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Trade-offs during the COVID-19 pandemic: A discrete choice experiment about policy preferences in Portugal

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Abstract

The need to control the sanitary situation during the COVID-19 pandemic has led governments to implement several restrictions with substantial social and economic impacts. We explored people's trade-offs in terms of their income, life restrictions, education, and poverty in the society, compared to their willingness to avoid deaths. We applied a web-based discrete choice experiment to elicit preferences of the Portuguese citizens for these attributes and computed the marginal rate of substitution in terms of avoided deaths. We recorded 2,191 responses that faced the possibility of having 250 COVID-19 related deaths per day as the worst possible outcome from the choice levels presented. Estimates suggested that individuals would be willing to sacrifice 30% instead of 10% of their income to avoid approximately 47 deaths per day during the first six months of 2021. For the same period, they would also accept 30% of the students' population to become educationally impaired, instead of 10%, to avoid approximately 25 deaths; a strict lockdown, instead of mild life restrictions, to avoid approximately 24 deaths; and 45% of the population to be in risk of poverty, instead of 25%, to avoid approximately 101 deaths. Our paper shows that avoiding deaths was strongly preferred to the remaining societal impacts; and that being a female, as well as working on site, led individuals to be more averse to such health hazards. Furthermore, we show how a DCE can be used to assess the societal support to decision-making during times of crisis.

1. Introduction

The management of the COVID-19 pandemic was characterised by difficult choices. In several phases of the pandemic, most governments were compelled to implement strict lockdowns.

These lockdowns made people stay at home, often only being allowed to leave for essential reasons. It also implied the temporary closure of schools, retail, and many other activities. All these measures had a clear and negative impact on families' income, education, and social lives [1,2]. These were significant policy choices that implied difficult trade-offs. It is not clear whether, when making these decisions, governments were able to understand and reflect society preferences and follow the scientific evidence, at the same time.

Understanding individuals' preferences in this context is extremely important as the efficacy of contingency measures depended heavily on individuals' behaviours. Literature has shown that it is challenging to capture these preferences [3,4]. To overcome this, researchers have been increasingly using Discrete Choice Experiments (DCE) to understand preferences and inform policy decisions, which is especially relevant in healthcare studies [5].

DCEs allow the study of choices with a high degree of flexibility. This tool is implemented by creating hypothetical games where individuals choose between options, implicitly revealing their preferences. Such knowledge of preferences, inherently linked to beliefs and behaviours, is a key piece of information to guide government decisions. It is particularly relevant in the context of a crisis, when unprecedented measures must be adopted in short time frames [6,7]. DCE studies have been used in the context of COVID-19, not only to measure how the citizens value the costs and benefits of lockdown policies [8–12] but also to understand potential barriers and preferences towards the uptake of COVID-19 measures, such as testing, contact-tracing and vaccination [13–16].

The objective of this study was to use a DCE to assess individuals' preferences regarding the consequences of COVID-19 related policies in Portugal and to explore which of their characteristics might be associated with heterogeneous preferences among the population.

We evaluated preferences in terms of five attributes: number of daily deaths, loss of household income, life restrictions (limitations to individual freedom), educational impairment, and levels of poverty in the society. Our study provides new information on how Portuguese citizens considered these policy trade-offs, by estimating their willingness to avoid deaths relative to the other attributes. We examined heterogeneous preferences based on an extensive set of individual characteristics collected in our survey through i) an unconditional subgroup analysis, and ii) a latent class model. Furthermore, we were able to capture preferences at a particularly challenging moment of the pandemic management. Our survey was applied during the third and most deadly COVID-19 wave in Portugal. The period that led to the third wave was marked by stronger public debate around restrictions. While conducting the survey, COVID-19 numbers were growing fast, and the Portuguese National Health Service (NHS) displayed signals of being overwhelmed. Thus, the survey captured preferences of individuals at a crucial phase of decision-making by the government.

2. The COVID-19 pandemic in Portugal

On March 18th, 2020, following the rapid increase of COVID-19 cases in European countries, Portugal declared the beginning of the "State of Emergency", allowing a set of exceptional legal provisions to be implemented in fighting the pandemic. Among other measures, over a six-week period, only citizens from the essential services could work outside their homes. All other citizens including children had to be confined and were only allowed to leave their homes in exceptional circumstances.

In mid-April, at the worst stage of the first wave, Portugal reached 1,516 daily new cases of COVID-19 and 37 daily deaths (Portugal has approximately 10 million inhabitants). In May, the numbers started to decrease significantly. Most measures adopted in the first stage of the pandemic were gradually scaled down in the following months. The summer was quiet, with

the number of new daily cases stabilising around 300 and the number of daily deaths in values below five.

The number of daily cases started to slowly rise again in September 2020, with the growth hitting an exponential trend in October. On November 9th, the country went back to a "State of Emergency". In this second wave, the maximum number of new daily cases increased to 6,994 (November 19th) and the highest number of daily deaths was 98 (December 13th).

After Christmas and New Year's Eve celebrations, when restrictions were partially relaxed and gatherings were allowed, the country saw a sudden rise in the number of cases that would lead to the third and worst wave of the pandemic. At this time, Portugal was among the first western countries to be hit with the third wave and recorded the highest levels of cases and deaths per capita at a global scale. On January 15th, the government reinstated a nationwide lockdown due to the surge in new daily cases. The highest daily number of new cases and deaths occurred on January 28th with 16,432 new cases and 303 deaths. Portugal remained in lockdown for the next few months. The "State of Emergency" was lifted on May 1st, 2021. From then onwards, the restrictive measures were gradually dropped.

Our survey was distributed between January 12th and March 14th, 2021, capturing the most precarious period of the pandemic in Portugal. During the survey collection period, vaccination was at a very early stage—in the peak of the third wave, only about 2.5% of the population had received a first dose of the vaccine.

3. Methodology

3.1. DCE

We used a DCE to evaluate the preferences of the Portuguese citizens regarding the possible effects of different COVID-19 policies. This is a recognized methodology to elicit latent preferences and has been used when presenting the respondents with difficult moral trade-offs [17,18].

3.2. Attributes and levels

The study used five attributes: number of COVID-19 related deaths, loss of household income, educational impairment, life restrictions, and poverty levels in the society (Table 1). Each attribute was divided into three levels of low, medium, and high intensity. Based on international literature, other DCEs were used to inform this study [8,12]. Their attributes were adapted to the Portuguese context based on the findings of a previous COVID-19 survey [19] and authors' perception of policy relevance of the outcomes. For each attribute we defined the high (worst) level based on a critical evaluation of the data and the policies implemented at the time of the survey [20]. For the quantitative attributes, medium and low levels were constructed by

Table 1. Attributes and levels of the survey for the period between January and June 2021.

Attributes	Units	Low	Medium	Maximum
COVID-19 related deaths	Daily deaths attributed to the pandemic either directly (i.e., COVID-19 infection) or indirectly (i.e., limited response by the health care system)	50	150	250
Household income lost	% decrease in respondent's household income motivated by the pandemic	10	20	30
Educational impairment	% of students permanently affected by the pandemic in the school population	10	20	30
Life restrictions	Type of restrictions in place for all the citizens	Large-events restrictions and no bars/ clubs	Night curfew and max 5 people gatherings	Full lockdown
Poverty level	% of the population in risk of poverty	25	35	45

adopting linear decrements of a third to a fourth of the highest level. In terms of the duration of the effects, we defined they would last for a period of six months (January to June 2021).

In Portugal, the number of COVID-19 deaths was in the spotlight every day since the beginning of the pandemic. This led us to include COVID-19 related deaths as the baseline attribute in our survey, i.e., the marginal rate of substitution (MRS) was defined as the number of deaths to be traded for other attributes. The highest level for this attribute was defined as Portugal's linear equivalent to the highest daily number of deaths observed in Spain in 2020, during that country's severe first wave.

With the consecutive lockdowns, the economy slowed down considerably (GDP in 2020 decreased by 8.4%). This led to a considerable loss of household income for many people, either because they owned a business that was affected or because they were laid off [21–23]. The second attribute was the percentage decrease in the respondent's household income related with the pandemic. The levels for this attribute were 10%, 20% and 30%. The choice of maximum loss of 30% considered that laid off employees or companies that had to shut down would still have access to 70% of their income, through social security schemes.

Schools belong to the wide range of institutions that closed during the first times of the pandemic. Portuguese high schools were closed for 97 days, between January 2020 and May 2021 [2]. As a third attribute, we included the percentage of the school population that would become permanently affected by the pandemic. To some extent, this percentage reflects the inequalities associated with schools' closure, distance learning and other mitigation strategies. The levels for this attribute were 10%, 20% and 30%. The maximum level was chosen in accordance with a report from the World Bank [24] estimating the number of students who may suffer from losses because of the school closures.

Strict restriction policies impacted the regular day-to-day life of the population. Being deprived of social interactions can be burdensome [25]. The fourth attribute was the level of life restrictions imposed by the government. The levels of the attributes were chosen to reflect different scenarios that occurred during the first year of the pandemic, as described in section 2. The low intensity level contemplated only large events' restrictions and bars and discos closed at night; the medium level was characterised by a mandatory curfew from 23h00 do 5h00 and gatherings restricted to five persons; the high level was a full lockdown, with people working from home, circulation restrictions and schools shut down.

The economic collapse driven by life restriction measures has led to an inevitable loss of global wealth. The potential measures to fight the pandemic ended up pushing people into poverty. The fifth attribute was the percentage of the population in risk of poverty. The levels for this attribute are 25%, 35% and 45%. The maximum level corresponded to the approximate percentage of the population at risk of poverty before any social transfer, observed in the past 10 years [26]. This would correspond to a catastrophic scenario where social transfers would be unavailable.

3.3. Survey

The project was approved by the NOVA School of Business and Economics Ethics Committee on the 28th of December 2020. When opting to answer the survey, the respondents have consented to the publication of potential findings.

The data was collected through an online survey between January 12th and March 14th, 2021. Most observations were collected during January. Any adult living in Portugal in this period was eligible to answer. The survey was distributed using social media and mailing lists of the University of Porto and Nova School of Business and Economics (in Lisbon). The survey was created in Qualtrics and divided in two parts. In the first part, respondents were asked

Table 2. Example of a choice set.

For the period between January and June 2021	Option A	Option B
Daily deaths attributed to COVID-19, directly or indirectly (e.g., delay on healthcare provision)	150	50
% decrease on household income motivated by the pandemic	20	10
% of students permanently affected by the pandemic	10	20
Level of restrictions to day-to-day life*	High	Low
% of the population in risk of poverty (living with < €6/day)	25	35

*Low: Large-events restrictions and no bars/clubs; Medium: Night curfew and maximum 5 people gatherings; High: Full lockdown.

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about their socio-demographic characteristics. The second part implemented a DCE with 16 choice sets, separated in two blocks. Participants were randomly allocated to respond to one of the two blocks of 8 choice sets. The alternatives for each set were generated by a D-Optimal design [27,28]. We conducted a pilot study between January 2nd and January 6th with 73 respondents. The pilot was used to pre-test our survey and adjust the D-Optimal design parameters. Since no changes were made to the survey, the pilot is also included in the analysis.

Table 2 shows a choice set translated to English (an original example and instructions in Portuguese can be found in S1 and S2 Figs in S1 Appendix). Before starting the DCE, respondents were informed about the scope of the survey. It was clearly stated that alternatives were hypothetical, and that respondents should disregard the potential relation between attributes. They were instructed to consider that effects would last for six months, between January and June of 2021. Respondents were also given a brief instruction on the measures included in each life restriction attribute level and on how to interpret the probability values in the other three attributes. In the first choice set respondents were given the alternative to quit.

3.4. Population in the survey

The survey had a total of 2,191 respondents. Key descriptive statistics are displayed in Table 3. Respondents' age ranged from18 years old up to over and 63% of our sample was represented by individuals below 35 years old. Most of the respondents were women (approximately 63%) and had a bachelor's degree (approximately 32%), or a master's degree or higher (approximately 40%). Individuals in the sample displayed a median monthly equivalised income of around €1,250. The poorer 25% (excluding missing answers) received an equivalent household income of less than €750 per individual; the 25%-50% equivalent household income quartile corresponded to €751-€1,250 per individual; the 50%-75% quartile was between €1,251-€1,750 per individual; and the 75%-100% quartile was above €1,750.

Nearly 42% of the individuals in the sample were living in Porto in comparison with approximately 23% of the respondents living in Lisbon and the remaining elsewhere in the country. Households presented a mean of three individuals, and approximately 60% of all households had no children. Our sample was mainly constituted by students (approximately 28%) and public servants (approximately 21%). Half of the sample (approximately 51%) was working from home at the time of the survey.

3.5. Analysis

We performed a fourfold analysis. First, we ran a conditional logit model [29], with all attribute levels coded as binary. Second, we re-estimated the model with number of daily deaths coded as

Table 3. Key descriptive statistics for the sample and comparison with the Portuguese population.

	SAMPLE	PORTUGAL
	N (%)	N (%)
Age		
19–25 years	646 (29.48)	557,119 (5.41)
26–35 years	739 (33.73)	1,114,060 (10.82)
36–45 years	426 (19.44)	1,435,773 (13.94)
46–55 years	219 (10.00)	803,727 (7.81)
56–65 years	135 (6.16)	1,423,032 (13.82)
66–75 years	21 (0.96)	1,178,309 (11.44)
76–85 years	4 (0.18)	788,663 (7.66)
> 85 years	1 (0.05)	328,066 (3.19)
No answer	-	-
Gender		
Female	1,379 (62.94)	5,430,098 (52.48)
Male	807 (36.83)	4,917,794 (47.52)
No answer	5 (0.23)	-
Education attainment level		
No college Degree[1]	579 (26.43)	-78.8
Bachelor's degree[2]	711 (32.45)	(21.2)[3]
Master's Degree or Higher[4]	894 (40.80)	
No answer	7 (0.32)	
Monthly equivalent household income		
< €750	497 (22.68)	N/A[5]
€751-€1,250	487 (22.23)	
€1,251-€1,750	515 (23.51)	
> €1,751	518 (23.64)	
No answer	174 (7.94)	
Area of residence		
Porto	917 (41.85)	1,729,390 (16.80)
Lisbon	512 (23.37)	2,270,980 (22.05)
Other	762 (34.78)	6,296,711 (61.15)
Number of persons in household		
Mean	3.01	2,5
Number of children in household		
Younger than 6	285 (13.01)	N/A[5]
Both older and younger than 6	101 (4.61)	
Older than 6	446 (20.36)	
None	1,287 (58.74)	
No answer	72 (3.29)	
Occupation		
Unemployed	108 (4.93)	N/A[5]
Student	620 (28.30)	
Student-Worker	21 (0.96)	
Researcher	34 (1.55)	
Public servant	457 (20.86)	
Retired	33 (1.51)	
Large enterprise employee	326 (14.88)	
SME employee	375 (17.12)	
Self-employed	194 (8.85)	
Other	9 (0.41)	
No answer	14 (0.64)	

(*Continued*)

Table 3. (Continued)

	SAMPLE	PORTUGAL
	N (%)	N (%)
Home Office		
No	1,070 (48.84)	N/A[5]
Yes	1,121 (51.16)	
No answer	-	

[1] - Levels 0, 1, 2, and 3 (ISCED).

[2] - Level 6 (ISCED).

[3] - Information on University Education was provided as an aggregate measure.

[4] - Level 7 and 8 (ISCED).

[5] - Non-Available Information.

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a continuous variable, to compute the MRS using deaths as a numeraire. Third, we performed unconditional subgroup analysis, through the estimation of a conditional logit for the relevant characteristics of the population collected in the survey. Fourth, we conducted a latent class analysis [30,31] to account for class preferences' heterogeneity. We tested models from 2 up to 10 latent classes. Three classes were selected to be presented in the manuscript based on the Consistent Akaike information criterion (CAIC) and the Bayesian information criterion (BIC).

Data analysis and the creation of the D-optimal design were made with STATA 17 software.

4. Results

4.1. Main results

Fig 1 shows the results of the conditional logit model and respective MRS. As expected, coefficients for high and medium levels of the attributes are negative and statistically significantly different from the low level, which serves as the baseline level. However, despite the difference relative to the low level, coefficients for medium and high levels for the education and life restrictions attributes have similar magnitudes.

From the relative size of coefficients for different attributes we can conclude that 250 daily deaths due to COVID-19 was the attribute level that affected preferences the most (relative to 50 deaths due to COVID-19). Considering only the maximum levels of each attribute, next comes 45% of the population at the risk of poverty (relative to 25%), followed by 30% loss of respondent's household income (relative to 10%), education impairment in 30% of the school population (relative to 10%), and the highest level of life restrictions–a full lockdown (relative to mild life restrictions).

Based on the analysis of the MRS, the respondents in this survey were willing to sacrifice 30% of their income (instead of 10%) for six months to avoid approximately 47 daily deaths during the same period. They would also accept 30% of the school population to become educationally impaired (instead of 10%) to avoid approximately 25 daily deaths; going from a situation in which there were only restrictions to large-events, bars, and clubs to a full lockdown to avoid approximately 24 daily deaths; and 45% of the population to be at the risk of poverty (instead of 25%) to avoid roughly 101 daily deaths, all for six months.

4.2. Subgroup analysis

Fig 2 shows the MRS for a range of subgroups. While estimates of MRS (coefficients available in S3 Table in S1 Appendix) differed in magnitude for several of the characteristic examined,
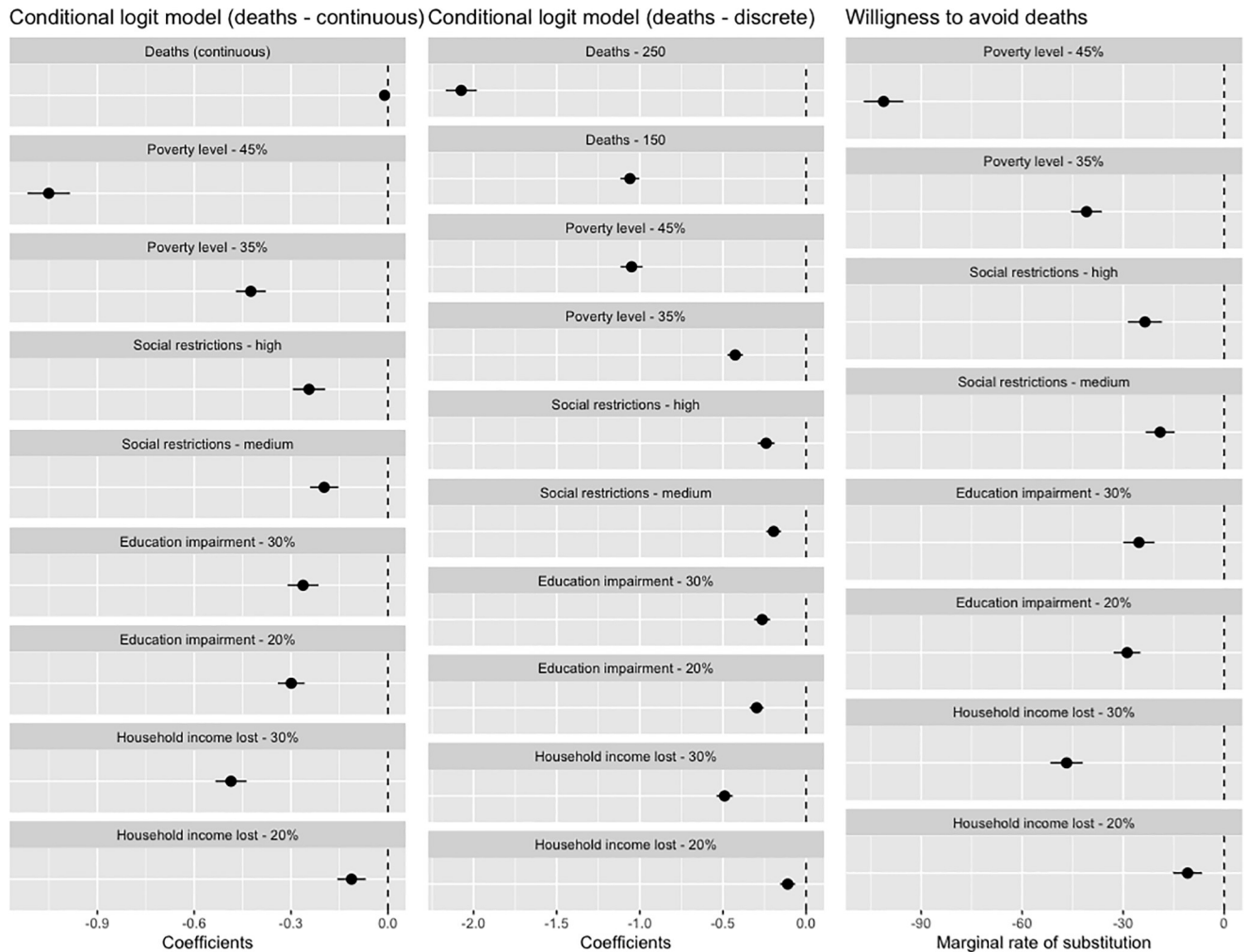
Fig 1. Coefficients from the main conditional logit model and the respective MRS. Note: S2 Table in S1 Appendix, displays the numbers supporting these graphs.

we were reluctant to interpret those without a statistically significant difference. There were, however, two characteristics for which we find statistically significant differences in preferences: gender and working location during the pandemic.

In Fig 2, we see that women had lower MRS than men for most attributes, significantly different in terms of life restrictions and higher level of educational impairment. For example, women were willing to accept a stricter lockdown, instead of milder restrictions, to avoid approximately eight daily deaths, whereas men were willing to accept a stricter lockdown, instead of milder restrictions, to avoid approximately 53 daily deaths.

The same pattern was observed in the workplace subgroup (first graph of the second column), where people working on site have statistically significantly lower MRS for the maximum levels of education impairment and life restrictions than those working from home. For example, people working on site were willing to accept a stricter lockdown, instead of milder restrictions, to avoid approximately 15 daily deaths, whereas people working from home were willing to accept a stricter lockdown, instead of milder restrictions, to avoid approximately 32 daily deaths.
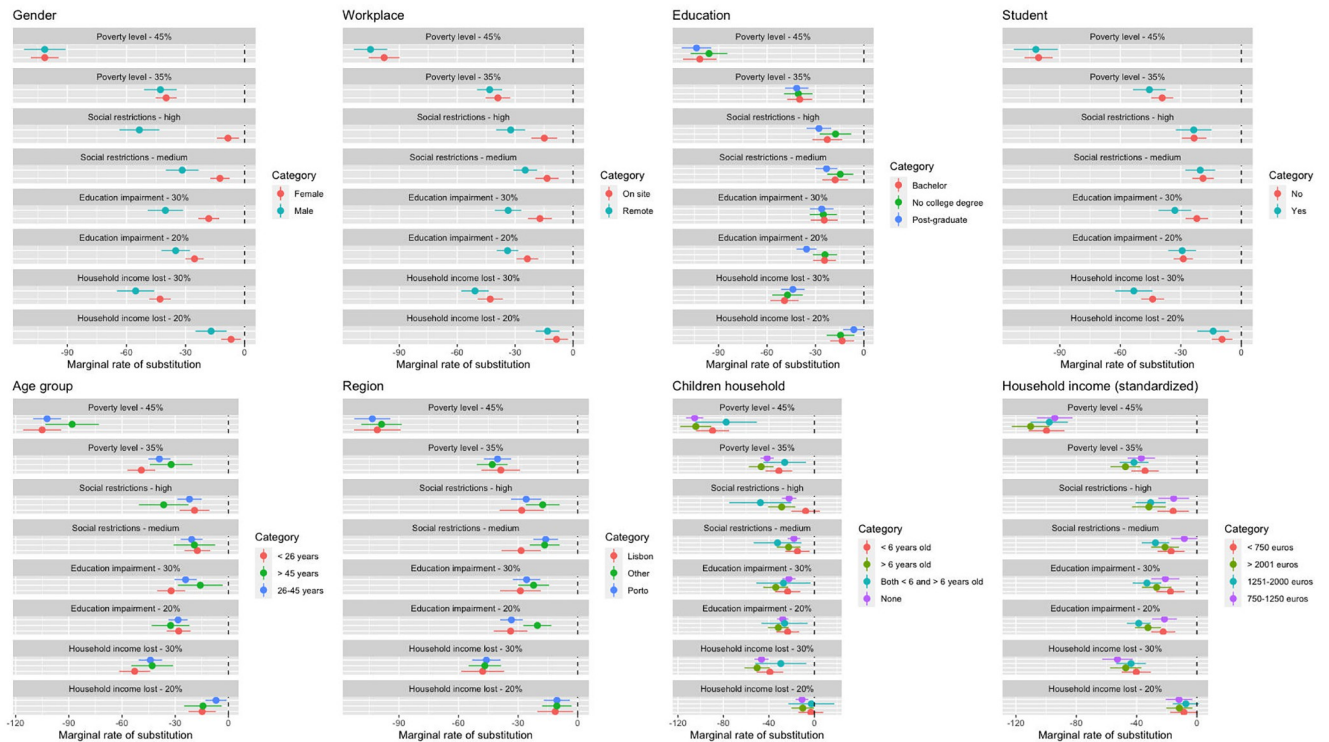
Fig 2. Marginal rate of substitution (MRS) by subgroups.

4.3. Latent class model

Three latent classes of patient preferences were identified. Results are shown in Table 4. People with Class 1 preferences, who make 28% of the sample, gave the lowest importance to COVID-19 deaths. According to Fig 3, they gave higher relative value to education, life restrictions, and risk of poverty than the other two classes. People with Class 1 preferences were more likely to be male, work remotely, and to be part of a household with only children older than six years old.

People with Class 2 preferences, representing 41% of the sample, were characterized by a higher valuation of COVID-19 deaths, when compared to people with Class 1 preferences. They also had a lower valuation for household income losses, when compared with people from Class 1 and Class 3. Fig 3 shows that they gave a relatively lower importance to education, life restrictions and poverty, then people with Class 1 preferences. People with Class 2 preferences were less likely to be aged 45 years or more and to be from Porto.

Individuals with Class 3 preferences, representing 31% of the sample, had the strongest valuation toward all levels of the deaths' attribute. However, they displayed rationally inconsistent results for the education impairment and life restriction attributes. Fig 3 shows that people in this class gave the most relative importance to deaths. People from Class 3 were more likely to be older than 45 years than people with Class 1 or 2 preferences.

5. Discussion

We found a high number of deaths due to COVID-19 to be the most impactful attribute on individual's preferences. Respondents were willing to trade-off considerable impacts on their lives in terms of income loss and limitations to individual freedom, as well as impacts for the

Table 4. Coefficients from the latent class model with 3 classes.

Attribute Levels	Class1 Coeff	Class1 95% CI		Class2 Coeff	Class2 95% CI		Class3 Coeff	Class3 95% CI	
Deaths—150	**-0.47**	-0.62	-0.32	**-1.31**	-1.52	-1.11	**-4.15**	-4.94	-3.35
Deaths—250	**-0.55**	-0.81	-0.29	**-2.64**	-3.04	-2.23	**-12.47**	-15.09	-9.86
Household income lost—20%	**-0.63**	-0.84	-0.42	**-0.16**	-0.28	-0.04	0.60	-0.62	1.83
Household income lost—30%	**-1.28**	-1.55	-1.01	**-0.60**	-0.73	-0.47	**-3.10**	-4.21	-1.99
Compromised education—20%	**-0.42**	-0.60	-0.25	**-0.41**	-0.53	-0.28	**-1.13**	-1.89	-0.37
Compromised education—30%	**-0.90**	-1.13	-0.68	**-0.54**	-0.67	-0.41	**3.91**	2.71	5.10
Life restrictions—medium	**-0.32**	-0.49	-0.14	0.00	-0.11	0.10	**0.55**	0.11	0.99
Life restrictions—high	-0.07	-0.23	0.09	**-0.18**	-0.31	-0.06	0.60	-0.14	1.33
Risk of poverty—35%	**-1.21**	-1.49	-0.93	**-0.56**	-0.68	-0.45	**4.36**	3.03	5.69
Risk of poverty—45%	**-1.60**	-1.85	-1.36	**-1.51**	-1.68	-1.34	**-4.02**	-5.38	-2.67
Class membership model									
Gender: Female (reference)							Reference Class		
Gender: Male	**0.49**	0.20	0.78	0.04	-0.25	0.33			
Age: 18–25 (reference)									
Age: 26–45	-0.24	-0.72	0.25	-0.40	-0.89	0.09			
Age: >45	**-0.58**	-1.14	-0.03	**-1.01**	-1.59	-0.43			
Working type: On site (reference)									
Working type: Remote	**0.31**	0.03	0.59	-0.09	-0.36	0.19			
Region: Other (reference)									
Region: Porto	-0.13	-0.44	0.18	**-0.33**	-0.64	-0.02			
Region: Lisboa	0.05	-0.31	0.42	-0.05	-0.42	0.33			
Children in HH: <6									
Children in HH: <6 & >6	0.09	-0.60	0.77	-0.03	-0.73	0.66			
Children in HH: Only >6	**0.63**	0.13	1.13	0.40	-0.11	0.90			
Children in HH: None	0.38	-0.05	0.81	0.31	-0.11	0.74			
Education: No college degree (reference)									
Education: Bachelors	0.19	-0.19	0.57	-0.17	-0.54	0.19			
Education: Masters+	0.04	-0.37	0.46	-0.36	-0.77	0.05			
HH eq. income: < €750									
HH eq. income: €751 – €1,250	-0.10	-0.47	0.27	0.00	-0.38	0.37			
HH eq. income: €1,251-€2,000	0.03	-0.34	0.41	0.25	-0.14	0.64			
HH eq. income: >€2,001	0.13	-0.26	0.52	0.34	-0.07	0.75			
Student: No (reference)									
Student: Yes	-0.09	-0.57	0.39	-0.09	-0.58	0.39			
Constant	-0.61	-1.42	0.20	0.69	0.03	1.34			
Class share		0.28			0.41			0.31	

Numbers in bold stand for statistically significant coefficients at 95% confidence level.

Number of observations: 33,808; Log likelihood = -8242.7859; AIC: 16609.61 CAIC: 17024.52; BIC: 16962.52.

society in terms of educational impairment and poverty, to avoid going from 50 to 250 daily deaths related to COVID-19. Levels of poverty were the second attribute in priority for our respondents, with individuals' household income losses coming in third. While the individual household income loss reported a more selfish view of the economic impacts of the pandemic, the levels of poverty captured a more altruistic perspective. The high importance given to poverty levels suggests that the respondents were very concerned with the pandemic effects on the
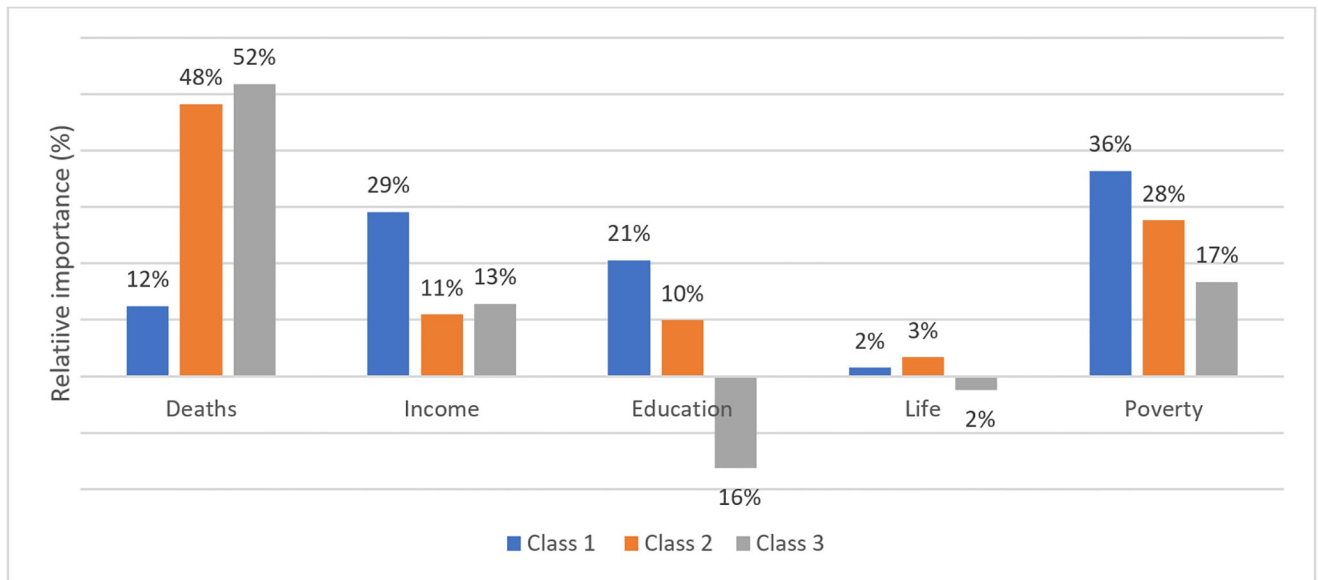
Fig 3. Relative importance of attributes per class. Note: The relative importance is computed by taking the absolute value of the maximum level of each attribute and dividing them by the sum of the absolute value of all the maximum levels of each attribute, per class [32]. The downward bars for "Education" and "Life" attributes in Class 3 are purely illustrative, to convey that the valuation given to those attributes' levels are contrary to rationally consistent preferences.

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economical capacity of their countrymen. Subgroup results suggest that women presented lower MRS than men for the education and life restriction attributes. S4 Table in S1 Appendix, shows that these results are driven by both a stronger negative effect of deaths and a weaker negative effect of the two attributes on women's preferences, when compared to men. Several studies conducted have found general evidence that women reported to agree more and be more compliant with the restrictions imposed in different countries [33–35]. Women reported greater fear, more negative expectations about health-related consequences and were more likely to consider COVID-19 infection a serious health problem. Moreover, during the pandemic, women reported higher levels of stress and concern, as well as higher levels of overwork and informal care, compared to their male counterparts [36–38]. Our results also support this evidence since being more worried naturally increases one's MRS to stop the spreading of the virus and avoid deaths. The gender differences found in our results might also be reflecting the sample selection bias induced in our data. There is, for example, a larger proportion of women than men working on site in our sample (67.38% vs. 32.62%), as shown in S1 Table in S1 Appendix. Our findings also suggest that the MRS of those working remotely was twice as high as the ones working on site, for the maximum level of the life restrictions' attribute. These results are compatible with potential saturation felt by individuals in remote working; but they might also result from lower exposition to risk. At the same time, this can also be explained by the largest share of female respondents working on-site. Further investigation would be needed to disentangle these two potential effects.

The latent class analysis supported, to some extent, the results found in the unconditional sub-group analysis. People with Class 1 preferences were more likely to be males and working from home. While the differences were now in different attributes, it remains that men and people working from home tended to have different preferences from women and people working on site. Also, the latent class model identified a class where people were more likely to give a major importance to the deaths' attribute, to a point where only the higher levels of the

household income loss and population in risk of poverty had rationally consistent coefficients. As this is not observed in other studies, such as in Chorus (2020) [8], we believe it may be a consequence of our analysis encompassing a period of higher emergency. The class in question had a larger share of people over 45 years old which may indicate that older people developed a bigger sense of urgency than younger people, on average.

Our results are broadly in line with other DCE studies focusing on a similar question in the Netherlands [8], United States of America [12], Australia [10] and Germany [11], even though these studies collected responses at an earlier phase of the pandemic: Chorus (2020) [8] in April 2020, Reed (2020) [12] in May 2020, Manipis (2020) [10] between July and August 2020, Li (2021) [9] end of August 2020 and Mühlbacher (2022) [11] from October to November 2020). Although there are some differences between the domains studied, attributes related to COVID-19 excess mortality were consistently those with a larger effect on individual's preferences. An exception was the German sample studied by Mühlbacher (2022) [11], in which the attribute related to a decrease of individual income was the most important. Most studies also pointed to considerable heterogeneity depending on individuals' characteristics. Chorus et al. (2020) [8] found older and more highly educated Dutch citizens to be less willing to sacrifice domains as mental health, educational disadvantage, and income loss to avoid fatalities; while Li et al. (2021) [9] identified differences by age, unemployment status and ability to work from home. In line with our results, the authors found respondents who can work from home to be less willing to sacrifice some attributes, namely, to have lower willingness to stay at home to reduce unemployment and number of COVID-19 daily cases.

An important limitation of this study is the survey's lack of representativeness, which resulted from the fact that it was collected online with two universities as key channels of dissemination. Therefore, the survey ended up reaching a larger share of individuals with higher education than that of the general population. This bias may also imply a higher proportion of high-income individuals in the sample.

Preferences displayed by individuals are likely to be affected by the timing of the study. This survey was distributed during the worst wave of the pandemic in Portugal, at a time where cases and deaths were growing fast, and the Portuguese NHS was displaying strong signals of being disrupted. While having information about preferences in the peak of the pandemic gives us important insight about decision-making under extreme situations of crisis, our results may be capturing some sense of urgency, potentially not appropriate for predicting preferences in other periods.

Moreover, the COVID-19 pandemic was characterised by substantial uncertainty. The DCE setting implies using fixed levels for each attribute, throughout the experiment. These levels are defined based on the literature and on existing expectations. Some of these levels may become less optimal at a given moment, considering ongoing changes in the pandemic situation. For instance, the highest level for deaths considered in our DCE, was below the maximum level observed afterwards. Combined with the required time to design and implement, DCEs do not present substantial flexibility in volatile contexts. Additionally, during the survey collection period, the vaccination program was already being rolled out. Even though the vaccination program could potentially affect one's preferences, we do not expect this to have substantially impacted the results. In fact, in the peak of the third wave, only 2.5% of the population had received a first dose.

In the specific case of the third COVID-19 wave in Portugal our results suggest our sample supported the decisions adopted by the Portuguese government, which prioritised lives over the economy and lifestyle, by implementing a second full lockdown in the country. This is an interesting finding, particularly considering that just before the onset of the third wave there were some signs of behavioural fatigue in the Portuguese population. In this context our

findings might suggest that individuals adapt their preferences quickly when facing serious health hazards. Depending on how many deaths we assume that a lockdown could avoid, we may use our MRS results for some back-of-the-envelope calculations on the quantitative level of support of our respondents. For example, according to Flaxman et al. (2020) [39] the lockdown during the first wave of the pandemic saved around 3.1 million lives, including 470,000 in the UK, 690,000 in France and 630,000 in Italy. Even though they do not contemplate Portugal, rescaling those numbers would yield approximately 1,000 daily deaths avoided in Portugal for the same period, which is much higher than the combined MRS for all the maximum levels of the other four attributes.

Last, and while our study is a product of a convenience survey with limited generalizability, it is a first step in gathering information about the public preferences for pandemic outcomes and support for government decision-making at a time of crisis. Additionally, no feedback regarding the completion of the DCE was collected from respondents. Overall, and despite these limitations, we show that DCE are instruments available to help guide policy decision making and we defend that they are a flexible and efficient tool to systematically assess implicit preferences of the population.

6. Conclusion

Our results show that, during the peak of the pandemic in Portugal, individuals in this sample were willing to sacrifice substantial amounts of their income, and everyday life freedom, as well as educational outcomes and levels of poverty in the society, to avoid the daily toll of COVID-19 deaths happening at that time. Additionally, findings from the heterogeneity analysis suggest that preferences varied with characteristics such as gender and place of work. These results provide some insights to inform future research on the topic and confirm that DCEs are a useful and flexible tool to incorporate public preferences and behaviours on the design of new policies, particularly, in the context of a crisis.

Supporting information

S1 Appendix.
(PDF)

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References

1. Fernandes N., "Economic Effects of Coronavirus Outbreak (COVID-19) on the World Economy." Rochester, NY, Mar. 22, 2020. https://doi.org/10.2139/ssrn.3557504

2. OECD, "The state of education during the COVID pandemic—OECD," *OECD Publ. Paris*, 2021, Accessed: Aug. 29, 2022. [Online]. https://www.oecd.org/education/state-of-school-education-one-year-into-covid.htm.

3. Craig B. M., Lancsar E., Mühlbacher A. C., Brown D. S., and Ostermann J., "Health preference research: an overview," *Patient—Patient-Centered Outcomes Res.*, vol. 10, no. 4, pp. 507–510, Aug. 2017, https://doi.org/10.1007/s40271-017-0253-9 PMID: 28597377

4. Jacobs M., "Accounting for Changing Tastes: Approaches to Explaining Unstable Individual Preferences," *Rev. Econ.*, vol. 67, no. 2, pp. 121–183, Aug. 2016, https://doi.org/10.1515/roe-2015-1007

5. Wang Y., Wang Z., Wang Z., Li X., Pang X., and Wang S., "Application of Discrete Choice Experiment in Health Care: A Bibliometric Analysis," *Front. Public Health*, vol. 9, 2021, Accessed: Aug. 29, 2022. [Online]. https://www.frontiersin.org/articles/10.3389/fpubh.2021.673698.

6. Rosenthal U. and Hart P., "Experts and Decision Makers in Crisis Situations," *Knowledge*, vol. 12, no. 4, pp. 350–372, Jun. 1991, https://doi.org/10.1177/107554709101200402

7. Sotiropoulos D. A., "Southern European Governments and Public Bureaucracies in the Context of Economic Crisis," *Eur. J. Soc. Secur.*, vol. 17, no. 2, pp. 226–245, Jun. 2015, https://doi.org/10.1177/138826271501700205

8. Chorus C., Sandorf E. D., and Mouter N., "Diabolical dilemmas of COVID-19: An empirical study into Dutch society's trade-offs between health impacts and other effects of the lockdown," *PLOS ONE*, vol. 15, no. 9, p. e0238683, Sep. 2020, https://doi.org/10.1371/journal.pone.0238683 PMID: 32936815

9. Li L., Long D., Rad M. R., and Sloggy M. R., "Stay-at-home orders and the willingness to stay home during the COVID-19 pandemic: A stated-preference discrete choice experiment," *PLOS ONE*, vol. 16, no. 7, p. e0253910, Jul. 2021, https://doi.org/10.1371/journal.pone.0253910 PMID: 34197531

10. Manipis K., Street D., Cronin P., Viney R., and Goodall S., "Exploring the Trade-Off Between Economic and Health Outcomes During a Pandemic: A Discrete Choice Experiment of Lockdown Policies in Australia," *Patient—Patient-Centered Outcomes Res.*, vol. 14, no. 3, pp. 359–371, May 2021, https://doi.org/10.1007/s40271-021-00503-5 PMID: 33694076

11. Mühlbacher A. C., Sadler A., and Jordan Y., "Population preferences for non-pharmaceutical interventions to control the SARS-CoV-2 pandemic: trade-offs among public health, individual rights, and economics," *Eur. J. Health Econ.*, Feb. 2022, https://doi.org/10.1007/s10198-022-01438-w PMID: 35138495

12. Reed S., Gonzalez J. M., and Johnson F. R., "Willingness to Accept Trade-Offs Among COVID-19 Cases, Social-Distancing Restrictions, and Economic Impact: A Nationwide US Study," *Value Health*, vol. 23, no. 11, pp. 1438–1443, Nov. 2020, https://doi.org/10.1016/j.jval.2020.07.003 PMID: 33127014

13. Dong D. et al., "Public preference for COVID-19 vaccines in China: A discrete choice experiment," *Health Expect.*, vol. 23, no. 6, pp. 1543–1578, Dec. 2020, https://doi.org/10.1111/hex.13140 PMID: 33022806

14. Jonker M., de Bekker-Grob E., Veldwijk J., Goossens L., Bour S., and Rutten-Van Mölken M., "COVID-19 Contact Tracing Apps: Predicted Uptake in the Netherlands Based on a Discrete Choice Experiment," *JMIR MHealth UHealth*, vol. 8, no. 10, p. e20741, Oct. 2020, https://doi.org/10.2196/20741 PMID: 32795998

15. Luyten J., Tubeuf S., and Kessels R., "Rationing of a scarce life-saving resource: Public preferences for prioritizing COVID-19 vaccination," *Health Econ.*, vol. 31, no. 2, pp. 342–362, Feb. 2022, https://doi.org/10.1002/hec.4450 PMID: 34787925

16. Zimba R. et al., "Patterns of SARS-CoV-2 Testing Preferences in a National Cohort in the United States: Latent Class Analysis of a Discrete Choice Experiment," *JMIR Public Health Surveill.*, vol. 7, no. 12, p. e32846, Dec. 2021, https://doi.org/10.2196/32846 PMID: 34793320

17. de Blaeij A., Florax R. J. G. M., Rietveld P., and Verhoef E., "The value of statistical life in road safety: a meta-analysis," *Accid. Anal. Prev.*, vol. 35, no. 6, pp. 973–986, Nov. 2003, https://doi.org/10.1016/s0001-4575(02)00105-7 PMID: 12971932

18. Mouter N., van Cranenburgh S., and van Wee B., "Do individuals have different preferences as consumer and citizen? The trade-off between travel time and safety," *Transp. Res. Part Policy Pract.*, vol. 106, pp. 333–349, Dec. 2017, https://doi.org/10.1016/j.tra.2017.10.003

19. Valente de Almeida S., Costa E., Lopes F. V., Santos J. V., and Pita Barros P., "Concerns and adjustments: How the Portuguese population met COVID-19," *PLOS ONE*, vol. 15, no. 10, p. e0240500, Oct. 2020, https://doi.org/10.1371/journal.pone.0240500 PMID: 33052976

20. European Centre for Disease Prevention and Control, "Data on country response measures to COVID-19," *European Centre for Disease Prevention and Control*, Aug. 25, 2022. https://www.ecdc.europa.eu/en/publications-data/download-data-response-measures-covid-19 (accessed Aug. 29, 2022).

21. Almeida V., Barrios S., Christl M., De Poli S., Tumino A., and van der Wielen W., "The impact of COVID-19 on households' income in the EU," *J. Econ. Inequal.*, vol. 19, no. 3, pp. 413–431, Sep. 2021, https://doi.org/10.1007/s10888-021-09485-8 PMID: 34093098

22. Cantó O. et al., "Welfare Resilience at the Onset of the COVID-19 Pandemic in a Selection of European Countries: Impact on Public Finance and Household Incomes," *Rev. Income Wealth*, vol. 68, no. 2, pp. 293–322, Jun. 2022, https://doi.org/10.1111/roiw.12530 PMID: 34548701

23. Gama A. et al., "Double jeopardy from the COVID-19 pandemic: risk of exposure and income loss in Portugal," *Int. J. Equity Health*, vol. 20, no. 1, p. 231, Oct. 2021, https://doi.org/10.1186/s12939-021-01569-1 PMID: 34670581

24. Azevedo J. P., Amer H., Goldemberg D., Koen G., and Iqbal S. A., "OUP accepted manuscript," *World Bank Res. Obs.*, vol. 36, no. 1, pp. 1–40, 2021.

25. Pancani L., Marinucci M., Aureli N., and Riva P., "Forced Social Isolation and Mental Health: A Study on 1,006 Italians Under COVID-19 Lockdown," *Front. Psychol.*, vol. 12, p. 663799, May 2021, https://doi.org/10.3389/fpsyg.2021.663799 PMID: 34093358

26. Pordata, "Taxa de risco de pobreza: antes e após transferências sociais," *Base de dados Portugal contemporâneo*, 2022. https://www.pordata.pt/Portugal/Taxa+de+risco+de+pobreza+antes+e+ap%C3%B3s+transfer%C3%AAncias+sociais-2399 (accessed Aug. 29, 2022).

27. Carlsson F. and Martinsson P., "Design techniques for stated preference methods in health economics," *Health Econ.*, vol. 12, no. 4, pp. 281–294, Apr. 2003, https://doi.org/10.1002/hec.729 PMID: 12652515

28. Cook R. D. and Nachtrheim C. J., "A comparison of algorithms for constructing exact d-optimal designs," *Technometrics*, vol. 22, no. 3, pp. 315–324, Aug. 1980, https://doi.org/10.1080/00401706.1980.10486162

29. D. McFadden, "Conditional logit analysis of qualitative choice behavior," 1973.

30. J. A. Hagenaars and A. L. McCutcheon, "Applied Latent Class Analysis," *Cambridge Core*, Jun. 2002. https://www.cambridge.org/core/books/applied-latent-class-analysis/30C364913C52083262DD7CE5A2E05685 (accessed Sep. 04, 2022).

31. Hole A. R., "Modelling heterogeneity in patients' preferences for the attributes of a general practitioner appointment," *J. Health Econ.*, vol. 27, no. 4, pp. 1078–1094, Jul. 2008, https://doi.org/10.1016/j.jhealeco.2007.11.006 PMID: 18179837

32. Arslan I. G. et al., "Patients', healthcare providers', and insurance company employees' preferences for knee and hip osteoarthritis care: a discrete choice experiment," *Osteoarthritis Cartilage*, vol. 28, no. 10, pp. 1316–1324, Oct. 2020, https://doi.org/10.1016/j.joca.2020.07.002 PMID: 32682071

33. Alsharawy A., Spoon R., Smith A., and Ball S., "Gender Differences in Fear and Risk Perception During the COVID-19 Pandemic," *Front. Psychol.*, vol. 12, p. 689467, Aug. 2021, https://doi.org/10.3389/fpsyg.2021.689467 PMID: 34421741

34. Galasso V., Pons V., Profeta P., Becher M., Brouard S., and Foucault M., "Gender differences in COVID-19 attitudes and behavior: Panel evidence from eight countries," *Proc. Natl. Acad. Sci.*, vol.

117, no. 44, pp. 27285–27291, Nov. 2020, https://doi.org/10.1073/pnas.2012520117 PMID: 33060298

35. New York University, "Women more likely to embrace behaviors aimed at preventing the spread of COVID-19," *ScienceDaily*, 2022. https://www.sciencedaily.com/releases/2020/10/201005092343.htm (accessed Aug. 29, 2022).

36. Office for National Statistics, "Coronavirus (COVID-19) and the different effects on men and women in the UK, March 2020 to February 2021—Office for National Statistics," 2022. https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/conditionsanddiseases/articles/coronaviruscovid19andthedifferenteffectsonmenandwomenintheukmarch2020tofebruary2021/2021-03-10 (accessed Aug. 29, 2022).

37. Raiber K. and Verbakel E., "Are the gender gaps in informal caregiving intensity and burden closing due to the COVID-19 pandemic? Evidence from the Netherlands," *Gend. Work Organ.*, vol. 28, no. 5, pp. 1926–1936, Sep. 2021, https://doi.org/10.1111/gwao.12725 PMID: 34548767

38. Smyth L., "The burden of informal care on women: how has it increased during COVID-19, and what are the implications for women's working lives?," Nov. 2021.

39. Flaxman S. et al., "Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe," *Nature*, vol. 584, no. 7820, Art. no. 7820, Aug. 2020, https://doi.org/10.1038/s41586-020-2405-7 PMID: 32512579