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Public preferences for vaccination campaigns in the COVID-19 endemic phase: insights from the VaxPref database

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ABSTRACT

Objective: Despite widespread perceptions that SARS-CoV-2 (COVID-19) is no longer a significant threat, the virus continues to loom, and new variants may require renewed efforts to control its spread. Understanding how individual preferences and attitudes influence vaccination behaviour and policy compliance in light of the endemic phase is crucial in preparation for this scenario.

Method: This paper presents descriptive data from a global stated choice survey conducted in 22 countries across 6 different continents between July 2022 and August 2023, and reports the methodological work developed to address the need for comparable data.

Results: This study included 50,242 respondents. Findings indicated significant heterogeneity across countries in terms of vaccination status and willingness to accept boosters. Vaccine hesitancy and refusal were driven by lower trust in public health bodies, younger age, and lower educational levels. Refusers and hesitant people reported lower willingness to take risks compared to those fully vaccinated ($p<0.05$). Lower mental health levels were found for the hesitant cohort ($p<0.05$).

Conclusions: Insights from this database can help public health authorities to gain a new understanding of the vaccine hesitancy phenomenon, support them in managing the transition from the pandemic to the endemic

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phase, and favour a new stream of research to maximise behavioural response to vaccination programs in preparation of future pandemics.

Lay summary

This study presents insights from the VaxPref database that collects information on COVID-19 vaccination attitudes encompassing 22 countries and 50,242 respondents. Trust, age, education, income, as well as religious beliefs significantly influence vaccination decisions. Vaccine refusers exhibit better physical health, while the hesitant group reports lower mental health. Uniquely, our dataset, gathered three years post-pandemic onset, aids in understanding evolving preferences. It distinguishes non-vaccinators based on logistical or medical reasons from outright refusers and categorizes hesitant individuals, shedding light on anti-vaccine attitudes versus indecision. Governments and policymakers can leverage this standardised, in-depth data on vaccine attitudes and policy preferences to design tailored vaccination strategies facilitating the transition from the pandemic to the endemic phase, marking a benchmark for future research on vaccine hesitancy's multifaceted nature.

Introduction

The SARS-CoV-2 (COVID-19) has infected over 600 million people and resulted in over 7 million deaths globally (as of December 2023 [1]). Despite the various stringent measures and vaccination efforts implemented to combat COVID-19, the virus has not lost its impetus and will likely be a threat for the foreseeable future [2]. The existing gaps in testing and vaccination are continuing to create the conditions for new variants of concern to emerge that could cause significant mortality [3]. This calls for increasing booster vaccine uptake, addressing the well-known and global phenomenon of vaccine hesitancy. In this context, closely monitoring public preferences and attitudes towards vaccination policies becomes critical for aligning population behaviour with the guidance provided by epidemiologists and public health experts [4,5]. This effort is also crucial in preparation for future pandemics and public health crises that are expected to intensify in the near future [6].

While numerous single-country studies and opinion trackers have provided valuable insights into vaccine attitudes and policy preferences during the pandemic, their reliance on non-standardised data collections and variations in data terminologies pose limitations [7]. Single-country data, while relevant for public health purposes, lacks the standardised approach crucial for cross-country comparisons. Similarly, opinion pools or comparative surveys fall short in providing a nuanced understanding of the complex interplay between individual attitudes towards vaccination and the contextual impact of policy restrictions [8].

To address the need for international comparative data, we conducted a global, online-based, stated-choice survey covering 22 countries on 6 continents from July 1, 2022, to August 12, 2023. By employing a discrete choice experiment (DCE), we collected quantitative data on public preferences for COVID-19 vaccines and related policy restrictions, as well as a wide range of sociodemographic data, moral attitudes, risk and time preferences, and political opinions from 50,242 respondents. This comprehensive dataset collectively forms the *VaxPref* database, serving as a valuable resource for analysing and understanding global perspectives on COVID-19 vaccination.

Our DCE is the first to consider the characteristics of pharmaceutical and non-pharmaceutical interventions concomitantly [9]. Additionally, it allows the examination of differences between non-vaccinators relating to logistical (e.g., access) or underlying medical reasons. The database aimed to distinguish between individuals with strong anti-vaccine attitudes, compared with those who are hesitant or undecided about COVID-19 vaccinations because of fear, indecision, or a lack of trust [10].

This article aims to provide a description of the data collected following the CROSS checklist [11] and outlines the methodology employed to develop the survey and the Vaxpref database. With its broad geographic coverage, timing, and comprehensive nature, our dataset serves a valuable resource for policymakers, researchers, and public health practitioners. It aids in enhancing the public health response to the COVID-19 pandemic and facilitates the transition to the COVID-19 endemic phase. This descriptive exercise also aims at presenting data that can be further explored by other researchers. Furthermore, the developmental work described in this article aims to set a benchmark for constructing high-quality, comparative surveys that are instrumental in investigating vaccine hesitancy and other public health issues.

The rest of the paper is structured as follows. Section 2 describes the developmental and methodological work conducted to create the questionnaire, the DCE, and the VaxPref database. Section 3 describes the data collected through descriptive statistics controlling for a range of socioeconomic information, attitudes, and beliefs. Section 4 discusses the significance of the VaxPref database for researchers, policymakers, and practitioners, while also proposing potential avenues for future research.

Methods

Ethics approval

Ethics approval has been obtained by the Human Care and Ethics Committee of the University of Newcastle (n. H-2021–0363).

Development of the questionnaire and translations

The initial questionnaire was developed for English-speaking countries (i.e., Australia, the United Kingdom, and the United States) and for Italy. We reviewed scientific literature, national and international (i.e., European Social Survey, World Value Survey, Gallup pool, etc.) census surveys to tailor the questionnaire and standardise it across countries.

The English and Italian questionnaires were tested using think-aloud interviews with 13 experts, including five from government organizations (such as the NSW Ministry of Health, Hunter New England Health Local Health District, Central Coast Local Health District, etc.), five from academia with backgrounds in public health, health services research, health economics, and medicine and biomedical research, and one from the general public. The questionnaire was modified to reflect expert feedback after each think-aloud. We further tested the clarity of the questionnaire with members of the general public in Australia ($n = 20$) and Italy ($n = 8$) up to the saturation point [12]. Respondents were recruited using social media adverts on Facebook and Microsoft Form from November 2021 to January 2022 (see Supplementary material for the recruitment campaign). Respondents were reimbursed with 10 AUD (6.50 Euro) vouchers. Comments were discussed between two team members after each interview, and changes to the text were made iteratively. The social media campaigns were run from November 2021 until January 2022. The interviews were completed in January 2022.

Once this process was finalised, the survey was professionally translated into other languages by translators from the survey company, and these versions were checked by researchers who were bilingual in the local language and English. Minor content changes were made to reflect variations in the population, healthcare systems, economy, and cultural traits, and to comply with data privacy regulations. A final check was conducted before data collection by mother tongue researchers once the translated questionnaires were uploaded on the

survey company online platforms.

The target group of our questionnaire is the general population >18 years old. A specialized market research company (Demetra Opinioni.net) circulated the online survey adopting Computer Assisted Web Interviewing (CAWI) methodology. They also ensured quota sampling based on age, gender, and location to ensure the representativeness of countries populations (see Table A3 and A4 for a comparison with the official statistics).

Structure of the survey

Seven sections make up the questionnaire (see the full questionnaire in the Online Material).

First, we introduced the questionnaire and its aim and ask basic demographic questions to enable the sampling quota method (i.e., age, gender, and geographical location).

Section 1 asks about the respondents' current vaccination status and their perceived trust toward public health authorities, newspapers, and social media.

Section 2 introduces the DCE to the respondents and describe attributes and levels in detail. We report all the steps followed to identify the attributes and to build the experimental design in the online material.

Section 3 presents the DCE choice tasks. Each respondent is randomly assigned to one of three blocks with 12 randomly assigned choice tasks. After the choice task, respondents are asked to describe how they choose their preferred options and their opinion on the need for boosters after the initial vaccination cycle.

Section 4 enquires about the respondents experience with COVID-19 and their attitude toward vaccines using the 12-item Vaccination Attitudes Examination (VAX) Scale [13]. This complemented by the collective responsibility sub-scale developed by Betsch et al. [14].

Section 5 explores the moral attitudes of respondents by exploiting some of the statements included in the MQF30(15).

Section 6 asks respondents about their political orientation (left vs right scale), complemented by agreement on other political dimensions (i.e., income redistribution by the government, view on migrants and homosexual relationships); their investment decisions; their willingness to take risk with their health. For the latter we use the "direct approach" as presented by Yang et al., [16]. We include two time discounting tests, in the style of a Price List developed by Coller & Williams [17], to understand how participants discount gains between today and 3-months in the future and between 3–6 months in the future. This allows to estimate the amount of present bias, which is the tendency to prefer smaller immediate payoffs to larger delayed payoffs [18].

Section 7 collects additional socioeconomic information (e.g., education, income, employment, religion, ethnicity, size of the household, financial behaviours, etc.), perceived physical and mental health status and three numeracy/literacy questions.

Income levels are collected at individual and household levels with eleven income brackets. Different income ranges are built for each country with different currency and income levels. To facilitate comparisons across countries we followed the OECD income classes classification [19], which divide the population in income classes as follow:

- Lower-income (middle-income, upper-income) class refers to households with income below 75 % (75 %−200 %, >200 %) of the median national income.

Therefore, the brackets were built from the median income in each country to further divide the respondents in low, middle, and high income. Furthermore, the ranges were expressed as annual or monthly levels according to common use in the country.

Development of attributes and levels for the DCE

The main section of the questionnaire is a DCE developed to elicit public preferences for vaccines and social movement restrictions. DCEs have been largely used in the fields of healthcare and decision-making in the last decade, and particularly during the Covid pandemic to elicit preferences for vaccine characteristics [8]. We identified the attributes in our experiment through a stepwise process.

Step 1 – Literature review and attributes selection

A rapid review of the literature of previous DCEs on vaccine hesitancy in January 2021 informed attribute selection. The search was conducted on Scopus using the following terms "willingness to pay" OR "willingness to wait" OR "hesitancy" AND "vaccine" AND "covid-19" OR "infectious disease" AND "discrete choice experiment" OR "dce". $N = 133$ results were retrieved, 10 studies matched the selection criteria and were used to identify attributes. A comprehensive review of scientific literature, policy documents and media outlets was conducted from January to June 2021 to identify additional attributes relevant to individual choice. We identified $n = 23$ attributes, which was restricted to $n = 10$ attributes due to the risk of fatigue and choice task complexity impacting the quality of the experiment.

To further restrict the number of attributes and validate the attributes selected, we relied on a selected number of researchers from the Value in Health Economics and Policy Network (VheP) ($n = 26$) that were not part of the research. We built an attributes scorecard where the researchers were asked to score the attributes according to their preferences and list any attributes that were not included in the scorecard (the outline of the scorecard is reported in the Supplementary material). Before sending the scorecard to the selected number of respondents, we piloted the scorecard through think-aloud interviews with $n = 3$ researchers from the University of Newcastle that were not related to the project. The respondents were asked to comment on the scorecard and show their level of understanding of the attributes chosen and their wording. After this process we identified 6 attributes that received the highest score (4 representing vaccine characteristics and 2 referring to potential policy restrictions faced by the respondents).

Step 2 - DCE design

The final questionnaire and the selected attributes were tested with 13 experts through think-aloud interviews. Following the outcome of these iterations, we included an additional vaccine attribute (*Origin of the manufacturer)* that was perceived to be important in vaccination decisions and finalised the design of the choice tasks. A total of 7 attributes are included in each option: 5 related to the vaccine characteristics (effectiveness in reducing severe symptoms, risk of severe-side effects, duration of the protection, time between the first clinical trial to the market approval and the origin of the manufactures); 2 related to the policy restrictions (stringency of the social restrictions for leisure activities and the vaccination mandate to return to informal or informal work activities). The levels of each attribute were informed by a review of policy documents and data reported by public health agencies [20–23], previous scientific literature on individual preferences for vaccination [24–26], and relevant newspapers. The attributes and the levels are reported in the Supplementary Material.

Attributes and levels were combined into pairwise choice tasks using a d-efficient design with informative priors and allowing estimation of non-linear effects of attributes [27]. The design was optimized for the estimation of a multinomial logit (MNL) model and was created using Ngene software (ChoiceMetrics) [28]. We imposed a constraint in the experimental design to avoid the co-existence of a 90 % effective vaccine against severe symptoms and the presence of full restrictions (i.e., lockdown). This decision was based on the real-world evidence observed during the COVID-19 pandemic where most countries abandoned lockdown measures for the vaccinated population relying on the highly effectiveness of the vaccines. The design resulted in 36 choice tasks that were blocked into three sets of twelve choice tasks to minimize

respondents' cognitive burden. A set of three candidate designs were created using a modified Fedorov algorithm combined with a swapping algorithm [27]. The best design was then selected based on the lowest d-error and lowest Pearson correlations between characteristics.

For each of the twelve choice tasks respondents faced a forced choice between two vaccination programs. Following the forced choice, they faced a follow-up question where they could confirm their previous choice or opted-out if they preferred neither of the two options presented (see the questionnaire in the Appendix). The order of the 12 tasks was randomized for each participant to minimize ordering effects [29].

Step 3 - Pilot

A pilot study was conducted in the USA and Italy with 150 participants each. The two countries were selected for consistency, as the questionnaire was initially developed for Italy and English-speaking countries. The main objective of this pilot was to test the survey and check whether the results aligned with the theoretical expectations. This was tested using conditional logit model [30] for each country and reconfirmed by pooling the data. The relatively large number of respondents included in the pilot ensured the robustness of this analysis.

Step 4 – Administration of the survey

Once the pilot was completed, the survey company administered the online survey across the 22 countries adopting Computer Assisted Web Interviewing (CAWI) methodology. An additional check on the robustness of the questionnaire and respondents' ability to understand questions was carried out with the first 50 respondents in each country. Therefore, we controlled for countries not included in the piloting phase.

Data quality

The target group of our questionnaire is the general population older than 18 years old. Quota sampling based on age, gender and location was used to ensure the representativeness of countries populations. Overall, the quotas matched the official statistics for all three variables (see Table A3 and A4 in the Supplementary Material) excluding the 65 and older groups in Chile (11/13 %), Lithuania (21/24 %), Norway (18/20 %), Singapore (14/19 %) and South Korea (16/20 %) due to lack of respondents. To compensate these deviations and minimise potential biases, we replaced the missing respondents with respondents aged 60–64 years old. It is worth specifically mentioning the Latvian sample. The share of population above 65 years old is high (26 %) and therefore a more consistent share of population in the previous age group was collected (25/17 %). To evaluate the representativeness of our dataset regarding real vaccination behaviours, we report the percentage of people vaccinated with at least one dose in the countries considered as reported by Our World in Data [31] (See Figure A2 in the supplementary material).

We introduced consistency and literacy questions throughout the questionnaire to detect inconsistencies in respondents' answers [32]. Before the finalisation of the quotas, *speeders* were identified and replaced with new respondents. We defined speeders as those individuals below 40 % of the median time taken to complete the survey (see Table A5 in the Supplementary material). Despite previous literature demonstrating that elimination of speeders is not always synonymous for higher data quality, it reduces random noise in the data [33] and lowers the share of inattentive respondents in self-administered surveys, which becomes particularly problematic for low-educated respondents [34].

Results

Countries involved, sample size and recruitment

A total of 50,242 respondents from twenty-two countries across six different continents anonymously completed the survey (see Fig. 1). Countries were chosen to provide heterogeneity on three dimensions: a) the epidemiological impact that COVID-19 had at the societal level; b) the response strategies adopted by governments; and c) the specific vaccination campaigns and measures used to increase vaccine uptake. An additional criterion for country inclusion was the presence of researchers in our team who are familiar with the country context, the language, and the COVID-19 experience in each country.

To accurately capture and ensure population representativeness, the sample size in each nation is dependant on that nation's population (see Table 1). Countries with a population of more than 15 million people had a sample size of 3000 respondents; those with a population of between 5.6 million and 15 million had 1500 respondents; and those with a population of less than 5.6 million had 1000 respondents. Table A1 reports the total number of respondents in each country and the underlying population. Quota sampling was based on gender, age, and location as reported by each country's official statistics. We include the sources for each nation's statistics in the supplemental material (see Table A2). A specialized market research company (DemetraOpinioni.net) circulated the online survey and ensured quota sampling.

Vaccination status & attitudes

Information regarding respondents' current COVID-19 immunization status was gathered to determine their immunization behaviours during the pandemic. Table 1 provides an overview of our sample's descriptive data by country. On average, 82 % received at least two doses of the vaccine. There are, however, variation across countries. Brazil, Chile, India, and Singapore report the highest share of people vaccinated with at least two doses (>95 %), whilst Russia presents the smallest share of fully vaccinated people (47.1 %). The scenario becomes more blurred when we look at the percentage of the population who received at least one booster, with Russia continuing to have the lowest percentage (15 %), followed by South Africa (22.1 %) and the other Eastern European countries.

Our detailed data enable the creation of a generalised classification of respondents' vaccination attitudes based on their revealed vaccination status. By separating those who i) face logistic issues to receive the vaccine or ii) those deliberately rejecting the vaccination from those iii) whose deliberations demonstrate something akin to indecision, we use the terminology of vaccine hesitancy proposed by Bedford et al., [10] and avoid presenting non-vaccination due to systemic problems as something that is the choice of end-users [35]. Specifically we distinguish those who are: a) vaccinated (received at least one dose), b) hesitant (those who did not get any dose and would get the vaccine only when they are sure it is effective or when they know more about the potential side effects), c) vaccine refusers (those who did not receive any dose and have no intention to get the vaccine), and d) finally those who cannot access vaccines for i) medical reasons or ii) accessibility issues (financial access or geographical access). In Fig. 2, we show the proportion of each of these categories on the total number of respondents by country.

Around 13 % of our sample chose not to be vaccinated at the time of survey. Of these, 8.7 % were outright refusers, while 4.7 % remained hesitant about COVID-19 vaccines and had not been vaccinated for that reason. There is significant heterogeneity across countries regarding vaccination preferences. A fraction of the sample (0.5 %) did not receive the vaccine due to accessibility problems, with the US having the highest share (1.4 % of the sample). Similarly, 1.5 % of respondents did not get vaccinated for medical reasons.

The data enables an understanding of current evidence that doses for

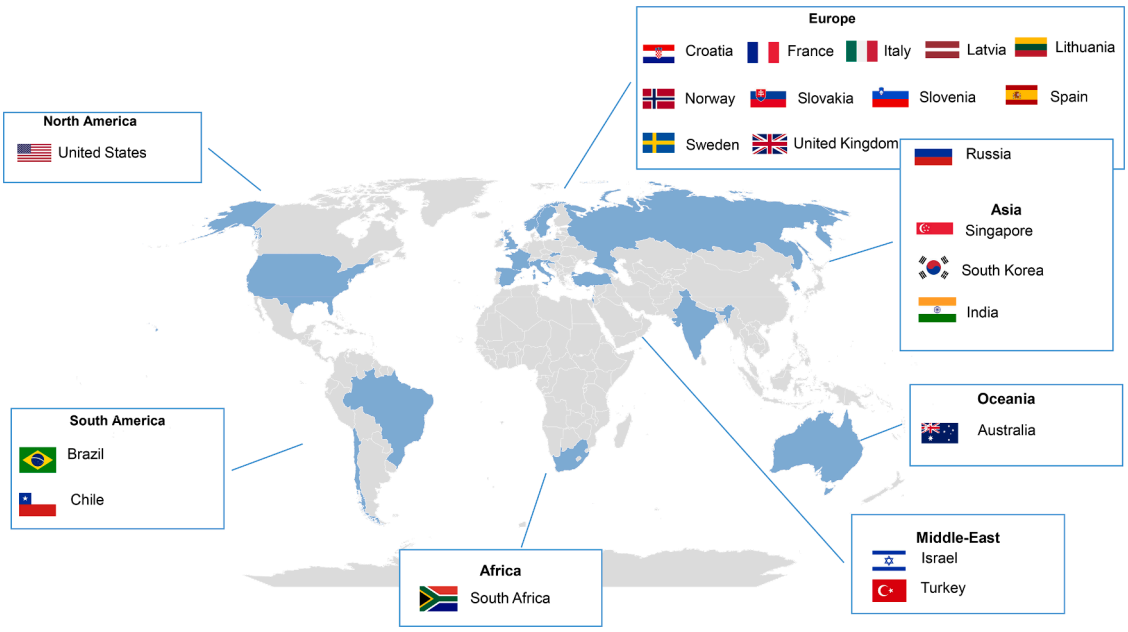

Fig. 1. Countries included in the project.

Table 1
Vaccination status by countries (%).

Country	N	Vaccinated					Hesitant			Refuser	Medical or logistic problems		
		>3 doses	3 doses	Waiting booster	2 doses	Waiting 2nd dose	I am planning my vaccination	Only when effective	Only when safe	No intentions	Medical conditions	Other	Access problems
Australia	3,004	1.7	67.9	9.5	10.0	1.5	0.9	0.6	0.9	5.5	0.9	0.1	0.7
Brazil	3,001	1.2	67.6	15.0	10.6	1.6	0.3	0.5	0.8	1.7	0.4	–	0.2
Chile	3,004	4.0	83.9	3.7	3.5	0.6	0.3	0.5	0.7	2.2	0.5	0.1	0.1
Croatia	1,062	0.7	32.4	4.9	25.7	3.2	2.5	3.9	3.7	20.6	1.6	0.7	0.2
France	3,165	3.3	61.4	7.1	12.5	1.3	0.7	1.0	1.9	9.3	0.9	0.1	0.6
India	3,128	–	43.2	33.5	17.7	2.1	0.9	0.6	0.5	0.7	0.6	0.0	0.4
Israel	1,513	1.8	66.7	7.2	11.7	2.1	0.6	1.3	1.1	5.6	1.1	0.1	0.7
Italy	3,001	1.5	82.5	2.8	6.4	0.4	0.4	0.3	0.8	4.6	0.2	–	0.1
Latvia	1,109	1.6	30.2	8.5	28.5	3.7	2.0	3.0	2.3	18.2	1.7	0.1	0.2
Lithuania	1,010	12.4	30.2	2.2	24.5	6.4	0.8	1.9	2.8	16.5	1.8	0.5	0.1
Norway	1,033	2.0	55.1	8.4	22.6	3.4	0.3	0.4	0.9	5.0	1.3	–	0.7
Russia	3,010	0.2	14.7	7.5	24.7	5.4	8.5	5.1	6.7	21.9	4.8	–	0.5
Singapore	1,002	0.5	85.6	5.2	4.5	1.0	0.2	0.2	0.7	1.2	0.4	–	0.5
Slovakia	1,009	–	42.7	5.4	16.0	3.5	2.2	2.9	2.8	20.4	3.8	0.1	0.4
Slovenia	1,061	1.1	36.0	7.2	20.2	3.4	1.5	3.5	3.6	21.8	1.5	–	0.3
South Africa	3,002	–	22.1	15.9	21.4	10.0	3.1	2.7	5.4	15.1	2.9	0.8	0.6
South Korea	3,000	0.3	61.7	6.1	21.3	1.5	0.7	1.1	1.7	3.8	1.1	–	0.7
Spain	3,266	2.9	62.4	11.3	14.9	1.6	0.3	0.4	0.8	4.6	0.6	–	0.2
Sweden	1,503	2.3	57.1	8.5	16.5	2.3	1.3	1.1	1.9	7.7	0.8	–	0.6
Turkey	3,086	24.2	29.5	5.6	24.7	4.0	0.5	1.1	1.4	8.3	0.3	0.1	0.4
United Kingdom	3,115	3.1	64.0	8.9	9.5	2.6	0.7	0.7	1.2	7.4	1.0	–	0.9
United States	3,185	0.7	47.1	12.0	11.4	3.9	2.3	1.7	2.1	14.7	2.4	0.2	1.4

Notes: The percentages presented herein reflect respondents' vaccination status at the time of data collection in each respective country. Refer to the Appendix for a comprehensive overview of the data collection period.

boosters are significantly lower than doses for the initial primary course double-dose [36]. Our data demonstrates that 16 % of the sample would not take the booster, claiming that there is no need for more than two doses (see Table A6 in the supplementary material). In particular, for Brazil and India, the share of the population that think boosters are not needed is below 10 % of the sample.

Demographic and socioeconomic information of the respondents

Demographic and socioeconomic characteristics cover a relevant role in understanding vaccination behaviours (see Table 2) and provide important indications in designing vaccination policies.

The proportion of women amongst the vaccine refuser respondents was slightly higher (53.1 %) compared to both the hesitant and vaccinated populations, which instead report a balanced gender distribution

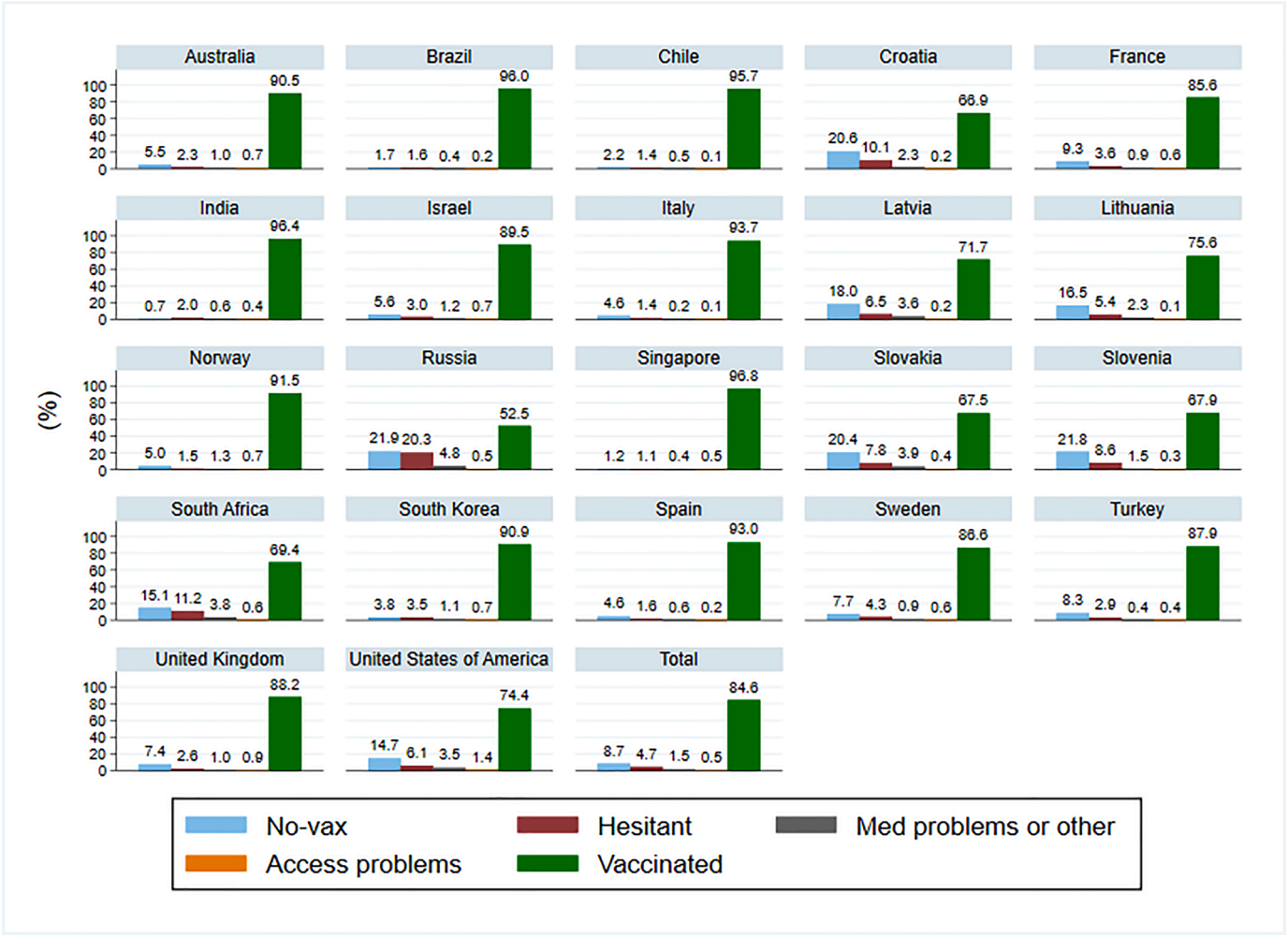

Fig. 2. Vaccination status categories (vaccinated; hesitant; refusers) on the total number of respondents by country.

(51.2 %). For education, there is a marked difference between the hesitant and vaccinated groups compared to those declaring themselves as vaccine refusers. Indeed, 36.0 % of vaccine refusers report to have at least a bachelor's compared to the 48 % and 52.6 % that was found for the hesitant and the vaccinated groups respectively. While this trend is consistent across most countries, variations in the relative composition of the three groups can be identified (see Figure A3). Regarding income distribution, 41.9 % of vaccine refusers, 33.3 % of hesitant and 26.5 % of vaccinated people were classified in low-income category (see income definition in the Methods section).

Additional evidence from our dataset indicates that religion plays a role in vaccination decisions. People that identify themselves as religious have higher vaccination coverage (51.1 %) compared to the vaccine refuser (42.5 %) and hesitant populations (47.9 %). In France, where it is not possible to ask about someone's religious status, the dataset provides information about whether the respondent *practices* a religion. The share of vaccinated people in France who state they practice a religion is 26 %, same as the refuser, while the hesitant is 29 %. We report the distribution of people that declared themselves to be the major contributor to the family income, which might suggest a role played by income security in vaccination decisions that should be further explored. Finally, a difference is observed looking at the number of children. Refusers reported a significantly lower share compared to the other groups.

Underlying health conditions and personal experience with the virus

Variables related to the physical and mental health status of our respondents and their vaccination decisions, including presence of chronic conditions and willingness to take risk with their health are reported in Table 3.

On average, the hesitant group reports lower levels of physical and mental health, with a significant difference for the latter ($p<0.05$). Conversely, refusers present the lowest level of chronic conditions ($p<0.05$). Interestingly, we found that non-vaccinated individuals reported higher levels of risk aversion with their health compared to vaccinated individuals.

Considering health status and perceived risk, it is essential to consider individuals' reported personal experiences with COVID-19. It has been suggested that the devastating effects of the virus might push individuals toward vaccination [37]. To test this hypothesis the questionnaire collected information about previous personal infection with the virus, previous infection of one's close network and death of one's close network (see Figure A4). Whilst there is small difference in terms of previous infection between the three groups, a larger share of vaccinated individuals knew someone in the close family or friendship that either was previously infected or died from COVID-19 compared to the refuser group (~+10 % percentage points).

Table 2
Sociodemographic information by vaccination category (%).

	Refuser	Hesitant	Vaccinated	Full sample
Age*	44	42	46	46
Female	53.1	51.2	51.2	51.2
Bachelor and over	36.0	47.6	52.5	50.8
Speak a language other than the country language *at home***	15.3	13.1	18.8	18.2
Religious	42.5	47.9	51.1	50.2
Population in hometown (<5000 inhabitants)	20.9	16.2	14.8	15.4
Low income***	41.9	33.3	26.5	28.2
Working†	67.8	74.1	72.9	72.5
Homemaker	7.5	5.9	4.8	5.1
Sector				
Construction	7.6	8.7	6.4	6.6
Education & training	5.4	6.7	10.2	9.6
Health & Social care	4.9	5.2	7.8	7.4
Hospitality	4.7	5.0	4.2	4.3
Retail trade	7.5	6.9	7.1	7.1
Married/Living with a partner	46.6	52.9	59.7	58.2
Major contributor to the family income	55.9	59.1	64.0	63.0
With children	60.8	69.0	68.4	67.8
N=	4,328	2,371	42,348	49,047[a]

Notes: *Median age; ** From these percentages we excluded the South African respondents due to the large number of languages spoken in the country. ***Below 0.75 % of the median household income. Income levels are collected at individual and household levels with eleven income brackets. Different income ranges are built for each country with different currency and income levels. To facilitate comparisons across countries we followed the OECD income classes classification [19], which divide the population in income classes as follow: Lower-income (middle-income, upper-income) class refers to households with income below 75 % (75 %−200 %, >200 %) of the median national income. Therefore, the brackets were built from the median income in each country to further divide the respondents in low, middle, and high income. Furthermore, the ranges were expressed as annual or monthly levels according to common use in the country.

[a] In this table, respondents who did not vaccinate due to medical reasons or logistic issues were excluded due to their limited numbers. Similarly, individuals who identified with a gender other than male or female, or did not report their gender, were also excluded based on the small percentage of respondents in these groups (<0.05%).

Table 3
Health status and willingness to take risk by vaccination category.

	Observations	Mean	S.E.	95 % Confidence Interval	
Physical Health					
Refuser	4,328	2.68	0.02	1.06	2.65
Hesitant	2,371	2.75	0.02	2.71	2.79
Vaccinated	42,348	2.71	0.01	2.70	2.72
Mental Health					
Refuser	4,328	2.53	0.02	2.50	2.57
Hesitant	2,371	2.62	0.02	2.57	2.66
Vaccinated	42,348	2.52	0.01	2.51	2.53
Chronic conditions*					
Refuser	4,187	0.22	0.01	0.21	0.23
Hesitant	2,289	0.29	0.01	0.27	0.30
Vaccinated	41,477	0.28	0.00	0.28	0.29
Willingness to take risk with own's health^					
Refuser	4,328	3.33	0.05	3.24	3.42
Hesitant	2,371	3.43	0.06	3.31	3.56
Vaccinated	42,348	3.74	0.02	3.71	3.77

Notes: Physical and mental health are calculated on a scale from Poor (1) to Excellent (5); *Chronic conditions is a dummy variable that takes values between 0 (no chronic conditions) and 1 (one or more chronic conditions). In the Table we exclude those that ticked the 'prefer not to answer option'. ^ average score on a scale from 0 to 10 using the "direct" approach suggested by Yang et al. [16].

Opinions on vaccines and trust

Beliefs against vaccines, concerns about vaccination safety, a general lack of trust, and political beliefs are some of the major factors influencing vaccine refusal or hesitancy for COVID-19 vaccines [38–40].

To control for beliefs against vaccines and the beliefs about collective responsibility, we collected information using the VAX scale [13] complemented by the collective responsibility sub-scale developed by Betsch et al. [14]. Fig. 3 reports an example of how data from these two scales can be utilized to determine country heterogeneity in vaccination beliefs and the collective responsibility. Specifically, we compare beliefs about vaccine effectiveness versus beliefs about vaccination as a collective responsibility action in South Korea, Italy, Russia, and the US. These countries were chosen to cover diverse geographic locations and cultural backgrounds. Out of the four nations, Russia reported the most polarized outcomes, with nearly a perfect split between those who strongly disagree with both statements and those who strongly agree with them. The results from the US and Italy are comparable, despite the Italian sample appearing to be relatively more reliable for vaccine effectiveness and yielding a relatively greater degree of consensus regarding vaccination as a collective action. In South Korea, beliefs are more centred towards middle values.

Despite an overall increase of trust towards scientists [41] as well as pharmaceutical and banking companies, in addition to governments over the pandemic [42], public trust still remains an essential dimension towards vaccine refusal [39,43], as well as corruption [44] and polarization [45]. Fig. 4 displays the level of trust towards public health bodies, newspapers and social media for the refuser, hesitant and vaccinated populations in our sample.

Vax-refusers report a consistently higher share of mistrust towards public health bodies and newspapers compared to hesitant and vaccinated groups. The difference is relatively lower when considering the information reported on social media. Significant heterogeneity is reported across countries, with Brazil, Norway, Chile and Australia presenting higher levels of trust across the three sources and Croatia, France, Slovenia and Slovakia the lowest.

Financial behaviours and vaccination decisions

The likelihood that a respondent will own a financial instrument (i.e., life insurance, bonds, shares firm, managed accounts) or invest some of their wealth in financial instruments is the final dimension we report from our dataset that relates to respondents' financial behaviours.

In all six categories identified, we observe an incremental increase in the likelihood of owning financial instruments by vaccination status (see Table 4). Vaccine refusers consistently report a lower share of positive answers comparted to the vaccinated group. Once again, the hesitant population in our sample is reported in the middle between the other two groups.

Discussion

Our findings underline the significant role played by trust, age, education and income in vaccination decisions. This database adds crucial information to the mixed findings found in previous literature and demonstrates a positive relationship between the status of being religious and vaccination behaviours [46,47]. Contrary to common beliefs, we observed an overall better physical health status for the refusers group compared to the vaccinated one. Simultaneously, the hesitant group reported significantly worse health status. Consideration of an individual experience with the virus, in the form of a family or close network member's death, is significantly larger amongst vaccinated groups compared to the hesitant and the refuser ones in line with existing findings [46]. This suggests that emotions (e.g., fear or anxiety) about the virus's effect on one's close network plays a role in vaccine decisions. Overall, we observed that the hesitant population is relatively

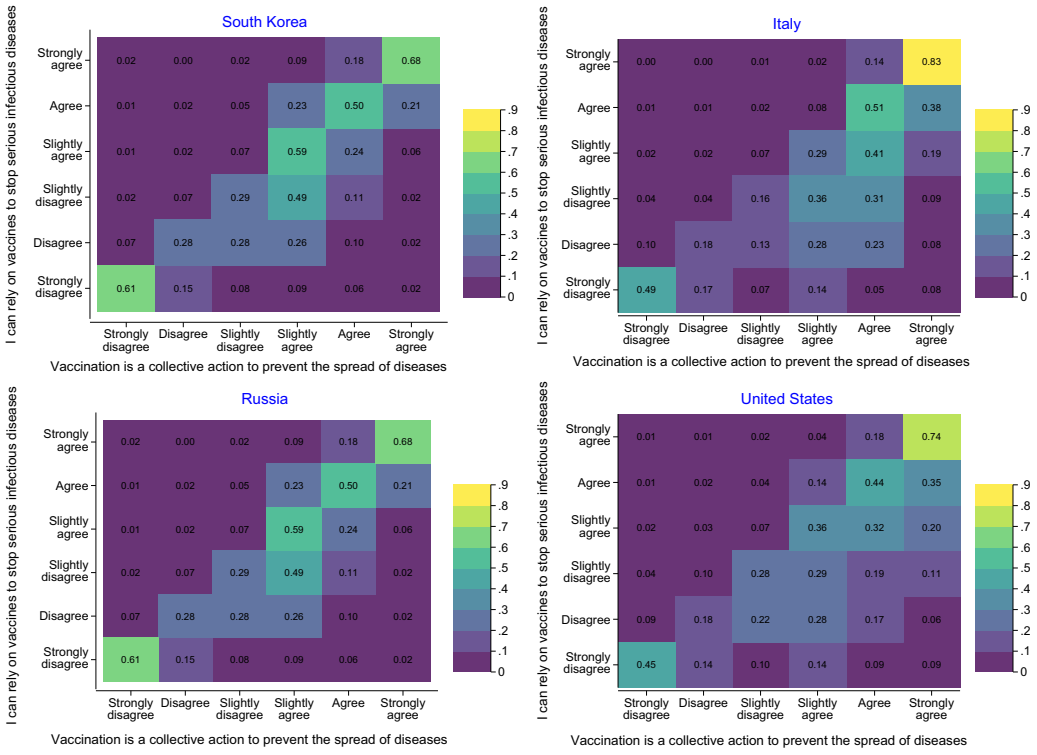

Fig. 3. Beliefs about vaccines effectiveness versus beliefs about vaccination as a collective responsibility action in South Korea, Italy, Russia and the United States. Notes: The y-axis indicates how effective the respondent considers vaccinations to stop infectious diseases and the x-axis indicates how much the respondent thinks vaccination should be a collective action. The number in each cell represents the conditional probability of beliefs about collective responsibility (columns) given one's beliefs about vaccine effectiveness (rows, which sum to 1). For instance, for South Korea, the top right cell value of 0.65 indicates that 65 % of the respondents who 'Strongly agree' with the statement "I can rely on vaccines to stop serious infectious diseases" also believe that vaccination must be a collective action.

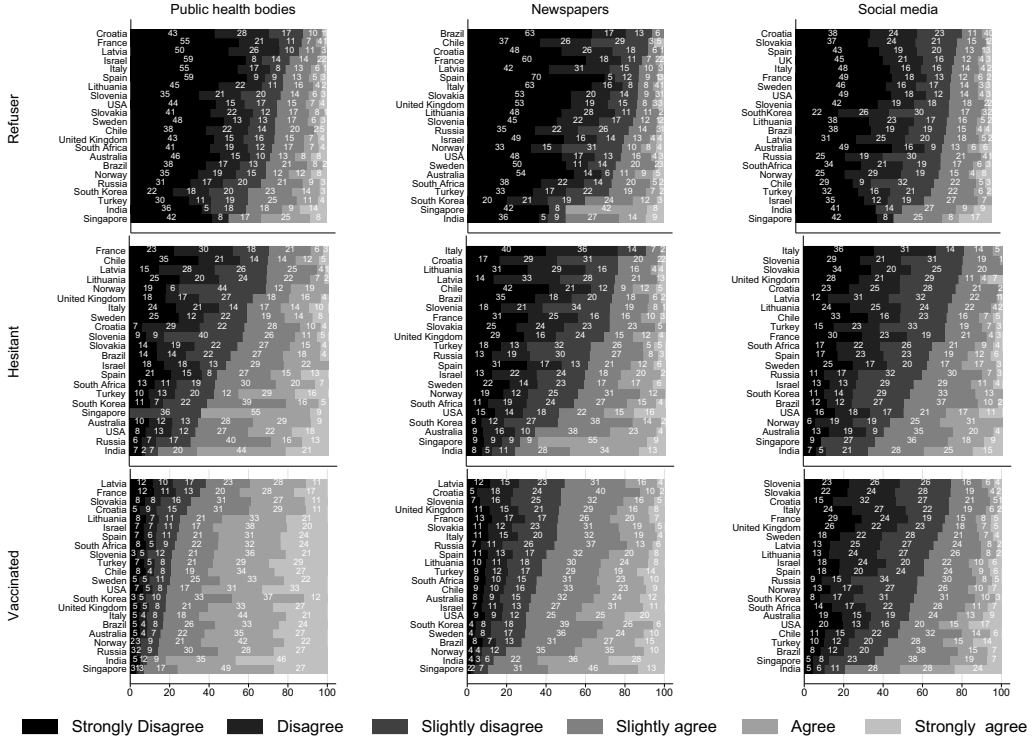

Fig. 4. Trust towards public health bodies, newspapers and social media by vaccination category (%).
Notes: in each panel, countries are sorted in descending order based on the sum of the three disagreement options

Table 4
Financial attitudes by vaccination category (%).

Do you have (alone or with other household members) …	Refuser	Hesitant	Vaccinated	Full sample
Any supplementary insurance policy/coverage on health or injuries	39.1	44.9	53.9	52.2
Any life insurance or supplementary pension policy	33.3	41.3	49.9	48.0
Any money in mutual funds or managed investment accounts	21.1	29.3	36.0	34.4
Any money in stocks or shares that are listed or unlisted on stock markets	18.7	25.2	30.8	29.5
Any money in government or corporate bonds	7.8	14.4	17.9	16.8
Own a firm, company, or business either entirely or as a partial ownership	13.9	18.6	18.4	18.0

Notes: *In this Table we did not report those who ticked the prefer to not answer option. **We did not include responses from Norway as we asked respondents about slightly different financial instruments from the items reported here.

more likely to own a financial instrument compared to the vaccine refuser. This might indicate a relatively larger margin of manoeuvre for policymakers to influence these individuals through financial incentive compared to the vaccine refuser group. Further research should investigate this dimension. The significant heterogeneity observed across and within study areas reinforces the idea that vaccination attitudes and preferences are complex and multifaced phenomena. Understanding the drivers of this heterogeneity is crucial for informing policies in future vaccination campaigns. In this context, the VaxPref database serves as a relevant resource for researchers and policymakers to further investigate this heterogeneity.

Throughout the pandemic, information on vaccination preferences and behaviours for COVID-19 vaccines was gathered by numerous studies, mostly single-country or with a limited number of countries included. The main reasons for vaccine resistance are found in the fear of the potential side effects [48–51], the rapid development of the vaccines [52,53] and the lack of trust in governments and employers [54–56]. The extent of these concerns greatly varies across countries [57]. Similarly, vaccination preferences differ within subgroups of the population [58–60]. Mixed evidence was found in previous literature about the association between religious beliefs and vaccination status [47]. There is evidence that vaccination refusal is negatively correlated with underlying health issues and health vulnerability [61].

Several dimensions make the VaxPref dataset and questionnaire unique. Firstly, new insight into public preferences for policy restrictions and vaccination is provided by examining preferences approximately three years after the beginning of the pandemic (July 2022 to August 2023). A later time period enables greater contextualisation and allowances for shifting time-based preferences due to the individual's learned experience from their country's response and international responses. As new variants arise and booster vaccination rates stagnate, a rethink of pharmaceutical and non-pharmaceutical policies to reduce the epidemiological and social impact of the virus is required. Our stated-choice data reflect the trade-offs made by the public between vaccine characteristics and policy restriction features and serve as an important input for policymakers to design optimal policies that consider public preferences for COVID-19 interventions. Further, the survey's duration enables comparisons of vaccination intentions with prior findings to investigate the possibility of a *pandemic fatigue effect* [62,63]. This yields indications about people's responses to future pandemic planning.

Secondly, our database differentiates between non-vaccinators for logistical or underlying medical reasons and non-vaccinators for reasons related to acceptance. Further, the database sub-categorises individuals in the second group who have strong anti-vaccine attitudes and are refusers rather than 'hesitant', and those who instead exhibit something akin to indecision. This distinction is essential for policymakers to create optimal combinations of policies that promote vaccination uptake and minimize the effects of the virus. Furthermore, for vaccination programs to be effective, distinct vaccination policies and communication must be developed to address the many causes of vaccine hesitancy [64]. The combination of the data reported in the dataset may serve this purpose. Additionally, this classification and collection strategy may set a benchmark for future research on vaccine hesitancy.

Third, throughout the pandemic, information on vaccine attitudes and policy preferences was gathered by numerous single-country studies and opinion trackers. Whilst relevant for public health purposes, single-country data has the disadvantage of relying on non-standardised data collections and heterogeneity in data terminologies. Similarly, data from opinion pools do not provide a deeper understanding of the relative role that vaccine and contextual policy restrictions may play in individuals 'attitudes towards vaccination. We address this by administering a standardised questionnaire that collects qualitative and quantitative information on public preferences for vaccines and vaccination policies.

Finally, the number of countries included, the rigorous methodological process followed, and the depth of data gathered at the individual level provide fresh perspectives on factors that influence vaccination practice and other crucial health behaviours, such as underlying moral attitudes drawn from the MFQ30 [15] and time discounting preferences and the financial profile of vaccine-hesitant and vax-refusing people. This data may also be used to complement existing administrative data and shed light on the role of personal beliefs and behavioural determinants on health and income inequalities [65].

The strong advantages of this new database outweigh its few limitations, specifically the use of online surveys and between-country comparability. Utilising online platforms may have introduced selection bias in the sample, which may result in biased estimates due to the exclusion of relevant types of respondents (such as those without an internet connection, migrants, etc.); other concerns are related to the potential presence of the so-called speeders who may have answered without paying much attention to the questions [32,66]. To address these limitations, quota sampling were used and speeders removed.

Further, our database provides an overview of vaccination preferences of upper-middle/high-income countries from five continents. Therefore, it is possible that the lessons learned about preferences from this database may not be transferable to low-income or middle-income countries.

Materials and code availability

Analysis code to reproduce figures in the manuscript, as well as all the material used to collect data and create the survey are available in the supplementary material. Please contact the corresponding author for additional information.

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Competing interests

J.K.W. is a member of the Commission Technique des Vaccinations at the Haute Autorité de la Santé. The other authors have nothing to declare.

Ethical approval

Ethics approval has been obtained by the Human Care and Ethics Committee of the University of Newcastle (n. H-2021–0363).

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Data availability

Researchers can request access to the microlevel data by contacting the corresponding author and providing a short description of the intended usage (i.e., research question). According to the access requested, ethics variations to the initial protocol might be required. This process will be handled by the corresponding author following the procedures reported in the Australian Code for the Responsible Conduct of Research.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.hlpt.2024.100849.

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