



Socio-demographic differences in citizen' preferences for distributing a scarce, lifesaving resource: A case study using COVID-19 vaccine distribution in Belgium

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ABSTRACT

The COVID-19 pandemic, particularly the period when safe and protective vaccines became available, presented an excellent opportunity to investigate public preferences regarding how to ration a scarce, life-saving resource. It is important to understand which distributive strategies are preferred but, as this is an inherently normative matter, also to which extent different socio-demographic groups hold different opinions. This study assesses the impact of socio-demographic characteristics on preferences for vaccine prioritization during the early stages of the COVID-19 pandemic at the moment when vaccines were not available yet. A representative sample of 2060 Belgians were asked to rank eight prioritization strategies. Based on the rankings, we clustered the eight strategies into five overarching groups. Then, we estimated the potential impact of respondents' socio-demographic characteristics on their preferences towards these five strategies. The ranking exercise shows that the vulnerability strategy (i.e. chronically ill and elderly) is preferred most often ($N = 1815$) and the market strategy (i.e. individuals who come first or pay the most) by the fewest respondents ($N = 116$). Preferences for vaccine distribution vary among population subgroups. Women, older or retired individuals, residents of Flanders, those with a positive attitude towards vaccination efforts and/or high vaccination willingness, and those who prefer the government or scientists to decide upon prioritization were more likely to prefer a designated priority strategy (i.e. vulnerability strategy, workers strategy or spreaders). Furthermore, younger respondents, residents of Wallonia, and those previously infected by COVID-19 tended to favour a risk-independent prioritization strategy (i.e. lottery or market strategy) more than others. This study validates the appropriateness of the implemented rationing approaches, by supporting a phased approach in which first vulnerables were vaccinated. However, it also demonstrates that different subgroups had substantially different preferences and the population was in disagreement about what constitutes a fair rationing policy for a scarce, potentially lifesaving resource.

1. Introduction

The COVID-19 pandemic has challenged our society significantly, especially during the early stages when the SARS-COV-2 virus was

spreading rapidly without any cure or vaccine to protect us. Shortages of hospital beds [1,2], medical products [3] and the strict suppression measures (i.e., lockdowns, curfews, and travel restrictions) made the pandemic even more straining [4,5]. Although the COVID-19 pandemic

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will be remembered as the deadliest health crisis since the Spanish influenza pandemic in the early 1900s [6], it also created an unprecedented research opportunity. One particular opportunity is that it allowed us to study how people want to distribute scarce, potentially life-saving resources, such as a safe and effective SARS-CoV-2 vaccine in the early stages of the pandemic. In health preference research, respondents are often asked questions about their preferences towards the management of health concerns in a purely hypothetical context [7]. Given that these studies cannot perfectly replicate a sense of real uncertainty and danger, respondents' decision-making behaviour is likely to be different when facing the real threat of a potentially deadly virus. Hence, preference data gathered during the pandemic will offer more accurate insights into what respondents truly prefer.

In an earlier study [8], we identified which of different strategies to prioritize vaccination across the population carried most public support. We found little support for libertarian-inspired approaches such as using the highest willingness-to-pay to distribute vaccines in a private market or a "first-come, first served" strategy. A strict egalitarian approach like distributing vaccines with a lottery also received little support. Instead, the most supported strategies were those where priority groups were explicitly defined at the policy level. The preferred priority groups were similar to those that were eventually prioritized, namely health workers and old and ill people at high risk of a severe COVID-19 infection or death. However, what was insufficiently investigated is whether these preferences were shared across the population or whether different socio-economic groups in the population had different preferences. In numerous other studies covering the early phases of the pandemic, researchers found important differences between population subgroups in terms of their vaccination willingness [9–12], hesitancy [13–15] and preferences for using a COVID-19 vaccine [16–19]. In Belgium, after the onset of national COVID-19 vaccination campaigns, studies found lower vaccine uptake rates among younger individuals and in geographical areas with higher ethnicity concentration or lower socio-economic status [20,21]. These findings are consistent with other studies focusing on willingness to adhere to suppression measures, which indicated that some respondent characteristics, such as being female, young age and lower educational level, were associated with lower adherence [9,13,22].

It is important to understand such heterogeneity in the population, particularly when it comes to inherently normative matters such as vaccine rationing, where there is no single 'right' approach and where reasonable people might disagree on what the best approach is. It is well-known that conceptions of distributive fairness differ across socio-economic, demographic or cultural groups. Moreover, the level of support for a rationing policy is also likely to determine participation in it, which will ultimately translate into different levels of vaccine uptake. We know that poor perceptions of government efforts to manage a health crisis can negatively influence future vaccination willingness [23]. Recognizing under-vaccination in population subgroups is also crucial, as it enhances the likelihood of antigenic evolution [24]. Therefore, a better understanding of group-specific preferences is needed to address future outbreaks more effectively.

With this study, we aim to further explore respondents' preferences regarding SARS-CoV-2 vaccine rationing during the early stages of the COVID-19 crisis. To do so, we re-analyze data from the initial study [8], in which respondents participated in a ranking exercise evaluating eight different vaccine distribution strategies from best to worst. Our objective is to investigate whether these preferences varied across socio-demographic groups. To be more precise, we assess whether preferences for a certain prioritization vaccination strategy depend on the following respondent characteristics: age, gender, educational level, occupation, region of residence (Flanders, Wallonia, or Brussels Capital region), household and financial situation, and general health status including prior COVID-19 infection history and risk level when infected. Additionally, we investigate whether preferences for a certain strategy are influenced by respondents' views on who (e.g. government,

scientists or the public) is best suited to determine which of the proposed strategies should be implemented, respondents' attitudes towards the government's current COVID-19 vaccination efforts and respondents' willingness to be vaccinated once a safe COVID-19 vaccine becomes available.

2. Methods

2.1. Sample and survey

To gather the necessary data, a representative panel of Belgian respondents was used. This panel was composed by a market research agency called 'Dynata'. The market agency continuously evaluates the pool of research participants and systematically eliminates low-quality responders. A sample consisting of 2698 individuals was drawn from 5500 volunteers who mirrored the Belgian population, aged between 18 and 80 years, as best as possible. About one in five ($N = 494$) did not complete the survey, bringing the number of respondents down to 2204. Of them, 144 respondents completed the survey in an unreasonably short time (i.e. in less than a third of the median completion time, which was 15 min), and were also excluded from analysis. This led to a final sample of 2060 respondents. This same sample was previously used in another study [25] in which the authors compared its representativeness to national Belgian data. During this analysis, they concluded that the sample fulfilled pre-determined quota for age, gender and province, and thereby was representative of Belgium's most comparable characteristics. However, they also noted that higher educated respondents were overrepresented in the sample compared to the population with a difference of 10 percentage-points. The participating panel members completed the survey between 6-16th October 2020, which means that the data were collected prior to the initial implementation of Belgium's national COVID-19 vaccination program.

The survey was divided into several sections. The first part focused on socio-demographic respondent characteristics and included questions regarding the respondent's gender, age, residence, educational level, household situation, occupation, financial situation, overall health status, opinion regarding vaccination and attitude towards the government's handling of the pandemic. Respondents were also asked if they had been infected by COVID-19 and whether they knew someone who had had COVID-19, was hospitalized and/or even passed away because of it. Furthermore, respondents needed to indicate whether their professional occupation could be considered "essential" in the pandemic time (i.e. if working in health care, law enforcement, fire protection, garbage collection, civil protection, etc.) and whether they could be categorized as "at high risk of COVID-19". In the case of the latter, they were asked to specify if their elevated risk was either age-related, or the result of a chronic illness, obesity, or something else. In the subsequent part of the questionnaire, the background of the study was explained and the respondents were requested to approach the ranking exercise (explained in details below) according to what they perceive to be the fairest strategy from a societal perspective to allocate vaccines in the event of limited initial supply, and hence not to choose the strategy that would serve their own personal interest most. In addition to the ranking exercise, the respondents were presented with a discrete choice experiment (whose results have been published in [8]) after which they had to indicate whom they considered best suited to decide on the individuals to receive a priority vaccination. Lastly, respondents were asked about their willingness to get vaccinated once a safe and effective vaccine becomes available to them, and to what extent they perceived the questionnaire easy to answer.

Prior to the official launch of the survey, various visualizations were tested among a convenience sample ($N = 10$). The full study was then piloted with 174 respondents, resulting in the identification and the correction of a few minor issues before the final launch.

2.2. Ranking exercise

The respondents were presented with a ranking exercise consisting of eight COVID-19 vaccine distribution strategies (chronically ill, elderly, spreaders, workers, essential workers, lottery, first-come first served, highest bidder). These eight strategies, summarized in Table 1, were selected after reviewing existing literature. Each prioritization strategy was displayed separately in a predefined order. After 10 s, respondents were allowed to move to a new screen where they were shown the subsequent prioritization strategy and description. Next, respondents had to rank these strategies from most to least preferred. During the ranking step, the strategies were listed using only keywords. If needed, respondents could revisit the detailed description of the distribution strategies. Also, they were informed that the COVID-19 vaccine was safe and equally effective for all individuals. For reflective purposes, we propose two overarching labels to categorize strategies with similar purposes. In strategy 1–5, prioritization is aimed at protecting a designated subgroup within the population to minimize either mortality, spread or economic/social collapse. In strategy 6–8, prioritization is determined without accounting for these risks.

2.3. Statistical analysis

The data were analysed using the software JMP Pro 17. To provide a holistic view on citizen preferences regarding the eight COVID-19 prioritization strategies, we first assessed whether some of these strategies could be clustered based on their rankings. For this assessment, we applied Ward's hierarchical clustering method. This technique aims to minimize the (squared) Euclidean distance between the rankings of the corresponding strategies. Five clusters (market strategies, vulnerability strategies, workers strategies, spreaders, and lottery) were identified for which dummy variables were created. Each dummy variable equalled 1 if respondents put at least one of its corresponding individual strategies in their Top-3 of most preferred prioritization methods, and 0 if none of them were included in the Top-3. Next, the Pearson's chi-squared test for independence was used to assess if preferences towards a clustered strategy differ significantly between socio-demographic subgroups of the population, for example between age categories. The variables in which the subgroups' preferences towards a certain cluster showed significant differences at level $p < 0.10$ were retained, and later included in the multiple logistic regression for prioritization of the clustered strategy. To check the robustness of our models, we clustered the dataset on the respondents (instead of the prioritization strategies) using Ward's hierarchical clustering method. We then performed a multiple logistic regression analysis on the respondents' clusters and examined if similar conclusions could be drawn. We refer to Appendix A for the results. Next, we assessed the robustness of our ranking threshold (Top-3 vs Top-2) (Appendix B). Lastly, in Appendix C we conducted a sub-analysis using a reduced sample (i.e., including only individuals with a positive vaccine willingness) to re-estimate our five clustered multiple logistic regressions models.

3. Results

3.1. Respondent characteristics

The 2060 respondents took on average 29 min (median 15 min) to complete the whole survey. Only 21 respondents (1%) indicated that the survey was 'too difficult', while 43% said it was 'difficult but doable'. Most of the respondents (56%) considered it 'easy'.

The average and median age of the respondents was 47 years. There were 1055 women (51.21%) and 1005 (48.79%) men. The majority ($N = 1141$) lived in Flanders, compared to 729 residing in Wallonia and 190 in the Brussels Capital region. Approximately two out of five respondents (38.54%) were higher educated, followed by 34.71% of respondents whose highest degree was 'third grade of secondary school'.

Table 1

Eight COVID-19 vaccination prioritization strategies (based on [8]).

Label of strategy	Vaccine prioritization strategy	Detailed description of strategy as presented in the ranking exercise	Studies discussing the use of the vaccination strategy
Designated priority strategies	1 Chronically ill	Distribute the available vaccines first to those who are at greatest risk of serious illness and death due to an underlying condition in order to protect those who are most vulnerable to the virus .	[26–29]
	2 Elderly	Distribute the available vaccines to individuals aged 60 years and older in order to protect those who are most vulnerable to the virus .	[26,29–31]
	3 Spreaders	Distribute the available vaccines to those who spread the virus the most. By vaccinating virus spreaders first, we can slow down the transmission of the virus as much as possible .	[27,28,32]
	4 Workers	Distribute the available vaccines to working individuals first in order to limit the economical damage of the virus to a minimum .	[32]
	5 Essential workers	Distribute the available vaccines to workers with an essential profession in order to ensure the normal functioning of our society .	[28,29,32]
	6 Lottery	Distribute the available vaccines randomly among the whole population so everyone has an equal chance to become vaccinated .	[32–35]
	7 First-come first-served	Distribute the available vaccines to those who enlist themselves the quickest for vaccination (as soon as there is a vaccine available) at the doctor's office, pharmacy or government.	[33,36]
	8 Highest bidder	Distribute the available vaccines to those who are willing to pay the most money .	[34,36]

About one in four (26.75%) reported to have ‘none or a basic degree’. More detailed sample characteristics are presented in Appendix D.

3.2. Cluster analysis

Based on the cluster analysis, displayed in Table 2, we were able to reduce the number of vaccination strategies of interest from eight to five. The two market-oriented strategies (i.e. ‘first come, first served’ and the highest bidder) were clustered, as well as the two vulnerable groups (i.e. the chronically ill and the elderly), and then the workers (i.e. the non-essential and essential workers). The rankings for the spreaders and the lottery strategies were not aligned and therefore these last strategies were not clustered and considered individually. For an overview of the respondent characteristics within each cluster, we refer to Appendix E.

3.3. Top-3 ranking of prioritization strategies

Table 3 shows for both the individual and clustered strategies how many times they were ranked by respondents in their Top-3. The strategies focused on prioritizing chronically ill ($N = 1565$), essential workers ($N = 1509$) and elderly ($N = 1465$) performed the best, while highest bidder was favoured the least as it only occurred 53 times in respondents’ Top-3. Overall, we can state based on the ranking of the individual strategies, that the designated priority strategies were preferred over the risk-independent ones. When focusing on the clusters, strategies prioritizing people most vulnerable to a COVID-19 infection (chronically ill and elderly) were ranked most often in the respondents’ Top-3, while both market strategies (highest bidder and first come, first served) were least frequent in the Top-3.

3.4. Logistic regression analysis of clustered prioritization strategies

The relevant respondent characteristics associated with each of the clustered prioritization strategies are shown in Table 4.

Our results indicate that the strategy of vaccinating the **vulnerables** first was significantly more appealing to those who want scientific experts or the government rather than citizens to determine vaccination prioritization ($p < 0.01$). Additionally, those who prefer this prioritization strategy tended to have a strong positive attitude towards vaccination efforts in general ($p < 0.05$), and they were more likely to be retired than non-retired ($p < 0.10$).

The **working population** was mostly preferred by women ($p < 0.01$), individuals living in Flanders ($p < 0.01$), as well as by people in the age groups of 45–54 ($p < 0.05$) and 65–80 ($p < 0.05$). Those at high risk of severe illness or mortality after a COVID-19 infection also ranked the workers strategies more often in their Top-3 compared to others with no risk factors ($p < 0.05$). Additionally, this strategy was more popular among the individuals who indicated that they ‘certainly’ ($p < 0.01$) or ‘probably’ ($p < 0.05$) would get vaccinated once a safe vaccine became available. The workers prioritization strategy was less appealing to individuals who wanted citizens to determine prioritization ($p < 0.001$), and to those who did not intend to become vaccinated ($p < 0.01$). It was also less preferred by younger individuals (in the age groups of 18–24 ($p < 0.01$) and 25–44 ($p < 0.05$)). Also, people living in the Brussels Capital region ranked the workers strategies less often in their Top-3 ($p < 0.10$).

Regarding the strategy aimed towards the **spreaders** of the virus,

few differences regarding the preferences across socio-demographic characteristics were observed. The spreaders prioritization strategy was preferred by individuals who themselves were not at high risk of a COVID-19 infection ($p < 0.05$), and by those who were not completely opposed to vaccination and who assessed it as rather useless ($p < 0.01$), and by those who saw some value in vaccination efforts ($p < 0.01$). On the contrary, individuals with a negative attitude towards COVID-19 vaccination were less likely to rank the spreaders strategy within their Top-3 ($p < 0.01$).

Individuals who classified the **lottery strategy** within their Top-3 believed that the public should have the authority to determine who receives a priority vaccine ($p < 0.01$), were residing in Wallonia ($p < 0.01$), were themselves not at high risk of a COVID-19 infection ($p < 0.01$) and were sceptical towards the usefulness of vaccination efforts ($p < 0.01$). Citizens with no or a basic degree were also more likely to prefer a strategy in which everyone had the same probability of getting the vaccine ($p < 0.05$). On the contrary, the lottery strategy was less chosen by individuals who believed that prioritization should be decided by either scientific experts ($p < 0.01$) or the government ($p < 0.05$), who lived in Flanders ($p < 0.01$) and who had a (strong) positive attitude towards vaccination efforts ($p < 0.05$).

As for the **market strategies**, which were least often ranked within the Top-3, we notice a generational disparity. Respondents in the age group of 18–44 preferred the market strategies significantly more ($p < 0.01$) than older individuals. Also, those who believed that the public should decide on prioritization were more inclined to opt for a market strategy ($p < 0.01$), as were individuals with a higher degree ($p < 0.01$) and people with a prior history of a COVID-19 infection ($p < 0.05$). Conversely, individuals aged 55–64 and above ($p < 0.10$; $p < 0.001$) and those who wanted to leave the prioritization decision up to scientific experts, were significantly less likely ($p < 0.01$) to rank a market strategy in their Top-3.

4. Discussion

Prior research revealed associations between citizen’ preferences regarding vaccine characteristics (e.g. effectiveness, cost, protection duration, adverse events, and injection frequency) and respondents’ traits, such as gender, region of residence, political affiliation and race [17,25,37–39]. Our study identified that socio-demographic characteristics of citizens also matter for preferences in scarce resource prioritization strategies, meaning that preference heterogeneity exists between different subgroups of the Belgian population regarding the initial distribution of COVID-19 vaccines. As this study conducts an original in-depth analysis to assess the presence of preference disparities regarding prioritization strategies, it is difficult to compare our results to other studies.

Of all clustered strategies, our analysis indicated that respondents ranked the **vulnerability strategy** (i.e. vaccine priority to chronically ill and elderly) most often within their Top-3. This aligns with the vaccination strategy that was proposed at the time by the Belgian government and which was designed upon recommendations from epidemiologists. Other studies also highlighted the importance of this strategy, as their evidence showed that prioritizing elderly and individuals with comorbidities would minimize mortality rates after infection [27,28,31,40]. Further analysis into the characteristics of the

Table 2
Clustered strategies based on Ward’s minimum distance method and correlation coefficients.

Clusters	Prioritization strategy 1	Prioritization strategy 2	Euclidean distance	Correlation between strategies in cluster (%)
1	Market strategies	First-come, first served	38	29
2	Vulnerability strategies	Chronically ill	39	28
3	Workers strategies	Workers	42	15
4	Spreaders	–	–	–
5	Lottery	–	–	–

Table 3

Ranking of the individual and clustered strategies (from most to least often ranked in the Top-3).

Individual strategy	Number of times in Top-3	Relative importance in Top-3 (%)	Clustered strategy (used in the analysis)	Number of times in Top-3	Relative importance in Top-3 (%)
1 Chronically ill	1565	25.32	1 Vulnerability strategy	1815	39.62
2 Essential workers	1509	24.42	2 Workers strategy	1656	36.15
3 Elderly	1465	23.71	3 Spreaders	736	16.07
4 Spreaders	736	11.91	4 Lottery	258	5.63
5 Workers	516	8.35	5 Market strategy	116	2.53
6 Lottery	258	4.17			
7 First-come, first-served	78	1.26			
8 Highest bidder	53	0.86			

Table 4

Multiple logistic regression models for the five clustered prioritization strategies.

Socio-demographic variables*	I. Vulnerability strategy		II. Workers strategy		III. Spreaders		IV. Lottery		V. Market strategy	
	Estimate	P-value [§]	Estimate	P-value [§]	Estimate	P-value [§]	Estimate	P-value [§]	Estimate	P-value [§]
Determination of vaccine prioritization		0.0004		0.0184	/			<0.0001		<0.0001
General public	−0.5239	<i>0.0001</i>	−0.3320	<i>0.0061</i>			0.8979	<i><0.0001</i>	0.6687	<i><0.0001</i>
Government	0.3158	<i>0.0675</i>	0.2107	<i>0.1396</i>			−0.4378	<i>0.0196</i>	0.1840	<i>0.3383</i>
Scientists	0.2081	<i>0.0643</i>	0.1213	<i>0.2012</i>			−0.4601	<i>0.0001</i>	−0.8528	<i><0.0001</i>
Attitude towards vaccination efforts		0.0173	/			<0.0001		<0.0001	/	
Very useless	−0.0590	<i>0.8384</i>			−0.7438	<i>0.0038</i>	0.7869	<i>0.0010</i>		
Rather useless	−0.1936	<i>0.3256</i>			0.4324	<i>0.0041</i>	0.1665	<i>0.3503</i>		
Rather useful	−0.1046	<i>0.4462</i>			0.3180	<i>0.0034</i>	−0.2824	<i>0.0249</i>		
Very useful	0.3572	<i>0.0147</i>			−0.0066	<i>0.9518</i>	−0.6711	<i><0.0001</i>		
Vaccination willingness	/			0.0100	/		/		/	
Certainly not			−0.3846	<i>0.0065</i>						
Probably not			−0.0797	<i>0.4766</i>						
Probably yes			0.1947	<i>0.0401</i>						
Certainly yes			0.2696	<i>0.0140</i>						
Age	/			0.0015	/		/			<0.0001
18–24			−0.4650	<i>0.0020</i>					1.0150	<i>0.0003</i>
25–44			−0.2008	<i>0.0499</i>					1.0567	<i><0.0001</i>
45–54			0.2934	<i>0.0254</i>					0.2967	<i>0.2810</i>
55–64			0.0382	<i>0.7736</i>					−0.7264	<i>0.0686</i>
65–80			0.3341	<i>0.0273</i>					−1.6421	<i>0.0048</i>
Region of residence	/			0.0017	/			<0.0001	/	
Brussels Capital region			−0.2183	<i>0.0857</i>			0.1344	<i>0.4065</i>		
Flanders			0.3091	<i>0.0005</i>			−0.4942	<i><0.0001</i>		
Wallonia			−0.0908	<i>0.3249</i>			0.3599	<i>0.0014</i>		
Gender	/			0.0010	/		/		/	
Female			0.1994	<i>0.0010</i>						
Male			−0.1994	<i>0.0010</i>						
At high risk of a COVID-19 infection	/			0.0391		0.0127		0.0040	/	
Yes			0.1525	<i>0.0407</i>	−0.1217	<i>0.0129</i>	−0.2353	<i>0.0048</i>		
No			−0.1525	<i>0.0407</i>	0.1217	<i>0.0129</i>	0.2353	<i>0.0048</i>		
History of a COVID-19 infection	/		/		/			0.0687		0.0001
Yes							0.1903	<i>0.0625</i>	0.4999	<i><0.0001</i>
No							−0.1903	<i>0.0625</i>	−0.4999	<i><0.0001</i>
Highest degree of education	/		/		/			0.0792		0.0175
None or basic degree							0.2413	<i>0.0244</i>	−0.1994	<i>0.2830</i>
Third grade of secondary school							−0.1024	<i>0.3556</i>	−0.2118	<i>0.2061</i>
Higher							−0.1389	<i>0.1898</i>	0.4112	<i>0.0051</i>
Retired		0.0807	/		/		/		/	
Yes	0.1564	<i>0.0879</i>								
No	−0.1564	<i>0.0879</i>								
Constant	1.9016				−0.7645		−1.2717		−0.7645	
Number of observations		1904		1904		2060		1904		1904
Adjusted R-squared		0.0254		0.0492		0.0107		0.1254		0.1583
AIC		1371.87		1816.24		2664.05		1288.40		678.57
BIC		1410.67		1893.74		2692.17		1354.86		733.97

* Variables indicated with “/” were not included in the final regression due to being non-significant (p -value >0.1).§ The p -values are calculated using the chi-squared statistic. The p -values in **bold** represent the significance of variables, while those in *italic* display the significance of individual parameter estimates.

respondents who chose this approach revealed that they (1) were overall positive towards vaccination efforts, (2) trusted the prioritization decision of governmental health authorities and scientists, and (3) were themselves more likely to fall within this category due to being retired.

Many respondents also seemed to have a strong preference towards

prioritizing **workers**, especially essential workers. This is not surprising, given that the importance of protecting workers with essential occupations were at high risk of coming in contact with the COVID-19 virus due to their work conditions, was often stressed in the media in order to avoid an economy collapse and understaffing in the healthcare sector

and to minimize indirect virus transmission to the most vulnerable. Respondents who preferred the workers strategy generally did not want the public to decide upon prioritization. They were also quite likely to accept a COVID-19 vaccine when it was offered to them, and tended to be older with a higher risk of severe illness or death after infection. An explanation for their preference could be that they wanted professionals they often interact with, such as health care professionals, to be vaccinated and thereby indirectly be less exposed to the virus. Women were also more in favour of this strategy compared to men. This contrasts with previous research [17,41,42] in which women showed a lower vaccination willingness.

The third most selected strategy was prioritization of **spreaders**. An argument for the attractiveness of this strategy could be that respondents recognized its usefulness as an attempt to minimize virus transmission [43]. Still, it might have been ranked third because of the practical difficulties of identifying spreaders, which requires diagnostic testing of the viral load to assess one's level of contagiousness. The strategy was mainly chosen by individuals who themselves were not particularly at risk of a COVID-19 infection. Results also indicated that people, who considered vaccination to be useless, ranked this strategy significantly less in their Top-3. Of course, this strategy later proved to be ineffective as vaccines did on average not prevent transmission.

Besides designated priority strategies, some respondents showed interest for a **lottery** system to distribute initial vaccines. Respondent identification revealed that they preferred a self-determining approach and did not want government nor scientists to decide on vaccine prioritization. This strategy was also more popular in Wallonia, and among lower educated individuals. The latter could infer a lower degree of health literacy, which in turn can explain scepticism about the usefulness of vaccination in an attempt to overcome the COVID-19 pandemic. This strategy was also more popular among those who were less at risk of severe health consequences from COVID-19 infections. Some researchers have acknowledged the fair nature of this strategy as it gives an equal chance to individuals to access the vaccine and can also be weighted according to relevant characteristics such as randomization across eligible citizens sharing similar characteristics [33,34,36,43].

Market strategies were ranked Top-3 by the smallest number of respondents. One explanation could be that these strategies favour those who have the ability to pay for a vaccine, and disadvantage others, hence fostering inequality among the population [33,34,43]. Individuals who considered this approach to be fair and wanted the public to decide on prioritization, were generally younger and higher educated, and had already experienced a COVID-19 infection at the time of the survey.

Similarly to previous studies [17,20,44] that found differences between geographical regions regarding willingness to be vaccinated and vaccine uptake, our results indicated geographical disparities in the distribution of priority vaccines. Citizens of Flanders had a stronger preference towards the designated strategy of prioritizing workers, and were less convinced by the lottery strategy, while the latter was significantly better ranked by respondents living in Wallonia. We wish to acknowledge that that geography (i.e. region of residence) may not be a direct explanatory factor, and could rather be acting as a surrogate for many other variables we did not account for. Although we did not specifically control for the presence of inequalities in terms of healthcare access, we acknowledge, based on earlier findings of the European Social Observatory [45] that individuals with certain characteristics (e.g. women, persons with low working activity, the disabled, and those with financial difficulties) may have higher unmet healthcare needs. People facing health inequalities may also have different rationing preferences.

When examining alternative model specifications in Appendix A, we noticed that the overall results are robust regarding the most important socio-demographic characteristics: determination of vaccine preferences, attitude towards vaccination efforts, region (Flanders), and COVID-19 infection risk. For other characteristics, dissimilarities exist but these can primarily be attributed to the different methods used.

Based on our findings, we would advise, in the event of a future pandemic, the implementation of a phased-vaccination approach as it was done in the Belgian COVID-19 vaccination campaign. This approach would prioritize the most vulnerable individuals first. This for several reasons: (1) being ranked most often in the Top-3, (2) people who preferred this strategy tended to have a positive attitude towards vaccination efforts in general and were thereby more likely to adhere to pandemic guidelines and restrictions, and (3) prior scientific evidence regarding the efficacy of this strategy to minimize mortality rates [23,27]. After vaccinating the elderly and chronically ill, using the Top-3-ranking we propose the vaccination of workers to protect essential occupations and to keep the economy from slowing down or collapsing. As a next step, we suggest targeting the spreaders of the virus to minimize transmission and antigenic evolution. This could be done for example by sending a vaccination invite to those with a high viral load after a diagnostic test. Whenever the above-mentioned groups have received the opportunity to become vaccinated, a lottery system could be implemented to allocate the remaining vaccines randomly. Please note that our prioritization recommendations are based on the results of our ranking exercise and supported by arguments from health organizations and authorities.

We noticed that younger individuals and the lower educated are more interested in risk-independent vaccination approaches compared to other respondents. Knowing that the majority of adolescents uses social media resources to access news and health information [46], combined with evidence that shows that adolescents have difficulties to distinguish facts from false information [47], they are particularly susceptible to adopting misinformation regarding COVID-19. As false beliefs may influence their attitude regarding (future) vaccination campaigns, we encourage the implementation of some sort of media literacy training in all layers of the secondary educational system. Improving media literacy has shown to be effective in combating misinformation by improving one's ability to analyze content and identify fake news [47]. To increase virology-related health literacy, governments can launch specific information campaigns. Previous research has shown that higher health literacy among social media users indirectly tends to lead to higher intentions to perform behaviors to manage one's own health [48]. Depending on the targeted audience and aims of the information campaign, the format of these campaigns and their content may vary, including for example workshops, seminars, posts or videos on social media.

Our study has some limitations that need to be addressed. We considered a prioritization strategy to be preferred by respondents if it was in their Top-3 (out of eight individual distribution strategies). As indicated in our robustness check (Appendix B), where we conducted a side-by-side comparison of Top-3 versus Top-2, we found that changing the ranking threshold (which was originally based on intuition) slightly altered the relation between some socio-demographic characteristics and the preference for a specific prioritization strategy. However, this was to be expected as the data used in the models did not match exactly. Due to our decision to cluster strategies and employ a Top-3 ranking, a respondent may rank two individual strategies of the same cluster in their Top-3. However, in our analysis this counted as a single preference for the cluster, resulting in a slight underrepresentation of the vulnerability and workers strategies, and an overrepresentation of the lottery and spreaders strategies. As cross-sectional data were used, the results only indicate associations between socio-demographic respondent characteristics and their preferred prioritization strategies, and therefore cannot be interpreted as causal. Although we controlled for various socio-demographic characteristics of respondents, our analysis inevitably suffers from omitted variable bias due to unobserved individual characteristics. One particularly interesting cluster of variables, which were not included in the survey but may have played a role and could be explored in further research, related to the 'mental model of illness', i.e. how respondents conceived and understood COVID-19 in terms of risk of transmission, severity of illness, early recognition of symptoms, etc.

[49,50]. One could speculate that respondents with a different mental model (which may be clustered in certain socio-demographic groups) had different distributive preferences too. Moreover, given that the descriptions of the vaccination strategies were displayed in a predefined order, we cannot exclude the presence of ordering bias, where respondents' rankings are influenced by the order in which the descriptions were presented to them. We also acknowledge that if the higher educated individuals were not overrepresented in our sample, the Top-3 ranking results would most likely have been different. We expect that the lottery strategy would have performed better and the market strategy worse. However, given their low relative importance in the overall Top 3-ranking (5.63% and 2.53% respectively) and the fact that the preferences for the other strategies did not seem to depend on respondents' education level, we assume that the impact of overrepresentation is minimal. Finally, the findings only reflect the preferences of Belgian citizens prior to the official implementation of the national COVID-19 vaccination campaign, and thus during a time where respondents had little information about the impact of the newly developed vaccines. As preferences can change over time, conclusions drawn in this study may not reflect current preferences. Caution is also needed when comparing these results to other countries, as respondent characteristics might be categorized differently. Health authorities must be wary when using our insights to design future vaccination programs, as preferences may be different if another virus with its own specific disease course is circulating.

5. Conclusion

This study shows that the designated priority strategies were preferred over the risk-independent ones for distributing a scarce resource across the population. The vulnerability strategy performed the best with 1815 respondents ranking it Top-3, followed closely by the workers strategy ($N = 1656$). The market strategy was ranked least often Top-3 ($N = 116$). The results also confirm the existence of preferences disparities between subgroups of the Belgian population. Depending on the vaccination strategy, differences were registered across generations, gender, regions, levels of education, attitudes towards vaccination and health states. More specifically, women, older or retired individuals, residents of Flanders, those with a positive attitude towards vaccination efforts and/or high vaccination willingness and those with a preference for the government or scientists to decide upon vaccine prioritization were more likely to prefer a designated priority strategy (i.e. vulnerability strategy, workers strategy or spreaders). On the other hand, younger respondents, residents of Wallonia and those previously infected by COVID-19 tended to favour one of the risk-independent priority strategies (i.e. lottery or market strategy).

CRedit authorship contribution statement

Nele Raskin: Writing – original draft, Validation, Methodology, Formal analysis. **Mickaël Hiligsmann:** Writing – review & editing, Methodology. **Jeroen Luyten:** Writing – review & editing, Resources, Methodology. **Sandy Tubeuf:** Writing – review & editing, Resources, Methodology. **Alexander Grigoriev:** Writing – review & editing, Methodology. **Roselinde Kessels:** Writing – review & editing, Validation, Supervision, Resources, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.vaccine.2025.126997>.

Data availability

Data will be made available on request.

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