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COVID-19 VACCINES IN SPAIN: POPULATION'S WILLINGNESS TO GET VACCINATED AND THEIR MAIN CONCERNS AND MISCONCEPTIONS

Vacunas contra la COVID-19 en España: disposición de la población a vacunarse y sus principales preocupaciones e ideas equivocadas

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Abstract

Introduction: COVID-19 has not only caused a pandemic of respiratory disease. An infodemic of false information has been reported these late months. These fake news are particularly relevant when concerning vaccines. In this study, we intend to describe the pro and against COVID-19 vaccination populations and find the main misconceptions about COVID-19 vaccines. **Methods:** To do so, we surveyed a group of Spanish population on their concerns and opinions on COVID-19 vaccines. Additionally, we asked the respondents about several false beliefs on COVID-19 vaccines. **Results:** The results showed that most people reluctant to get vaccinated were more likely to be female, to not have health-related studies, to have a compulsory basic level of education and to not be willing to get the general vaccines suggested by their general practitioner. These people were not found, however, to be more religious, which contradicts what many other studies have demonstrated before. It was also found that most people are worried about the distribution of vaccines and that most people also want vaccines to be compulsory. The results also showed that people less willing to get vaccinated are more likely to be worried about vaccines' safety, to believe

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in conspiracy theories involving vaccines and to believe in misconceptions or false beliefs. **Discussion:** We believe that our results show that the COVID-19 vaccination campaign faced more hesitancy than most common vaccines, and that we can affirm that the profile of those hesitant to the COVID-19 vaccination was also quite different, being less related to religiosity and much more related to misinformation spread through social media. **Conclusions:** We believe our study to reveal some key differences in the profiles of those hesitant to COVID-19 vaccination. We believe that this study shows that spreading a survey before any vaccine awareness campaign may provide a lot of information about the main concerns and misconceptions that the target population has, and it might allow for a much better communication strategy.

Keywords: COVID-19, Vaccines, Hesitancy, Fake news, scientific communication, Misinformation, Anti-vaccination movement.

Resumen

Introducción: El COVID-19 no solo ha provocado una pandemia de enfermedades respiratorias. En estos últimos meses se ha reportado una infodemia de información falsa. Estas noticias falsas son particularmente relevantes cuando se trata de vacunas. En este estudio, pretendemos describir las poblaciones vacunadas a favor y en contra de la COVID-19 y encontrar los principales conceptos erróneos sobre las vacunas contra la COVID-19. **Metodología:** Para ello, encuestamos a un grupo de población española sobre sus preocupaciones y opiniones sobre las vacunas contra el COVID-19. Además, preguntamos a los encuestados sobre varias creencias falsas sobre las vacunas contra el COVID-19. **Resultados:** Los resultados mostraron que la mayoría de las personas renuentes a vacunarse eran más propensas a ser mujeres, no tener estudios relacionados con la salud, tener un nivel de educación básico obligatorio y no estar dispuestas a recibir las vacunas generales sugeridas por su médico de cabecera. No se encontró que estas personas fueran más religiosas, lo que contradice lo que muchos otros estudios han demostrado antes. También se encontró que la mayoría de la gente está preocupada por la distribución de vacunas y que la mayoría de la gente también quiere que las vacunas sean obligatorias. Los resultados también mostraron que las personas menos dispuestas a vacunarse tienen más probabilidades de preocuparse por la seguridad de las vacunas, creer en teorías de conspiración relacionadas con las vacunas y creer en conceptos erróneos o creencias falsas. **Discusión:** Con nuestros resultados creemos que la campaña de vacunación del COVID-19 presentó más resistencia que la mayoría de las vacunes comunes, y que podemos afirmar que el perfil de las personas reticentes a vacunarse fue también bastante distinto, con menos relación con la religiosidad y mucho más relacionadas con la desinformación a través de redes sociales. **Conclusiones:** Creemos que nuestro estudio muestra algunas diferencias clave en los perfiles de las personas reticentes a vacunarse del COVID-19 respecto a los grupos antivacunas tradicionales. Creemos que este estudio muestra que difundir una encuesta antes de cualquier campaña de concienciación sobre vacunas puede proporcionar mucha información sobre las principales preocupaciones y conceptos erróneos que tiene la población objetivo, y podría permitir una estrategia de comunicación mucho mejor

Palabras clave: COVID-19, Vacunas, Indecisión, Fake news, Comunicación científica, Desinformación, Antivacunas.

1. INTRODUCTION

COVID-19, the illness caused by the SARS-CoV-2 virus has revealed another pathology: "infodemic", the concept to describe modernity's epidemic of false information. This problem can be translated into numbers. A recent study points out that, because of misinformation about COVID-19, in the first few months of 2020, at least 800 people may have lost their lives and 5,800 may have been admitted to the hospital (Islam, 2020). But what is the best solution to this misinformation problem? We believe the best solution is the combination of quick and targeted interventions aimed at delegitimizing fake information.

The complex dynamics between indecisive individuals, anti-vaccination, and pro-vaccination mean that traditional mass-action models cannot be used reliably to make predictions about herd immunity (Johnson et al., 2020)**.** Therefore, the intervention on the beliefs and knowledge of the population is crucial when dealing with vaccine hesitancy.

Hesitant attitudes towards vaccinations are more prevalent than what we would expect, focusing only on vaccine uptake rates. Several studies have consistently shown that many people may be getting vaccinated but remain reluctant to vaccinate (Islam et al., 2020) (Johnson et al., 2020). Most of these people are not uninformed, quite the opposite. In fact, the main reason for their hesitancy is distrust, especially towards pharmaceutical companies. However, advice from professional health workers is the most valued source of information for most people (Yaqug, 2014).

That should make us change our classical approach towards these problems. Usually, the scientific community may be prone to try to "educate" those who oppose such an accepted measure as vaccination when it comes to public health. That belief (that increased knowledge will help improve science's support) is often called the "Deficit Model" (Dudo and Besley, 2016).

The parents who have vaccination hesitancy, in their management of risk consider those derived from vaccination more relevant than the individual or collective consequence of not doing so (Wlodarska et al., 2021). When assessing how vaccine attitudes relate to psychosocial and demographic aspects, the anti-vaccines share common characteristics such as conspiracy thinking, female gender and religiousness among others (Rozbroj et al., 2019) (Schwarzinger et al., 2021).

Focusing on COVID-19 vaccination, a new situation that brings scientific uncertainty and might be used for the management of other situations that present similar scientific features. A study shows that COVID-19 vaccine acceptance in the working-age population depends on the characteristics of new vaccines and national vaccination strategy, among many other factors (Wang et al., 2021).

Attitudes towards COVID-19 vaccination have changed throughout the pandemic. A study in China showed that even though the desire to get vaccinated has not changed significantly: 92% of people in March 2020 and 89% in November 2020, the willingness of doing so immediately has significantly changed. 58% of people were willing to immediately get a COVID-19 vaccine in March 2020. However, in November-December 2020 only 23% of the population would get immediately vaccinated. 75% of those people said vaccines' safety was their main concern (Murphy et al., 2021).

A study performed in the United Kingdom and Ireland during the first days of the pandemic (late March to early April 2020) has shown very concerning data about COVID-19 vaccine hesitancy.

In Ireland, 35% of people were found to be hesitating or even refusing the vaccine. In the UK, that proportion was slightly lower (31%). However, if all those people refused to get vaccinated, herd immunity would not be achieved. The evidence found by this study was also consistent with other studies we have mentioned before: vaccine hesitancy or refusal was strongly associated with conspiratorial beliefs (Sallam et al., 2021), which has also been found in studies performed in Arabic countries (Kepka et al., 2011).

Our goal with this project is to characterize the anti and pro-COVID-19 vaccine populations and specifically study the most widely spread false beliefs or legitimate concerns about COVID-19 vaccines. We expect to be able to find subpopulations within our populations according to their willingness to get vaccinated. We believe that we will be able to find distinctive characteristics among those subpopulations that would allow for best targeted vaccine-awareness campaigns to be designed, by using an engaging approach to scientific communication.

Therefore, the main objective of this project is to stratify the population according to their willingness to get vaccinated and find distinctive traits of those subpopulations. It is our belief that some of these traits will be sociodemographic characteristics (like gender or religiousness) but also their main concerns and their false beliefs.

To the best of our knowledge, so far only one similar study has been performed in Spain. This study focused on vaccine stance and its correlation on health-related studies (Eguia et al., 2021). We plan on developing much more extensive research (considering knowledge, beliefs and religiousness, among others), as we have stated before.

2. GOALS OF THE STUDY

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3. METHODS

To answer the main questions presented previously, we designed a survey directed at the general population of Spain for an observational study. The main issues it is meant to measure are vastly diverse: from some basic knowledge about the COVID-19 vaccines to personal opinions, concerns and miss-beliefs the surveyed may have about them. Its main goal was to precisely characterize the anti and pro-COVID-19 vaccine groups within the population and identify correlations between the presence of concerns, miss-beliefs and/or fake news regarding the vaccines and the sociological factors (age, gender, studies, religiousness...) of the surveyed.

The survey is structured in five main parts: *a) sample characterization; b) vaccination opinion; c) COVID-19 vaccination aspects; d) concerns about COVID-19 vaccines and e) vaccination management*.

In the first section (a), to be able to discern between different groups during the analysis, we asked the survey respondents about their age, gender, habitual residence, level of studies, religiousness and field of studies (one of the questions was whether the respondents had or not health science studies).

The second part (b) helped us to determine if the respondents were in favour or contrary to vaccines in general and their COVID-19 knowledge convictions. A key question where their confidence in the vaccines is reflected is, for example, whether they would vaccinate right now on the advice of their doctor.

The third section (c) was about general knowledge and was meant to describe whether there exists a correlation between how much people know about the COVID-19 vaccines and if they are for or against them. It contained some basic questions about COVID-19 vaccines and tried to measure in an objective way how much they know about the topic. The selected statements, in Likert scale format, used in the questionnaire were chosen based on viral news, widely reported in the media such as television or social networks. Examples include thrombosis associated with the AstraZeneca vaccine or the modification of our genome by mRNA vaccines, questions that can be resolved through scientific articles.

The fourth part (d) of the survey tried to discover preoccupations about COVID-19 vaccines and the spread of fake news related to them, and how these fit the different characteristics of the surveyed. Some examples of the main concerns in the population we think could be the vaccines security as well as the distribution, effectiveness and sustainability, among others. It also includes a question to identify the main sources of information that respondents used to stay updated on the COVID-19 vaccines.

The last section (e) of the survey aimed to know the opinion of the population about the management of vaccination, not only at the state level but also in a more global aspect. Topics such as the release of patents, or the obligation of vaccination appear. In addition, some questions are presented to test the degree of conspiracy of the people.

The survey was designed on Google Forms and distributed through social media for 1 week, mainly via WhatsApp and Instagram, through close contacts who shared the survey. Along with the link to the form, we attached an explanation about who we are, the general topic of the survey, the time needed to answer it and what we would do with the data obtained, as well as the anonymity of the results. Structurally, our goal was to make the survey as short as possible to reach the largest sample size, with a duration between 5 and 10 minutes. The survey is composed of multiple-choice, Likert-scale questions (1-5) and open-ended questions.

Ethics statement

The study protocol was approved by the Academic Coordination Office (OCA) of the School of Health and Life Sciences of our university. The protocol stated that participants were informed of the objective and the methods of the survey and that their participation was voluntary and anonymous. They gave their written consent to be included as participants and accepted following

the study requirements before starting to answer the questionnaire. The OCA board approved this consent procedure as Institutional Review Board (IRB) did not consider a formal approval of the study.

3.1. Result analysis

Statistical studies were carried out to verify our hypothesis. A Principal Component Analysis (PCA) has been performed with SIMCA (SIMCA17) to obtain qualitative results that allow us to create subpopulations. Those results allowed us to narrow the possible correlations so that we could perform statistical tests to determine whether the correlations observed in the PCA were statistically significant for α=0,05. The statistical tests performed were chi-squared tests for categorical variables and one-way ANOVA for ordinal variables. These were performed through SPSS (IBM SPSS23).

3.2. Sample characterization

We decided to close the survey on 05/24/2021 at 10:00 AM, after approximately 6 days and 15 and a half hours of runtime. We did so because we received the great majority of our responses on the first day of the survey, and engagement with the survey sharply decreased after that. The total amount of gathered responses is 1137.

According to the results obtained in the first section of the survey (Extended data Fig. 1), 65.2% of the surveyed identify as female, 34.2% identify as male and 0.6% identify as non-binary. The main age groups (in years old) present in our sample correspond to 16-25 (40.6%) and 46-65 (36.8%), followed by 26-45 (13%), 66 or more (9.2%) and 15 or less (0.4%). 80.8% of our sample resides in Catalunya, with the next most represented regions being Comunitat Valenciana (5.6%), Comunidad de Madrid (3.5%) and Illes Balears (3.5%), while 0.6% does not reside in Spain. Of this 80.8% residing in Catalunya, 77.7% resides in Barcelona, 2.5% in Girona, 1.1% in Lleida, and 1% in Tarragona. When asked about their level of education, 45.4% of the surveyed reported having finished an undergraduate university degree or equivalent studies, 30.4% had finished their baccalaureate or equivalent studies, 17% had completed a Master's degree or a Doctorate, 6.3% had completed their obligatory studies, and 0.9% referred to having "Other" studies. Additionally, 58.8% of our sample is not studying or hasn't studied a Biological or Health Sciences degree (while 41.2% has done/is doing so). Finally, 76.8% of our sample considers themselves non-religious, while 23.2% considers themselves religious (non-specified).

We believe that, even though our sample may not be representative of the general population of Spain, it may be representative of a very important population in the public discussion of these kind of matters, that is, the highly educated population, which recently has become largely female, as our sample also reflects. We also believe that women may be more prone to answer surveys as this one, but that may also correlate with them being more involved in the on-line discussion of this kind of matters, though more studies should be carried out about that possible correlation.

4. DISCUSSION

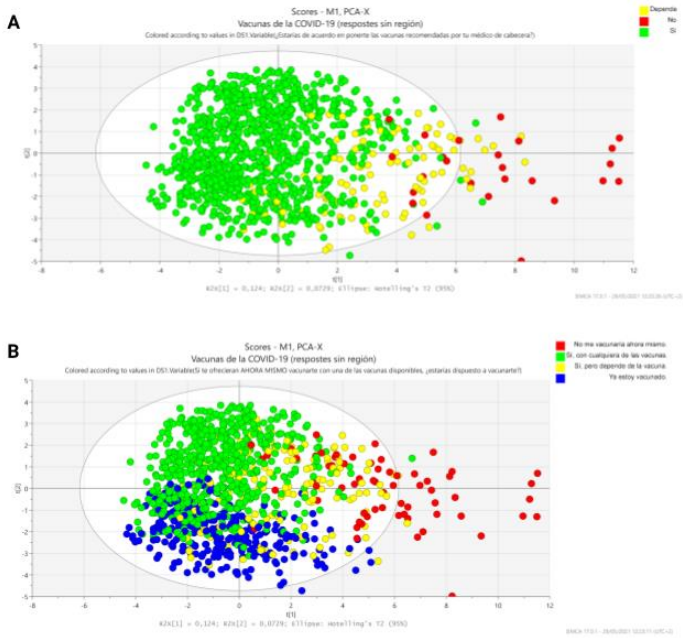
4.1. General opinion about vaccines

87.2% of respondents would take the vaccines recommended by their General practitioner (GP) mostly because of the trust that they have in their doctor and in science, as well as for both community and personal health. On the other hand, there are 10.2% of people who would take the recommended vaccine depending on which one it was. The remaining 2.6% would not take the recommended vaccines due to distrust of their doctor or conspiracy theories (Fig. 1A, Table 1).

As for the COVID-19 vaccines, there are 55.5% of respondents who would get vaccinated with any of the actually available ones, 13.2% who would be willing depending on the vaccine, 24.8% who are already vaccinated and 6.5% who would not get vaccinated right now. Many respondents stated that they would not get the AstraZeneca or Janssen vaccines because of the associated thrombosis. This was, in fact, the most recurrent argument against COVID-19 vaccination (28.7% of open responses). Other reasons given by respondents were the questionable safety of vaccines, side effects or lack of information, among others (Fig. 1B, Table 1).

Of note, there is a statistically significant association ($p<0.001$) between those who would not get the vaccines recommended by their physician and those who would not get the COVID-19 vaccines at this moment.

Figure 1. *General opinion about vaccines. A) PCA about the willingness to receive the vaccines recommended by GP. PCA's key: green for 'yes', red for 'no' and yellow for 'depends on'. B) PCA about the willingness to get vaccinated right now with the current available vaccines against COVID-19.* ***PCA's key****: green for 'yes, with any of the vaccines', yellow for 'yes, but it depends on the vaccine', red for 'I would not get vaccinated at this moment' and blue for 'I am already vaccinated'.*



Source: Own elaboration.

Table 1. *General opinion about vaccines. Percentages extracted from the open responses of the survey carried out. To the left of the table, the arguments for or against getting the vaccines recommended by the family doctor are illustrated (percentages obtained from 846 valid responses). On the right, arguments about the non-vaccination of COVID-19 (percentages obtained from 122 valid responses). The 'others' category includes issues such as lack of knowledge about the immunity provided by vaccines in the long term, interactions with other drugs or the low efficacy of single-dose vaccines.*

VACCINATION RECOMMENDED BY THE DOCTOR		**VACCINATION AGAINST COVID-19**	
Arguments in favor	**%**	**Argument against COVID-19 vaccination**	**%**
Confidence in the doctor's judgment	35.60	AstraZeneca or Janssen vaccines and thrombosis	28.70
Community and personal health	26.96	Questionable safety (short development time)	12.30
Confidence in the results of science	19.47	Side effects (short and long term)	11.50
Counterarguments	**%**	Enough information	11.50
Null responses	9.16	Just a business, not trust the laboratories, the media or where the vaccines have been developed	7.40
Depends on the vaccine and the doctor's explanation	4.48	They consider that they are not exposed or are not part of a risk group (do not think it is strictly necessary)	6.60
Mistrust not argued	1.66	Less than 6 months since they passed COVID-19	5.70
Conspiracy and unscientific theories	1	Others	16.30
Side effects	1		
Distrust of the doctor	0.50		
Chronically ill	0.17		

Source: Own elaboration.

4.2. Relationship between sample characterization and COVID-19 vaccines

Regarding the sample characterization, it should be noted that women are more hesitant about the vaccine and many of them do not want to be vaccinated ($p<0.01$). In addition, being between 16 and 25 years old seems to be associated with wanting to be vaccinated right now ($p<0.01$). The other age groups do not show statistically significant results. Furthermore, it should be noted that there is no significant association between wanting to be vaccinated and being a religious person (Extended Data Fig. 2)

In reference to the level of studies, the group that said the most not wanting to be vaccinated at the moment was that with compulsory basic education (16.7%), followed by: other studies (10%), high school or intermediate level FP (7.5%), master and doctorate (5.2%) and university degree or higher level FP (4.8%). The difference between the group with basic or compulsory studies and the other groups was statistically significant ($p<0.01$). Having health studies and wanting to be vaccinated has a statistically significant association ($p<0.05$). In fact, 4.7% of people who have health-related or biological studies do not want to be vaccinated, while 7.8% of people who do not have such studies do not want to be vaccinated (which represents almost twice as many as the percentage above).

4.3. Knowledge on COVID-19 and willingness to get vaccinated

When the survey participants were asked about their level of knowledge on COVID-19 in general, the majority (60.8%) punctuated themselves 4 or higher out of 5 in regard to their notions of the disease. Only 10.1% of the surveyed stated to have a knowledge equal or below 2 out of 5 (Fig. 2A).

However, when the surveyed were asked about their awareness on COVID-19 vaccines, the amount of people who answered 4 or higher fell to 34.8%. In this case, the majority (38.4%) punctuated themselves with a 3 out of 5.

Furthermore, those surveyed that had studies in health sciences believe to have a higher level of knowledge of COVID-19 disease as well as of COVID-19 vaccines.

In regard to the production of vaccines, 53.7% of the participants firmly believe that the COVID-19 vaccines have fulfilled every safety and efficacy requisite demanded by the health administrations. The 3.1% strongly consider vaccines have not overcome the safety requirements. Finally, 13.5% of the surveyed did not position themselves (Fig. 2B).

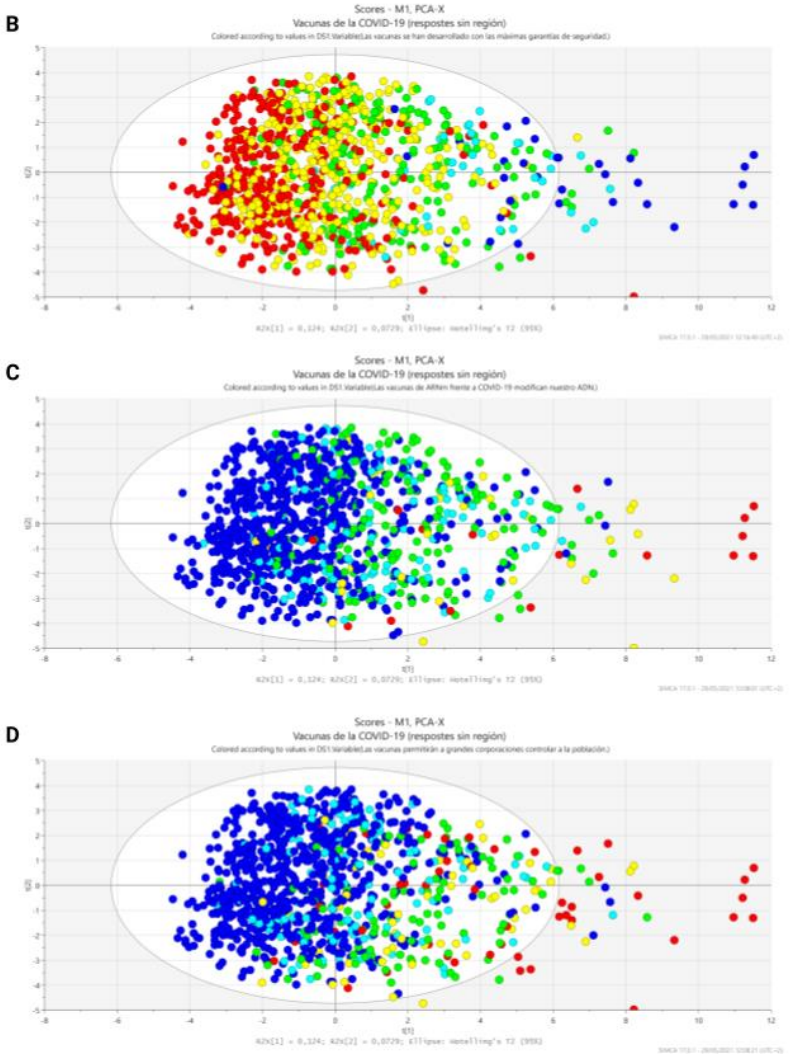
The question that raised the most doubts among those surveyed was regarding the composition of Janssen, AstraZeneca and Sputnik vaccines. 38.8% of those surveyed stated that they did not know if these vaccines were made up of viruses.

The proportion of the surveyed that strongly disagree that the mRNA vaccines will alter our DNA (66.2%), also disagree with the fact that the vaccines will allow large corporations to control the population (66.4%) (Fig. 2C, D). Only 1.5% and 5.1% strongly agreed to these statements respectively. There is a significant correlation ($p<0.001$) between those who do not want to be vaccinated and those who agreed to the statements (Extended Data table 1).

Figure 2. *General aspects about COVID-19 vaccines. A) Table showing the percentages of self-declared knowledge about COVID-19 and vaccines, on a scale from 1 (very little knowledge) to 5 (a lot of knowledge). B) PCA representing the perception on the safety requirements of COVID-19 vaccines. C) PCA representing the belief that mRNA vaccines alter our DNA. D) PCA showing the thought that vaccines will allow the population to be controlled by large corporations. PCA's key: dark blue for 1, light blue for 2, green for 3, yellow for 4 and red for 5, being 1 the lowest level of agreement and 5 the highest. 3 corresponds to "no answer/do not know".*

A

	1	2	3	4	5
What level of knowledge do you think to have about to the COVID-19 **disease**?	2.3%	7.8%	29.1%	**42.7%**	18.1%
What level of knowledge do you think to have about to the COVID-19 **vaccines**?	6.4%	20.4%	**38.4%**	26.6%	8.2%



Source: Own elaboration.

4.4. Concerns on the vaccination plan management for COVID-19 and vaccines safety

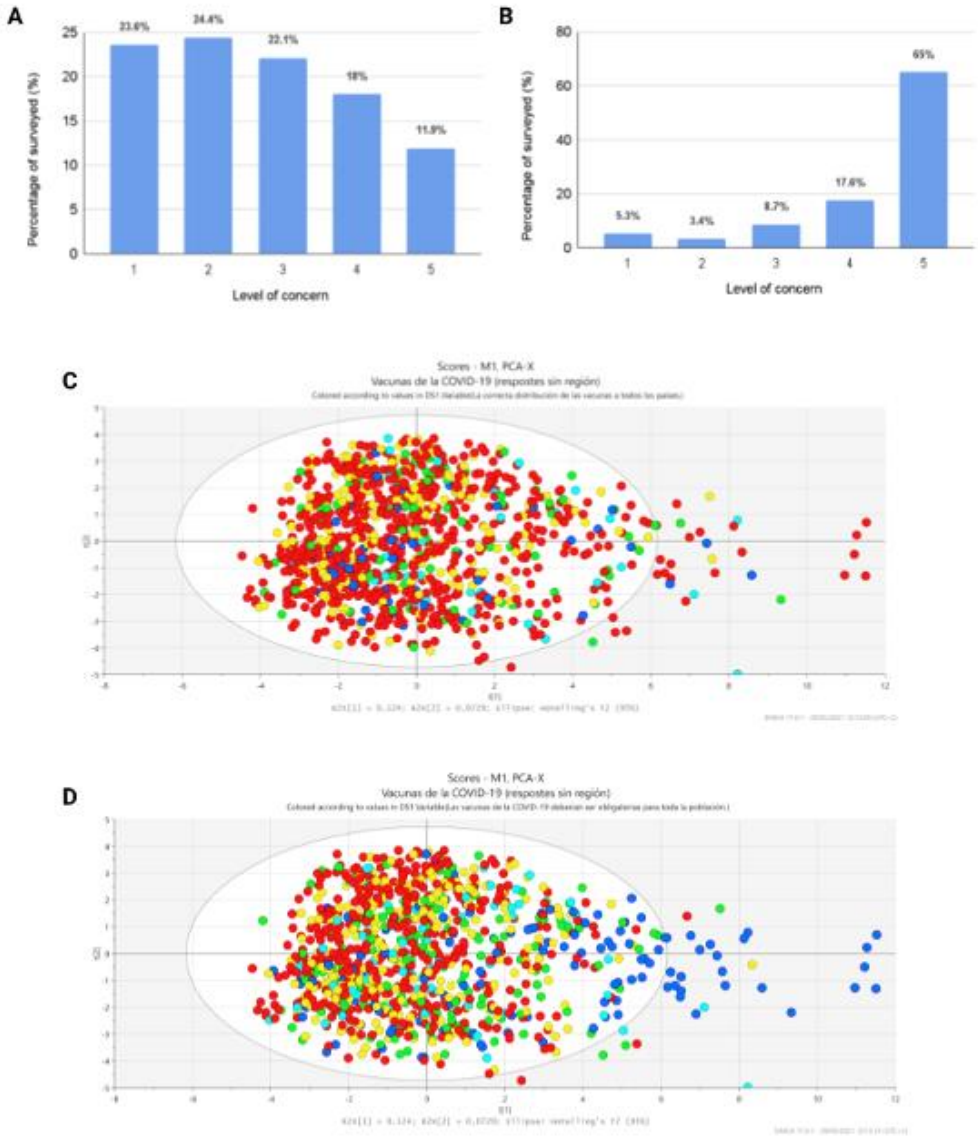
Only the 11.9% of the surveyed were extremely concerned about the vaccine safety, while a vast majority (48%) exposed a low level of concern (Fig. 3A). Also, there is a correlation ($p<0.001$) between those who were concerned about the safety of the vaccines and those who oppose vaccination.

The highest preoccupation among the population was the need to distribute the vaccines in all the countries, 65% exposed the highest level of concern (Fig. 3B, C). Moreover, 82.1% firmly believe that developed countries should redistribute leftover vaccines to developing countries. Related to vaccine distribution, 59.2% strongly supported the liberalization of the vaccines´ patents. 57.2% of the surveyed have shown a high degree of concern about the fact that governments and corporations have hidden information about the disease. A correlation ($p<0.001$) was observed between those who expressed this preoccupation and those who opposed getting vaccinated.

In relation to COVID-19 vaccination, 68% of the surveyed consider the administration of COVID-19 vaccines should be mandatory (Fig. 3D). Besides, a correlation ($p<0.001$) was observed between those who consider the vaccines should not be mandatory and those who oppose vaccination.

At the end of the survey, we asked respondents to write down other issues of concern that were not covered by our questions. The most common response (18.5%) was about the misinformation of the population, as well as the reliability of the media. Another significant percentage of respondents, 16.2%, showed great concern about the global distribution of vaccines and the release of patents (Table 2, Extended Data Table 2,3).

Figure 3. *Preoccupations about COVID-19 vaccines. A) Bar chart showing level of concert on vaccines' security, on a scale from 1 (very little concerned) to 5 (very concerned). B) Bar chart showing the level of concern on the correct distribution of the vaccines to all the countries, on a scale from 1 (very little concerned) to 5 (very concerned). C) PCA representing the level of preoccupation about the correct distribution of the vaccines to all the countries. D) PCA showing the willingness about mandatory COVID-19 vaccination. PCA's key: dark blue for 1, light blue for 2, green for 3, yellow for 4 and red for 5, being 1 the lowest level of agreement and 5 the highest. 3 corresponds to "no answer/do not know".*



Source: Own elaboration.

Table 2. *Other concerns that have not been treated in the survey. Percentages obtained from 130 valid responses. Most concerns stem from the lack of information given to the population, as well as the equitable distribution of vaccines globally. The category 'others' encompasses issues such as the irresponsibility of the population, mental health, persistent COVID-19 or science in Spain.*

Other concerns that have not been treated in the survey	Percentage (%)
Misinformation and reliability of the media	18.50
Global distribution of vaccines and release of patents	16.20
Long-term effects of the vaccines	12.30
Protection of the vaccines against all the virus variants	12.30
The government's changing vaccination plan	5.40
Combination of doses of different vaccines	3.80
Speed of vaccination	3.08
Obligatory nature of vaccination for travel and work	3.08
Novelty of mRNA vaccines	2.30
Others	23.04

Source: Own elaboration.

5. CONCLUSIONS

Regarding the population's general opinion about vaccines, it seems the majority would get the vaccines recommended by their physician. Those who would not would also be less likely to get the COVID-19 vaccines immediately, as foreseeable. While the majority would get vaccinated right now with any of the available COVID-19 vaccines, some people would only do so depending on which vaccine they were offered. As we observed, this is probably due to the reluctance of part of the population to receive AstraZeneca or Janssen vaccines because of the associated thrombosis.

Female participants were more hesitant to get vaccinated than male participants. Most of the studies performed in other countries also found women to be more reluctant towards vaccines (Rozbroj et al., 2019; Schwarzinger et al., 2021), so this finding seems to be consistent. We don't think we can extract a solid conclusion on whether age affects the decision to get vaccinated or not, as older respondents were mostly already vaccinated. Surprisingly, no significant association between religiousness and an unwillingness to get vaccinated was found. This opposes what different articles carried out in other countries suggest (Rozbroj et al., 2019; Schwarzinger et al., 2021). However, it should be noted that 76.8% of our sample self-declare as non-religious, which is perhaps non-representative of the general population. According to data from a study carried out by the CIS in 2021, 60.9% of the spanish population consider themselves religious (CIS, 2021), thus our sample appears to be skewed towards non-religiousness.

Regarding education level, we found that people with basic studies were more reluctant to get vaccinated, but we also found that people with "middle" studies were the most willing to get

vaccinated right now. Therefore, we cannot say that a higher level of studies correlates with vaccine reluctance nor endorsement. On the other hand, having biological and health science studies seems to increase the willingness to get vaccinated. This raises the question of whether it would be beneficial to encourage efforts to improve the level of health-related knowledge of the general population in order to increase vaccination rates. We believe so, and that it is key for the scientific community to find an appropriate communication strategy that engages the public.

Our participants were far more conservative when rating their own knowledge about vaccines in comparison to COVID-19 in general. Additionally, those who study or have studied biological or health-related studies rated themselves significantly higher in both aspects. This suggests an important gap of knowledge between the two subgroups. When asked about several misconceptions, those more reluctant to get vaccinated were more likely to say they believed them. One of these beliefs (that mRNA vaccines modify our DNA) was, in fact, the closest variable on the PCA loadings chart to stating that they wouldn't get vaccinated right now. Therefore, this belief seems to be the best variable to predict vaccine reluctance, and we believe that a national level campaign should take place in order to clarify this misconception. The results also showed that most people did not know what to answer when asked whether AstraZeneca, Sputnik and Janssen vaccines were made out of viruses. We believe it is essential that the whole population understands how vaccines are made and how they work, as well as their benefits, since that is key to achieve people's trust. Therefore, greater efforts should be made to educate the public on this matter, as it has become a part of our daily life and should be hence treated as elemental knowledge.

The survey also gathered information regarding vaccination management and the main preoccupations of the participants regarding the whole vaccination process. The results were quite surprising, revealing that the main concern that affects our population would be the distribution of vaccines among developing countries in order to ensure global immunity. Through PCA, it was observed that even people unwilling to get vaccinated right now want vaccines to be available for all countries, making it clear that this concern is widespread. We believe this should make governments reconsider strategies of vaccine stockpiling. Moreover, when asked about any other concerns they had, the second most common response among the participants was vaccine distribution and patents' release, further supporting this finding. The most common response was misinformation of the population and reliability of the media, which we believe should be further targeted in additional studies.

The results also showed that most people were in favour of making COVID-19 vaccination mandatory, which is consistent with the results of a recent survey aimed at Spain's general population (IPSOS, 2021). We believe further research is needed to find out the reasons why people advocate for mandatory vaccination.

People were also asked about the safety of vaccines and conspiracy theories involving COVID-19 vaccines. As foreseeable, people with conspiratorial beliefs and less trust on the vaccines' safety were more reluctant to get vaccinated (Rozbroj, 2019) (Schwarzinger, 2021) (Kepka, 2011). We believe that facts about vaccine safety have been stressed repeatedly over the last months, but that a more engaging approach could make hesitant people understand that the vaccines are indeed safe.

Finally, while the general population of Spain was our target population, our results are most likely better representative of Barcelona's population. However, we don't expect the population of Barcelona to be particularly different from the one from Spain when it comes to its stance on

vaccination. Furthermore, we have a selection bias, as we spread the survey through our acquaintances, and therefore the answers we have received are not entirely representative of the general population. There are, for instance, 62.4% of individuals in our sample with higher education, versus 40.4% in the general population of Spain (CIS, 2021). However, we believe the main contribution of our study relies on the thorough analysis of the main concerns and opinions about the vaccines and the vaccination campaign, and the results that indicate that the main profile of anti-vaccinations groups has shifted during this pandemic, as we found religiousness not to be a predictive variable.

To conclude, we believe that more studies should be conducted to validate our findings. We think that this approach (a survey to find out the main concerns and misconceptions present in the population) should become the standard procedure before every awareness campaign, allowing for a much more engaging communication, and thus making them much more effective.

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Authors contributions
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ANNEXES

Below we attach the original survey questions (in Spanish) that we spread among the population.

Información demográfica

1. ¿Con qué género te identificas?
   a. Femenino
   b. Masculino
   c. No binario
   d. Otros
2. ¿Qué edad tienes?
   a. 15 años o menos
   b. 16-25 años
   c. 26-45 años
   d. 46-65 años
   e. 66 años o más
3. ¿Cuál es tu comunidad autónoma de residencia? *(Marca una opción)*
4. Si resides en Cataluña, ¿en qué provincia?
   a. Barcelona
   b. Girona
   c. Lleida
   d. Tarragona
   e. No resido en Cataluña
5. ¿Qué estudios tienes?
   a. Estudios básicos u obligatorios
   b. Bachillerato o FP de grado medio
   c. Grado universitario o FP de grado superior
   d. Master o doctorado
   e. Otros
6. ¿Cursas o has cursado estudios en ciencias de la salud o biológicas?
   a. Sí
   b. No
7. ¿Te consideras una persona religiosa?
   a. Sí
   b. No

Opinión sobre las vacunas

8. ¿Estarías de acuerdo en ponerte las vacunas recomendadas por tu médico de cabecera?
   a. Sí
   b. No
   c. Depende
9. Explica brevemente por qué. *(Respuesta abierta)*
10. ¿Estás vacunado/a de la COVID-19 (ya sea una o dos dosis)?
    a. Sí
    b. No
11. Si te ofrecieran AHORA MISMO vacunarte con una de las vacunas disponibles, ¿estarías dispuesto a vacunarte?

a. Sí, con cualquiera de las vacunas.
b. Sí, pero depende de la vacuna.
c. No me vacunaría ahora mismo.
d. Ya estoy vacunado.

12. Si no te vacunarías (con una o con ninguna vacuna), explica brevemente por qué. *(Respuesta abierta)*
13. ¿Qué nivel de conocimiento crees que tienes acerca de la enfermedad de la COVID-19 (sintomatología, patología, transmisión...)? *(Escala de Likert, siendo 1 "muy poco conocimiento y 5 "mucho conocimiento)*
14. ¿Qué nivel de conocimiento crees que tienes acerca de las VACUNAS de la COVID-19? *(Escala de Likert, siendo 1 "muy poco conocimiento y 5 "mucho conocimiento)*

Aspectos sobre las vacunas de la COVID-19 *(Escala de Likert, siendo 1 "muy en desacuerdo" y 5 "muy de acuerdo". El valor 3 equivale a "no sabe/no contesta")*

15. En todas las vacunas de la COVID-19 se nos inyecta el virus de forma atenuada.
16. Se ha asociado la vacuna de AstraZeneca con la producción de trombos.
17. La probabilidad de trombosis con AstraZeneca es superior que en los fumadores, mujeres en tratamientos anticonceptivos y encamados de larga duración.
18. Las vacunas pueden contener un chip que es usado por las compañías telefónicas para expandir la red de 5G.
19. Las vacunas son seguras porque han cumplido con todos los requisitos de seguridad y eficacia que obligan a pasar las administraciones sanitarias (como la EMA en la Unión Europea), aunque se hayan desarrollado en relativamente poco tiempo.
20. Las vacunas de ARNm frente a COVID-19 modifican nuestro ADN.
21. Las vacunas permitirán a grandes corporaciones controlar a la población.
22. Se ha demostrado que las vacunas contra el COVID-19 pueden causar esterilidad.
23. Las vacunas Janssen, AstraZeneca y Sputnik están formadas por virus.
24. Tras la vacunación puedes relajar las medidas de seguridad (mascarilla, distancia social...).
25. Una persona vacunada con pauta completa puede seguir transmitiendo la COVID-19.

Preocupaciones sobre las vacunas de la COVID-19 *(de la pregunta 26 hasta la 32: escala de Likert, siendo 1 "muy poco preocupante" y 5 "muy preocupante")*

26. La seguridad de las vacunas en general.
27. La trombosis asociada a la vacuna de AstraZeneca.
28. La efectividad real de las vacunas, más allá de la calculada en ensayos clínicos.
29. La correcta distribución de las vacunas a todos los países.
30. La falta de sostenibilidad en el desarrollo de las vacunas (gran uso de plásticos entre otros).
31. El virus no podrá ser erradicado y deberemos vacunarnos cada año como con la gripe.
32. Las vacunas pueden causar la aparición de nuevas variantes más contagiosas o letales.
33. De las siguientes opciones, ¿qué fuentes de información son las que más utilizas para informarte sobre las vacunas de la COVID-19?
    a. Redes sociales
    b. Televisión
    c. Periódico físico o digital
    d. Artículos científicos

Gestión de la vacunación *(de la pregunta 34 hasta la 38: escala de Likert, siendo 1 "muy en desacuerdo" y 5 "muy de acuerdo")*

34. Las vacunas de la COVID-19 deberían ser obligatorias para toda la población.
35. Las patentes de las vacunas deberían ser liberadas.
36. Los gobiernos y las grandes corporaciones nos han ocultado muchos datos sobre las vacunas y el virus.
37. Los países desarrollados deberían redistribuir las vacunas sobrantes a los países en vías de desarrollo.
38. Las vacunas se han desarrollado con las máximas garantías de seguridad.
39. ¿Hay algún otro asunto que te preocupe en relación con las vacunas de la COVID-19 y que no haya quedado recogido en la encuesta? Escríbelo aquí. *(Respuesta abierta)*

Extended Figure 1. *Sample Characterization. A) Gender distribution. B) Age distribution. C) Maximum level of completed studies. D) Autonomous communities of residence distribution.*

A

Gender	Percentage (%)
Female	**65.2**
Male	34.2
Non-binary	0.6

B

Age	Percentage (%)
15 or less	0.3
16-25	**39.4**
26-45	15.7
46-65	35.6
65 or more	9

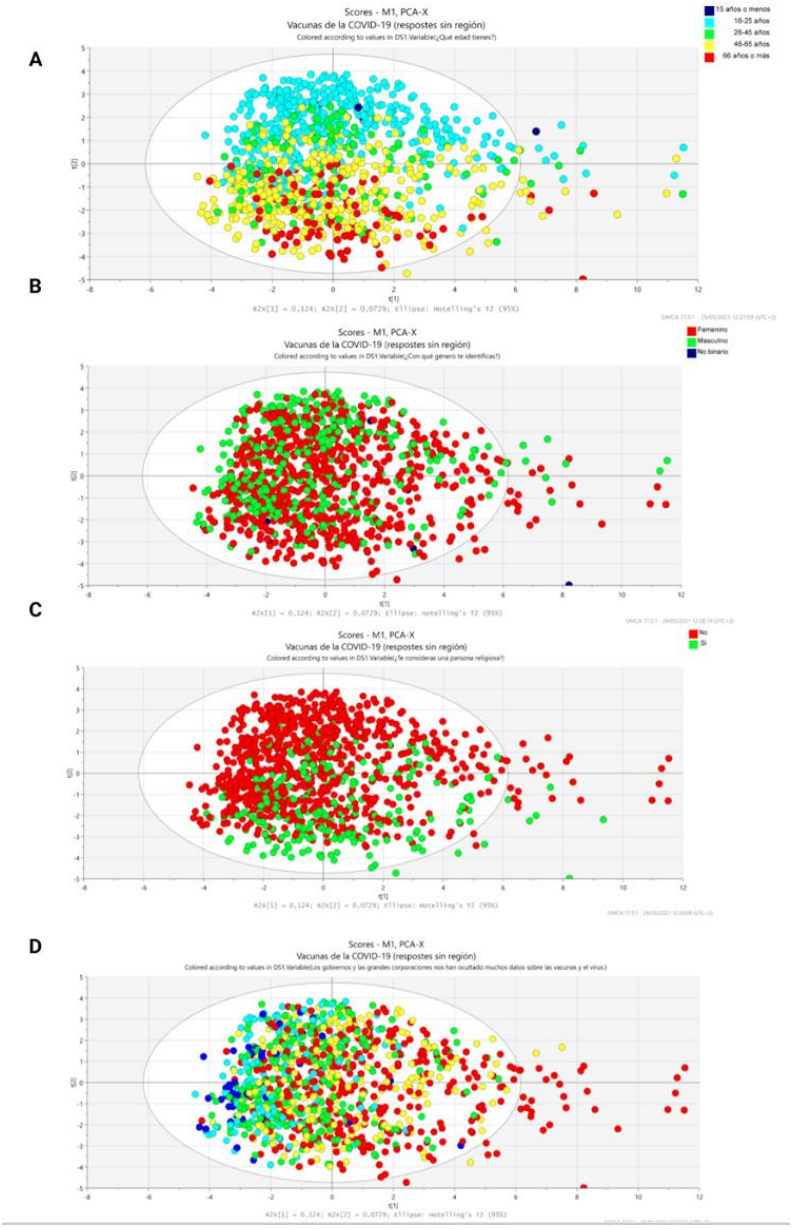
C

Studies	Percentage (%)
Basic obligatory studies	6.3
Baccalaureate or Mediumgrade FP	30.4
University degree or Spuerior grade FP	**45.4**
Master or doctorate	17
Others	0.9

D

Autonomous community	Percentage (%)
Andalucía	0.53
Aragón	0.09
Asturias	0.18
Baleares	3.52
Canarias	0.97
Cantabria	0.09
Castilla - La Mancha	0.26
Castilla y León	0.26
Cataluña	**80.83**
Ceuta	0.09
Comunidad de Madrid	3.52
Comunidad Valenciana	5.63
Extremadura	0.35
Galicia	0.62
La Rioja	1.32
Navarra	0.62
País Vasco	0.35
Región de Murcia	0.18
Outside form Spain	0.62

Extended Data Figure 2. *Relationship between sample characterization and COVID-19 vaccines. A) PCA representing the age ranges of the study population. B) PCA showing the gender of the population studied. C) PCA representing the distribution of the population according to whether or not they consider themselves religious. D) PCA showing the thought that governments and corporations have hidden information about the disease. PCA's key: dark blue for 1, light blue for 2, green for 3, yellow for 4 and red for 5, being 1 the lowest level of agreement and 5 the highest. 3 corresponds to "no answer/do not know".*



Extended Data Table 1. *Hoaxes and statements about COVID-19 vaccines. Table showing the positioning with respect to different COVID-19 disease and vaccine statements, on a scale from 1 (strongly disagree) to 5 (strongly agree).*

	1	2	3	4	5
In all COVID-19 vaccines, we are injected with the virus in an attenuated form	**37.5%**	12.3%	20.9%	15.4%	13.9%
AstraZeneca's vaccine has been associated with thrombus production	6.2%	8.6%	16%	27.6%	**41.6%**
The probability of thrombosis with AstraZeneca is higher than in smokers, women on contraceptives and long-term bedridden	**46.9%**	12%	20%	10.7%	10.5%
Vaccines can contain a chip that is used by phone companies to expand the 5G network	**89.6%**	4.7%	3.1%	1.6%	1.1%
COVID-19 vaccines are safe as they have fulfilled every safety and efficacy requisite demanded by the health administrations (such as the EMA), even though they have been developed in a short period of time	3.1%	3.6%	13.5%	26.1%	**53.7%**
The mRNA vaccines against COVID-19 modify our DNA	**66.2%**	12%	16.9%	3.3%	1.5%
Vaccines will allow large corporations to control the population	**66.4%**	12.9%	10.2%	5.4%	5.1%
COVID-19 vaccines have been shown to cause sterility	**64%**	16.6%	17.2%	1.3%	0.9%
The Janssen, AstraZeneca and Sputnik vaccines are made up of viruses	12.7%	11.8%	**38.8%**	16.3%	20.5%
After vaccination, you can relax the security measures (mask, social distance...)	**50.5%**	23.9%	12.4%	8.6%	4.6%
A person vaccinated with a complete schedule can continue to transmit COVID-19	3.2%	4.7%	20.7%	24%	**47.7%**

Extended Data Table 2. *Main concerns about COVID-19. Table showing the level of concern on different aspects of COVID-19 disease and vaccination, on a scale from 1 (very little concerned) to 5 (very concerned).*

	1	2	3	4	5
Vaccine's safety in general	23.6%	**24.4%**	22.1%	18.1%	11.9%
Thrombosis associated with the AstraZeneca vaccine	25.3%	**28.7%**	23.5%	13.7%	8.8%
The real effectiveness of vaccines, beyond that calculated in clinical trials	15.6%	20.9%	**29.6%**	22.2%	11.7%
The correct distribution of vaccines to all countries	5.3%	3.4%	8.7%	17.6%	**65%**
The lack of sustainability in the development of vaccines (great use of plastics among others)	8.3%	10.5%	25.4%	26.6%	**29.3%**
The virus cannot be eradicated and we will have to get vaccinated every year as with the flu	10.2%	15.6%	**30.2%**	24.6%	19.4%
Vaccines can cause new, more contagious or deadly variants to emerge	21.2%	19.3%	**23.7%**	17.5%	18.3%

Extended Data Table 3. *Vaccination management. Table showing the positioning of the population regarding vaccination management, on a scale from 1 (strongly disagree) to 5 (strongly agree).*

	1	2	3	4	5
COVID-19 vaccines should be mandatory for the entire population	11%	6.8%	14.2%	23.6%	**44.4%**
Vaccine patents should be released	3.9%	5.1%	17.2%	14.7%	**59.2%**
Governments and large corporations have kept a lot of data from us about vaccines and the virus	5%	13.3%	24.5%	23%	**34.2%**
Developed countries should redistribute surplus vaccines to developing countries	1.2%	0.9%	4.7%	11.2%	**82.1%**

The vaccines have been developed with the maximum guarantees of safety	3%	3.9%	18.5%	**39.5%**	35.2%