** p<.01.

*** p<.001.

Table A.5
Treatment-taking estimates, individual predictors.

	(1) R.E.															
Vaccine:		SeasVax	CoVax	CoTreat		SeasVax	CoVax	CoTreat		SeasVax	CoVax	CoTreat		SeasVax	CoVax	CoTreat
Side effects:					High	High	High	High					High	High	High	High
Trials:									High	High	High	High	High	High	High	High
Age	−0.044	−0.003	−0.020	0.018	0.044	−0.006	0.009	−0.010	−0.015	−0.009	0.002	−0.017	0.006	−0.013	−0.020	−0.017
	(0.031)	(0.031)	(0.030)	(0.030)	(0.026)	(0.026)	(0.027)	(0.026)	(0.017)	(0.021)	(0.020)	(0.019)	(0.019)	(0.024)	(0.026)	(0.026)
Age^2	0.000	−0.000	−0.000	0.000	−0.000	−0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	−0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Health status	−0.211	0.258	0.637**	0.184	0.108	−0.209	−0.263	−0.171	−0.245	0.164	0.267	0.183	0.110	0.268	0.137	0.116
	(0.247)	(0.258)	(0.241)	(0.217)	(0.157)	(0.194)	(0.181)	(0.174)	(0.181)	(0.227)	(0.210)	(0.226)	(0.179)	(0.248)	(0.277)	(0.258)
Health $status^2$	0.035	−0.050	−0.120**	−0.041	−0.010	0.029	0.053	0.034	0.033	−0.027	−0.041	−0.021	−0.010	−0.052	−0.040	−0.035
	(0.045)	(0.045)	(0.044)	(0.038)	(0.030)	(0.035)	(0.035)	(0.032)	(0.033)	(0.039)	(0.038)	(0.040)	(0.033)	(0.044)	(0.050)	(0.047)
Gender: Male	0.155	0.026	−0.018	−0.040	−0.123	0.076	0.026	0.042	0.016	0.070	0.072	0.022	0.004	−0.037	−0.023	−0.052
	(0.096)	(0.089)	(0.090)	(0.083)	(0.068)	(0.070)	(0.073)	(0.067)	(0.061)	(0.069)	(0.066)	(0.066)	(0.070)	(0.082)	(0.088)	(0.088)
Dep. children in hh.	−0.347*	0.079	0.221	0.070	0.182*	−0.162	−0.291**	−0.159	−0.067	0.020	−0.109	−0.057	−0.150	0.096	0.231*	0.136
	(0.140)	(0.138)	(0.134)	(0.126)	(0.083)	(0.092)	(0.101)	(0.087)	(0.077)	(0.088)	(0.092)	(0.083)	(0.086)	(0.103)	(0.115)	(0.112)
Student	0.089	0.088	−0.036	0.084	0.132	−0.149	−0.035	−0.088	0.012	−0.067	0.044	0.054	−0.026	0.071	−0.012	−0.064
	(0.118)	(0.117)	(0.114)	(0.104)	(0.094)	(0.100)	(0.104)	(0.097)	(0.079)	(0.091)	(0.083)	(0.086)	(0.094)	(0.116)	(0.119)	(0.119)
Unemployed	0.082	−0.354**	−0.255	0.003	−0.018	0.197*	0.167	0.004	−0.109	0.049	0.174*	0.147	0.067	−0.053	−0.110	−0.024
	(0.124)	(0.136)	(0.132)	(0.115)	(0.087)	(0.092)	(0.099)	(0.090)	(0.071)	(0.082)	(0.085)	(0.084)	(0.086)	(0.096)	(0.124)	(0.118)
Educ.: A-levels or equivalent	0.155	0.091	0.081	0.101	0.002	−0.049	−0.030	0.043	0.026	0.041	0.114	0.070	0.137	−0.111	−0.350*	−0.288
	(0.194)	(0.210)	(0.197)	(0.184)	(0.140)	(0.155)	(0.152)	(0.159)	(0.114)	(0.163)	(0.159)	(0.136)	(0.134)	(0.171)	(0.173)	(0.179)
Educ.: Bachelor's or equivalent	0.311	0.032	0.118	0.117	0.030	−0.069	−0.100	0.009	0.066	−0.033	0.056	0.133	0.028	−0.046	−0.229	−0.154
	(0.194)	(0.211)	(0.196)	(0.184)	(0.140)	(0.157)	(0.151)	(0.162)	(0.116)	(0.168)	(0.165)	(0.141)	(0.135)	(0.174)	(0.180)	(0.181)
Educ.: Master's or higher	0.295	0.301	0.244	0.229	−0.118	−0.082	−0.040	0.058	0.138	−0.092	0.003	0.106	0.163	−0.148	−0.272	−0.260
	(0.212)	(0.224)	(0.214)	(0.194)	(0.156)	(0.169)	(0.168)	(0.174)	(0.123)	(0.177)	(0.175)	(0.154)	(0.146)	(0.192)	(0.197)	(0.208)
Math score	−0.014	−0.016	0.034	0.072**	−0.016	0.003	0.005	−0.029	0.010	−0.002	0.018	−0.006	0.005	0.014	−0.003	0.014
	(0.029)	(0.028)	(0.028)	(0.025)	(0.021)	(0.023)	(0.022)	(0.024)	(0.020)	(0.023)	(0.022)	(0.021)	(0.022)	(0.029)	(0.027)	(0.030)
C-19 income loss	−0.115	−0.135	0.014	−0.031	−0.042	0.096	−0.066	−0.046	−0.000	0.066	0.063	0.030	0.005	−0.054	−0.039	0.002
	(0.089)	(0.086)	(0.085)	(0.076)	(0.064)	(0.069)	(0.075)	(0.065)	(0.058)	(0.069)	(0.062)	(0.063)	(0.065)	(0.082)	(0.087)	(0.085)
News use	0.134***	−0.008	−0.011	−0.027	0.019	−0.006	−0.008	0.022	−0.000	0.037	−0.005	−0.010	−0.014	−0.004	0.002	−0.022
	(0.038)	(0.036)	(0.035)	(0.033)	(0.027)	(0.027)	(0.028)	(0.025)	(0.024)	(0.028)	(0.026)	(0.026)	(0.027)	(0.033)	(0.034)	(0.033)
Social Network use	0.062	−0.015	−0.029	−0.004	−0.033	−0.008	0.031	0.010	−0.006	−0.013	−0.011	0.006	0.019	0.006	−0.020	0.003
	(0.036)	(0.036)	(0.039)	(0.035)	(0.024)	(0.026)	(0.031)	(0.027)	(0.024)	(0.027)	(0.024)	(0.026)	(0.025)	(0.028)	(0.033)	(0.031)
Web use	−0.101	0.070	0.100*	0.073	0.104**	−0.136**	−0.129**	−0.098**	0.087*	−0.121*	−0.056	−0.059	−0.095*	0.139**	0.047	0.087
	(0.052)	(0.053)	(0.048)	(0.042)	(0.040)	(0.044)	(0.043)	(0.037)	(0.040)	(0.048)	(0.035)	(0.042)	(0.040)	(0.054)	(0.048)	(0.056)
Tv use	0.108***	−0.007	0.002	−0.001	−0.024	0.005	−0.014	−0.003	0.000	−0.011	0.007	−0.028	0.004	0.016	0.010	0.027
	(0.031)	(0.030)	(0.030)	(0.027)	(0.020)	(0.021)	(0.023)	(0.021)	(0.020)	(0.022)	(0.022)	(0.021)	(0.021)	(0.025)	(0.026)	(0.026)
Constant	3.968***	−0.314	−0.785	−1.348	−2.022**	1.120	0.489	0.935	0.753	0.350	−0.634	0.285	−0.053	−0.890	0.578	−0.006
	(0.788)	(0.866)	(0.749)	(0.743)	(0.630)	(0.710)	(0.653)	(0.617)	(0.517)	(0.631)	(0.524)	(0.603)	(0.556)	(0.752)	(0.730)	(0.717)
Within R-squared	0.316															
Between R-squared	0.286															
Overall R-squared	0.298															
Intraclass correlation	0.585															
N	11,917															

SE clustered by ID. Cholesterol treatment as base level.

* p<.05.

** p<.01.

*** p<.001.

Table A.6
Treatment-taking estimates, vaccine confidence and Covid-19 anxiety.

	(1) R.E.															
Vaccine:		SeasVax	CoVax	CoTreat		SeasVax	CoVax	CoTreat		SeasVax	CoVax	CoTreat		SeasVax	CoVax	CoTreat
Side effects:					High	High	High	High					High	High	High	High
Trials:									High	High	High	High	High	High	High	High
COVID-19 anxiety	0.051	0.102	0.309**	0.302**	−0.106	0.053	−0.173*	−0.048	0.105	0.041	−0.040	−0.005	−0.070	−0.126	0.029	0.003
	(0.100)	(0.095)	(0.111)	(0.115)	(0.066)	(0.069)	(0.082)	(0.076)	(0.061)	(0.067)	(0.061)	(0.073)	(0.062)	(0.079)	(0.075)	(0.090)
Vaccination attitude	0.449***	0.191**	0.402***	0.285***	−0.179***	−0.049	−0.186***	−0.068	0.218***	−0.063	−0.045	−0.027	−0.047	−0.013	0.046	0.052
	(0.061)	(0.063)	(0.062)	(0.058)	(0.046)	(0.049)	(0.049)	(0.045)	(0.036)	(0.041)	(0.036)	(0.041)	(0.042)	(0.046)	(0.049)	(0.049)
Interaction	0.029	−0.008	−0.094**	−0.101**	0.030	−0.034	0.047	0.015	−0.043*	0.001	0.013	0.008	0.030	0.039	−0.002	0.003
	(0.030)	(0.030)	(0.033)	(0.034)	(0.023)	(0.024)	(0.026)	(0.025)	(0.020)	(0.022)	(0.020)	(0.024)	(0.022)	(0.026)	(0.027)	(0.029)
Constant	1.810***	−0.849***	−1.076***	−0.672***	−0.137	0.194	0.372**	0.103	−0.045	−0.069	−0.046	0.038	0.024	0.127	−0.067	−0.080
	(0.177)	(0.175)	(0.185)	(0.177)	(0.117)	(0.116)	(0.123)	(0.118)	(0.094)	(0.102)	(0.094)	(0.111)	(0.102)	(0.114)	(0.114)	(0.131)
Within R-squared	0.315															
Between R-squared	0.540															
Overall R-squared	0.451															
Intraclass correlation	0.468															
N	11,933															

SE clustered by ID. Cholesterol treatment as base level.

* p<.05.

** p<.01.

*** p<.001.

References

Antonopoulou, V., Goffe, L., Meyer, C.J., Grimani, A., Graham, F., Lecouturier, J., Tang, M.Y., Chadwick, P., Sniehotta, F.F., 2022. A comparison of seasonal influenza and novel COVID-19 vaccine intentions: A cross-sectional survey of vaccine hesitant adults in England during the 2020 pandemic. Hum. Vaccines Immunother. 18 (5).

Azarpanah, H., Farhadloo, M., Vahidov, R., Pilote, L., 2021. Vaccine hesitancy: evidence from an adverse events following immunization database, and the role of cognitive biases. BMC Public Health 21 (1), 1–13.

Bedford, H., Attwell, K., Danchin, M., Marshall, H., Corben, P., Leask, J., 2018. Vaccine hesitancy, refusal and access barriers: The need for clarity in terminology. Vaccine 36 (44), 6556–6558.

Bendau, A., Plag, J., Petzold, M.B., Ströhle, A., 2021. COVID-19 vaccine hesitancy and related fears and anxiety. Int. Immunopharmacol. 97, 107724.

Betsch, C., Böhm, R., Chapman, G.B., 2015. Using behavioral insights to increase vaccination policy effectiveness. Policy Insights Behav. Brain Sci. 2 (1), 61–73.

Betsch, C., Renkewitz, F., Haase, N., 2012. Effect of narrative reports about vaccine adverse events and bias-awareness disclaimers on vaccine decisions: A simulation of an online patient social network. Med. Decis. Making 33 (1), 14–25.

Bliemer, M.C.J., Rose, J.M., 2024. Designing and conducting stated choice experiments. In: Handbook of Choice Modelling. Edward Elgar Publishing, pp. 172–205.

Böhm, R., Betsch, C., Korn, L., 2016. Selfish-rational non-vaccination: Experimental evidence from an interactive vaccination game. J. Econ. Behav. Organ. 131, 183–195.

Bordalo, P., Gennaioli, N., Shleifer, A., 2012. Salience theory of choice under risk. Q. J. Econ. 127, 1243–1285.

Brewer, N.T., Chapman, G.B., Gibbons, F.X., Gerrard, M., McCaul, K.D., Weinstein, N.D., 2007. Meta-analysis of the relationship between risk perception and health behavior: The example of vaccination. Health Psychol. 26 (2), 136–145.

Ferrer-i Carbonell, A., Frijters, P., 2004. How important is methodology for the estimates of the determinants of happiness? Econ. J. 114 (497), 641–659.

Carlsson, F., Martinsson, P., 2003. Design techniques for stated preference methods in health economics. Health Economics 12 (4), 281–294.

Chandler, J., Mueller, P., Paolacci, G., 2014. Nonnaïveté among amazon mechanical turk workers: Consequences and solutions for behavioral researchers. Behav. Res. Methods 46 (1), 112–130.

Colman, A., 2003. Group think: bandwagon effect. In: Oxford Dictionary of Psychology, vol. 77.

Denes-Raj, V., Epstein, S., Cole, J., 1995. The generality of the ratio-bias phenomenon. Pers. Soc. Psychol. Bull. 21 (10), 1083–1092.

DiBonaventura, M.d., Chapman, G.B., 2008. Do decision biases predict bad decisions? Omission bias, naturalness bias, and influenza vaccination. Med. Decis. Making 28 (4), 532–539.

Diks, M.E., Hiligsmann, M., Van der Putten, I.M., 2021. Vaccine preferences driving vaccine-decision making of different target groups: a systematic review of choice-based experiments. BMC Infect. Dis. 21 (1), 879.

Fox, C.R., Tversky, A., 1995. Ambiguity aversion and comparative ignorance. Q. J. Econ. 110 (3), 585–603.

Garcia-Retamero, R., Galesic, M., 2009. Communicating treatment risk reduction to people with low numeracy skills: a cross-cultural comparison. Am. J. Public Health 99 (12), 2196–2202.

Garrouste, C., Juet, A., Samson, A.-L., 2023. Direct and crowding-out effects of a hepatitis b vaccination campaign. Econ. Hum. Biology 51, 101279.

Goodwin, J.S., Black, S.A., Satish, S., 1999. Aging versus disease: The opinions of older black, hispanic, and non-hispanic white Americans about the causes and treatment of common medical conditions. J. Am. Geriatr. Soc. 47 (8), 973–979.

Hainmueller, J., Hangartner, D., Yamamoto, T., 2015. Validating vignette and conjoint survey experiments against real-world behavior. Proc. Natl. Acad. Sci. 112 (8), 2395–2400.

Hershey, J.C., Asch, D.A., Thumasathit, T., Meszaros, J., Waters, V.V., 1994. The roles of altruism, free riding, and bandwagoning in vaccination decisions. Organ. Behav. Hum. Decis. Process. 59 (2), 177–187.

Hill, W.T., Brase, G.L., Kenney, K.L., 2019. Developing a better and more user-friendly numeracy scale for patients. HLRP: Health Lit. Res. Pr. 3 (3).

Huang, Y., Feng, S., Zhao, Y., Wang, H., Jiang, H., 2024. Preferences for COVID-19 vaccines: systematic literature review of discrete choice experiments. JMIR Public Health Surveill. 10, e56546.

Kahneman, D., Slovic, P., Tversky, A., 1982. Judgment Under Uncertainty: Heuristics and Biases. Cambridge University Press.

Kahneman, D., Tversky, A., et al., 1979. Prospect theory: An analysis of decision under risk. Econometrica 47 (2), 363–391.

Kaplan, R.M., Milstein, A., 2021. Influence of a COVID-19 vaccine's effectiveness and safety profile on vaccination acceptance. Proc. Natl. Acad. Sci. 118 (10), e2021726118.

Kessels, R., Luyten, J., Tubeuf, S., 2021. Willingness to get vaccinated against COVID-19 and attitudes toward vaccination in general. Vaccine 39 (33), 4716–4722.

Kibbey, M.M., Fedorenko, E.J., Farris, S.G., 2021. Anxiety, depression, and health anxiety in undergraduate students living in initial US outbreak "hotspot" during COVID-19 pandemic. Cogn. Behav. Ther. 50 (5), 409–421.

Klüver, H., Hartmann, F., Humphreys, M., Geissler, F., Giesecke, J., 2021. Incentives can spur COVID-19 vaccination uptake. Proc. Natl. Acad. Sci. 118 (36).

Klüwer, B., Margrethe Rydland, K., Nybru Gleditsch, R., Mamelund, S.-E., Laake, I., 2023. Social and demographic patterns of influenza vaccination coverage in Norway, influenza seasons 2014/15 to 2020/21. Vaccine 41 (6), 1239–1246.

Kreps, S., Prasad, S., Brownstein, J.S., Hswen, Y., Garibaldi, B.T., Zhang, B., Kriner, D.L., 2020. Factors associated with US adults' likelihood of accepting COVID-19 vaccination. JAMA Netw. Open 3 (10), e2025594–e2025594.

Leng, A., Maitland, E., Wang, S., Nicholas, S., Liu, R., Wang, J., 2021. Individual preferences for COVID-19 vaccination in China. Vaccine 39 (2), 247–254.

Lipkus, I.M., Samsa, G., Rimer, B.K., 2001. General performance on a numeracy scale among highly educated samples. Med. Decis. Making 21 (1), 37–44, PMID: 11206945.

Loewenstein, G.F., Weber, E.U., Hsee, C.K., Welch, N., 2001. Risk as feelings. Psychol. Bull. 127 (2), 267.

Luo, J., Wang, P., Li, Z., Cao, W., Liu, H., Meng, L., Sun, J., 2021. Health anxiety and its correlates in the general Chinese population during the COVID-19 epidemic. Front. Psychiatry 12.

Martin, L.R., Petrie, K.J., 2017. Understanding the dimensions of anti-vaccination attitudes: The vaccination attitudes examination (VAX) scale. Ann. Behav. Med. 51 (5), 652–660.

Murphy, J., Vallières, F., Bentall, R.P., Shevlin, M., McBride, O., Hartman, T.K., McKay, R., Bennett, K., Mason, L., Gibson-Miller, J., Levita, L., Martinez, A.P., Stocks, T.V.A., Karatzias, T., Hyland, P., 2021. Psychological characteristics associated with COVID-19 vaccine hesitancy and resistance in Ireland and the United Kingdom. Nat. Commun. 12 (1).

Nikčević, A.V., Marino, C., Kolubinski, D.C., Leach, D., Spada, M.M., 2021. Modelling the contribution of the big five personality traits, health anxiety, and COVID-19 psychological distress to generalised anxiety and depressive symptoms during the COVID-19 pandemic. J. Affect. Disord. 279, 578–584.

Nikčević, A.V., Spada, M.M., 2020. The COVID-19 anxiety syndrome scale: Development and psychometric properties. Psychiatry Res. 292, 113322.

Peters, E., Västfjäll, D., Slovic, P., Mertz, C., Mazzocco, K., Dickert, S., 2006. Numeracy and decision making. Psychol. Sci. 17 (5), 407–413.

Pomares, T.D., Buttenheim, A.M., Amin, A.B., Joyce, C.M., Porter, R.M., Bednarczyk, R.A., Omer, S.B., 2020. Association of cognitive biases with human papillomavirus vaccine hesitancy: A cross-sectional study. Hum. Vaccines Immunother. 16 (5), 1018–1023.

Rosenstock, I.M., 1974. Historical origins of the health belief model. Health Educ. Monogr. 2 (4), 328–335.

Sarkisian, C.A., Hays, R.D., Mangione, C.M., 2002. Do older adults expect to age successfully? The association between expectations regarding aging and beliefs regarding healthcare seeking among older adults. J. Am. Geriatr. Soc. 50 (11), 1837–1843.

Schmitz, H., Wübker, A., 2010. What determines influenza vaccination take-up of elderly Europeans? Health Econ. 20 (11), 1281–1297.

Schwarzinger, M., Watson, V., Arwidson, P., Alla, F., Luchini, S., 2021. COVID-19 vaccine hesitancy in a representative working-age population in France: a survey experiment based on vaccine characteristics. Lancet Public Health 6 (4), e210–e221.

Shapiro, Y., 2016. Vaccinations: Weighing the risks and benefits. Sci. J. Lander Coll. Arts Sci. 9 (2), 5.

SteelFisher, G.K., Findling, M.G., Caporello, H.L., McGowan, E., Espino, L., Sutton, J., 2023. Divergent attitudes toward COVID-19 vaccine vs influenza vaccine. JAMA Netw. Open 6 (12), e2349881.

Tversky, A., Kahneman, D., 1974. Judgment under uncertainty: Heuristics and biases: Biases in judgments reveal some heuristics of thinking under uncertainty. Science 185 (4157), 1124–1131.

Vietri, J.T., Li, M., Galvani, A.P., Chapman, G.B., 2012. Vaccinating to help ourselves and others. Med. Decis. Making 32 (3), 447–458.

Weinstein, N.D., 1988. The precaution adoption process. Health Psychol. 7 (4), 355–386.

Welch, V.L., Metcalf, T., Macey, R., Markus, K., Sears, A.J., Enstone, A., Langer, J., Srivastava, A., Cane, A., Wiemken, T.L., 2023. Understanding the barriers and attitudes toward influenza vaccine uptake in the adult general population: A rapid review. Vaccines 11 (1), 180.

Yamagishi, K., 1997. When a 12.86% mortality is more dangerous than 24.14%: Implications for risk communication. Appl. Cogn. Psychol.: Off. J. Soc. Appl. Res. Mem. Cogn. 11 (6), 495–506.

Yaqub, O., Castle-Clarke, S., Sevdalis, N., Chataway, J., 2014. Attitudes to vaccination: A critical review. Soc. Sci. Med. 112, 1–11.