# Preferences for COVID-19 epidemic control measures among French adults: a discrete choice experiment

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Jonathan Sicsic[±], Serge Blondel[*], Sandra Chyderiotis[°], François Langot[†], Judith E. Mueller[‡]

## Abstract

In this stated preferences study, we describe for the first time French citizens' preferences for various epidemic control measures, to inform longer-term strategies and future epidemics. We used a discrete choice experiment in a representative sample of 908 adults in November 2020 to quantify the trade-off they were willing to make between restrictions on the social, cultural, and economic life, school closing, targeted lockdown of high-incidence areas, constraints to directly protect vulnerable persons, and reduction in the risk of hospital overload. The estimation of mixed logit models with correlated random effects shows that some trade-offs exist to avoid overload of hospitals and intensive care units. The willingness to accept restrictions was shared to a large extent across subgroups according to age, gender, education, vulnerability to the COVID-19 epidemic, and other socio-demographic or economic variables. However, individuals who feel at greater risk from COVID-19, and individuals with high confidence in the governmental management of the health and economic crisis, more easily accept all these restrictions. Policy simulations show that the scenario close to a targeted lockdown or with medically prescribed self-isolation are those satisfying the largest share of the population while achieving high gain in average welfare.

[±] Université de Paris (LIRAES). jonathan.sicsic@u-paris.fr
[*] Université d'Angers (GRANEM-TEPP) & Université de Paris (LIRAES)
[°] Institut Pasteur. sandra.chyderiotis@outlook.com.
[†] Université du Mans (GAINS-TEPP, IRA) & Institut Universitaire de France & Paris School of Economics & Cepremap & IZA. flangot@univ-lemans.fr
[‡] EHESP French School of Public Health & Institut Pasteur. judith.mueller@ehesp.fr.

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**Keywords**: SARS-CoV-2 epidemic, COVID-19, Epidemic control measures, Preferences, Discrete choice experiment, Correlated mixed logit model

**JEL Codes**: C91, I12, I18

## 1. Introduction

Epidemic control measures - or non-pharmaceutical interventions - are widely used during the COVID-19 epidemic to curb increases in hospitalizations, admissions to intensive care units, and mortality. In the absence of highly effective treatments, these measures are required either on an on-off mode or throughout a period of several months until vaccination directly protects vulnerable populations, or until a sufficient level of immunity is achieved (through natural infection or vaccination) to eliminate the disease or at least transform its occurrence into endemicity.

Strict lockdowns are extreme epidemic control measures that put a high burden on social and economic life. Other individual measures can represent more nuanced degrees of constraints and can be adapted to the required impact and societal needs. Governments need to arbitrate between the negative consequences of a complete lockdown and the consequences of hospital overload. Economic analysis can provide guidance regarding these trade-offs in two ways. Fist, cost-benefit analysis can inform about optimal allocation of ressources by comparing each measure (or set of measures) cost to their benefits, converted from number of lifes saved into monetary equivalent based on value of a statistical life (VSL) estimates (Rowthorn and Maciejowski, 2020). Yet, VSL values calculated in one context may not be easily transposed in another, and this approach makes it difficult to account for non monetary costs of Sars-

Cov-2 infection (e.g., post-COVID-19 syndrome) or control measures' side effects (e.g., mental health disorders).

A second approach is to directly account for individuals' opinions and preferences, using preference elicitation tools such as stated preferences surveys (Blayac et al., 2021; Genie et al., 2020; Krauth et al., 2021). The usefulness of this second approach relies on the assumption that the closer the measures are aligned with public preferences, the more sustainable and acceptable they will be for indivividuals and society. It can be argued that studies based on individual preferences are crucial to ensure population's compliance with the set of epidemic control measures over several months. Therefore, we propose to follow this stream of research in order to identify the most acceptable measures as well as their combinations (strategies) in France. We use a discrete choice experiment (DCE) method (Lancsar and Louviere, 2008; Ryan and Gerard, 2003) to quantify the trade-offs French adults are willing to make between epidemic control measures and their public health consequences. DCE is a type of stated preferences survey, where each respondent is asked to repeatedly choose among a set of several (hypothetical) alternatives, the one they would prefer (Ben-Akiva et al., 2019; Louviere et al., 2000). Discrete choice models are grounded in standard economic theory, thus aiming for making predictions about the demand for alternative goods or programmes (McFadden, 1986, 1974).

In this study, we estimate for the first time the welfare loses or gains that is induced by each constraint composing a strategy, relative to a benchmark welfare characterized by a baseline strategy. The potential success of a strategy can be measured by the magnitude of its theoretical acceptance/adhesion rate in the population, this latter being deduced from the number of individuals experimenting a welfare increase after a strategy change. The welfare impacts of these strategies are specific to the individual and societal needs, as well as to the values of the country. Therefore, the results of our study, based on an original survey of a representative sample of French cannot be easily transposed to another country.

We compare six alternative policy scenarios (also referred as “strategies”), each of one being more restrictive than the baseline strategy already implemented in France in November 2020. These alternative strategies are imagined to respond to an increase of the pandemic with the main objective to lower the peak of occupation of hospital intensive care beds. Four main tools are considered: "restrictions measures on economic, cultural and social life", "targeted lockdown", "homeschooling at high school", "constraints to directly protect vulnerable persons". With a specific degree of strictness, these four measures are combined to define each strategy under the constraint that the combination allows reducing intensive care unit (ICU) overload.

Our main results suggest that all six analyzed strategies generate positive welfare gains (increased mean utility) by avoiding the need to postpone surgery, at the expense of stricter control measures, compared to the baseline scenario (the scenario prevailing in November 2020). Two scenarios increase welfare for more than 85% of the population while achieving high gain in mean utility: a scenario close to a targeted lockdown and a scenario with medically prescribed self-isolation and with restrictions in nursing homes. On the opposite, the scenario with the highest restrictions on public spaces and the scenario favoring the highest restrictions on schooling both generate a lower mean utility and a smaller fraction of the population experimenting a welfare increase (lower than 75%). Therefore, it seems that scenarios that directly protect vulnerable persons improve welfare for the largest proportion of the population even if they do not allow to reach the highest increase in average welfare. We expect that the results of our study can provide relevant information that helps to define a sustainable mid-term (1-year) strategy of epidemic control in France in a situation of a slow but prolonged period of Sars-CoV-2 propagation in the population, to keep the incidence of severe cases compatible with health care capacities.

Our study complements previous research that evaluated the epidemic control for influenza pandemic threats (World Health Organization, 2017), as well as studies about the perceptions and practices of the French population concerning the 8-week lockdown that occurred in France in between March and May 2020 (Peretti-Watel et al., 2020). In May 2020, one DCE study has investigated the trade-offs French people were willing to make to avoid a lockdown extension by 8 weeks: wearing masks and limiting interregional travel (Blayac et al., 2021). Another DCE study in Germany investigated the trade-offs Germans citizens were willing to make between various exit strategies from lockdown and showed that two attributes dominated the trade-offs: avoiding a mandatory tracing application, and providing sufficient intensive care capacities (Krauth et al., 2021).

The remainder of the paper is structured as follows. We detail the DCE design, participant selection, and recruitment in section 2. The main econometric models and sensitivity analyses are presented in sections 3 and 4. Section 5 presents our results and section 6 concludes.

## 2. The discrete choice experiment (DCE)

### 2.1. Selection of attributes and levels

Our selection of attributes and levels describing the hypothetical epidemic management strategies was based on a three-step procedure. First, analysis of existing literature and theoretical relevance allowed pre-selection of attributes and levels. Second, the list was refined based on qualitative work including consultation of experts involved in the Sars-CoV-2 epidemic management (epidemiology, clinical medicine, modeling, social psychology, economics, and public policy). Third, we conducted think-aloud interviews by selfadministering the questionnaire to a sample of 9 participants and recording their thoughts and information processing (Ryan et al., 2009). All participants provided feedback that helped us identify the most appropriate formulation of levels, and simplify the introduction text of scenarios.

The final list of attributes and levels is displayed in Table 1. Four attributes concern economic and social life, including school closure and targeted lockdown. The last attribute is risk of ICU overload and its consequences. The occupation of ICU beds appeared to be the most appropriate health care outcome to consider in trade-offs around the Sars-Cov-2 epidemic. Consequences of variable degree of negative impact are, for example, reprogramming of non-urgent surgery, transfer of COVID-19 patients to other hospitals in distant geographic areas, and ultimately, triage of patients for admission in ICU based on prognostic factors (a level that was not considered in our DCE for ethical reasons). For each attribute - except targeted lockdown with two levels - we defined three levels with increasing severity, from low severity/strictness (level 1) to high severity/strictness (level 3).

## 2.2. Design of choice tasks

We used a pairwise DCE design, a format that asked respondents to repeatedly choose which scenario would be most acceptable between two hypothetical scenarios (see Figure 1 for an example choice task). The content of scenarios (optimal combinations of attributes' level) was selected using an efficient fractional design using NGENE software (Choice metrics). We defined non-informative prior values for the preferences parameters corresponding to the four non-ICU related attributes, and negative prior values for levels 2 ("need to postpone elective surgery") and 3 ("need to postpone elective surgery + patient evacuation") of the ICU overload attribute. We specified a non-linear utility function allowing independent estimation of all attributes' levels (using level 1 – the less restrictive measures - of each attribute as

**Table 1.** Definition of attributes and levels

| Attributes | Level | Level description |
|---|---|---|
| **Restriction measures on economic and social life** | **1** | No generalized closure measure |
| | **2** | Closure of public spaces |
| | **3** | Closure of public spaces + transport and office |
| **Targeted lockdown** | **1** | No targeted lockdown |
| | **3** | Targeted lockdown for sectors with high incidence |
| **Homeschooling at high school** | **1** | All teaching in-site |
| | **2** | Homeschooling at high school for 2 weeks |
| | **3** | Homeschooling at high school for 2 months |
| **Medically prescribed self-isolation** | **1** | Information campaign on COVID-19 risk factors |
| | **2** | Medically prescribed self-isolation (SI) |
| | **3** | Medically prescribed SI + restrictions for visits in nursing homes |
| **Measures to overcome ICU overload** | **1** | Measures to increase the number of health care workers available |
| | **2** | Need to postpone elective surgery |
| | **3** | Need to postpone surgery + patient evacuation |

Legend

Level 1 of restriction (low) – **Reference level in choice models**
Level 2 of restriction (moderate)
Level 3 of restriction (high)

reference) as well as some pre-specified interactions. We hypothesized that respondents could be reluctant to choose scenarios presenting a restriction measure that appeared particularly 'soft' given the measures taken to avoid ICU overload. We thus posited a negative interaction between the level 3 (need to postpone elective surgery + patient evacuation) of the *ICU overload* attribute, and the level 1 (lowest restriction) of the *economics and social life* (i.e., "no generalized closure measure"), *homeschooling* (i.e., "all teaching in site"), and *medically prescribed self-isolation* (i.e., "information campaign on COVID-19 risks factors")[1] attribute.

**Figure 1**. Example choice task

**Reminder: We ask you to imagine a post-lockdown situation in which a clear increase in the number of people treated in intensive care or who died as a result of COVID-19 is observed in your department. A competent decision-maker will announce additional measures for your department, which will enter into force from the following week.**

Between the two scenarios presented, choose the scenario that would be the most acceptable overall. There are no right or wrong answers, only your opinion matters.

| | **Scenario 1** | **Scenario 2** |
|---|---|---|
| **Restriction measures on economic and social life** | No generalized closure measure | Closure of public spaces |
| **Targeted lockdown** | No targeted lockdown | Targeted lockdown for sectors with high incidence * |
| **Homeschooling at high school** | Homeschooling for **2 weeks** | Homeschooling for **2 months** |
| **Protection of vulnerable people** | - Medically prescribed self-isolation<br>- Restrictions for visits in nursing homes | Information campaign on COVID-19 risk factors |
| **Measures to overcome ICU overload** | Measures to increase the number of health care workers available | Need to postpone elective surgery |
| **Q1. Which scenario would be most acceptable to you ?** (tick only one box) | ☐ | ☐ |

* with financial aid in case of absence of social security coverage.

**Q2.** On a scale from 0 à 10, how certain are you of the choice you just made? (0: absolutely uncertain; 10: perfectly certain)

[1] We did not plan to estimate an interaction effect between high ICU overload and the level 1 of the *targeted lockdown* attribute ("no targeted lockdown"), because at the time of the survey, absence of targeted lockdown was not considered as a particularly lenient measure, but rather the default..

A total of 18 pairwise tasks were necessary to estimate all effects. We randomly assigned 6 tasks to the respondents, and the order of choice task varied for each respondent (Appendix A shows the content of all 18 choice tasks). After each choice task, respondents were asked to indicate the degree of their decision certainty on a scale from 0 to 10 (Dekker et al., 2016; Lundhede et al., 2009; Regier et al., 2019).

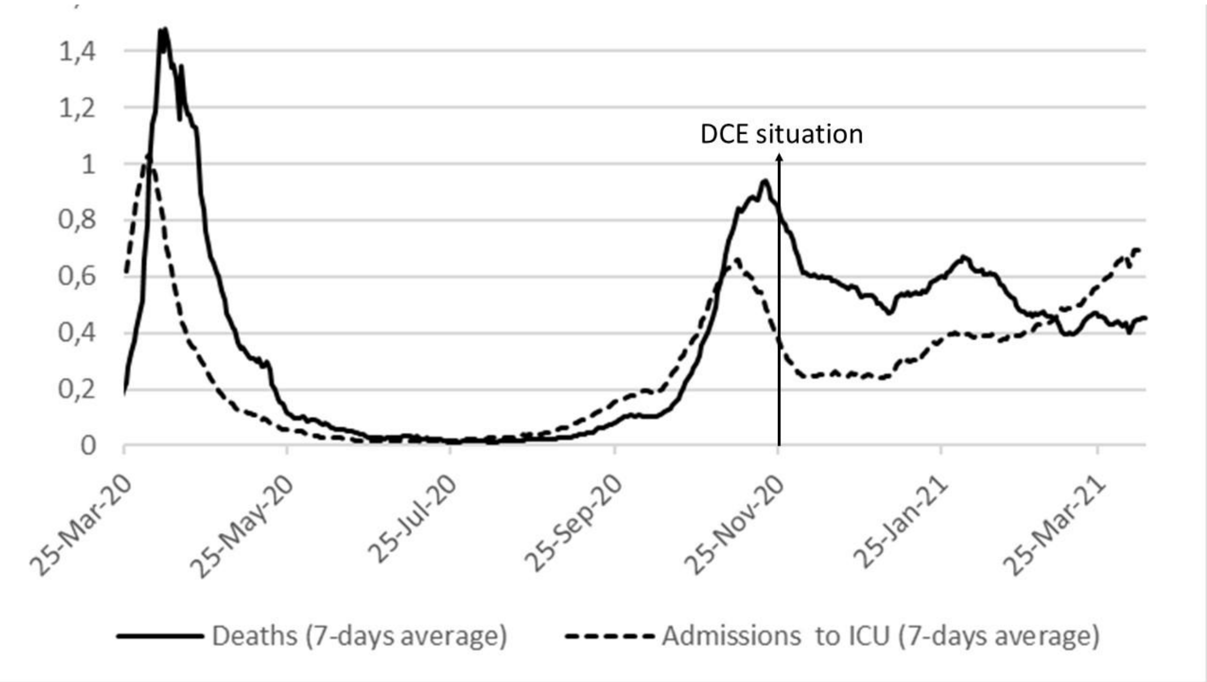
### 2.3. Participant selection and recruitment

We used Johnson and Orme's rule of thumb formulae (de Bekker-Grob et al., 2015) to determine the minimum acceptable sample size requirement per strata analysis. Considering six choice tasks, two alternatives per choice task, and a maximum of three levels per attribute, the minimum required sample size was167. We arbitrarily multiplied this minimum sample size by a factor of 5 - thus aiming for > 850 respondents – in order to investigate preference heterogeneity by modeling variation in preferences according to different individual characteristics.

Any French resident aged between 18 and 80 years was eligible for participation. Participants were recruited through a survey institute using a representative internet panel, using the quotas method, and the usual procedures of confidentiality and incentives (i.e. a 3€ voucher per completed questionnaire). The selection procedure defined quotas according to age, gender, geographical location, and socio-economic groups (study invitations were sent until the completion of the expected sample size was reached). Invited respondents completed the anonymous online questionnaire between November 26th and December 1st, at the end of the second lockdown, during which the French population could move freely to go to work, high school teaching was on-site, and before first efficacy data from COVID-19 vaccine trials were published. French citizens had strong views on this crisis, which had been undergone for nearly nine months. Intensive care admissions and deaths had just passed their peak in mid-

November (Figure 2), but uncertainties for the future were high. The closure of so-called nonessential retailers raised questions, as did the non-reopening of cultural venues. French people were moving from lockdown to an equally tight curfew.

**Figure 2**. COVID-19 consequences over time: 24 hours statistics, for 100,000 inhabitants




Source: Santé Publique France

2.4. Design of the final questionnaire

The final questionnaire consisted of two parts. In part 1, basic socio-economic information was collected. Socio-economic status was approximated through the level of the highest diploma obtained (below, at or above French baccalaureate), subjective deprivation (positive answer to the question :« did your household have financial problems during the last 12 months that hindered paying in time the rent, mortgage, consumer credits or every-day bills such as water, gas or electricity?"), having a dependent child (elementary or high school), and having a close relative in a nursing home. We also evaluated whether respondents were affected (or knew someone who was affected) by the COVID-19, whether they thought having a risk factor for severe COVID-19, and their degree of confidence towards the national authorities ("on a 0-10 scale, how much confidence do you place in the authorities to manage the health and economic crisis due to COVID-19?"). Part 2 was the DCE, which contained an introduction describing the context of choices (namely, a post-lockdown situation, and non-availability of an effective treatment or vaccine), followed by the 6 random choice tasks.

The study protocol received internal clearance and the database was registered by Institut Pasteur according to the GRDP regulation. Participants saw a complete study information and had to agree to participate before starting the questionnaire. Study participation was entirely anonymous.

## 3. Econometric modeling

3.1 Analysis of individual preferences

The choice data were analyzed within a random utility maximization framework i.e., assuming a random utility function for each hypothetical scenario (including a systematic and unobserved portion of utility) and assuming utility maximization decision rule (McFadden, 1974). We used a mixed multinomial logit (MIXL) model specification, allowing the preference parameters to be randomly distributed across the sample and thus accounting for (i) unobserved preference heterogeneity and (ii) correlation of choices between participants (McFadden and Train, 2000). The main utility function was specified as follow:

$$\begin{cases} U_{njt} = \beta_{1,n}Closure_{2_j} + \beta_{2,n}Closure_{3_j} + \beta_{3,n}Lockdown_j + \beta_{4,n}School_{2_j} + \beta_{5,n}School_{3_j} \\ \quad + \beta_{6,n}SelfIsolation_{2_j} + \beta_{7n}SelfIsolation_{3_j} + \beta_{8,n}ICUoverload_{2_j} \\ \quad + \beta_{9,n}ICUoverload_{3_j} + \varepsilon_{njt} \end{cases} \quad (1)$$

where $U_{njt}$ is the utility individual *n* derives from choosing alternative (scenario) *j* in choice situation *t*, $Closure\_2_j$,…, $ICUoverload\_3_j$ represent dummy coded attributes' levels displayed in scenario *j* (level 1 of all attributes was used as reference), $\beta_{1,n}, \dots, \beta_{9,n}$ are the respective random effects (part-worth utilities) associated with each attribute level (compared with the reference), the subscript *n* denoting respondent-specific parameters. Finally, $\varepsilon_{njt}$ is the error term  assumed extreme value type 1 distributed, thus leading to the multinomial logit choice specification (McFadden, 1974).

We estimated a MIXL (using 500 Halton draws) with correlated random coefficients between all 9 attributes' levels, assuming normal distribution for each parameter $\beta_{k,n}$. Though particularly computationally intensive, this model is known to be most flexible (Hess and Train, 2017). In particular, it allows accounting for scale heterogeneity, i.e., various degrees of consistency of decisions across respondents (Hess and Rose, 2012).

### 3.2. Analysis of preference heterogeneity

To model observed preference heterogeneity, we predicted individual-level coefficients from the MIXL model (i.e. $\hat{\beta}_{k,n}, k = 1, \dots, 9$) using the methodology detailed in (Revelt and Train, 1998). Second, we analyzed the determinants of each $\hat{\beta}_{kn}$ by estimating multivariate seemingly unrelated regressions (SUR) allowing for the unobserved determinants of each part-worth utility coefficient to be correlated. We estimated two SUR models: one model including the four 'moderately' severe restriction measures (i.e., level 2 of all attributes, see Table 1), the second model including the five 'highly' severe restriction measures (i.e., level 3 of all attributes). In each model, we included individual socio-demographic characteristics (e.g., age, gender, region of residence, education level, having a dependent child, subjective deprivation) as well as perception variables (feeling at risk for severe COVID-19, confidence level in disease management) to explain preferences.

3.3. Simulation of welfare impacts of alternative epidemic management strategies

Based on the resulting estimated individual coefficients ($\hat{\beta}_{k,n}$), we simulated the overall effect of alternative epidemic management strategies in terms of welfare gains (utility increases) or losses (utility decrease).

We defined a baseline scenario, similar to the situation in France at the time of the survey in November 2020 (during the second lockdown), combining the following attributes' levels : (i) closure of public spaces but not transport or offices, (ii) no targeted lockdown, (iii) all high school teaching on-site, (iv) information campaign on COVID-19 risk factors, (v) need to postpone elective surgery (**baseline scenario**). Then, we defined six alternative scenarios that varied in the levels of restriction for the four non-ICU-related attributes, with the less restrictive measures to overcome ICU overload (increase health care workforce). We aimed to simulate the welfare gains or losses of various strategies aiming at reducing hospital overload to a lower level.

- **Maximal homogeneous scenario 1**: highest levels of restrictions for all non-ICU-related attributes. This scenario must be expected to have higher effectiveness than scenarios 2-6 and does not put more constraint on one target group.
- **Alternative focused scenario 2,3,4,5**: highest levels of restriction for one attribute, and moderate level for the others, thus putting more constraint on one target group.
- **Minimal homogeneous scenario 6**: moderate levels of restrictions for all non-ICU-related attributes. This scenario must be expected to have lower effectiveness than scenarios 2-5 and 1, and does not put more constraint on one target group.

It is difficult to evaluate health outcomes of different epidemic control measures. However, based on the recent experiences in countries around the world, modeling studies have estimated the effectiveness of several measures (including school closure or public spaces closure) based on their capacity to reduce the frequency of contacts or risk of transmission given a contact (Nussbaumer-Streit et al., 2020). If Sars-CoV-2 elimination is not feasible due to intensive transmission from asymptomatic persons, it appears that stricter control measures lead to lower transmission rates, with the gain of lower peak occupation of ICU beds, thus providing a rationale for the six proposed alternative strategies.

The welfare gains and losses of these alternative management strategies were first evaluated by computing the average utility variation between each fictive scenario and the baseline scenario. Second, by predicting the proportion of respondents with positive utility variation.

## 4. Sensitivity analyses

### 4.1. Use of decision heuristics

In stated preferences surveys, it is often the case that respondents may use decision heuristics or mental shortcuts to facilitate the decision process (Cairns et al., 2002; Dhami et al., 2018). Even flexible models (e.g., correlated MIXL models) may not be able to capture such behaviors. To analyse the robustness of our results, we re-estimated Eq. (1) by excluding respondents employing simplified (deterministic) lexicographic decision rules, i.e. when their choices could be explained only by the variation of one dominant attribute (Campbell et al., 2006). Such individual were defined as those always chosing the scenario presenting the most favorable level of one attribute. We hypothesized that two attributes could dominate the decision-making and lead to lexicographic preferences: (i) the restriction measures on economic and social life, and (ii) the measures to overcome ICU overload. Indeed, these two attributes represent the trade-off that has been constantly put in front of the public debate. Besides, the two attributes were always respectively in first and last position of the choice tasks. Previous work suggested that attributes either ranked first (Auspurg and Jäckle, 2017) or last (Kjaer et al., 2006) could be more considered (Ryan et al., 2018).

### 4.2. Low engagement in choice tasks

Following the framework defined by Regier et al (2019), we used information about mean choice certainty and certainty variability to identify more thoughtful respondents. We identified thoughtful respondents as those (1) being sufficiently certain of their choices (i.e., having a mean choice certainty > 5), and (2) having sufficient certainty variability. Indeed, Regier et al (2019) have shown that respondents with either low mean certainty or low certainty variability (or both) exhibit lower response 'quality' as defined by the more frequent use of decision heuristics (such as serial non-trading or non-demanding behavior), more frequent deviations from monotonic preferences, lower interval validity and/or choice consistency. Estimation of heteroskedastic MNL models on our data confirmed that respondents with either low certainty (< 5) or no certainty variability had lower choice consistency (results not shown but available upon request). We thus re-estimated Eq. (1) by first excluding individuals with an average certainty < 5, and second excluding individuals with no certainty variability.

### 4.3. Non-linear utility function

As explained in section 2.2 (Design), we suspected negative interaction effects suggesting disutility for laxist or 'too lenient' policies. We thus estimated a second model including pre-specified interactions between attributes, using the following specification:

$$\begin{cases} U_{njt} = \sum_{k=1}^{9} \beta_{k,n} Level_{kj} \\ +\beta_{10} Closure_{1_j} * ICUoverload_{2j} + \beta_{11} Closure_{1_j} * ICUoverload_{3j} \\ + \beta_{12} School_{1j} * ICUoverload_{3j} + \beta_{13} SelfIsolation_{1j} * ICUoverload_{3j} + \varepsilon_{njt} \end{cases} \quad (2)$$

Where $Level_k$ denotes a generic dummy indicator for eacg main attributes' levels (9 parameters, see Eq. (1)), $Closure_{1_j} * ICUoverload_{2j}$, …, $SelfIsol * ICUoverload_{3j}$ denote the interaction effects between e.g. "no generalized closure measure" ($Closure_{1_j}$) and "need to postpone elective surgery" ($ICUoverload_{2j}$), with $\beta_{10}, \dots, \beta_{13}$ the associated (fixed) coefficients, and *j* indicates the choice task. We expected negative values for $\beta_{10}, \dots, \beta_{13}$.

## 5. Results

### 5.1.Sample description

Our sample consists of 908 French citizens, representative of the population in terms of standard socio-demographic variables (see Appendix B). In our sample, 20% were between 18 and 29 years old and 26% were >60 years old (Table 2). Overall, 49% were males, 22.5% lived in rural areas, 19.5 % lived in cities with more than 100,000 inhabitants, 24% had an educational level below French baccalaureate (high school diploma), and 31% higher than a bachelor's degree. Besides, 11% felt subjectively deprived, 9% declared having a close relative in a nursing home, 14% declared having had the COVID-19 disease themselves (or knew a close relative who got it), 30% stated having a risk factor for severe COVID-19. The proportion of respondents reporting a confidence level of 0-3 (low), 4-6 (medium), or 7-10 (high) in the authorities to manage the health and economic crisis due to COVID-19 were respectively 32%, 33% and 36% (Table 2).

**Table 2.** Descriptive statistics of the sample (N=908)

| | N | % |
|---|---|---|
| Age: | | |
| 18-29 years | 180 | 19.82 |
| 30-39 years | 161 | 17.73 |
| 40-49 years | 167 | 18.39 |
| 50-59 years | 167 | 18.39 |
| >60 years | 233 | 25.66 |
| Sex: Male | 443 | 48.79 |
| Size of municipality of residence | | |
| Rural area (<2,000 inhabitants) | 205 | 22.58 |
| 2,000-20,000 inhabitants | 262 | 28.85 |
| 20,000-100,000 inhabitants | 264 | 29.07 |
| >100,000 inhabitants | 177 | 19.49 |
| Region of residence | | |
| Ile-de-France | 173 | 19.05 |
| North-East | 205 | 22.58 |
| North-West | 203 | 22.36 |
| South-East | 228 | 25.11 |
| South-West | 99 | 10.90 |
| Education level | | |
| Lower than French baccalaureate (including no diploma) | 220 | 24.23 |
| French baccalaureate level (high school diploma) | 210 | 23.13 |
| 2 years after French baccalaureate | 197 | 21.70 |
| >=3 years after French baccalaureate | 281 | 30.95 |
| Feeling deprived | 108 | 11.89 |
| Having a dependent child | 324 | 35.68 |
| Having a close relative in a nursing home | 78 | 8.59 |
| Experience of Covid-19 (personal or among relatives) | 126 | 13.88 |
| Believing having a risk factor for severe Covid-19 | 276 | 30.40 |
| Confidence level in disease management | | |
| Low (0-3) | 288 | 31.72 |
| Moderate (4-6) | 296 | 32.60 |
| High (7+) | 324 | 35.68 |
| N | 908 | |

### 5.2. Stated preferences

#### 5.2.1. Results of mixed logit models

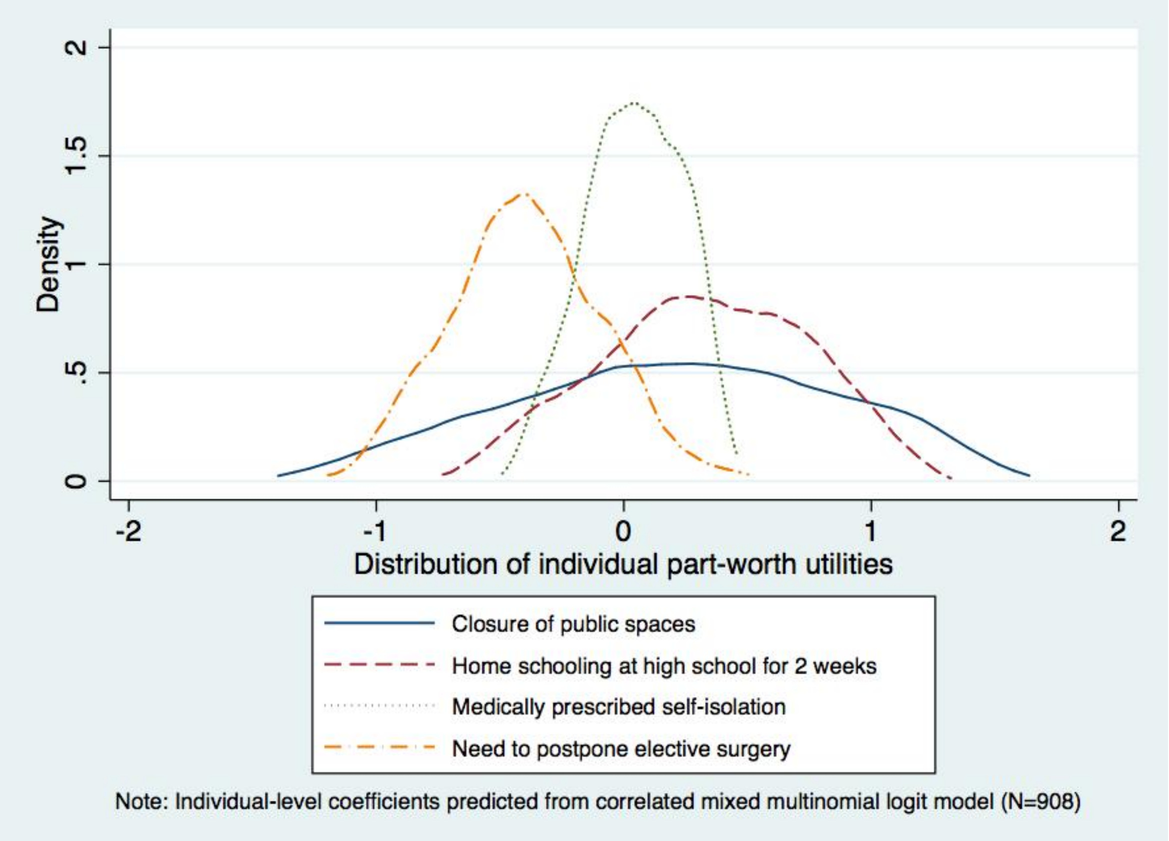
In mixed logit models with correlated random coefficients, five attributes' levels had positive and statistically significant part-worth utilities (Table 3): closure of public spaces ($\beta$=0.198), targeted lockdown for sectors with high incidence levels ($\beta$=0.311), homeschooling for 2 weeks ($\beta$=0.338), homeschooling for 2 months ($\beta$=0.258), and medically prescribed self-isolation with limited visits in nursing homes ($\beta$=0.245). In other words, all other measures being equal, respondents' likelihood to choose one scenario over the other increased with these measures (relatively to the reference). Two epidemic control measures generated significant disutility: need to postpone elective surgery due to ICU overload ($\beta$= -0.408) and need to postpone elective surgery and evacuate patients to other countries or regions ($\beta$= -0.4446).

Significant preference heterogeneity for all attributes' levels - except medically prescribed self-isolation- was observed, with statistically significant standard deviations of the underlying normal random effects (Table 3).

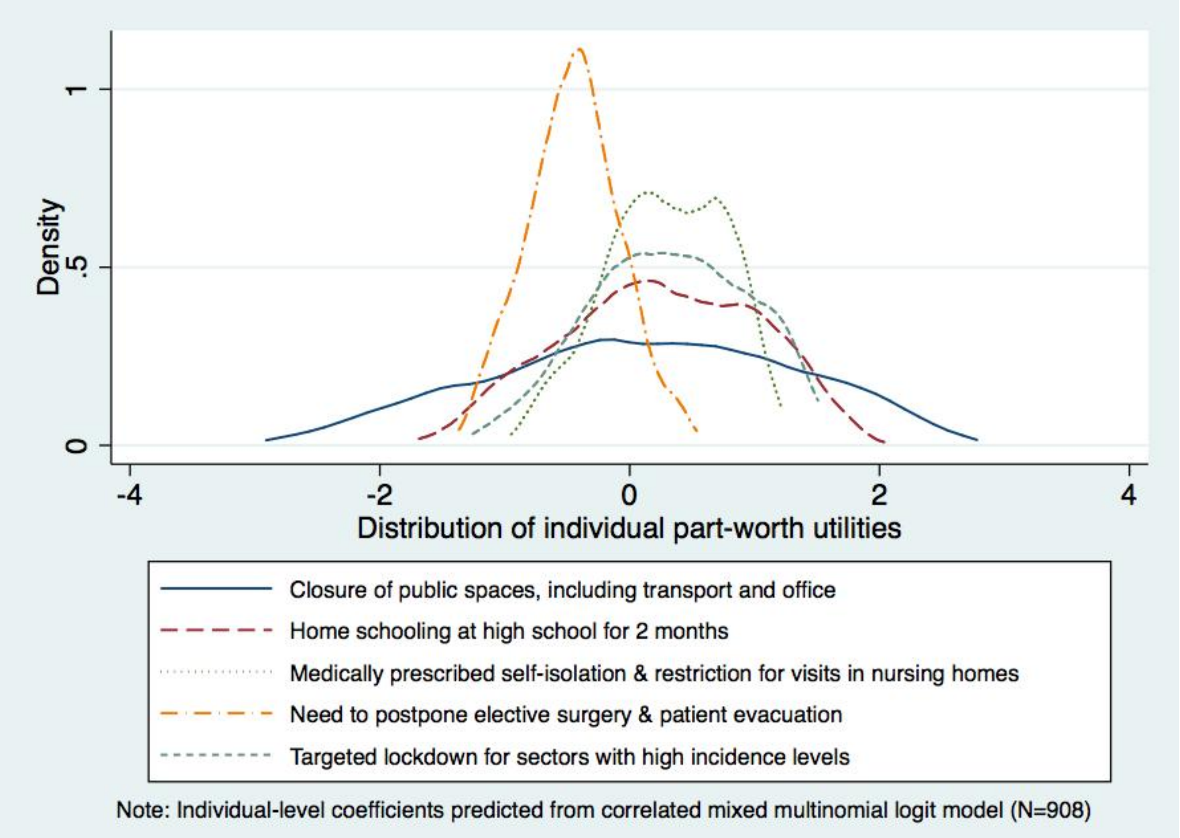
#### 5.2.2. Analysis of preference heterogeneity and their determinants

Graphical distribution of the predicted individual level coefficients ($\beta_n$) (Figure 3, panel A and panel B) confirm significant variability in preferences for the various control measures. The proportions of respondents having predicted negative utility for the more restrictive attributes' levels were: closure of public spaces (38%), closure of public spaces + transport and office (47%), targeted lockdown for sectors with high incidence levels (32%), homeschooling for 2 weeks (23%), homeschooling for 2 months (39%), and medically prescribed self-isolation with limited visits in nursing homes (29%). The majority of respondents (90%) had negative predicted utility for the two measures to overcome the ICU overload (Figure 3).

**Figure 3**. Distribution of individual-level coefficients derived from correlated MIXL model




*Panel A – Moderately severe restriction measures*




*Panel B – Highly severe restriction measures*

Only three individual characteristics were significantly associated with lower (or higher) utility for the ‘moderately’ severe restriction measures (Table 4) or ‘highly’ severe restriction measures (Table 5). Respondents declaring having a close relative in a nursing home experienced relatively lower utility for the “need to postpone elective surgery” measure and “need to postpone elective surgery & patient evacuation”. Respondents stating having a risk factor for severe COVID-19 risk had relatively higher utility for all measures, except the “need to postpone elective surgery”. Finally, individuals declaring high confidence level (7+) in disease management by the authorities also had higher utility for “closure of public spaces” (including transport and office), and “need to postpone elective surgery” (including patient evacuation). Note that the conclusions did not change when (i) using univariate SUR models, (ii) including additional information of working situation for individuals in the labor market such as the type of work (salaried or self-employed) or the sector of activity (e.g., industry, tourism, food, healthcare, sport, culture).

**Table 3**. Results of the MIXL model (N=908) – correlated random coefficients

| | **Mean** | | **SD** | |
|---|---|---|---|---|
| | Est | Std. Err | Est | Std Err. |
| Closure of public spaces | 0.198*** | (0.066) | 0.660*** | (0.184) |
| Closure of public spaces (+ transport and office) | 0.137 | (0.102) | 2.920*** | (0.601) |
| Targeted lockdown for sectors with high incidence | 0.311*** | (0.058) | 0.873*** | (0.199) |
| Home schooling at high school for 2 weeks | 0.338*** | (0.067) | 0.539** | (0.217) |
| Home schooling at high school for 2 months | 0.258*** | (0.081) | 1.476*** | (0.378) |
| Medically prescribed self-isolation (SI) | 0.028 | (0.057) | 0.125 | (0.109) |
| Medically prescribed SI +restrictions for visits in nursing homes | 0.245*** | (0.065) | 0.566*** | (0.205) |
| Need to postpone elective surgery | -0.408*** | (0.078) | 0.554** | (0.236) |
| Need to postpone surgery + patient evacuation | -0.446*** | (0.104) | 0.678** | (0.329) |
| N (individuals) | 908 | | | |
| Choice observations | 5448 | | | |
| Log-likelihood | -3564.3584 | | | |

Statistical significance: ***: 1% **: 5%; *: 1%

**Table 4**. Seemingly unrelated regression of the determinants of individual part-worth utilities for 'moderately' severe restriction measures

| Attribute level | **Closure of public spaces ($\hat{\beta}_1$)** | | **Homeschooling at high school for 2 weeks ($\hat{\beta}_4$)** | | **Self-Isolation ($\hat{\beta}_6$)** | | **Need to postpone elective surgery ($\hat{\beta}_8$)** | |
|---|---|---|---|---|---|---|---|---|
| | Est | Std. Err. | Est | Std. Err. | Est | Std. Err. | Est | Std. Err. |
| Age: 18-29 years | -0.004 | (0.063) | 0.048 | (0.041) | -0.009 | (0.019) | -0.002 | (0.03) |
| 30-49 years | *ref* | | *ref* | | *ref* | | *ref* | |
| 50-64 years | 0.012 | (0.057) | 0.017 | (0.037) | -0.005 | (0.017) | 0.029 | (0.027) |
| 65 years + | -0.03 | (0.076) | 0.011 | (0.050) | -0.014 | (0.023) | 0.008 | (0.036) |
| Sex: Male | 0.025 | (0.043) | 0.027 | (0.028) | -0.008 | (0.013) | -0.035* | (0.02) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Size of municipality of residence: rural area (<2.000 inhabitants) | *ref* | | *ref* | | *ref* | | *ref* | |
| 2.000-20.000 inhabitants | -0.008 | (0.06) | -0.003 | (0.039) | 0.006 | (0.018) | -0.013 | (0.028) |
| 20.000-100.000 inhabitants | -0.022 | (0.062) | -0.049 | (0.041) | -0.01 | (0.019) | 0 | (0.029) |
| >100.000 inhabitants | -0.044 | (0.068) | -0.01 | (0.044) | 0.014 | (0.021) | 0.054* | (0.032) |
| Region: Ile-de-France | *ref* | | *ref* | | *ref* | | *ref* | |
| North-East | -0.006 | (0.069) | 0.059 | (0.045) | 0.021 | (0.021) | -0.007 | (0.033) |
| North-West | -0.126* | (0.07) | 0.015 | (0.046) | -0.014 | (0.021) | -0.038 | (0.033) |
| South-East | -0.026 | (0.067) | 0.059 | (0.043) | 0.015 | (0.02) | -0.067** | (0.031) |
| South-West | 0.03 | (0.083) | 0.089 | (0.054) | 0.026 | (0.025) | -0.058 | (0.039) |
| Education (ref: lower than French baccalaureate) | *ref* | | *ref* | | *ref* | | *ref* | |
| baccalaureate level | -0.03 | (0.063) | 0.019 | (0.041) | -0.005 | (0.019) | 0.021 | (0.029) |
| 2 years after baccalaureate | -0.03 | (0.064) | -0.001 | (0.042) | -0.008 | (0.02) | 0.021 | (0.03) |
| >=3 years after baccalaureate | -0.081 | (0.061) | 0.025 | (0.04) | -0.007 | (0.019) | 0.005 | (0.029) |
| Subjective deprivation | -0.03 | (0.068) | -0.007 | (0.045) | -0.007 | (0.021) | -0.022 | (0.032) |
| Having a dependent child | 0.068 | (0.05) | -0.006 | (0.032) | 0 | (0.015) | 0.022 | (0.023) |
| Having a close relative in nursing home | -0.061 | (0.076) | 0.032 | (0.049) | -0.001 | (0.023) | -0.081** | (0.036) |
| Experience of Covid-19 (personal or among relatives) | 0.112* | (0.063) | 0.056 | (0.041) | 0.022 | (0.019) | 0.024 | (0.03) |
| Believing having a risk factor for severe Covid-19 | 0.148*** | (0.049) | 0.064** | (0.032) | 0.041*** | (0.015) | -0.032 | (0.023) |
| Confidence level in disease management: low (0-3) | *ref* | | *ref* | | *ref* | | *ref* | |
| Moderate (4-6) | 0.090* | (0.053) | -0.032 | (0.035) | 0.021 | (0.016) | 0.064** | (0.025) |
| High (7+) | 0.151*** | (0.052) | -0.02 | (0.034) | 0.022 | (0.016) | 0.062** | (0.025) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Constant | -0.144 | (0.183) | 0.083 | (0.119) | -0.03 | (0.056) | -0.283*** | (0.086) |
| N | | | | 908 | | | | |

Regression results on individual-level parameters predicted from MIXL model with correlated random parameters.

Statistical significance: ***: 1% **: 5%; *: 1%.

**Table 5**. Seemingly unrelated regression of the determinants of individual part-worth utilities for 'highly' severe restriction measures

| Attribute level | **Closure of public spaces, transport & office ($\hat{\beta}_2$)** | | **Targeted lockdown ($\hat{\beta}_3$)** | | **Homeschooling at high school for 2 months ($\hat{\beta}_5$)** | | **Self-Isolation, restriction for visits in nursing homes ($\hat{\beta}_7$)** | | **Need to postpone elective surgery & patient evacuation ($\hat{\beta}_9$)** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Est | Std. Err. | Est | Std. Err. | Est | Std. Err. | Est | Std. Err. | Est | Std. Err. |
| Age: 18-29 years | -0.007 | (0.118) | -0.037 | (0.061) | 0.074 | (0.076) | -0.036 | (0.047) | -0.031 | (0.036) |
| 30-49 years | *ref* | | *ref* | | *ref* | | *ref* | | *ref* | |
| 50-64 years | 0.015 | (0.106) | -0.012 | (0.055) | 0.031 | (0.069) | 0 | (0.042) | 0.025 | (0.033) |
| 65 years + | -0.058 | (0.142) | -0.054 | (0.074) | -0.004 | (0.092 | -0.071 | (0.056) | -0.025 | (0.044) |
| Sex: Male | 0.058 | (0.08) | 0.013 | (0.041) | 0.053 | (0.051 | 0.004 | (0.032) | -0.028 | (0.024) |
| Size of municipality of residence: rural area (ref: <2.000 inhabitants) | *ref* | | *ref* | | *ref* | | *ref* | | *ref* | |
| 2.000-20.000 inhab. | -0.021 | (0.111) | 0.013 | (0.058) | -0.025 | (0.072) | -0.029 | (0.044) | -0.032 | (0.034) |
| 20.000-100.000 inhab. | -0.029 | (0.116) | -0.044 | (0.061) | -0.097 | (0.075) | -0.064 | (0.046) | -0.011 | (0.036) |
| >100.000 inhabitants | -0.105 | (0.126) | -0.026 | (0.066) | -0.034 | (0.082) | -0.018 | (0.05) | 0.013 | (0.039) |
| Region: Ile-de-France | *ref* | | *ref* | | *ref* | | *ref* | | *ref* | |
| North-East | -0.03 | (0.13) | 0.053 | (0.067) | 0.109 | (0.084) | 0.074 | (0.051) | -0.013 | (0.04) |
| North-West | -0.225* | (0.131) | -0.072 | (0.068) | 0.024 | (0.084) | -0.015 | (0.052) | -0.058 | (0.04) |
| South-East | -0.045 | (0.124) | 0.044 | (0.065) | 0.111 | (0.08) | 0.053 | (0.049) | -0.080** | (0.038) |
| South-West | 0.05 | (0.156) | 0.093 | (0.081) | 0.167* | (0.1) | 0.085 | (0.062) | -0.072 | (0.048) |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Education (ref: lower than French baccalaureate) | *ref* | | *ref* | | *ref* | | *ref* | | *ref* | |
| baccalaureate level | -0.061 | (0.117) | -0.037 | (0.061) | 0.032 | (0.075) | -0.001 | (0.046) | 0.015 | (0.036) |
| 2 years after baccalaureate | -0.066 | (0.12) | -0.034 | (0.062) | -0.02 | (0.077) | -0.037 | (0.047) | 0.011 | (0.037) |
| >=3 years after baccalaureate | -0.159 | (0.113) | -0.057 | (0.059) | 0.033 | (0.073) | -0.015 | (0.045) | -0.015 | (0.035) |
| Subjective deprivation | -0.052 | (0.127) | -0.007 | (0.066) | -0.012 | (0.082) | 0 | (0.051) | -0.012 | (0.039) |
| Having a dependent child | 0.132 | (0.093) | 0.007 | (0.048) | -0.008 | (0.06) | -0.018 | (0.037) | 0.019 | (0.028) |
| Having a close relative in nursing home | -0.095 | (0.142) | 0.001 | (0.074) | 0.064 | (0.091) | 0.018 | (0.056) | -0.094** | (0.043) |
| Experience of Covid-19 (personal or among relatives) | 0.196* | (0.117) | 0.068 | (0.061) | 0.099 | (0.075) | 0.035 | (0.046) | 0.015 | (0.036) |
| Believing having a risk factor for severe Covid-19 | 0.270*** | (0.092) | 0.154*** | (0.048) | 0.131** | (0.059) | 0.105*** | (0.036) | -0.015 | (0.028) |
| Confidence level in disease management : low (0-3) | *ref* | | *ref* | | *ref* | | *ref* | | *ref* | |
| Moderate (4-6) | 0.153 | (0.099) | 0.053 | (0.052) | -0.045 | (0.064) | 0.038 | (0.039) | 0.081*** | (0.03) |
| High (7+) | 0.264*** | (0.097) | 0.097* | (0.051) | -0.024 | (0.063) | 0.055 | (0.039) | 0.105*** | (0.03) |
| Constant | -0.555 | (0.341) | 0.009 | (0.177) | -0.218 | (0.22) | 0.1 | (0.135) | -0.326*** | (0.104) |
| N | | | | | 908 | | | | | |

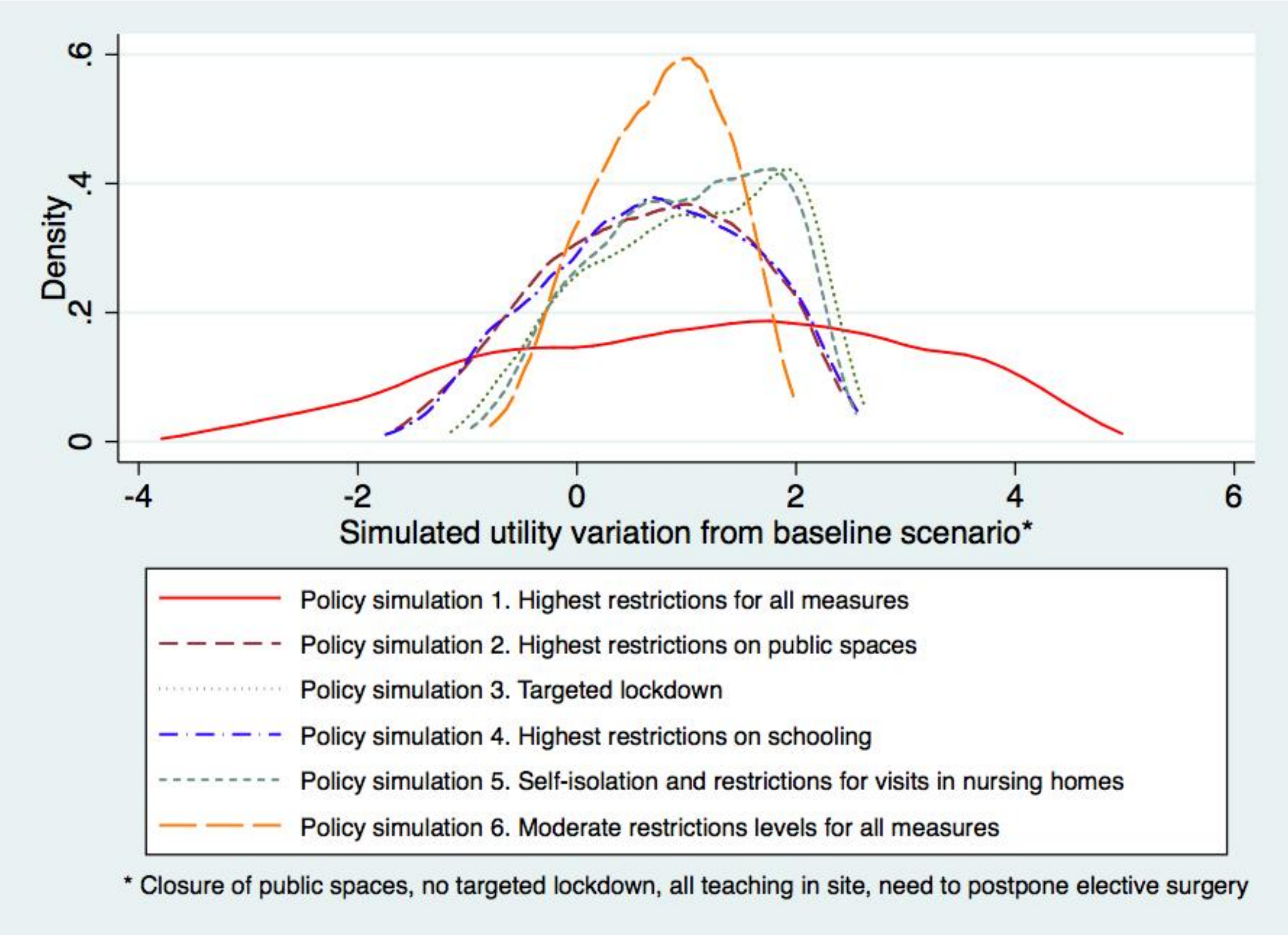
Regression results on individual-level parameters predicted from MIXL model with correlated random parameters.

Statistical significance: ***: 1% **: 5%; *: 1%

### 5.2.3. Results of policy simulations

Compared to the baseline scenario that was expected to prevail in November 2020, the six alternative strategies generated positive welfare gains (increased mean utility) by avoiding the need to postpone surgery, at the expense of stricter control measures (Table 6, Figure 4). Scenario 1 generated most heterogeneous welfare variations, and scenario 6, most homogenous welfare variations (Figure 4).

**Figure 4**. Distribution of welfare gains or losses for each alternative policy scenario




Note. Simulations based on estimation of individual part-worth utilities from correlated MIXL model.
The six curves represent the distribution of the utility difference between the alternative policy scenarios and the baseline scenario that prevailed in November 2020. Positive utility difference indicates a welfare gain, and negative utility difference indicates a welfare loss.

**Table 6**. Simulation of welfare gains or losses from stricter control measures

| Scenario | Attribute's levels | Severity of measure | Simulated utility variation: Δ utility Mean | Δ utility [Min ; Max] | Δ utility >0 % | Δ utility >0 [95% CI] |
|---|---|---|---|---|---|---|
| **Baseline scenario** | Closure of public spaces<br>No targeted lockdown<br>All teaching in-site<br>Information campaign on COVID-19 risk factors<br>Need to postpone elective surgery | | *ref* | *ref* | *ref* | *ref* |
| **Alternative scenarios with lowest level of ICU overload expected (*no need to postpone elective surgery*)** | | | | | | |
| **Scenario 1.** Highest level of restrictions for all measures | Closure of public spaces + transport and office<br>Targeted lockdown<br>Homeschooling at high school for 2 months<br>Medically prescribed SI + nursing homes visit restrictions | | 1.12 | [-3.36 ; 4.54] | 70% | [67%; 73%] |
| **Scenario 2.** Highest restrictions on public spaces | Closure of public spaces + transport and office<br>No targeted lockdown<br>Homeschooling at high school for 2 weeks<br>Medically prescribed self-isolation | | 0.65 | [-1.65 ; 2.41] | 74% | [71%; 77%] |
| **Scenario 3.** Targeted lockdown | Closure of public spaces<br>Targeted lockdown<br>Homeschooling at high school for 2 weeks<br>Medically prescribed self-isolation | | 1.03 | [-1.15 ; 2.62] | 85% | [82%; 87%] |
| **Scenario 4.** Highest restrictions on schooling | Closure of public spaces<br>No targeted lockdown<br>Homeschooling at high school for 2 months<br>Medically prescribed self-isolation | | 0.68 | [-1.75 ; 2.56] | 74% | [71%; 77%] |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Scenario 5.** Highest restrictions on medically prescribed self-isolation (SI) | Closure of public spaces<br>No targeted lockdown<br>Home schooling at high school for 2 weeks<br>Medically prescribed SI + nursing homes visit restrictions | | 1.00 | [-0.97 ; 2.55] | 86% | [84%; 88%] |
| **Scenario 6.** Moderate level of restrictions for all measures | Closure of public spaces<br>No targeted lockdown<br>Home schooling at high school for 2 weeks<br>Medically prescribed self-isolation | | 0.76 | [-0.79 ; 1.98] | 87% | [85%; 90%] |

Legend

Level 1 of restriction (low)
Level 2 of restriction (moderate)
Level 3 of restriction (high)

**Δ utility**: utility variation compared to the baseline scenario

The maximal, but homogeneous scenario 1 generated the highest average welfare gains (+1.12 mean utility), but only 70% (95% CI [67% - 73%]) of the sample experienced a welfare increase compared to the baseline situation (Table 6). The minimal homogeneous scenario 6 generated a relatively low welfare gain (+0.76 mean utility) but increased welfare for 87% (95% CI [85% - 90%]) of the sample.

Among the alternative focused scenarios (scenarios 2 to 5), scenarios 3 and 5 increased welfare for more than 80% of the sample while achieving high gain in mean utility: 85% (95% CI [82% - 87%]) and +1.03 mean utility for scenario 3 (targeted lockdown), 86% (95% CI [84% - 88%]) and +1.00 for scenario 5 (medically prescribed self-isolation plus restrictions in nursing homes). In the scenario 2 and 4, increase in mean utility and the sample fraction with welfare increase were low: 74% [71% - 77%], +0.65 mean utility for scenario 2 (highest restrictions on public spaces) and 74% (95% CI [71% - 77%]), +0.68 mean utility for scenario 4 (highest restrictions on schooling). Complementary analyses showed that welfare variations were not explained by individual characteristics (e.g., gender, age, education, working-related variables) at the 5% level[2].

#### 5.2.4. Results of sensitivity analyses

*Decision heuristics or choice certainty*

Only 11 individuals (1.21%) always chose the scenario with the lowest ICU overload level (decision heuristic 'ICU overload') and only 1 individual always chose the scenario with the lowest restrictions on economic and social life. In terms of decision certainty, 12,65% of individuals were classified as insufficiently certain (mean certainty <5), and 22.25% did not vary in their certainty. We replicated the main analyses by excluding individuals who

[2] We estimated (i) multivariate SUR and (ii) univariate SUR models using the same individual variables used in Table 4 and 5 (as well as work-related variables such as sector of activity). These models allowed accounting for the correlation between unobserved determinants of welfare variations for the six simulated scenarios.

exhibited either issue of decision heuristic, low certainty, and no certainty variability (Appendix C, Table C.1). Results of policy simulations were unaffected by these subgroups analyses. For instance, the share of respondents having positive utility variation for scenario 1 varied from 69% (no decision heuristics) to 71% (varying certainty). No statistically significant differences were found when comparing 95% confidence intervals in these subgroups compared to the total sample.

*Non-linearity in attributes' impact on utility*

Results of the interaction models (Appendix C.2) do not confirm our assumption that respondents may experience disutility from too "lenient" policies. First, none of the interaction coefficients were significant at the 5% level. Note that only the interaction between 'all teaching in site' and 'need to postpone surgery + patient evacuation' was significant (and negative, as expected) at the 10% level. The log-likelihood only increased by 3 points, thus showing that the interaction model did not provide better fit to the data than the main effects model.

## 6. Discussion

In this stated preferences study, we contribute to the debate about the "social acceptability" of COVID-19 control measures, by describing French citizens' preferences for various epidemic control measures, to inform longer-term strategies (beyond winter 2020-21) and future epidemics. We used a DCE in a large representative sample of French adults to quantify the trade-off adults were willing to make between restrictions on the social, cultural, and economic life, school closing, targeted lockdown of high-incidence areas, constraints to directly protect vulnerable persons, and reduction in the risk of hospital overload. Our results show that some trade-offs exist to avoid overload of hospitals and intensive care units: (i) closure of public spaces if this did not imply restrictions on public transport and access to offices, (ii) targeted local lockdown even if it creates unequal treatments, (iii) school closure for short to medium term period, even if they can break the learning process of adolescents, (iv) self-isolation of high-risk groups if combined with restrictions in access to nursing homes. The willingness to accept restrictions was shared to a large extent across subgroups according to age, gender, vulnerability to the COVID-19 epidemic, and other socio-demographic or –economic variables. However, it appears that individuals who feel at greater risk from COVID-19, and individuals with high confidence in the governmental management of the health and economic crisis, more easily accept all these restrictions.

One important question was whether preferences would be highly specific to subgroups (e.g, parents refusing homeschooling, high-risk groups refusing self-isolation) or shared. Our results suggest highly shared preferences beyond individual interests. Significant heterogeneity was found in preferences in mixed logit models, and most of this heterogeneity remained unobserved.

Little evidence is available on preferences around epidemic control measures (Blayac et al., 2021; Krauth et al., 2021), and this paper contributues to this emerging literature. The closest element in the literature is a DCE conducted in France at the end of the first lockdown, which focused on generally applicable measures such as wearing masks, travel limitation, and digital tracking (Blayac et al., 2021). Substantial differences were observed only for young adults with particular disutility from the extension of lockdown, digital tracking, and highest preference for financial compensation. Disutility from mandatory tracing and quarantine from the elderly was observed among German citizens, with almost equal weight given to these attributes' levels compared to utility from sufficient available ICU capacities (Krauth et al., 2021).

Our study faces two main limitations. First, preference estimates and simulations of alternative epidemic management strategies are based on the assumption of stable intrinsic preferences for all control measures. It is however likely that these preferences may have varied in time along with the epidemic evolution, and lassitude generated by repeated lockdown and absence of clear strategy (as well as organizational difficulties). Second, we cannot exclude a framing effect. Our study took place during the second lockdown in France, including restriction measures taken to avoid hospital overload. The trade-offs elicited in our DCE may thus suffer from this framing, with more weight given to sanitary outcomes. Besides, our DCE survey was developed to study preferences in the perspective of avoiding a general lockdown, and in a context where vaccination was not available. The trade-offs could be different when considering immunity provided by massive vaccination of the population, which is expected in the fourth quarter of 2021. Future studies should thus consider these aspects to produce estimates that more closely match the current situation. In particular, the prevalence of vaccinated subjects and / or the effectiveness of vaccination (in the presence of SARS-CoV-2 mutations) should be included as additional attributes or contextual factors.

Finally, the choice experiment was likely difficult for some individuals because of the complexity of trade-offs involving uncertain outcomes. Yet we showed that our results remained robust in the presence of individuals with either lexicographic preferences, low certainty (Dekker et al., 2016), or no certainty variability, potentially less engaged in the choice exercise (Regier et al., 2019). Note however that we used a rather simple "deterministic" conception of lexicographic preferences, based on the analysis of a single attribute deemed dominant, instead of using a more comprehensive modeling of possible decision heuristics (Heidenreich et al., 2018).

*Conclusion*

Public policies around complex problems can be tailored and thus optimized based on evidence of the preferences of the population and their trade-offs. In this respect, we simulated the acceptance of various management strategies for control of the epidemic in France from autumn 2020 to summer 2021. In particular, we showed that among the alternative scenarios, the one close to a targeted lockdown as well as the one with medically prescribed self-isolation and with restrictions in nursing homes increased welfare for more than 85% of the sample while achieving high gain in average utility. In other words, in a situation with no existing pharmaceutical treatment, no available vaccine, and pressure on hospitals due to increased number of ICU admission, French citizens would be likely to accept the above mentioned epidemic control measures. The scenarios with the strongest restrictions on public spaces or highest restrictions on schooling generated the lowest increase in the average utility. Therefore, our results provide decision-makers with quantitative evidence on the public opinion, thus contributing to a solid basis for debate and decision. In particular, they can provide theoretical expectations for decision-makers to make an informed choice when tailoring the epidemic management strategy for France at the national and subnational level in the year to come. Beyond the current Sars-CoV-2 epidemic, this information will be important to optimize control measure protocols for epidemic and pandemic preparedness.

## References


Auspurg, K., Jäckle, A., 2017. First Equals Most Important? Order Effects in Vignette-Based Measurement. Sociol. Methods Res. 46, 490–539. https://doi.org/10.1177/0049124115591016

Ben-Akiva, M., McFadden, D., Train, K., 2019. Foundations of Stated Preference Elicitation: Consumer Behavior and Choice-based Conjoint Analysis. Found. Trends® Econom. 10, 1–144. https://doi.org/10.1561/0800000036

Blayac, T., Dubois, D., Duchêne, S., Nguyen-Van, P., Ventelou, B., Willinger, M., 2021. Population preferences for inclusive COVID-19 policy responses. Lancet Public Health 6, e9. https://doi.org/10.1016/S2468-2667(20)30285-1

Cairns, J., van der Pol, M., Lloyd, A., 2002. Decision making heuristics and the elicitation of preferences: being fast and frugal about the future. Health Econ. 11, 655–658. https://doi.org/10.1002/hec.720

Campbell, D., Hutchinson, W.G., Scarpa, R., 2006. Lexicographic Preferences in Discrete Choice Experiments: Consequences on Individual-Specific Willingness to Pay Estimates (No. 12224), Sustainability Indicators and Environmental Valuation Working Papers.

de Bekker-Grob, E.W., Donkers, B., Jonker, M.F., Stolk, E.A., 2015. Sample Size Requirements for Discrete-Choice Experiments in Healthcare: a Practical Guide. Patient - Patient-Centered Outcomes Res. 8, 373–384. https://doi.org/10.1007/s40271-015-0118-z

Dekker, T., Hess, S., Brouwer, R., Hofkes, M., 2016. Decision uncertainty in multi-attribute stated preference studies. Resour. Energy Econ. 43, 57–73. https://doi.org/10.1016/j.reseneeco.2015.11.002

Dhami, S., al-Nowaihi, A., Sunstein, C.R., 2018. Heuristics and Public Policy: Decision Making Under Bounded Rationality. SSRN Electron. J. https://doi.org/10.2139/ssrn.3198739

Genie, M., Loría-Rebolledo, L., Paranjothy, S., Powell, D., Ryan, M., Sakowsky, R., Watson, V., 2020. Understanding public preferences and trade-offs for government responses during a pandemic: a protocol for a discrete choice experiment in the UK. BMJ Open 10, 43477. https://doi.org/10.1136/bmjopen-2020-043477

Heidenreich, S., Watson, V., Ryan, M., Phimister, E., 2018. Decision heuristic or preference? Attribute non-attendance in discrete choice problems. Health Econ. 27, 157–171. https://doi.org/10.1002/hec.3524

Hess, S., Rose, J.M., 2012. Can scale and coefficient heterogeneity be separated in random coefficients models? Transportation 39, 1225–1239. https://doi.org/10.1007/s11116-012-9394-9

Hess, S., Train, K., 2017. Correlation and scale in mixed logit models. J. Choice Model. 23, 1–8. https://doi.org/10.1016/j.jocm.2017.03.001

Kjaer, T., Bech, M., Gyrd-Hansen, D., Hart-Hansen, K., 2006. Ordering effect and price sensitivity in discrete choice experiments: need we worry? Health Econ. 15, 1217–1228. https://doi.org/10.1002/hec.1117

Krauth, C., Oedingen, C., Bartling, T., Dreier, M., Spura, A., De Bock, F., Von Rueden, U., Betsch, C., Korn, L., Robra, B.-P., 2021. Public Preferences for Exit Strategies From COVID-19 Lockdown in Germany—A Discrete Choice Experiment. Int. J. Public Health 66, 591027. https://doi.org/10.3389/ijph.2021.591027

Lancsar, E., Louviere, J., 2008. Conducting discrete choice experiments to inform healthcare decision making: a user's guide. PharmacoEconomics 26, 661–677.

Louviere, J.J., Hensher, D., Swait, J., 2000. Stated Choice Methods (Cambridge Books). Cambridge University Press.

Lundhede, T.H., Olsen, S.B., Jacobsen, J.B., Thorsen, B.J., 2009. Handling respondent uncertainty in Choice Experiments: Evaluating recoding approaches against explicit modelling of uncertainty. J. Choice Model. 2, 118–147. https://doi.org/10.1016/S1755-5345(13)70007-1

McFadden, D., 1986. The Choice Theory Approach to Market Research. Mark. Sci. 5, 275–297.

McFadden, D., 1974. Conditional Logit Analysis of Qualitative Choice Behavior., in: Frontiers in Econometrics. Academic Press: New York, pp. 105–142.

McFadden, D., Train, K., 2000. Mixed MNL models for discrete response. J. Appl. Econom. 15, 447–470. https://doi.org/10.1002/1099-1255(200009/10)15:5

Nussbaumer-Streit, B., Mayr, V., Dobrescu, A.I., Chapman, A., Persad, E., Klerings, I., Wagner, G., Siebert, U., Christof, C., Zachariah, C., Gartlehner, G., 2020. Quarantine alone or in combination with other public health measures to control COVID-19: a rapid review. Cochrane Database Syst. Rev. 4, CD013574. https://doi.org/10.1002/14651858.CD013574

Peretti-Watel, P., Seror, V., Cortaredona, S., Launay, O., Raude, J., Verger, P., Fressard, L., Beck, F., Legleye, S., L'Haridon, O., Léger, D., Ward, J.K., 2020. A future vaccination campaign against COVID-19 at risk of vaccine hesitancy and politicisation. Lancet Infect. Dis. 20, 769–770. https://doi.org/10.1016/S1473-3099(20)30426-6

Regier, D.A., Sicsic, J., Watson, V., 2019. Choice certainty and deliberative thinking in discrete choice experiments. A theoretical and empirical investigation. J. Econ. Behav. Organ. 164, 235–255. https://doi.org/10.1016/j.jebo.2019.05.031

Revelt, D., Train, K., 1998. Mixed Logit with Repeated Choices: Households' Choices of Appliance Efficiency Level. Rev. Econ. Stat. 80, 647–657. https://doi.org/10.1162/003465398557735

Rowthorn, R., Maciejowski, J., 2020. A cost–benefit analysis of the COVID-19 disease. Oxf. Rev. Econ. Policy. https://doi.org/10.1093/oxrep/graa030

Ryan, M., Gerard, K., 2003. Using discrete choice experiments to value health care programmes: current practice and future research reflections. Appl. Health Econ. Health Policy. 2, 55–64.

Ryan, M., Krucien, N., Hermens, F., 2018. The eyes have it: Using eye tracking to inform information processing strategies in multi-attributes choices. Health Econ. 27, 709–721. https://doi.org/10.1002/hec.3626

Ryan, M., Watson, V., Entwistle, V., 2009. Rationalising the "irrational": a think aloud study of discrete choice experiment responses. Health Econ. 18, 321–336. https://doi.org/10.1002/hec.1369

World Health Organization, 2017. Prevention and control of outbreaks of seasonal influenza in long-term care facilities: a review of the evidence and best-practice guidance 130.

# Appendices

**Appendix A**. Description of the choice tasks and frequency of choices

| | Scenario 1 | | | | | Scenario 2 | | | | | Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Choice task** | Closure of public spaces | Targeted Lockdown | Home schooling | Self-isolation | ICU overload | Closure of public spaces | Targeted Lockdown | Home schooling | Self-isolation | ICU overload | choices (N) | choice scenario1* |
| 1 | 3 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 304 | 65.5% |
| 2 | 3 | 1 | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 1 | 297 | 36.4% |
| 3 | 2 | 1 | 2 | 2 | 2 | 3 | 3 | 1 | 3 | 1 | 309 | 40.8% |
| 4 | 2 | 3 | 2 | 3 | 3 | 1 | 1 | 3 | 2 | 2 | 305 | 61.6% |
| 5 | 1 | 3 | 1 | 2 | 3 | 3 | 1 | 1 | 3 | 2 | 297 | 46.1% |
| 6 | 2 | 1 | 1 | 3 | 2 | 3 | 3 | 3 | 1 | 1 | 300 | 41.7% |
| 7 | 2 | 3 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 279 | 55.9% |
| 8 | 1 | 1 | 3 | 3 | 1 | 2 | 3 | 2 | 1 | 2 | 287 | 54.3% |
| 9 | 1 | 1 | 1 | 1 | 2 | 1 | 3 | 3 | 2 | 1 | 311 | 37.3% |
| 10 | 2 | 1 | 3 | 1 | 1 | 1 | 3 | 2 | 3 | 2 | 308 | 49.4% |
| 11 | 3 | 1 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 3 | 314 | 45.5% |
| 12 | 1 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 3 | 301 | 63.5% |
| 13 | 3 | 3 | 2 | 2 | 1 | 2 | 3 | 3 | 1 | 2 | 316 | 58.2% |
| 14 | 2 | 3 | 1 | 1 | 3 | 1 | 1 | 2 | 2 | 3 | 307 | 53.4% |
| 15 | 1 | 3 | 1 | 1 | 1 | 2 | 1 | 2 | 3 | 1 | 325 | 42.7% |
| 16 | 1 | 3 | 3 | 1 | 3 | 3 | 3 | 1 | 3 | 3 | 316 | 48.7% |
| 17 | 3 | 1 | 2 | 3 | 1 | 2 | 1 | 3 | 2 | 3 | 294 | 62.9% |
| 18 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 299 | 51.5% |

*Percentage of the sample that chose choice scenario 1.

**Appendix B.** Comparison between our sample and the general French population (Insee, 2019)

| | Quotas (French aged 18-75 years) Source : Insee | | DCE survey respondents | | Discrepancy Insee vs. DCE survey |
|---|---|---|---|---|---|
| *Females* | % | N | N | % | Percentage points |
| 18 - 29 years | 10% | 87 | 89 | 10% | 0.1 |
| 30 - 39 years | 9% | 82 | 82 | 9% | -0.1 |
| 40 - 49 years | 9% | 84 | 84 | 9% | 0 |
| 50 - 59 years | 10% | 87 | 87 | 10% | 0 |
| 60 - 75 years | 14% | 123 | 123 | 14% | -0.1 |
| *Males* | | | | | |
| 18 à 29 years | 10% | 89 | 91 | 10% | 0.2 |
| 30 à 39 years | 9% | 78 | 79 | 9% | 0.1 |
| 40 à 49 years | 9% | 82 | 83 | 9% | 0 |
| 50 à 59 years | 9% | 83 | 80 | 9% | -0.4 |
| 60 à 75 years | 12% | 110 | 110 | 12% | 0 |
| "High" social category* | 32% | 289 | 303 | 33% | 1.5 |
| "Low" social category* | 32% | 292 | 272 | 30% | -2.3 |
| Inactive | 36% | 324 | 333 | 37% | 0.9 |
| North-East | 22% | 199 | 205 | 23% | 0.6 |
| North-West | 23% | 205 | 203 | 22% | -0.2 |
| Île-de-France | 19% | 173 | 173 | 19% | 0 |
| South-East | 25% | 226 | 228 | 25% | 0.1 |
| South-West | 11% | 102 | 99 | 11% | -0.4 |
| Total | 100% | 908 | 908 | 100% | |

"High" and "low" social category estimated based on the answers to the question: "what is your current socio-professional category ?": "farmer, craftman, executive, intermediate profession, skilled worker, unskilled worker, unemployed, or retired".

**Appendix C**. Sensitivity analyses

**Table C.1**. Simulation of welfare gains or losses from stricter control measures excluding specific subgroups

| | | **Simulated utility variation** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **No decision heuristic** | | | **No constant certainty** | | | **No mean certainty <5** | | |
| | Severity of | **Δ utility** | **Δ utility >0** | | **Δ utility** | **Δ utility >0** | | **Δ utility** | **Δ utility >0** | |
| Scenario | measure | Mean | % | [95% CI] | Mean | % | [95% CI] | Mean | % | [95% CI] |
| **Baseline scenario** | | Closure of public spaces<br>No targeted lockdown<br>All teaching in-site<br>Information campaign on COVID-19 risk factors<br>Need to postpone elective surgery | | | | | | | | |
| **Alternative scenario with lowest level of ICU overload expected (*no need to postpone elective surgery*)** | | | | | | | | | | |
| **Scenario 1.** Highest level of restrictions for all measures | | 1.08 | 69% | [66%; 72%] | 1.18 | 71% | [68%; 74%] | 1.21 | 69% | [66%; 72%] |
| **Scenario 2.** Highest restrictions on public spaces | | 0.63 | 74% | [71%; 77%] | 0.67 | 72% | [69%; 75%] | 0.69 | 72% | 69%; 75%] |
| **Scenario 3.** Targeted lockdown | | 1.01 | 85% | [82%; 87%] | 1.11 | 85% | [83%; 87%] | 1.15 | 82% | [79%; 85%] |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Scenario 4.** Highest restrictions on schooling | 0.63 | 75% | [72%; 78%] | 0.68 | 73% | [70%; 76%] | 0.75 | 76% | [73%; 79%] |
| **Scenario 5.** Highest restrictions on medically prescribed self-isolation (SI) | 0.98 | 88% | [86%; 90%] | 1.06 | 86% | [84%; 88%] | 1.13 | 88% | [86%; 90%] |
| **Scenario 6.** Moderate level of restrictions for all measures | 0.73 | 88% | [86%; 91%] | 0.79 | 85% | [82%; 87%] | 0.85 | 91% | [89%; 93%] |
| **N** | | **896** | | | **706** | | | **793** | |

**Table C.2.** Results of the correlated MIXL model (N=908) with fixed interaction effects

| | **Mean** | | **SD** | |
|---|---|---|---|---|
| | Est | Std. Err | Est | Std Err. |
| No general closure measure * need to postpone elective surgery | 0.004 | (0.137) | - | - |
| No general closure measure * need to postpone surgery + patient evacuation | -0.097 | -0,127 | - | - |
| All teaching in site * need to postpone surgery + patient evacuation | -0.181* | -0,108 | - | - |
| Information campaign on Covid-19 * need to postpone surgery + patient evacuation | 0.103 | -0,109 | - | - |
| Closure of public spaces | 0.180* | -0,096 | 0.898*** | (0.262) |
| Closure of public spaces (+ transport and office) | 0,08 | -0,128 | 3.259*** | (0.650) |
| Targeted lockdown for sectors with high incidence | 0.321*** | -0,063 | 1.045*** | (0.227) |
| Home schooling at high school for 2 weeks | 0.284*** | -0,081 | 0.612*** | (0.214) |
| Home schooling at high school for 2 months | 0.205** | -0,093 | 1,647*** | (0.385) |
| Medically prescribed self-isolation (SI) | 0,082 | -0,075 | 0.243*** | (0.149) |
| Medically prescribed SI +restrictions for visits in nursing homes | 0.290*** | -0,08 | 0.787*** | (0.248) |
| Need to postpone elective surgery | -0.422*** | -0,093 | 0.683*** | (0.255) |
| Need to postpone surgery + patient evacuation | -0.412*** | -0,111 | 0.929*** | (0.411) |
| N (individuals) | 908 | | | |
| Choice observations | 5448 | | | |
| Log-likelihood | -3561.863 | | | |