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Perceived benefits of plant-based diets

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August, 2023

Abstract

A global shift toward plant-based diets could significantly mitigate the negative impact of the food system on the environment, health, and animal welfare. While information provision has become a popular tool among policy-makers and social scientists to push consumers toward more sustainable diets, little is known about the population’s knowledge about the benefits of adopting a plant-based diet. Using data from a representative sample of the French population (N=715), we elicit the average knowledge about the relative merits of plant-based diets on the environment, health, and animal welfare. We show that people have on average a good knowledge of the relatively lower environmental impact of plant-based diets (GHG, land use) but considerably underestimate their health benefits. We also find that people significantly underestimate the prevalence of intensive farming and, therefore, the merits of adopting a plant-based diet for the animals. Our results show that society is predominantly divided into two groups: those who have a positive opinion of plant-based diets on all dimensions, and those who see less benefit in plant-based diets on all dimensions. We discuss the implications of these findings for the role of information campaigns in changing people’s diets.

JEL codes: Q10, Q18

Keywords: plant-based diets, animal-based diets, externalities, environment, health, animal welfare

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1 Introduction

A global shift towards plant-based diets is expected to considerably decrease the negative externalities of the food system. While agriculture currently accounts for about 40% of global land use (Foley et al., 2005), up to 30% of global greenhouse gas emissions (Vermeulen et al., 2012), and 70% of freshwater consumption (Molden, 2013; Steffen et al., 2015), plant-based diets have indeed been shown to require less land, emit fewer GHG emissions (Springmann et al., 2020), and necessitate less water than animal-based diets (Harris et al., 2020). Adopting vegetarian or vegan diets at a large scale could halt deforestation (Erb et al., 2016), and contribute to carbon sequestration (Hayek et al., 2021), which makes it one of the most important solutions to mitigate climate change (Clark et al., 2020) and to reduce the burden on biodiversity (Read et al., 2022).

Scientific work further shows that a large-scale shift towards plant-based diets would also bring sizable co-benefits for human health. Plant-based diets are indeed projected to significantly reduce mortality (Springmann et al., 2016). Recent scientific evidence shows that larger consumption of red and processed meat is associated with larger overall mortality, while plant-based foods such as fruits and vegetables tend to reduce mortality (Clark et al., 2019). Recent projections estimate that about 18 million deaths could be avoided in 2030 worldwide with the adoption of plant-based diets, saving USD 1.2–1.3 trillion in healthcare-related costs (Springmann, 2020). Furthermore, plant-based diets could reduce the risk of amplification and propagation of zoonoses induced by the animal farming system (Espinosa et al., 2020).

Large-scale adoption of plant-based diets would also significantly improve animal welfare. More than 70 billion terrestrial animals are farmed and killed each year for food production, including 69 billion chickens and 1.5 billion pigs (FAO). A great share of these animals is raised on intensive farms. In the US, the Sentience Institute estimates that about 99% of the farmed animals live on factory farms.¹ In the EU, over 300 million animals are estimated to live in cages.² The poor rearing conditions of the current agricultural system generate high levels of animal suffering, which are likely to make the lives of farmed animals not worth living (Espinosa and Treich, 2021a). Switching to a plant-based diet could significantly reduce the number of farmed animals and/or the pressure for intensive farming, thereby alleviating animal suffering.

Over the past few years, numerous scientists and policy-makers have sought to induce shifts towards plant-based diets by informing consumers about the associated benefits (e.g., Vellinga et al. (2022); Segovia et al. (2022); Campbell-Arvai et al. (2014)). Previous evidence suggests for instance that consumers tend to systematically underestimate the environmental impact of food (Imai et al., 2022), especially for animal-based products (Camilleri et al., 2019). Social scientists have then investigated whether teaching or providing information to consumers might change their dietary choices and attitudes (Jalil et al., 2020; Perino and Schwirplies, 2022; Espinosa and Treich, 2021b;

¹<https://web.archive.org/web/20220530102600/https://www.sentienceinstitute.org/us-factory-farming-estimates>

²Source: End the cage age Initiative. <https://web.archive.org/web/20220530103037/https://www.endthecageage.eu/>

Kwasny et al., 2022). Other researchers pointed out the limits of informing consumers about the externalities of animal-based foods as people might be reluctant to get informed (Hestermann et al., 2020; Epperson and Gerster, 2020; Espinosa and Stoop, 2021).

We identify two main challenges for the role of information in supporting a global shift towards plant-based diets that we address in this paper. First, policy-makers and social scientists need to know the actual level of knowledge of the population about the merits of plant-based diets before deciding on the interventions to implement to support their adoption. Should the population already be knowledgeable about the merits of plant-based diets, any intervention designed to inform would necessarily have a limited impact. In a world of scarce resources, policy-makers might then prefer to invest in other policies such as nudging (e.g., Kurz (2018); Hansen et al. (2021)) or taxation (e.g., Funke et al. (2021)). Second, if there is room for improving people’s knowledge about the merits of plant-based diets, policy-makers and social scientists need to figure out which group of consumers should be targeted. Aiming at the appropriate group of consumers could reduce the cost of information campaigns and could help improve the support for policies designed to reduce the consumption of animal-based products.

In this paper, we address these two research questions. We design a survey that assesses the level of (reported) knowledge of the French population on the relative merits of plant-based diets over animal-based diets.³ The French case is particularly interesting as French consumption is representative of the EU27 (79.20 vs 78.26 kg of meat per year per capita according to the FAO in 2020), and France produces about 13.8% of the European meat (FAO, 2021). In the survey, we explore three types of externalities generated by the food system: the environmental impact (land use, GHG emissions), the health impact (overall mortality), and the impact on animal welfare (number of killed animals, rearing conditions, and intensive farming). Using data from a representative sample of the French population (N=715), we elicit the average knowledge of French citizens on these dimensions. We further explore the heterogeneity of views in the population and analyze whether views about the externalities (environment, health, animal welfare) correlate. Last, we investigate whether we can identify some socio-economic groups that have significantly different views about the externalities of diets. Note that this study is exploratory and was not pre-registered.

First, we find that French people have on average a good knowledge of the relatively lower environmental impact of plant-based diets (GHG, land use). We observe however a strong heterogeneity of views regarding the environmental impact of diets rich in meat. In addition, the environmental benefits of the vegan diet are underestimated compared to the vegetarian diet. Second, while people tend to have a good perception of the healthiness of foods, we observe a strong and systematic underestimation of the overall health benefits of adopting a plant-based diet compared to what scientific works predict. Third, we find that people tend to systematically underestimate the impact of the current diet rich in animal-based foods on farmed animals. People largely underestimate the number of animals slaughtered daily for food production and the intensity of animal farming for

³We might here underestimate the level of real knowledge as some people might hide some information for self-serving reasons. See Espinosa and Stoop (2021).

broilers, pigs, and egg-laying hens.

Our results also show significant correlations between views on diets. We find indeed that people who tend to perceive larger benefits of plant-based diets on one dimension also tend to see larger benefits on other dimensions (environment, health, animal welfare). When we look at the heterogeneity of views regarding the relative benefits of plant-based diets, we observe two groups of individuals in the population: those who have positive views on plant-based diets on all dimensions, and those who have more negative views on all dimensions. Individuals with positive and negative views on the benefits of plant-based diets do not differ with respect to their demographics. However, respondents with more negative views are more likely to eat animal-based products and are less willing to get informed on the impacts of animal-based diets.

The remainder of the paper is organized as follows. Section 2 introduces our survey and Section 3 our data. Section 4 presents the results. Section 5 discusses the results. Last, Section 6 concludes.

2 Survey

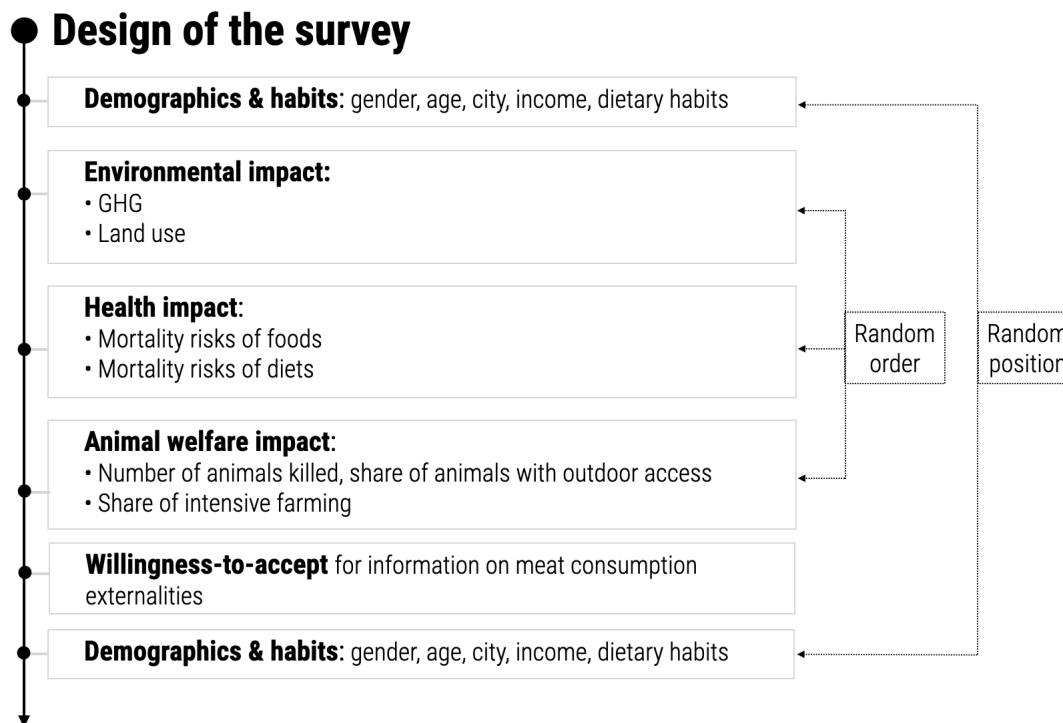
We design a survey that assesses the perception of the relative benefits of plant-based diets over animal-based diets. The survey is made of five blocks: demographics, environmental questions, health questions, animal-welfare questions, and an incentivized willingness-to-accept game. We randomize the position of the demographics and dietary habits block between the beginning and the end of the survey with equal probability (see Figure 1).⁴ We also randomize with equal probability the order of the environmental, health, and animal-welfare blocks. The full survey is displayed in Appendix.

First, in the demographics block, we ask participants about their gender, their postal code, their age, their job, and their highest-level diploma. We further ask them about their diet, namely the frequency to which they eat red meat, white meat, fish, eggs, dairy products, vegetables, legumes, fruits, and starchy foods.

Second, we ask participants a series of questions about the environmental impact of diets in France. We explain that the French Environmental National Agency (ADEME) has analyzed the diets of French people and has categorized five representative diets: a diet with 30g of meat per day, a diet with 75g of meat per day, a diet with 170g of meat per day, a vegetarian diet without meat or fish, and a vegan diet without meat or fish and almost no dairy or eggs. We show the participants the composition of each diet in terms of grams of foods consumed daily (legumes, fruits, red meat, white meat, processed meat, etc). We then elicit the participants' beliefs about the relative environmental impact of these diets with the following question: "Suppose that eating 75g of meat per day generates 100 units of greenhouse gases per year. How many units of greenhouse

⁴Unfortunately, the software did not save the randomization decision, so we are unable to discuss whether there is an order effect as we originally planned. If there is an effect, half of the data were exposed to the dietary habits questionnaire first, and the other half were exposed to the dietary habits last. The results must thus be seen as the average between the two treatment conditions.

Figure 1: Summary of the survey



Notes: Equal probability randomization of the appearance order for the demographics block. Equal probability randomization of the appearance order for the environmental, health, and animal-welfare blocks.

gases do other diets generate per year?"⁵ We ask a similar question about land use. Respondents must report a positive integer for each diet, which is shown in a random order, and are explicitly asked to report 100 units for the 75g-meat diet. Last, participants are asked to report to which extent they are confident in their answers to the environmental questions.

Third, we ask a series of questions regarding the health impact of foods. We start by introducing the concept of mortality (i.e., the number of deaths in a given year) and then ask participants to which extent they think that a series of foods impact mortality (whole grains, nuts, legumes, fruits, vegetables, fish, dairy, eggs, chicken, and red meat). Participants must indicate how much they think an additional daily serving of each of these foods can increase/decrease the number of deaths using a slider in percentage points. The order of foods is randomized. To limit the risks of framing effects, we tell participants that the lower and upper limits of the slider are determined randomly, but that they always contain the values found in a 2019 scientific study that assessed the mortality impact of these foods. In our survey, we randomize with an equal probability between two types of slider limits: either (-20%, +20%), or (-40%, +40%). Next, we proceed similarly for diets. We ask participants how they expect mortality to change in France if people were to switch to a flexitarian diet (red meat limited at 100g per week, more vegetables, more legumes), a vegetarian diet, or a

⁵We used here GHG units rather than CO₂-eq units because people might be unfamiliar with this concept. Note that Camilleri et al. (2019) use light-bulb minutes as a measurement unit.

vegan diet compared to the current diet French people have. Last, respondents report to which extent they are confident in their answers to the health questions.

Fourth, we include some questions about animal welfare in the current French farming system. First, we ask participants how many terrestrial animals are killed daily in France for the food system. Second, respondents must report the proportion of egg-laying hens and pigs that are raised with outdoor access on French farms. Third, we ask participants their beliefs about intensive farming in France. More specifically, we ask them to report, out of 100 animals raised on French farms, how many are raised on farms of different sizes. For instance, we ask them, out of 100 chickens raised in French farms with 1,000 animals or more, how many are raised in the following farms: farms with 1,000 to 2,000 chickens per farm, farms with 2,000 to 10,000 chickens per farm, farms with 10,000 to 20,000 chickens per farm, farms with 20,000 to 50,000 chickens per farm, and farms with 50,000 chickens per farm or more. We discuss in Appendix how these questions are informative about animal welfare. We ask this question for chickens, egg-laying hens, pigs, and cows using the farm categories of the French Ministry of Agriculture. Last, we ask respondents to indicate their level of confidence in their answers to the questions relating to animal welfare.

Last, respondents face an incentivized willingness-to-accept game. We tell them that they have the opportunity to watch a 5-minute video at the end of the survey depending on their following choice. We introduce them with three Multiple-Price-Lists (MPLs) associated with a video each: one video on the environmental impact of meat consumption, one on the health impact of meat consumption, and one on the impact of meat consumption on animal welfare. For each MPL, respondents must report whether they would like to see the video for the associated increase in gains (from 0% up to +20% with 2.5 percentage-point increments). Participants are told that only one line over the three MPLs will be randomly selected and that their associated choice will be implemented. We also tell participants that, should they have chosen to watch the video for the randomly selected price, they will need to correctly answer a series of attention checks about the video to receive the selected bonus payment.

3 Data

We ran the survey in March 2022 online using Dynata for the recruitment of participants. In total, 1,727 respondents answered the questionnaire and fulfilled the quality criteria of the polling institute. We further decide to apply the following exclusion criteria to ensure a sufficiently good quality of answers. First, we exclude participants who do not report 100 units for the 75g-meat diet in the questions about GHG emissions and land use as it was explicitly told them to do. Second, we drop participants who report the same answer to all the related subquestions more than once (i.e., for GHG emissions, land use, mortality of diets, and the distributions of animals in farms), which is known as straight-lining. Third, we remove participants who say that 0 terrestrial animal is killed daily for the food system. Fourth, we drop participants who filled the questionnaire in less than 6 minutes. Last, we also exclude participants who spent less than 30 seconds on the environmental,

health, and animal welfare screens. We analyze in the Robustness Check section below how these exclusion rules might affect our results.

Our final sample consists of 715 respondents. The sample is representative of the French population with respect to gender, age, and region of residence. We find indeed no statistical difference between the distribution in our sample and in the French population for gender ($p = 0.448$), for age ($p = 0.907$), or for region of living ($p = 1.000$) (see Table A1 in Appendix). Our sample is also representative of the French population in terms of income (Chi-squared test: $p = 0.801$, Table A2).

4 Results

4.1 Perception of environmental benefits

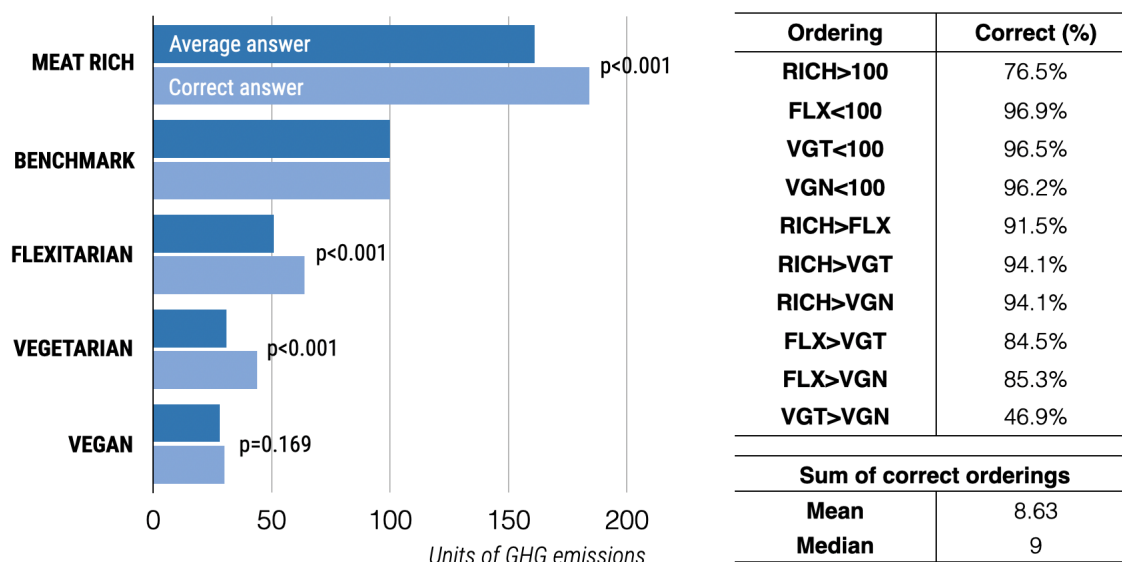
We start by looking at the perception of the environmental benefits of switching to plant-based diets. First, we compare the respondents' answers about the GHG emitted by the different types of diets presented in the survey with the actual level of emissions estimated by the French Environmental National Agency. We observe that consumers tend to have, on average, a good knowledge of the GHG impact of diets (Figure 2). Indeed, more than nine out of ten consumers declare that flexitarian (96.9%), vegetarian (96.5%) and vegan diets (96.2%) emit fewer GHG than the benchmark diet (75g meat). In addition, about 76.5% of consumers consider that the diet rich in meat emits more GHG compared to the benchmark diet. Out of the ten pairwise comparisons, the median respondent has 9 correct orderings. This suggests that a large majority of consumers have a correct representation of the ordering of diets in terms of GHG emissions. One exception concerns the comparison between the vegetarian and the vegan diets: only 46.9% of the consumers correctly report that the vegetarian diet emits more GHG than the vegan diet.⁶ The heterogeneity of views varies across diets. Figure A1 in Appendix shows the distribution of (winsorized) answers. We observe a relatively small heterogeneity of views with respect to the flexitarian, vegetarian, and vegan diets. The heterogeneity is much larger for the diets rich in meat.

Second, we observe similar trends for land use (Figure 3). About 9 out of 10 respondents correctly report that the flexitarian, vegetarian and vegan diets use less land than the benchmark diet (resp. 93.4%, 86.2%, 87.1%). Similarly, about 75.1% of the respondents report that the rich-in-meat diet needs more land than the benchmark diet. The median respondent also reports 9 correct orderings out of 10 pairwise comparisons. Here also, the major incorrect belief concerns the vegetarian vs. vegan comparison: only 42.2% of the consumers correctly report that the vegetarian diet necessitates more land than the vegan diet.⁷ Figure A2 in Appendix also shows a much larger heterogeneity in the perceptions of land use for the rich-in-meat diet than for the flexitarian, vegetarian, and vegan diets.

⁶While the GHG gains in switching from a vegetarian diet to a vegan diet are much smaller than those of going from 75g of meat per day to a vegetarian diet, note that a vegetarian diet still emits 45% more GHG than a vegan diet, which is not negligible. It is likely that respondents underestimate the impact of dairy products.

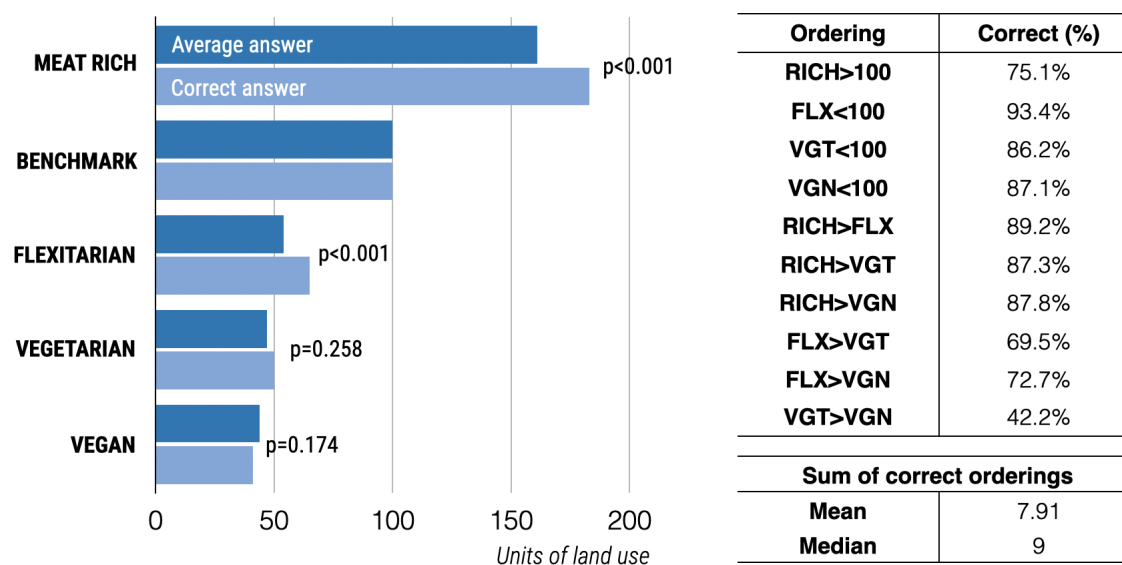
⁷Note here as well that a vegetarian diet necessitates 21.7% more lands than a vegan diet according to the estimates of the French Environmental National Agency.

Figure 2: Reported levels of GHG emissions by type of diet.



The Benchmark diet (75g of meat per day) is normalized to 100 units of GHG emissions. P-values corresponds to one-sample t-tests.

Figure 3: Reported levels of land use by type of diet.



The Benchmark diet (75g of meat per day) is normalized to 100 units of land use units. P-values corresponds to one-sample t-tests.

Third, we run a principal component analysis (PCA) on the reported GHG emissions and land use of the four types of diets (see Table A3 in Appendix). The PCA allows us to identify whether there is a latent perception of diets that drive the answers on all environmental issues. We also use the PCA scores to analyze whether the latent perceptions across topics correlate. The first dimension

of the PCA explains 42% of the variance and positively correlates with the externalities of all types of diets. The second dimension explains about 22% of the variance. It positively correlates with the negative externalities of the rich-in-meat diet and negatively with the externalities of plant-based diets (vegetarian and vegan diets). We consider that the second axis reflects a general tendency of perceiving higher benefits associated with a switch to plant-based diets. We project the scores of the individuals on this second dimension (*Pro-Veg Environment*).

Results: On average, French people have a good knowledge of the relatively lower environmental impact of plant-based diets. There is however a strong heterogeneity of views regarding the environmental impact of diets rich in meat. The environmental benefits of the vegan diet are underestimated compared to the vegetarian diet.

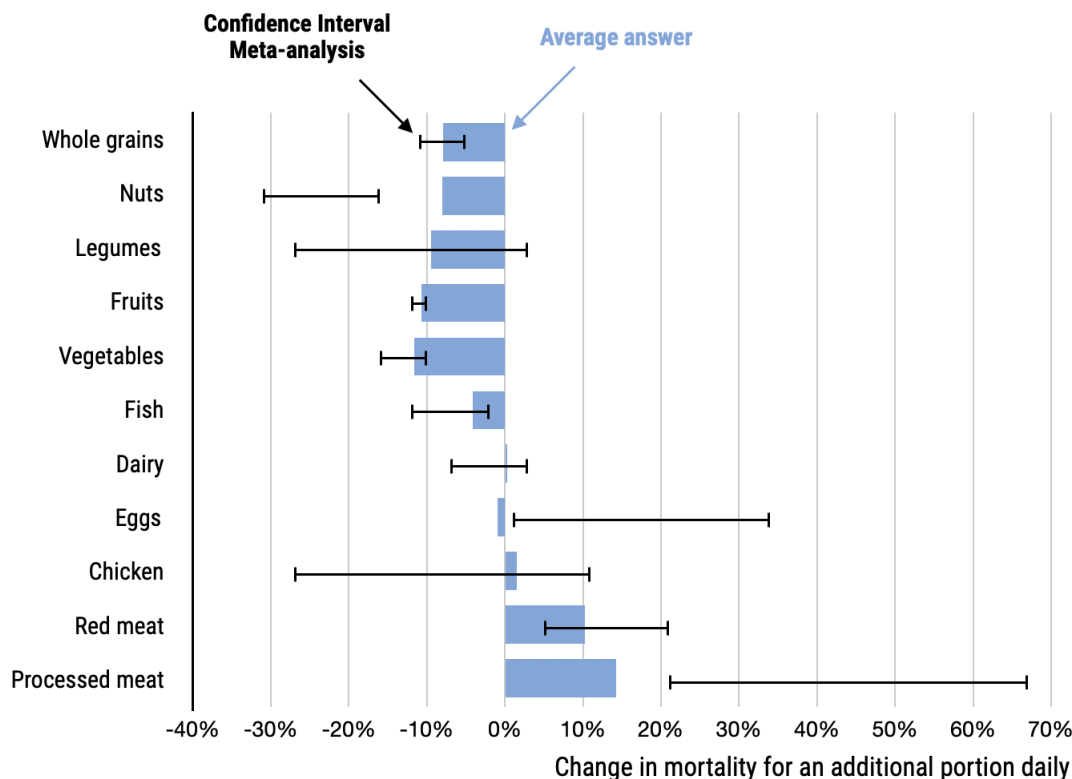
4.2 Perception of health benefits

We now explore the perception of health benefits of plant-based diets through two sets of questions (mortality of foods, and mortality of diets). First, we look at the participants' perception of the mortality impact of an additional serving of food per day for a series of foods. We compare the respondents' answers with the latest scientific data, i.e., data from a recent meta-analysis (Clark et al., 2019). We observe in Figure 4 a good average knowledge of the health benefits of foods. Indeed, on average, people correctly estimate the healthiness of whole grains, legumes, fruits, vegetables, fish, dairy, chicken, and red meat (i.e., the average answer lies in the confidence interval of the meta-analysis). However, respondents tend on average to underestimate the healthiness of nuts and to slightly overestimate the health benefits of consuming eggs. More importantly, while consumers tend to recognize that processed meat is unhealthy, they underestimate how unhealthy it is.

We further observe a large heterogeneity in the perception of the benefits of foods. Figure 5 shows the percentage of responses that fall in the meta-analysis' confidence interval. Foods that have a small confidence interval (e.g., fruits) have, by construction, a smaller share of correct estimates, such that comparing the share of participants who underestimate or overestimate the healthiness of a food is more informative. Eggs and processed meats are the two foods whose healthiness is largely more overestimated than underestimated by the population: 60% (respectively 71%) of the respondents think that eggs (resp. processed meat) are healthier than what the meta-analysis finds. On the contrary, nuts are the only food whose healthiness is largely more underestimated than overestimated by the respondents (79% of the sample).

Second, we observe that consumers tend on average to significantly underestimate the health benefits of switching to plant-based diets (see Figure 6). Indeed, only six out of ten respondents report that the flexitarian diet is expected to decrease overall mortality (60.4%), and half of the respondents expect plant-based diets to do so (45.7% for vegetarianism, 49.8% for veganism). Out of the six possible pairwise comparisons, the median respondent has only three correct orderings when comparing the relative mortality impact of diets. This reflects the fact that, on average, respondents

Figure 4: Expected and estimated changes in mortality associated with an additional serving of food.



tend to consider the flexitarian as the healthiest diet, and that larger shares of plant-based foods in the diets are expected to mitigate the decrease in mortality, while scientific predictions conclude the opposite. It is likely that participants consider on average that a small amount of meat is healthier than no meat or, more globally, than no animal-based products.

We further observe a strong heterogeneity of views regarding the impact of plant-based diets on overall mortality. Figure A3 shows that a large share of the respondents report that plant-based diets could lead to a higher overall mortality. Only one or two respondents out of ten correctly estimate the change in mortality associated with the flexitarian (19%), vegetarian (16%), and vegan (13%) diets in a ± 5 percentage points window. Only a small minority of respondents overestimate the mortality reduction of those diets (less than 7%). On the contrary, more than seven out of ten respondents underestimate the health benefits of plant-based diets compared to the benchmark diet.

Third, we run a PCA on all mortality rates (foods and diets). Table A4 in Appendix shows that the first dimension, which explains 39.51% of the variance, is associated to lower mortality for all elements but for red and processed meat. The second dimension is positively correlated with the mortality of animal-based foods and negatively with plant-based foods and with plant-based diets (especially vegetarian and vegan diets). We consider that the second axis represents a greater perception of the health benefits of plant-based diets compared to animal-based diets. We compute the individual scores on this second dimension (*Pro-Veg Health*).

Figure 5: Expected changes in mortality associated with an additional serving of food.

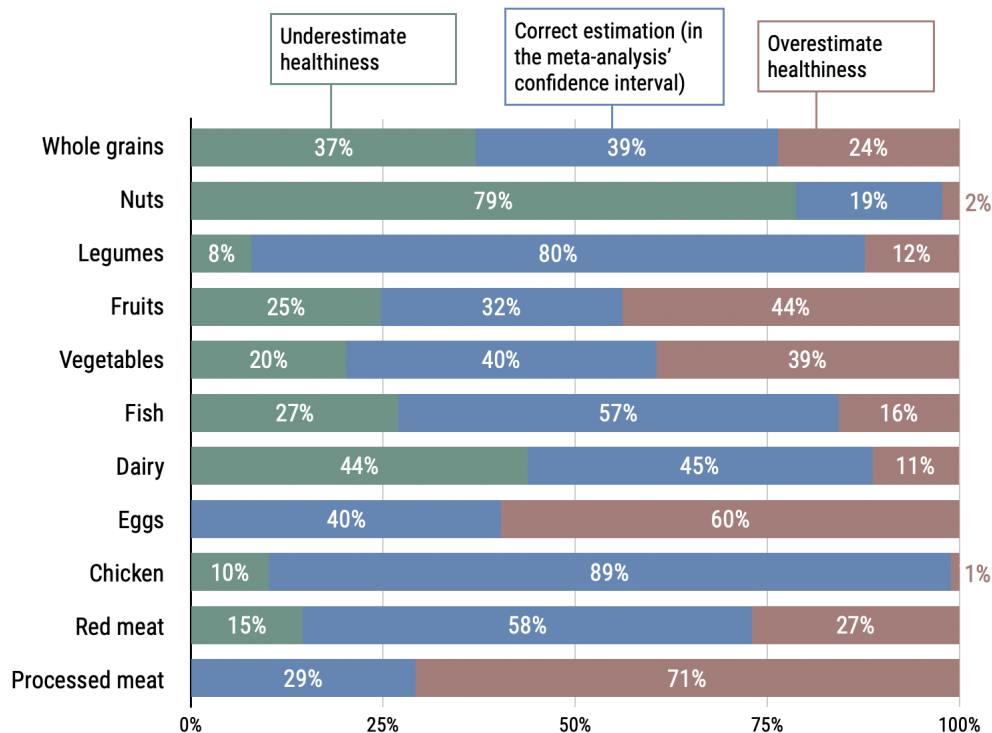
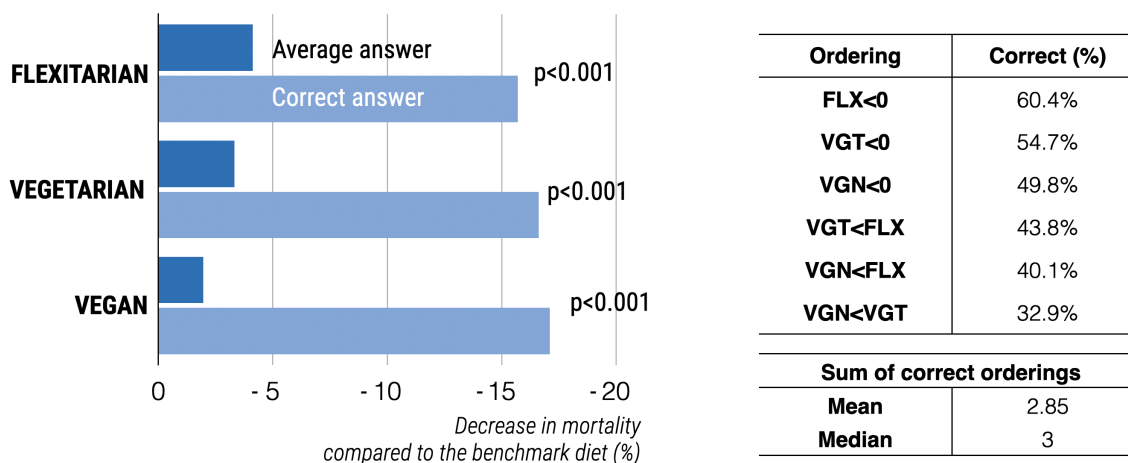


Figure 6: Expected decrease in mortality associated with a change of diet.



Note: The Benchmark diet corresponds to the average French diet. P-values corresponds to one-sample t-tests.

Results: On average, people have a relatively good perception of the healthiness of foods except for nuts (whose healthiness is underestimated), eggs (slightly overestimated), and processed meat (greatly overestimated). We further observe a strong and systematic underestimation of the overall health benefits of plant-based diets compared to the scientific projections.

4.3 Perception of animal welfare benefits

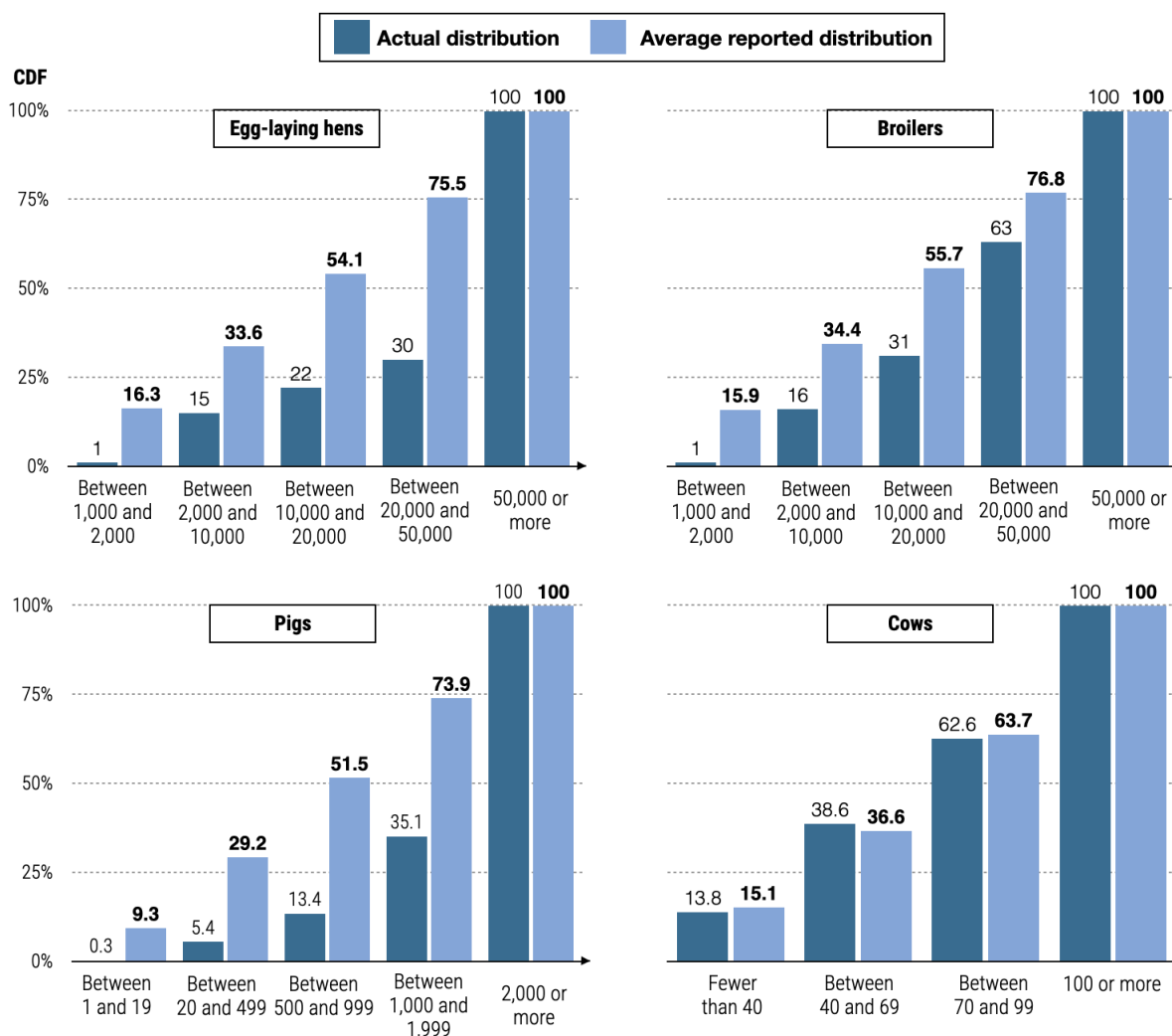
Next, we analyze the respondents' perception of the benefits of adopting a plant-based diet by looking at the externalities of animal-based consumption on animal welfare. First, we observe that a large majority of respondents (73%) underestimate the number of terrestrial animals slaughtered daily for the food system. While about 3 million terrestrial animals are slaughtered daily in France for food production, only 11% of the respondents report that between 2 and 4 million animals are killed daily. About 16% of the participants overestimate this number (more than 4 million animals slaughtered daily), and three-quarters of the respondents underestimate this figure. Regarding outdoor access on farms, we find mixed results. On the one hand, respondents tend to slightly underestimate the share of egg-laying hens that have outdoor access. Indeed, respondents report on average that 30% of the hens have outdoor access, while 34% do have access. However, 63% of the respondents report less than 29% (5 points below the correct answer), while only 23% report about 39% (5 points above the correct answer), which suggests that people tend to underestimate outdoor access for egg-laying hens. On the other hand, people significantly overestimate outdoor access for pigs. While only 5% of pigs have access to the outdoor in France, the median respondent believes that 20% of them do so.

Second, we investigate whether respondents underestimate or overestimate the level of concentration of farmed animals in large-scale farms, which we consider as a proxy for intensive farming. Figure 7 shows the actual and estimated cumulative distributions of farmed animals on French farms. The associated probability density functions are displayed in Appendix (Figure A4). We observe that respondents tend on average to underestimate intensive farming for egg-laying hens, broilers, and pigs. For instance, respondents believe on average that half of the hens (54.1%) or broilers (55.7%) are raised on farms with less than 20,000 animals on the farm, while only 22% of the hens and 31% of the broilers do so. The underestimation is worse for pigs: on average, participants believe that 51.5% of the pigs are raised on farms with less than 1,000 pigs, while only 13.4% do so.

We then construct an indicator that accounts for the views about the intensity of animal farming in France. The indicator, called the *Intensive Farming Underestimation Score* (IFUS) computes the difference between the actual cumulative density function (CDF) of farmed animals and the reported CDF. It takes positive values if an individual underestimates the intensity of animal farming and negative if he/she overestimates it. We detail in the Supplementary Materials the full method to compute the IFUS. Figure 8 shows that respondents tend to correctly estimate the prevalence of intensive farming for cows, but systematically underestimate the level of intensive farming for pigs, egg-laying hens, and chickens.

Third, we conduct a PCA on the variables related to animal welfare (see Table A5 in Appendix). The first dimension explains 46.5% of the variance. It positively correlates with the log of the number of animals slaughtered daily, and negatively with the Intensive Farming Underestimation Scores and the share of pigs and hens with outdoor access. Participants with higher scores on this dimension perceive therefore larger benefits associated with a reduction in the consumption of animal-based products with respect to animal welfare (*Pro-Veg Animals*).

Figure 7: Estimated and actual distributions of animals in French farms per size of farm and per species of animal (Cumulative Distribution Function).

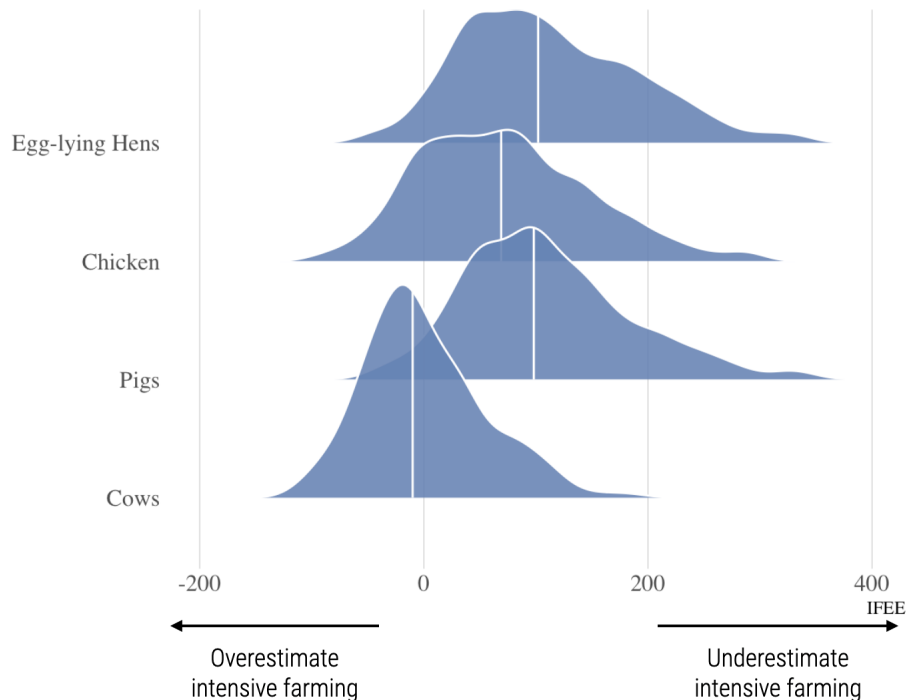


Results: People tend to systematically underestimate the number of animals slaughtered daily for food production. We observe a moderate overestimation of outdoor access for egg-laying hens and a severe underestimation of outdoor access for pigs. We further detect a systematic underestimation of intensive farming practices for broilers, pigs, and egg-laying hens.

4.4 Correlation between perceived benefits

We now look at whether the views about the benefits of plant-based diets correlate across dimensions. Our objective is to understand whether the perceived benefits on each single dimension originate from a single latent overall perception of the benefits of plant-based diets. The above Principal Component Analyses allowed us to detect, for each dimension under consideration, the presence of a latent division between a positive and negative perception of plant-based diets. If these latent

Figure 8: Distribution of the Intensive Farming Underestimation Scores.



Note: The vertical bars represent the median answer.

perceptions correlate, this would suggest that there is a common latent view that can explain the perceived benefits on each single dimension.

To do so, we first compute the Pearson correlation coefficients between the three variables derived from the Principal Component Analyses (*Pro-Veg Environment*, *Pro-Veg Health*, and *Pro-Veg Animals*). Note that we use here Pearson correlation such as to compare the *ranks* of participant for each score. This reduces the risks of comparing PCA scores that can have different variances as they are based on different types of questions. We observe positive and significant correlations between the three dimensions. Participants who perceive larger environmental benefits for plant-based diets also perceive larger health gains ($\hat{\rho} = 0.124, p < 0.001$) and also larger benefits for animal welfare ($\hat{\rho} = 0.114, p = 0.002$). In addition, respondents who have a better view of the health gains of plant-based diets also perceive larger gains for animal welfare ($\hat{\rho} = 0.078, p = 0.037$).

Next, we explore the heterogeneity of the views on the relative benefits of plant-based diets. We want to identify for instance whether the population is mostly divided between proponents and opponents to plant-based diets, or whether there are groups that hold positive views on some dimensions (e.g., environment) but not on others (e.g., health). To do so, we run a K-mean clustering analysis on the three Pro-veg dimensions. A Silhouette plot analysis concludes that the data mostly distinguish two groups of respondents (see Figure A5 in Appendix). When we retrieve these two groups, we observe that they tend to oppose on all dimensions: environmental aspects (means: -0.316 vs. 0.231), health aspects (-0.275 vs. 0.201), and animal welfare issues (-1.687 vs. 1.234). In

other words, it means that individuals in our sample tend either to have positive views of plant-based diets on all dimensions or more negative views on all dimensions.

Results: People who tend to perceive larger benefits of plant-based diets on one dimension tend to see larger benefits on other dimensions (environment, health, animal welfare). As a result, we observe two groups of consumers: those who have positive views of plant-based diets on all dimensions, and those who have more negative views on all dimensions.

4.5 Willingness to get informed

We analyze the participants' willingness to get informed by looking at their decision to accept to watch the informative video about the externalities of meat consumption for different levels of incentives. We see in Figure 9 that the willingness-to-accept is increasing with the levels of incentives, as we would expect from standard economic theory. We further observe similar trends for the three dimensions at stake.

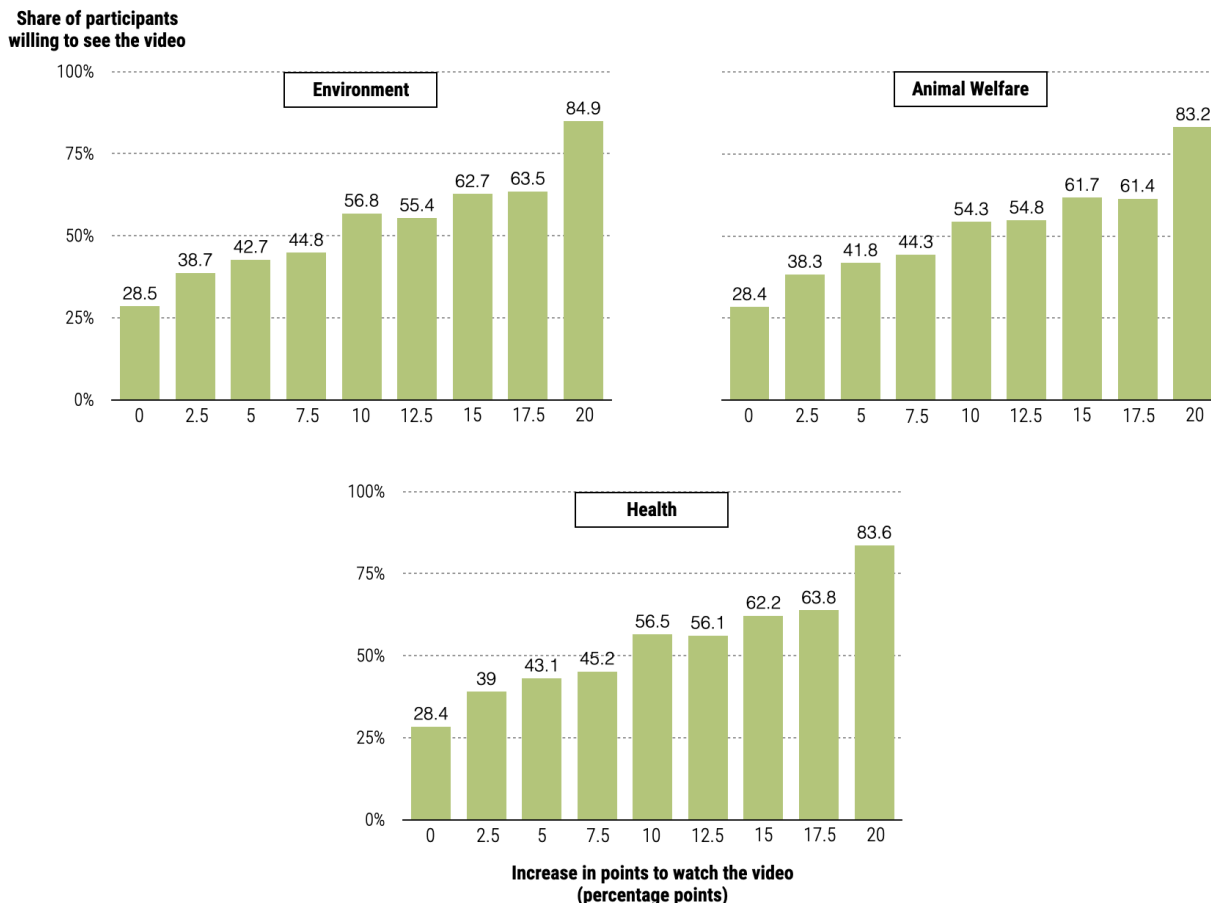
Overall, the data suggest two main phenomena about the WTA for information. First, participants show a small willingness to get informed when they are not incentivized: only 28% of the participants agree to watch the video in the absence of incentives. It suggests that people, on average, will not be likely to look for the information themselves, and most of them are likely to disregard it when it is provided for free without incentives (like in our survey). Second, we see that the WTA is relatively elastic. When participants can obtain 20% additional points for watching the video, about 84% of them are willing to do so. These incentives are relatively cheap for the researchers or the policy-makers but it demonstrates that people need sufficiently high incentives to get informed on the topic.

4.6 Socio-economic characterization of perceived benefits

Last, we look at the profile of consumers who hold positive views on plant-based diets. We start by running a series of univariate analyses (multivariate analyses yield similar results and can be found in Table A8 in Appendix). First, we observe that gender or the region of living does not affect the views about plant-based diets (ANOVA analyses, see Table A6 in Appendix). While numerous works have shown significant differences in the attitudes of men and women towards meat and plant-based diets (e.g. Graça et al. (2015)), we do not detect here statistically significant differences in the way they see the relative merits of plant-based diets. Second, we do not see statistically different views about the environmental and health benefits of plant-based diets across age categories. Individuals between 30 and 50 seem however to see more benefits with respect to animal welfare relative to younger (below 30) and older (above 50) respondents. We do not see strong differences across income categories, except for individuals who reported not knowing their monthly income (N=30).

Next, we observe statistical differences between individuals with diverging behaviors. First, we construct a score of animal-based consumption (ABC) running a PCA on the reported levels of

Figure 9: Willingness to accept to watch the video about meat consumption externalities for different levels of incentives



consumption of animal-based products (see Table A7). We observe that individuals who consume more animal-based products report more negative views on plant-based diets. The correlation coefficient between ABC and the perception of the environmental perception is negative but not statistically significant ($\hat{\rho} = -0.052, p = 0.167$), but is positive and statistically significant for the health benefits ($\hat{\rho} = -0.107, p = 0.004$) and the animal-welfare benefits ($\hat{\rho} = -0.084, p = 0.024$). These findings are in line with previous results that show that individuals with the least knowledge about the environmental impact of food buy most red meat (Edenbrandt and Lagerkvist, 2022). In addition, we also observe a negative relationship between willingness-to-get-informed and views about the benefits of animal welfare. Individuals who chose not to see the video with a higher frequency report indeed less positive views about plant-based diets. The correlation coefficient is negative for the three dimensions and statistically significant for animal welfare (univariate analysis: $p = 0.014$, univariate analysis: $p = 0.059$).

Last, we detect no statistical difference in the perceived benefits of plant-based diets between the reported levels of confidence in the answers given to each series of questions, neither in the univariate nor in the multivariate analyses (Tables A6 and A8 respectively). However, should there

be an effect, our data suggest that individuals who report being totally certain about their answers tend to have more negative views about plant-based diets on the three dimensions than the other respondents (Table A8).

Results: Individuals with positive and negative views on the benefits of plant-based diets do not differ with respect to their demographics. However, respondents with more negative views are more likely to eat animal-based products and are less willing to get informed on the impact of animal-based diets.

4.7 Robustness checks

We now investigate the robustness with respect to our exclusion rules of participants. We initially dropped participants who spent less than 6 minutes on the survey. We analyze whether the answers vary if we set this exclusion rule at 5 minutes (Robustness Check 1.1) or 7 minutes (RC 1.2). Similarly, we dropped participants who spent less than 30 seconds on each of the three main series of questions (environment, health, animal welfare). We look at whether answers differ if we set this limit to 15, 45, or 60 seconds (respectively RC2.1, RC2.2, and RC2.3).

For each variable that we discussed above, we compute the Cohen’s *d* scores to estimate the robustness of the answers with respect to the exclusion rule. Results are displayed in Table 1. We observe very low Cohen’s *d* scores (below 0.1), which suggests that our results are robust to single deviations from our set of exclusion rules.

Last, the environmental and health questions differ to the extent that we asked for the impact of single food items for food but not for the environment. In the above analysis, we performed a PCA for health using all data (e.g., single food items and overall diet items) while we focused on overall diet assessments for environmental dimensions. We explore the robustness of our results by dropping the single food assessments. The new PCA score correlated very strongly with the original PCA score ($\hat{\rho} = 0.607$, $p < 0.001$). The 2-group clustering method now explains 30.5% of the total variance instead of 32.1%. However, the individuals are placed in the same two groups of participants, and these two groups are still opposed on the three dimensions (environment, health, animal welfare).

5 Discussion and policy implications

Food or diet impacts. Our results show that people tend to have, on average, a good knowledge of the environmental benefits of plant-based diets over animal-based diets. This finding somehow contradicts previous results of Camilleri et al. (2019) who show that people significantly underestimate the GHG emissions of GHG-intensive foods, which include animal-based products and those of Hartmann and Siegrist (2017) who conclude that people underestimate the environmental impact of meat. However, our results are consistent with the findings of Shi et al. (2018) who show that people correctly order foods in terms of their environmental impact. Overall, it suggests that people

Table 1: Robustness check: Sensitivity of the answers with respect to the exclusion rules (Cohen’s *d*)

	Cohen’s <i>d</i> scores				
	RC1.1	RC1.2	RC2.1	RC2.2	RC2.3
GHG - Meat rich	-0.023	0.005	-0.002	0.016	0.045
GHG - Flexitarian	-0.005	-0.017	-0.005	-0.013	-0.021
GHG - Vegetarian	-0.002	-0.009	-0.004	0.001	-0.036
GHG - Vegan	-0.001	-0.010	-0.002	-0.005	-0.027
LU - Meat rich	-0.021	0.010	<0.001	0.006	0.053
LU - Flexitarian	-0.018	0.001	0.001	0.014	0.018
LU - Vegetarian	-0.003	-0.005	-0.004	0.011	-0.001
LU - Vegan	-0.001	-0.007	-0.004	0.007	0.008
Mortality - Flexitarian	0.008	-0.004	0.003	-0.018	-0.053
Mortality - Vegetarian	0.007	-0.003	-0.001	0.006	0.006
Mortality - Vegan	-0.002	-0.008	0.005	0.003	0.003
Animals killed	-0.006	0.006	0.001	0.023	0.054
Outdoor access - hens	-0.001	0.007	-0.003	0.004	0.035
Outdoor access - pigs	0.002	-0.002	0.002	-0.004	0.011
IFUS - hens	0.004	-0.004	-0.005	-0.017	-0.013
IFUS - broilers	0.003	-0.002	-0.004	-0.017	-0.030
IFUS - pigs	0.001	-0.005	-0.003	-0.006	0.002
IFUS - cows	<0.001	-0.006	-0.001	-0.009	-0.008
Change in observations	-12	+14	-14	+62	+174

Notes: (1) Cohen’s *d* scores are computed using the difference in means across samples divided by the standard deviation of the benchmark sample.

(2) Deviations from the exclusion rules: exclusion of participants with less than 5 minutes on the survey (RC1.1) or less than 7 minutes (RC1.2); exclusion of participants with less than 15 seconds per screen (RC2.1) less than 45 seconds (RC2.2) or less than 60 seconds (RC2.3).

tend to misestimate the GHG emissions of single foods but to correctly estimate the relative impact of different types of diets.

The two dimensions might matter in different ways for food choices. On the one hand, if people have a good knowledge of the relative environmental burden of different types of diets, they are likely to correctly estimate the benefits of changing their diet at the *extensive* margin (e.g., switching from a meaty to a vegetarian diet). On the other hand, it is possible that people have more difficulties in thinking about their diet at the *intensive* margin, i.e., estimating the benefits of reducing a little bit some types of foods (e.g., eating meat 10 times a week instead of 11 times a week).

Surprisingly, we find opposing results for health. We observe indeed that, on average, people tend to have a good perception of the healthiness of single foods (changes in mortality associated with an additional daily serving). However, people considerably underestimate the overall benefits of adopting a plant-based diet on mortality compared to scientific projections. On average, people acknowledge indeed that an additional daily serving of fruits and vegetables decreases mortality by 10% each and that red meat increases it by 10%, but they estimate on average that a shift towards

more plant-based diets would not decrease mortality by more than 5%.

Consistent views on plant-based diets. We observe in our sample a positive correlation of views of plant-based diets across dimensions at the individual level. This leads to some form of polarization of beliefs on the topic. We find indeed that the population is mostly divided between two groups of individuals: those who tend to hold positive views of plant-based diets on all dimensions, and those who see fewer benefits in adopting a plant-based diet.

Two theories can account for this phenomenon. First, previous works on the *halo effect* showed that people tend to have consistent views about a product or a person, i.e., they are more likely to see positively one dimension of a product when they positively view the product in another dimension (e.g., Apaolaza et al. (2017)). In our case, it could be for instance that people tend to hold positive views on the environmental impact of foods when they see the benefits in terms of animal welfare. Second, it could be that people engage in some forms of motivated reasoning or biased information acquisition. Works on cognitive dissonance show indeed that people might hinder the acquisition of information such as to justify their consumption (Hestermann et al., 2020) or might fake ignorance (Espinosa and Stoop, 2021). People would then seek to have positive views about their diets on all dimensions such as to avoid cognitively dissonant information.

The results suggest that motivated beliefs could indeed be at play, as participants who are less likely to watch the videos on the impact of meat tend to have worse opinions about plant-based diets. The presence of motivated beliefs could induce some endogeneity as respondents who consume more animal-based products will also have worse views about the benefits of plant-based diets. In other words, our results might be lower-bound estimates of the true knowledge of the population as the largest meat-eaters might fake ignorance (Espinosa and Stoop, 2021).

Information campaigns and optimal policies. Social scientists and policymakers might be interested in determining the optimal policies to implement to foster the adoption of plant-based diets. Policymakers can choose from a large range of interventions, which includes both classical economic tools (e.g., taxation) and behavioral policies (e.g., nudges). Potential interventions vary on several dimensions, most notably in their effectiveness to change behaviors and their acceptability by the population. In a democratic system, policymakers might look for a good balance between these two objectives. More coercive interventions like bans or high taxation levels are likely to be more effective, by changing people’s set of choices or by substantially affecting their extrinsic motivations, but they benefit from low popular support (Espinosa and Nassar, 2021). On the other hand, behavioral interventions like nudges or information campaigns are more widely accepted but rely on intrinsic motivations (e.g., social desirability, altruism), which is likely to have a more limited impact on (immediate) behaviors.

Information provision has become a popular policy tool among social scientists and policymakers for its high acceptability level. Some researchers have focused on the effect of informing consumers on one type of externalities (e.g., Perino and Schwirplies (2022)), while others have focused on the overall effects of informing consumers about all kinds of externalities (e.g., Espinosa and Treich

(2021b); Jalil et al. (2020)). However, our results show that information campaigns on plant-based diets might have a limited impact on behaviors. First, our results suggest that informing people about the environmental benefits of plant-based diets might have limited potential in the long run, as people already report on average a good knowledge of the topic. On the contrary, we observe that people tend to significantly underestimate the health benefits of plant-based diets and considerably underestimate the level of intensive farming. It could be therefore more efficient in the long run to invest in informing consumers about the health and animal-welfare benefits of adopting plant-based diets. Second, even if policymakers decided to inform the population about the animal-welfare benefits of plant-based diets, participants could still avoid information (e.g. Hestermann et al. (2020)). In our data, 72% of the participants do not want to see the video when they are not paid. Assuming that people were willing to get informed on this dimension, the effectiveness of information campaigns would also require sufficiently high altruistic concerns toward animals to induce a behavioral change.⁸ Third, informing participants about the health benefits of plant-based diets could be the most promising option. This strategy would benefit from large acceptability, would inform participants on a topic where they are likely to significantly underestimate the benefits of a change, and would target selfish motivations (i.e., preserving one’s own health).

Notwithstanding these limitations, information campaigns might still be a valuable option for policymakers for at least four reasons. First, more coercive interventions like taxation might be more effective (Funke et al., 2021) when information campaigns are deemed to fall short, but they are much less accepted by the population (Douenne and Fabre, 2020; Espinosa and Nassar, 2021). If the opposition to more coercive measures is too large, information campaigns might be better than nothing. Second, policies might not be mutually exclusive. For instance, informing people might achieve longer-run objectives beyond immediate consumption change and could prepare the population for more coercive measures. Publicly displaying information about the externalities of some products might help increase popular awareness about the necessity to intervene and might thus pave the way for stronger interventions. Third, information campaigns might help reduce the heterogeneity of views on a topic. Our results show indeed that people hold very heterogeneous views about the benefits of plant-based diets. Information campaigns could help reduce the polarization of views on the topic, facilitating the implementation of other policies in the future. Fourth, information campaigns can help reinforce people’s information about the topic. For instance, participants in our survey report relatively low levels of confidence, even for the environmental questions where they are well knowledgeable (only 15% report being confident in the environmental questions). People might be reluctant to change their diet when they are unsure about the information they have, and information campaigns might be a way to reduce uncertainty and promote change.

⁸We can mention that animal welfare is also a public good (Espinosa, 2021): it is costly for the consumer to buy a product that is more respectful to the animals while it benefits everyone who has altruistic concerns for them. To induce a change in market behavior, altruistic concerns must be strong enough to ensure that consumers effectively change their contribution to the public good with information shock only.

Multiple topic comparisons. Our survey aimed at measuring views on different dimensions associated with diets. Comparing the views of individuals on different dimensions is challenging as the questions are *de facto* framed differently across topics. For instance, we asked for GHG points in the environmental section (which can take only positive values) and for the shares of farmed animals in the animal welfare section. Furthermore, comparing the shares of people who have ‘correct’ or ‘incorrect’ beliefs has little sense here as the definition of correct / incorrect answers is sensitive to the thresholds we consider. When comparing beliefs across topics, we thus decided to rely on PCA scores on each dimension. Because PCA scores are centered (i.e., the mean is equal to zero), it helps compare individuals on different dimensions. Second, because the distribution of PCA scores might be different across topics, we further used Pearson correlation, such as to compare the *ranks* of individuals across dimensions rather than their absolute scores.

Limitations. Last, let us note three limitations to our study. First that our results on the environmental part might be partly driven by the way the questions were framed. We used indeed the wording of the French Agency for the Environment (ADEME), which labeled the diets with "Meat 35g", "Meat 70g" and "Meat 170g". We cannot exclude the fact that these wordings somehow influenced the participants during the experiment. Second, we can also note that our measure about the willingness-to-get-informed may fail to account for information resistance: both people who are resistant to information and those who are already knowledgeable are likely to refuse to see the video. We might therefore fail at detecting this source of heterogeneity in the data. Third, the health discussion about the benefits of plant-based diets mostly focused on well-executed plant-based diets. However, we might note that not all plant-based diet might be as beneficial, especially if it contains a large share of ultra-processed food.

On the methodological side, we can underline the difficulty to capture people’s perceptions of the healthiness of foods and diets and compare them with scientific estimates and projections on the topic. In the survey, we tried to make the questions as cognitively easy as possible for the participants. For instance, we proposed a slider answer format rather than an open-ended format. We also framed the risk ratios as reductions in the number of death at the aggregate level. However, participants might still be unfamiliar with this type of question, leading to uncertain responses (although the health section received the highest confidence scores).

6 Conclusion

A global shift towards plant-based can considerably mitigate the negative externalities generated by the food system. Numerous scientists and policy-makers have recently sought to induce this change by informing consumers about the impact of animal-based diets and the benefits of plant-based diets. In this study, we design a survey to elicit the perception of the population about the (relative) benefits of plant-based diets on the environment, health, and animal welfare. We gather data from a representative sample of the population.

First, we show that French individuals have on average a good perception of the environmental gains of plant-based diets on land use and GHG emissions. However, we see a strong heterogeneity of perceptions of the environmental impact of meaty diets. Second, we further show that people have good knowledge about the healthiness of single foods, but they systematically underestimate the overall health benefits of adopting a plant-based diet. Third, our results indicate that people considerably underestimate the burden of animal-based diets on farmed animal welfare (number of killed animals, intensity of animal farming).

Next, we find significant correlations between the perceptions of diets regarding their environmental, health, and animal welfare impacts. Indeed, people who see larger benefits of plant-based diets on one dimension tend to perceive larger benefits on the two other dimensions. As a result, the population tends to be divided into two groups: the individuals who positively see plant-based diets on all dimensions, and those who have more negative views on all dimensions. However, we do not detect any socio-demographic group that would significantly differ in their views about plant-based diets. Last, we find that respondents who negatively perceive plant-based diets are more likely to consume animal-based products and are less willing to get informed on the impacts of animal-based diets.

These results suggest that strategies aiming to inform consumers about the environmental benefits of plant-based diets might have a limited impact: on average, consumers have relatively good knowledge of the environmental question but we still observe high levels of meat consumption in our society (about 80kg of meat per year per capita in France). Strategies that aim to inform consumers about the health or animal welfare benefits of plant-based diets might be more powerful.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest: The authors acknowledge financial support from Rennes School of Business and ANR under grant ANR-19-CE21-0005-01.

Research involving Human Participants and/or Animals: This research follows standard survey practices and has no impact on the well-being of human participants.

Informed consent: All participants in the survey expressed informed consent for participating in the survey.

Appendix: Additional Tables

Table A1: Distribution of demographics in the sample and in the population (percentages)

Variable	Sample	Population
Gender (female)	55.24	51.53
Age 18-29	13.99	17.61
Age 30-44	26.01	23.83
Age 45-59	25.17	25.45
Age 60+	34.83	33.11
Auvergne-Rhône-Alpes	13.57	12.49
Bourgogne-Franche-Comté	4.2	4.27
Bretagne	5.37	5.21
Centre-Val-de-Loire	4.62	3.93
Grand Est	9.37	8.49
Hauts-de-France	6.71	9.17
Île-de-France	17.62	18.99
Normandie	3.92	5.07
Nouvelle-Aquitaine	9.23	9.32
Occitanie	9.93	9.27
Pays de la Loire	7.27	5.93
Provence-Alpes-Côte d'Azur	7.69	7.86

Notes: (1) Proportion test for gender: $p = 0.448$

(2) Chi-squared tests for age ($p = 0.907$) and for regions ($p = 1.000$)

(3) Source for population data: INSEE

Table A2: Distribution of income in the sample and in the population (percentages)

Net income per month	Sample	Sample (without "Don't know")	French population
Less than 750€	3.08	3.21	3
Between 750€ and 999€	3.36	3.51	3
Between 1000€ and 1499€	7.97	8.32	14
Between 1500€ and 1999€	12.31	12.85	16
Between 2000€ and 2999€	23.5	24.53	24
Between 3000€ and 3499€	13.85	14.45	9
Between 3500€ and 4999€	21.68	22.63	18
5000€ and more	10.07	10.51	13
Don't know	4.2	.	.
Total	100	100	100

Notes: (1) Chi-squared test for columns 2 and 3: $p = 0.801$.

(2) Source for population data: Estimated from *Enquêtes Revenus fiscaux et sociaux, 2018*, INSEE

Table A3: Principal Component Analysis on environmental variables.

	Correlation coefficients	
	1st dimension	2nd dimension
GHG - MEAT RICH	0.207	0.890
GHG - FLX	0.698	0.185
GHG - VGT	0.758	-0.193
GHG - VGN	0.729	-0.211
LU - MEAT RICH	0.090	0.897
LU - FLX	0.687	0.128
LU - VGT	0.820	-0.111
LU - VGN	0.761	-0.119
Share of explained variance	42.11%	21.94%

Table A4: Principal Component Analysis on health variables.

Mortality	Correlation coefficients	
	1st dimension	2nd dimension
FLX	-0.494	-0.124
VGT	-0.022	-0.594
VGN	-0.152	-0.552
Whole Grains	-0.741	-0.042
Nuts	-0.749	-0.069
Legumes	-0.882	-0.122
Fruits	-0.904	-0.051
Vegetables	-0.904	-0.069
Fish	-0.692	0.261
Dairy	-0.523	0.452
Eggs	-0.648	0.355
Chicken	-0.464	0.599
Red Meat	0.267	0.707
Processed Meat	0.531	0.526
Share of explained variance	39.51%	15.97%

Table A5: Principal Component Analysis on animal welfare variables.

	Correlation coefficients
	1st dimension
Daily killed animals (log)	0.273
Share of egg-laying hens with outdoor access	-0.352
Share of pigs with outdoor access	-0.375
IFEE - Hens	-0.904
IFEE - Broilers	-0.897
IFEE - Pigs	-0.871
IFEE - Cows	-0.732
Share of explained variance	46.5 %

Table A6: ANOVA analyses of the perception of the benefits associated with plant-diets.

	ANOVA (p-values)		
	ProVeg-Environment	ProVeg-Health	ProVeg-Animals
Age	0.555	0.935	0.004
Gender	0.241	0.538	0.627
Income	0.703	0.048	0.052
Region	0.608	0.200	0.758
Uncertainty	0.697	0.652	0.449
Info Resistance	0.188	0.101	0.014
N	714	714	714

Table A7: Principal Component Analysis on animal-based food consumption.

	Correlation coefficients
	1st dimension
Red meat	0.720
White meat	0.778
Fish	0.685
Eggs	0.498
Dairy	0.568
Share of explained variance	43.3%

Table A8: Multivariate analysis of the perception of the benefits associated with plant-based diets (Seemingly Unrelated Regressions model).

	ProVeg Environment	ProVeg Health	ProVeg Animals
Animal-based consumption	-0.0538 (0.0348)	-0.1013*** (0.0389)	-0.0960** (0.0466)
Willingness-to-get-informed	-0.0165 (0.0147)	-0.0248 (0.0164)	-0.0368* (0.0195)
Totally uncertain		Reference group	
Rather uncertain	0.0564 (0.1125)	-0.0416 (0.1357)	-0.1658 (0.1506)
Rather certain	-0.1189 (0.167)	-0.0877 (0.1616)	-0.0963 (0.2286)
Totally certain	-0.2960 (0.3999)	-0.4598 (0.4089)	-0.7403 (0.4981)
Demographics	Yes	Yes	Yes
N	714	714	714
R2	0.033	0.056	0.066

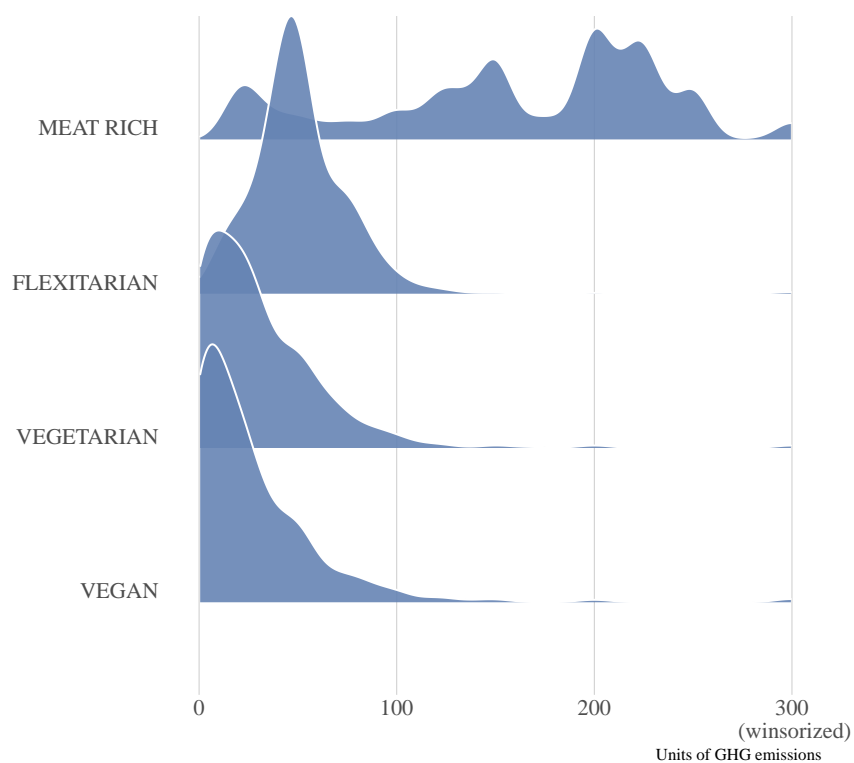
Notes: (1) The figures here are the estimated coefficients, with standard errors in parentheses.

(2) * significant at 10%, ** significant at 5%, *** significant at 1%.

(3) All regressions include demographic controls for age, gender, income level, region of living place.

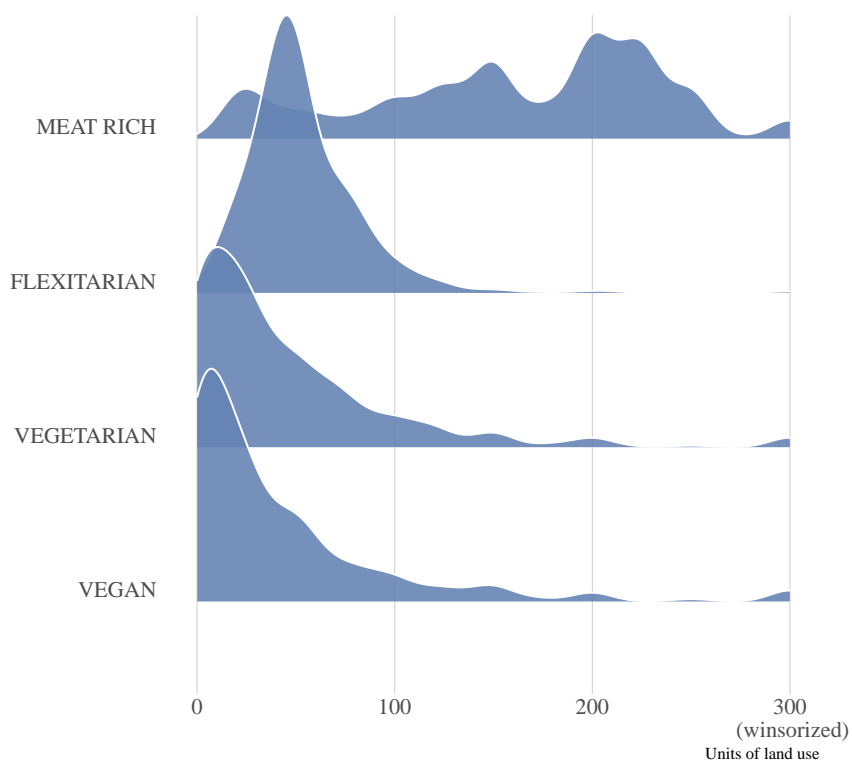
Appendix: Additional Figures

Figure A1: Reported levels of GHG emissions by type of diet.



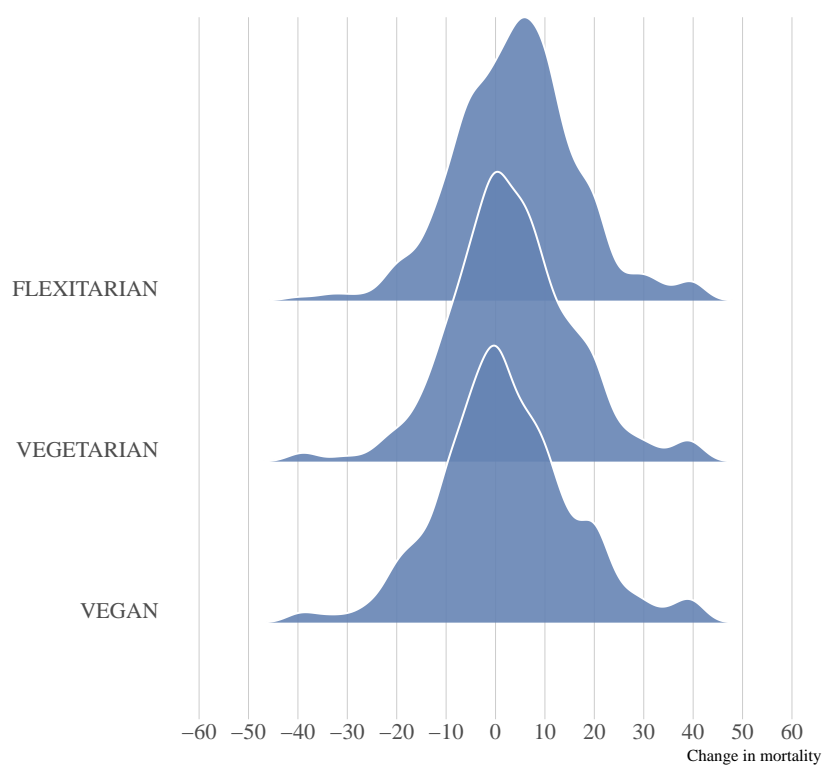
Note: Relative GHG emissions by type of diet. The Benchmark diet (75g of meat per day) is normalized to 100 units of GHG emissions.

Figure A2: Reported levels of GHG emissions by type of diet.



Note: Relative land use by type of diet. The Benchmark diet (75g of meat per day) is normalized to 100 units of land use.

Figure A3: Reported changes in mortality by type of diet.



Note: Relative changes in mortality by type of diet. The Benchmark diet corresponds to the current average French diet.

Figure A4: Estimated and actual probability density distributions of animals in French farms per size of farm and per species of animal.

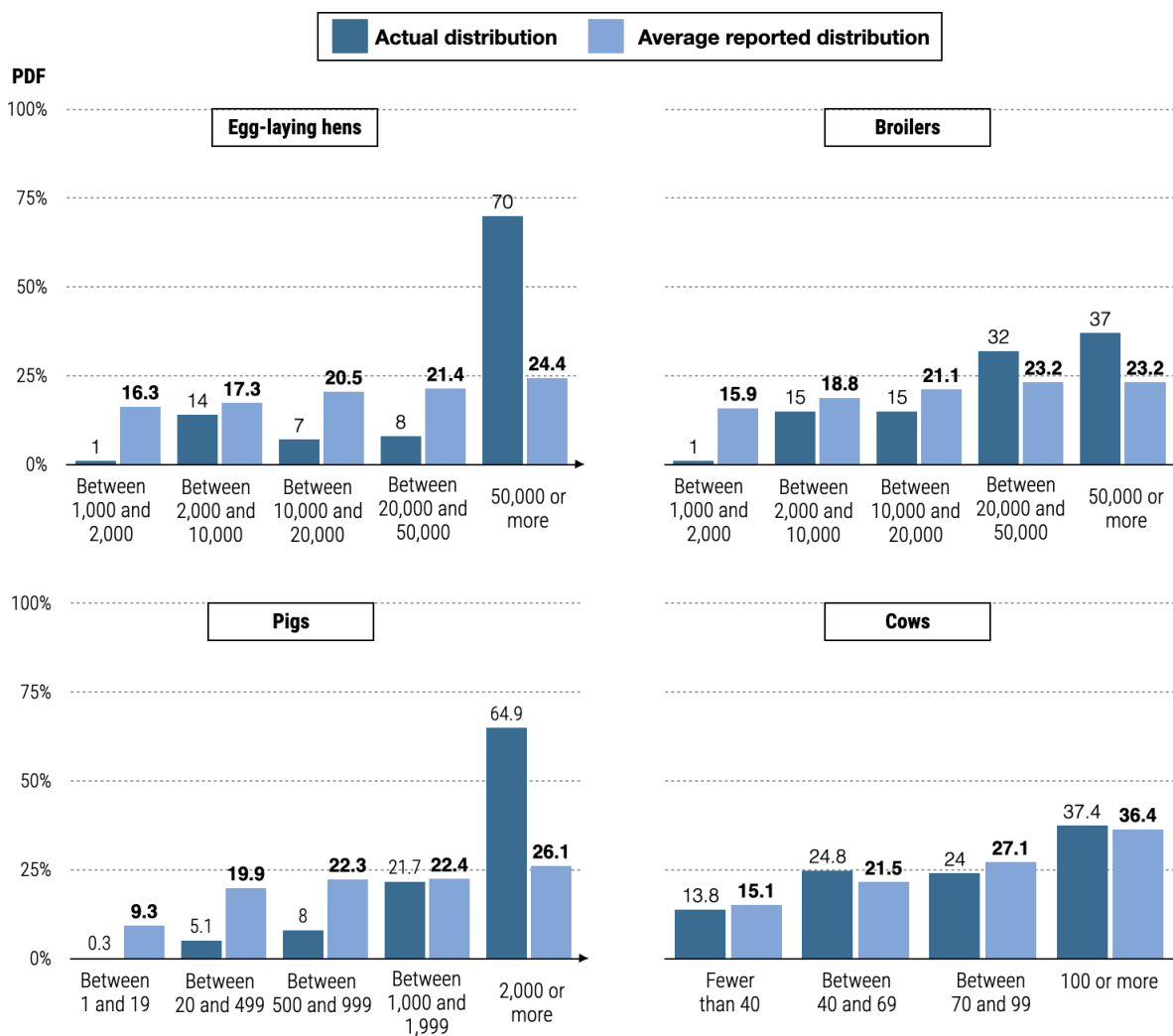
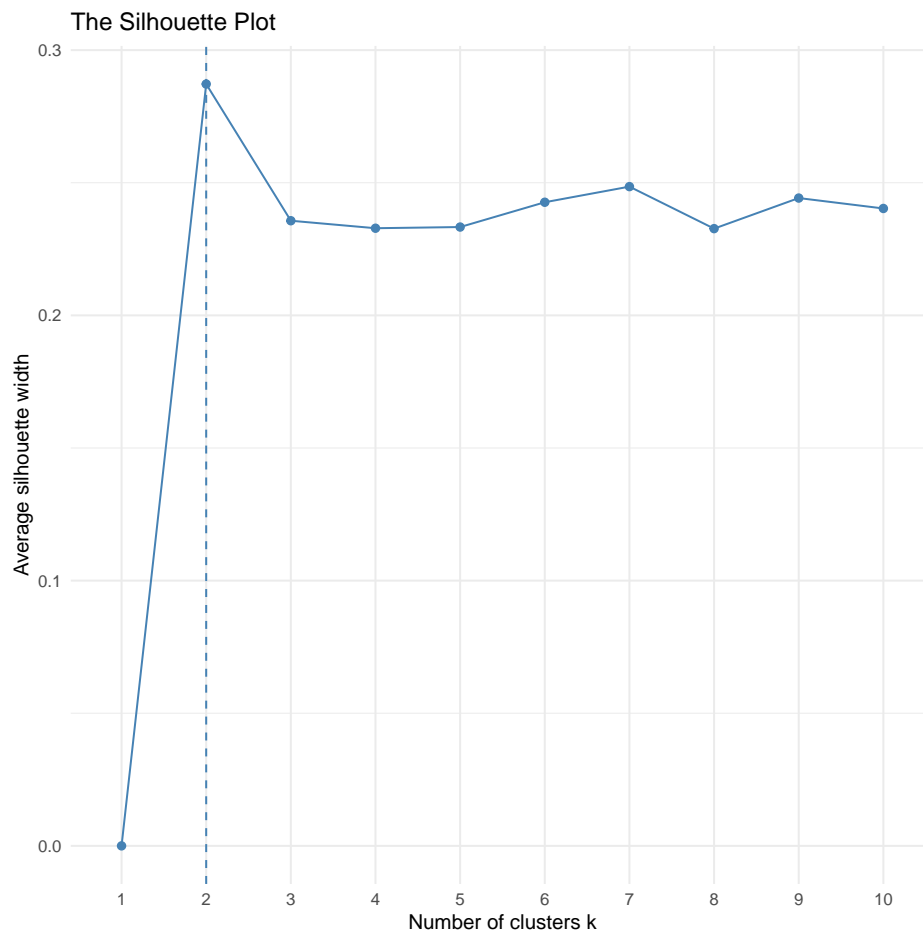


Figure A5: Silhouette Plot for K-mean clustering analysis.



Appendix: Evaluating benefits about animal welfare

Eliciting the perceived benefits of dietary changes on animal welfare is challenging. The main reason is that official data on farm practices do not always exist or are not made public by authorities. For instance, administrative data do not report the average density of farmed animals, nor the share of specific practices (e.g., grinding of piglets' teeth, death by CO₂ stunning, etc). When reported, these figures are not presented as averages per animal but as averages per farm, which makes limited sense when it comes to animal welfare.

Here, we decided to focus on farm sizes as a proxy for animal welfare. Some argue that farm size does not directly determine animal welfare *per se*, as larger farms might be more specialized and might offer, therefore, better services to animals. However, large farms are associated with multiple negative features (Robbins et al., 2016), which can offset the benefits.

Empirically, we observe that larger farms of egg-laying hens in France tend to be associated with lower animal welfare scores. According to the French National Institute *France AgriMer* (2019), farms producing code-3 eggs (the worst category of eggs for animal welfare) have on average 86.000 animals per farm. In these farms, animals are kept in cages with up to 16 hens per square meter, no outdoor access, no natural light, and no access to the ground. On the contrary, farms with higher animal welfare standards (respectively codes 2, and 0) have on average significantly fewer animals per farm (resp. 18.000, and 6.000 hens per farm). In code-0 production systems, there are up to 6 hens per square meter, and the animals have access to outdoor and natural light.

The correlation between farmed size and animal welfare also applies for other animals. For instance, there exist four categories of farms for broilers: 'standard', 'certified', 'Label rouge', and organic farms. These farm categories have increasing protection for animal welfare. The two lowest categories (i.e., standard and certified) have no limit regarding the maximal size of the farm, and density can be as high as 25 chickens (respectively 18 chickens) per m² for standard farms (resp. certified farms). The high density and no size limit lead to large-scale farms (sometimes called factory farms) for these two types of broilers. On the contrary, *Label rouge* and organic farms, which offer the highest level of welfare for the broilers, are much smaller farms given that they cannot exceed 400m² and 480m² respectively, and the density is 11 chickens and 10 chickens per m² respectively.

In other words, we observe a significant association between farm size and animal welfare score in France, and a larger concentration of animal farming in large farms correlates therefore with lower animal welfare. We believe that this correlation is well known in the public as environmental and animal-advocacy NGOs often criticize large-scale farms. For instance, Greenpeace France released in 2018 a campaign condemning these farms.⁹

⁹https://web.archive.org/web/20230112145910/https://cdn.greenpeace.fr/site/uploads/2018/11/Dossier-de-presse-Fermes-usines.pdf?_ga=2.257981711.42964562.1543228049-473213507.1542271947

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Supplementary Materials

Perceived benefits of plant-based diets

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August, 2023

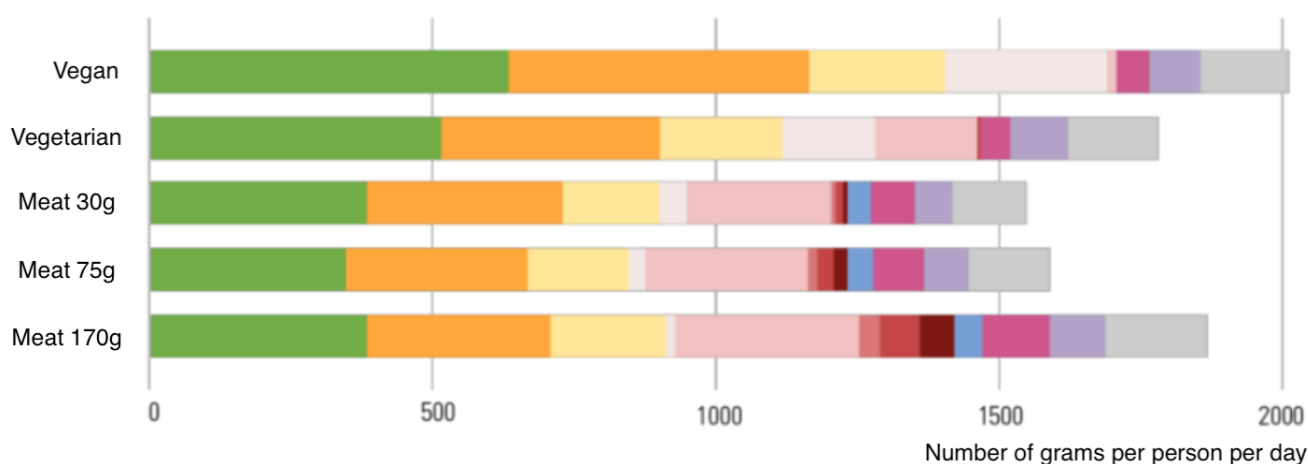
SM 1: Extended Presentation of the Survey

We describe now the full survey. The order of the environmental, health and animal welfare screens were randomized. The position of the demographics screen was also randomized (either first or last).

SM 1.1: Environmental Screen

We are interested in the question of the environmental impact of diets in France. The French Environmental National Agency (ADEME) has assessed the environmental impact of different power supplies on two dimensions: greenhouse gas emissions and land use. To do this, ADEME looked at five major diets, based on what the French say they eat: a diet with 30g of meat per day (Meat 30g), a diet with 75g of meat per day (Meat 75g), a diet with 170g of meat per day (Meat 170g), a vegetarian diet without meat or fish (Vegetarian), and a vegan diet without meat or fish and almost no dairy products or eggs (vegan).

The composition of these main types of food (as practiced by the French according to what they declare to eat) is summarized in the following graph:



We are interested here in the greenhouse gas emissions of the 5 main types of diets presented above. Imagine that we could express greenhouse gas emissions in “greenhouse gas units”. Suppose that eating 75g of meat per day generates 100 units of greenhouse gases per year. How many units of greenhouse gases do other diets generate per year?

Imaginary examples:

If a diet produces 70 units of greenhouse gases per year, it means that it produces 30% less greenhouse gases than the diet of 75g of meat per day. If a diet produces 120 units of greenhouse gases per year, it means that it produces 20% more greenhouse gases than the diet of 75g of meat per day.

Note: Enter 100 in the "Diet - 75g of meat per day" box.

- Diet - 30g of meat per day¹ [*Positive Integer Input*]
- Diet - 75g of meat per day [*Positive Integer Input*]
- Diet - 170g of meat per day [*Positive Integer Input*]
- Diet - Vegetarian diet (no meat, no fish) [*Positive Integer Input*]
- Diet - Vegan diet (no meat, no fish, no eggs, no dairy products) [*Positive Integer Input*]

We are interested here in the agricultural area used by the 5 major types of diets presented above. Imagine that we could express the agricultural area used by each diet in “units of agricultural area”. Suppose that eating 75g of meat per day requires 100 units of agricultural area. How many units of agricultural area do the other supplies require?

Imaginary examples: If diet requires 70 units of agricultural area, it means that it requires 30% less agricultural area than the diet of 75g of meat per day. If a diet requires 120 units of agricultural area, it means that it requires 20% less agricultural area than a diet of 75g of meat per day.

Note: Enter 100 in the "Diet - 75g of meat per day" box.

- Diet - 30g of meat per day² [*Positive Integer Input*]
- Diet - 75g of meat per day [*Positive Integer Input*]
- Diet - 170g of meat per day [*Positive Integer Input*]
- Diet - Vegetarian diet (no meat, no fish) [*Positive Integer Input*]
- Diet - Vegan diet (no meat, no fish, no eggs, no dairy products) [*Positive Integer Input*]

The French Environmental National Agency identifies all greenhouse gas emissions in France. According to you, out of 100 units of greenhouse gases emitted in France today, how many are due to food? [*Positive Integer Input*]

How certain are you of the answers you have given on this page dedicated to the environment?
[*Fully certain, certain, uncertain, fully uncertain.*]

¹The order of the diets was randomized.

²The order of the diets was randomized.

SM 1.2: Health Screen

We are interested here in the impact of food on health. Many studies analyze the link between diet and the number of deaths (what we call 'mortality'). Some researchers study all of this work to determine whether certain foods are associated with higher or lower mortality (i.e. the risk of dying), or if there is no relationship.

In a study published in 2019, researchers summarized the most important work available on the subject and measured whether consuming one more serving of certain foods increases, decreases, or does not affect mortality.

For each of the following foods, how do you think consuming one more serving daily affects the risk of dying?

Please note: the limits of the scale on which you will answer (e.g., from -20% to +20%) is determined randomly. However, the scale still contains the values found by the study.

Imaginary examples: Consuming one more serving of food A daily would increase the number of deaths by X%. Consuming one more portion of food B daily would decrease the number of deaths by X%. Consuming one more portion of food C daily would have no impact on the number of deaths (=0%).

- Whole grains [*Slider Input*] ³
- Nuts [*Slider Input*]
- Legumes (e.g., lentils) [*Slider Input*]
- Fruits [*Slider Input*]
- Vegetables [*Slider Input*]
- Fish [*Slider Input*]
- Dairy products [*Slider Input*]
- Eggs [*Slider Input*]
- Chicken [*Slider Input*]
- Red meat [*Slider Input*]
- Processed meat [*Slider Input*]

More generally, researchers published a work in 2020 in which they estimate the number of deaths in society according to several types of diet. In your opinion, how would mortality evolve if French people adopted the following diets compared to the current situation?

Please note: the limits of the scale on which you will answer (e.g., from -20% to +20%) is determined randomly. However, the scale still contains the values found by the study.

Imaginary examples: If French people adopted diet A rather than the current diet, the number of deaths per year in France would decrease by X%. If the French adopted diet B rather than the

³Slider Input from -20% to 20% or from -40% to +40%. Random allocation between the two types of sliders. The bounds of the sliders are the same for all foods.

current diet, the number of deaths per year in France would increase by $X\%$.

- Flexitarian diet - Consumption of red meat limited (100g per week), more vegetables, more legumes [*Slider Input*]⁴
- Vegetarian diet - No meat, no fish [*Slider Input*]
- Vegan diet - No meat, no fish, no dairy products, no eggs [*Slider Input*]
- Diet that follows dietary guidelines of the Health Ministry [*Slider Input*]

Researchers recently published a study aimed at estimating the share of deaths in the adult population worldwide that is due to unhealthy diets. According to you, out of 100 adults who died in the world in 2017, how many deaths did they estimate to be due to poor diets? [*Positive Integer Input*]

How certain are you of the answers you have given on this page dedicated to health? [*Fully certain, certain, uncertain, fully uncertain.*]

SM 1.3: Animal Welfare Screen

We are interested in the question of animals slaughtered in France for meat consumption. The Ministry of Agriculture lists the number of terrestrial animals (chickens, cows, pigs, etc.) slaughtered every year in France for the agri-food system.

According to you, how many land animals are killed per day in France on average for meat consumption? [*Positive Integer Input*]

Out of 100 laying hens reared in France, how many of them do you think have access to the outside? [*Positive Integer Input between 0 and 100*]

Out of 100 pigs reared in France, how many of them do you think have access to the outside? [*Positive Integer Input between 0 and 100*]

We are interested in the size of farms in France for several types of animals. The Ministry of Agriculture lists in France the number of animals bred in farms of different sizes.

Consider 100 chickens reared in France in farms with 1,000 or more animals. Of these 100 chickens, how many were reared in the following farms on average?

Imaginary examples: If you indicate X in the category "Between 2,000 and 10,000 chickens", this means that on average of the 100 chickens raised in France, X were raised in farms comprising between 1,000 and 2,000 chickens.

- Between 1,000 and 2,000 chickens per farm [*Positive Integer Input between 0 and 100*]⁵

⁴Slider Input from -20% to 20% or from -40% to +40%. Same randomization group as for the previous question.

⁵The sum of inputs must be equal to 100.

- Between 2,000 and 10,000 chickens per farm [*Positive Integer Input between 0 and 100*]
- Between 10,000 and 20,000 chickens per farm [*Positive Integer Input between 0 and 100*]
- Between 20,000 and 50,000 chickens per farm [*Positive Integer Input between 0 and 100*]
- 50,000 chickens per farm and more [*Positive Integer Input between 0 and 100*]

Same question for 100 egg-laying hens.

- Between 1,000 and 2,000 egg-laying hens per farm [*Positive Integer Input between 0 and 100*]⁶
- Between 2,000 and 10,000 egg-laying hens per farm [*Positive Integer Input between 0 and 100*]
- Between 10,000 and 20,000 egg-laying hens per farm [*Positive Integer Input between 0 and 100*]
- Between 20,000 and 50,000 egg-laying hens per farm [*Positive Integer Input between 0 and 100*]
- 50,000 egg-laying hens per farm and more [*Positive Integer Input between 0 and 100*]

Same question for 100 pigs.

- Between 1 and 19 pigs per farm [*Positive Integer Input between 0 and 100*]⁷
- Between 20 and 499 pigs per farm [*Positive Integer Input between 0 and 100*]
- Between 500 and 999 pigs per farm [*Positive Integer Input between 0 and 100*]
- Between 1,000 and 1,999 pigs per farm [*Positive Integer Input between 0 and 100*]
- 2,000 pigs per farm and more [*Positive Integer Input between 0 and 100*]

How certain are you of the answers you have given on this page dedicated to animals? [*Fully certain, certain, uncertain, fully uncertain.*]

SM 1.4: Willingness-to-accept Screen

Here is the last part of this questionnaire. We give you the opportunity to watch a 5-minute video at the end of this questionnaire. The viewing of this video depends on the choices you will indicate below.

We ask you to indicate the amount of points you would be willing to accept for carefully watching a 5 minute video. You can earn up to +20% points on the amount initially planned for this questionnaire if you decide to watch this video. (Attention, there will be basic questions on the video to validate the additional points.) You must indicate for each amount of points proposed if you are ready to watch this video. The computer will choose a line at random among all those present below: if you have indicated that you are ready to watch this video for the number of points selected, then the viewing will start and you will then answer a few short questions to validate the additional points. If you have indicated for the number of extra points selected that you do not want to watch the video, then you will not watch the video.

⁶The sum of inputs must be equal to 100.

⁷The sum of inputs must be equal to 100.

For the following amounts, are you willing to watch a 5 minute video that contains material on the environmental impact of meat consumption?

- For 0% more points [*Yes (see the video) /No (do not see the video)*]
- For 2.5% more points [*Yes (see the video) /No (do not see the video)*]
- For 5% more points [*Yes (see the video) /No (do not see the video)*]
- For 7.5% more points [*Yes (see the video) /No (do not see the video)*]
- For 10% more points [*Yes (see the video) /No (do not see the video)*]
- For 12.5% more points [*Yes (see the video) /No (do not see the video)*]
- For 15% more points [*Yes (see the video) /No (do not see the video)*]
- For 17.5% more points [*Yes (see the video) /No (do not see the video)*]
- For 20% more points [*Yes (see the video) /No (do not see the video)*]

For the following amounts, are you willing to watch a 5 minute video that contains material on the health impact of meat consumption?

- For 0% more points [*Yes (see the video) /No (do not see the video)*]
- For 2.5% more points [*Yes (see the video) /No (do not see the video)*]
- For 5% more points [*Yes (see the video) /No (do not see the video)*]
- For 7.5% more points [*Yes (see the video) /No (do not see the video)*]
- For 10% more points [*Yes (see the video) /No (do not see the video)*]
- For 12.5% more points [*Yes (see the video) /No (do not see the video)*]
- For 15% more points [*Yes (see the video) /No (do not see the video)*]
- For 17.5% more points [*Yes (see the video) /No (do not see the video)*]
- For 20% more points [*Yes (see the video) /No (do not see the video)*]

For the following amounts, are you willing to watch a 5 minute video that contains material on the impact of meat consumption on animal welfare?

- For 0% more points [*Yes (see the video) /No (do not see the video)*]
- For 2.5% more points [*Yes (see the video) /No (do not see the video)*]
- For 5% more points [*Yes (see the video) /No (do not see the video)*]
- For 7.5% more points [*Yes (see the video) /No (do not see the video)*]
- For 10% more points [*Yes (see the video) /No (do not see the video)*]
- For 12.5% more points [*Yes (see the video) /No (do not see the video)*]
- For 15% more points [*Yes (see the video) /No (do not see the video)*]
- For 17.5% more points [*Yes (see the video) /No (do not see the video)*]
- For 20% more points [*Yes (see the video) /No (do not see the video)*]

SM 1.5: Demographics Screen

You are... [*A man / a woman / other*]

How old are you? [*Positive Integer Input*]

What is the postal code of your city? [*Open field*]

Currently, you are...

- Business manager
- Self-employed, trader, craftsman
- Liberal profession
- Employee of the private sector
- Employee of a public company
- Civil servant (national, local, or hospitals)
- Unemployed
- Student
- Retired
- Man/woman at home

What is the highest diploma you obtained?

- No diploma
- Certificate of primary studies or equivalent
- *Brevet des collèges*
- *CAP / BEP*⁸
- General or technological baccalaureate or equivalent
- Professional baccalaureate or equivalent
- Two years of university degree
- Three years of university degree
- Four years of university degree
- Five years of university degree or higher (PhD)
- Engineering, business or management school degree

Please indicate how often you consume the following items: Never, a few times a year, a few times a month, a few times a week, almost at each meal.

- Red meat
- White meat
- Fish
- Eggs
- Dairy products
- Vegetables

⁸Professional degrees

- Legumes
- Fruit
- Starchy foods

Taking into account all the resources of your household, that is to say net wages, family allowances, unemployment benefits, retirement, pensions and other net income, in which bracket are the NET monthly income of your household?

- Less than 750 Euros per month
- From 750 to 999 Euros per month
- From 1,000 to 1,499 Euros per month
- From 1,500 to 1,999 Euros per month
- From 2,000 to 2,999 Euros per month
- From 3,000 to 3,499 Euros per month
- From 3,500 to 4,999 Euros per month
- 5,000 Euros and more per month
- I don't know

SM 2: Constructions of variables

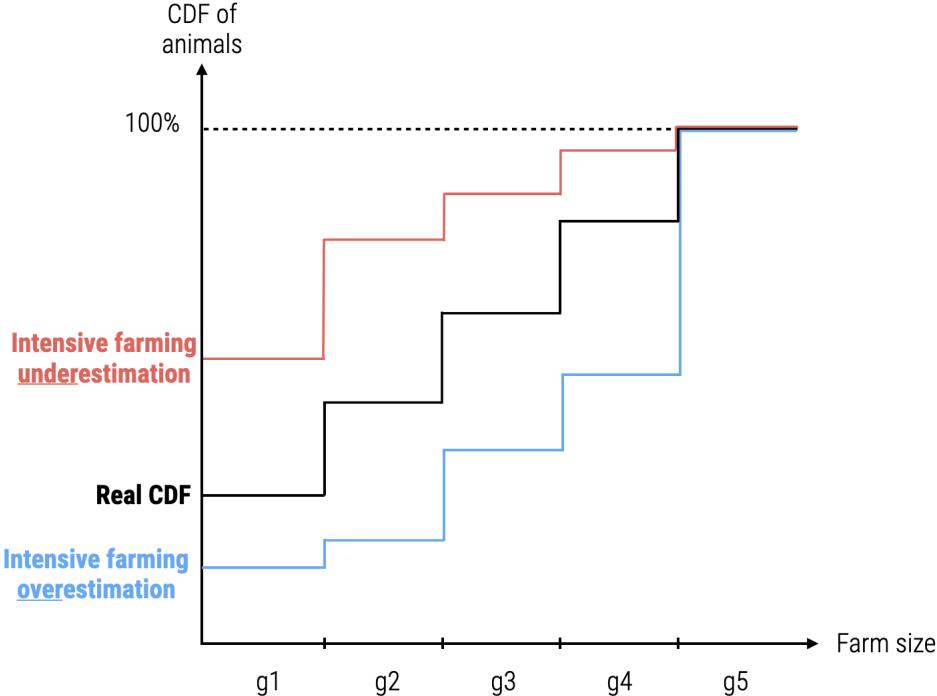
Intensive Farming Underestimation Score

We explore the respondents' opinion about how animals are raised in France and, more specifically, whether animals are raised in small or large farms. For each type of animal (egg-laying hens, broilers, pigs, and cows), we analyze the distribution of animals with respect to the size of the farms. We retrieved data from the French Ministry of Agriculture.

Let us consider one type of animals denoted a (e.g., broilers). For this type of animals, we have groups of farms that we can order from the group of smallest farms to the group of largest farms, such that each farm belongs to one of these groups ($g \in \{1, \dots, G\}$), and where G is the total number of groups. We can then define the cumulative distribution function $CDF(g)$, which returns the number of animals that are raised in farms of size g or in smaller farms.

Figure SM1 gives an illustration of the CDFs. The black CDF corresponds to the actual distribution of farmed animals, while two hypothetical CDFs are drawn in red and in blue. In red, the respondent underestimates intensive farming as he/she believes that more animals are raised in small farms than it is actually the case. In blue, the agent overestimates intensive farming as he/she believes that there are fewer animals raised in small farms than it is actually the case.

Figure SM1: Illustration of the cumulative distribution functions of farmed animals with respect to the size of farms



Comparing the actual distribution of animals (CDF) with the perceived CDF (CDF_r), we define an Intensive Farming Underestimation Score (IFUS), which takes positive (resp. negative) values when the respondent underestimates (resp. overestimates) the level of intensive farming for the

type of animal under consideration. It is defined as follows:

$$\text{IFU} = \frac{\sum_{g=1}^{G-1} \text{CDF}_r(g) - \text{CDF}(g)}{G - 1} \quad (1)$$

The IFUS can take values between 1 (full underestimation: all animals are raised in the group of the largest farms and the agent believes that they all live in the group of smallest farms) and -1 (full overestimation: the reverse). When IFUS equals zero, the agent either perfectly estimates the real distribution of animals in farms, or his/her overestimation of one group compensates the underestimation of another group (except the last group, which is excluded as the CDF always equals to 100% for this group).