Acceptance, refusal, and hesitancy of Covid-19 vaccination in Mexico: Ensanut 2020 Covid-19

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Abstract

Objective. To estimate the willingness to vaccinate against Covid-19 (acceptance) in the Mexican population and to identify socioeconomic factors associated with vaccine hesitancy and refusal. **Materials and methods.** We estimated the acceptance, refusal and hesitancy proportions using data from the Covid-19 National Health and Nutrition Survey conducted from August to November 2020. Factors associated with refusal and hesitancy were explored using multinomial logistic regression. **Results.** Covid-19 vaccination acceptance was 62.3%, refusal 28.2% and hesitancy 9.5%. Refusal and hesitancy were associated with being female, having older age, lower educational level, lower socioeconomic status and working in the informal sector. **Conclusion.** National campaigns to incentivize vaccine acceptance need to consider specific subgroups were the likelihood of hesitancy and refusal is high. In Mexico, refusal and hesitancy were higher in vulnerable groups, and people at a higher risk of Covid-19 complications and death.

Keywords: Covid-19; SARS-CoV-2; vaccination; acceptance; surveys; Mexico

Resumen

Objetivo. Estimar la aceptabilidad de la vacunación contra Covid-19 en la población mexicana e identificar factores socioeconómicos asociados con el rechazo o la duda. **Material y métodos.** Se estimó la proporción de aceptabilidad, rechazo y duda utilizando los datos de la Encuesta Nacional de Salud y Nutrición 2020 sobre Covid-19 levantada durante agosto y noviembre de 2020. Se exploraron los factores asociados con rechazo y duda mediante un modelo de regresión multinomial. **Resultados.** La aceptabilidad de la vacunación contra Covid-19 fue de 62.3%, el rechazo de 28.2% y la duda de 9.5%. El rechazo y la duda se asociaron con ser mujer, tener mayor edad, menor nivel de educación, menor nivel socioeconómico y trabajar en el sector informal. **Conclusión.** Las campañas para incentivar la aceptabilidad de la vacuna necesitan considerar los subgrupos específicos con una alta proporción de rechazo y duda. En México observamos un mayor rechazo y duda en grupos con mayor riesgo de complicaciones y muerte por Covid-19.

Palabras clave: Covid-19; SARS-CoV-2; vacunación; aceptabilidad; encuestas; México

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From January to August 2020 in Mexico, Covid-19 was the second cause of death in men and the third cause in women according to official reports.[1] Vaccination against SARS-CoV-2 is a major primary intervention to prevent Covid-19. It has been estimated that 75 to 90% of the population needs to be vaccinated to achieve herd immunity.[2] To do so, we need effective, affordable, and accessible vaccines. However, the success of Covid-19 vaccination programs also depends on the populations willingness to accept the vaccine. It has been reported that women,[3-6] people without employment,[4-6] and in lower socioeconomic levels[6] tend to refuse or hesitate more frequently Covid-19 vaccination. Describing the associated factors with vaccination refusal considering the context of each country is key to understand countries differences and target interventions.

Misinformation about vaccine efficacy and safety could decrease acceptance for Covid-19 vaccines. Anti-vaccination groups have become prominent around the world and are actively calling for the refusal to vaccinate against Covid-19.[7] Mistrust about vaccine benefits, concerns about potential side effects[8,9] as well as over the speed of vaccine development have been associated with uncertainty and unwillingness to vaccinate against Covid-19.[6]

Of particular concern is the possibility of higher refusal and hesitancy among groups at higher risk for Covid-19 complications and mortality, such as men and people over 50 years of age.[10] Comparing the acceptance of the Covid-19 vaccine versus influenza's could help to identify if a refusal to all vaccines is occurring in Mexico. Also, analyzing specific subgroups with higher vaccine refusal and hesitancy will help to identify target subgroups for information campaigns and to prepare an appropriate and equitable vaccination campaign.

We aimed to estimate the willingness to vaccinate against Covid-19 and to identify socioeconomic factors associated with vaccine refusal and hesitancy, using a nationally representative sample of the Mexican population. We also identified the key groups with low vaccine acceptance but high mortality risk due Covid-19.

Materials and methods

Study design

The 2020 National Health and Nutrition Survey for Covid-19 (Ensanut 2020 Covid-19) is a nationally representative probabilistic multistage stratified cluster sampling survey (representative at regional [nine regions] and urban/rural level). The Ensanut 2020 Covid-19 was conducted from August to November 2020. The survey uses a multistage and stratified sampling to select the participating households. From each household, an adolescent (10-19 years), an adult aged 20-59 years and an adult 60 years and older were randomly selected to respond to a Covid-related questionnaire for vaccination, more details of the design have been documented elsewhere.[11] A total of 10 796 respondents aged 10 or older were included.

Acceptance, refusal and hesitancy for Covid-19

The willingness to accept the vaccine (hereafter, referred as acceptance), refusal and hesitancy towards Covid-19 vaccination were measured using the following question: "Would you be willing to receive the Covid-19 vaccine once the vaccine is available?" with potential response options: "yes", "no", and "Do not know or did not answer" (hesitancy).

Covariates

Participants self-reported their sex, age (10-19, 20-29, 30-39, 40-49, 50-59, 60 years and older) and previous medical diagnosis of chronic disease (diabetes, obesity, hypertension, cardiovascular disease, chronic obstructive pulmonary disease, cancer, or HIV). Location size was categorized as rural (<2 500 inhabitants), urban (2 500 to 100 thousand) and metropolitan (>100 thousand or more), according to the latest national census. Education level was categorized as elementary school or less, middle school, high school, or graduate education. Socioeconomic status was constructed using household characteristics, goods and services by principal component analysis and categorized into tertiles: low, medium, and high. Employment was included for 16 and older and formal employment defined as those employed and with private o social health insurance. Covid-19 symptoms were self-reported from March 2020 to the survey date. Based on symptoms reported by the respondent household member, participants were considered *symptomatic* if they complied with the standard epidemiological definition for a Covid-19 case as defined by the Ministry of Health.[12] This includes at least one major symptom (cough, fever, headache, difficulty breathing, chest pain or shortness of breath) and at least one minor symptom (sore throat, runny nose, conjunctivitis, muscle or joint pain, chest pain, loss of smell, loss of taste).[12] Participants were categorized as *pauci-symptomatic* if they had at least one symptom, including diarrhea or vomit, and *asymptomatic* if they reported no symptoms.

Statistical analysis

We estimated the vaccine acceptance, refusal and hesitancy proportions for the Covid-19 vaccines with 95% confidence intervals. Proportions were stratified by sex, age, location size, education, socioeconomic level, employment, social security, region, chronic disease, and symptoms. To explore factors associated with refusal and hesitancy, we used a multinomial logistic regression, with acceptance as the reference outcome, including the variables significantly associated (*p* value<0.05). We report the exponentiated coefficients as relative probabilities of refusal and hesitancy, using acceptance as reference group, given the calculation of the probability ratio estimated by the model.[13] E.g.:

$$\frac{(\text{Pr}(Refusal \mid female)}{\text{Pr}(Acceptance \mid female)} = \frac{0.22}{0.66} = 0.33$$

$$\frac{\text{Pr}(Refusal \mid male)}{\text{Pr}(Acceptance \mid male)} = \frac{0.20}{0.70} = 0.28$$

Relative Probability Ratio (RPR)= 0.33/0.28 = 1.17, which means that women have 1.17 times the relative probability of refusal over acceptance compared to men.

To evaluate the relationship between acceptance and mortality, we calculated a Covid-19 mortality/acceptance ratio. The ratio weights individual's willingness to accept the vaccine—the predicted probabilities of the multinomial regression model—against their Covid-19 mortality risk, given their age, sex, and region. Mortality was calculated using the total number of deaths by Covid-19 as reported by the Epidemiological Surveillance System of Mexico (SISVER, by its acronym in Spanish); a 30-day delay after the mean date of the survey application in each region to consider the delay between infection and death. The best scenario is when the ratio approaches zero, that reflects high acceptance and low mortality risk. Conversely, values higher than one indicate lower vaccine acceptance and higher Covid-19 mortality risk. Of note, the ratio of the age group 16-29 considers all deaths in the group 10 to 29. All analyses were conducted in Stata 14.0.* Survey commands were used to account for survey design and sampling weights.

Results

Overall, 62.3% of the population accepted the Covid-19 vaccine, 28.2% refused and 9.5% hesitated. The highest

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* Stata: Release 14. Statistical Software. College Station, TX: StataCorp LLC.

acceptance was observed among 20-29 years old (68.3%), and the lowest among participants 60 years and older (54.0%). Hesitancy also increased with age, from 6.7% in adults 20 to 29 years to 11.7% among participants 60 years and older. Females, in comparison to males, showed lower acceptance, and higher refusal and hesitancy to the Covid-19 vaccine. Acceptance increased with higher education and socioeconomic status. By employment status, formal employees showed the highest acceptance. We observed heterogeneity in acceptance across regions, with Mexico City presenting the highest acceptance (69.3%) and Central Pacific the lowest (54.7%). Those who reported Covid-19 symptoms had the highest acceptance rate (72.3%); pauci-symptomatics had the highest hesitancy (12.9%), and asymptomatic the highest refusal (29.6%) (table I).

Table II presents the socio-demographic factors associated with refusal and hesitancy among adolescents and adults. Age was associated with a higher relative probability of refusal over acceptance, being 1.24 for participants 30-39 years, 1.21 for 40-49 years, and 1.43 for 60 and older. Similarly, the relative probability of hesitancy over acceptance was 1.4 for participants 50-59 years, and 1.55 for adults 60 years of age and older, in comparison to the 16-29 years group. Females, compared to males, had 1.15 times the relative probability of refusal over acceptance and 1.37 times the relative probability of hesitancy over acceptance. Compared to formal employees, unemployed and informal employees had 1.53 and 1.71 times the relative probability of refusal over acceptance to vaccination. In addition, informal employees had 1.58 times the relative probability of hesitancy over acceptance, compared to formal employees. Compared to Mexico City, the Central-North region had 1.6 times the relative probability of refusal over acceptance to vaccination, while Central-Pacific, Central-North, Center, North-Pacific and South-Pacific had higher relative probability of hesitancy over acceptance (2.1 times, 2.32 times, 1.93 times, 1.87 times and 1.62 times, respectively). Also, being asymptomatic, lower education and socioeconomic status were associated with higher refusal over acceptance.

Table III shows the ratio of mortality to acceptance for Covid-19 vaccines. Acceptance was always higher than Covid-19 mortality risk (ratio below 1). A perfect scenario is a ratio near zero because either the acceptance is considerably higher than mortality or mortality is very low. Men aged 60 years and older showed values higher than 0.5 in all regions, while women aged 60 or older presented ratios ranging from 0.34 to 0.69. Among participants 60 years and older, the highest ratio of mortality/acceptance—the mortality risk is similar vaccine acceptance—was observed in males living in the in

Table I
Acceptance, refusal, and hesitancy for Covid-19 vaccine by participants characteristics (10 years and older). Ensanut-Covid-19, 2020, Mexico

	Sample size (n)	Population N (millions)	Acceptance %	95%CI	Refusal %	95%CI	Hesitancy %	95%CI
Total	10 796	105.7	62.3	60.7-63.8	28.2	26.9-29.6	9.5	8.7-10.4
Age								
10-19	2 201	21.9	**65.1**	**62.6-67.5**	**28.2**	**25.9-30.6**	**6.7**	**5.5-8.1**
20-29	1 757	21.3	**68.3**	**65.3-71.2**	**23.1**	**20.7-25.8**	**8.5**	**6.9-10.5**
30-39	1 617	16.4	**61.4**	**58.3-64.4**	**28.7**	**25.8-31.8**	**10.0**	**8.3-11.9**
40-49	1 765	17.8	**61.7**	**58.7-64.6**	**28.2**	**25.6-31.0**	**10.1**	**8.5-12.0**
50-59	1 408	11.1	**60.3**	**56.8-63.6**	**28**	**25.0-31.2**	**11.7**	**9.9-13.8**
60 and older	2 048	17.2	**53.9**	**50.8-56.9**	**34.4**	**31.7-37.2**	**11.7**	**10.1-13.6**
Sex								
Male	4 562	51.2	**64.7**	**62.8-66.7**	**26.8**	**25.0-28.6**	**8.5**	**7.5-9.5**
Female	6 234	54.5	**59.9**	**58.2-61.7**	**29.6**	**28.0-31.2**	**10.5**	**9.5-11.6**
Location size*								
Rural	2 526	22.0	**55.3**	**51.2-59.3**	**34.2**	**30.6-38.0**	**10.6**	**9.0-12.4**
Urban	3 291	31.2	**61.4**	**58.7-64.0**	**29.0**	**26.6-31.5**	**9.6**	**8.2-11.2**
Metropolitan	4 979	52.5	**65.7**	**63.7-67.6**	**25.3**	**23.7-27.0**	**9.0**	**7.9-10.3**
Education								
Elementary school	3 531	30.8	**52.0**	**49.6-54.3**	**36.3**	**34.1-38.6**	**11.7**	**10.4-13.1**
Middle school	3 074	30.1	**62.4**	**59.7-65.0**	**27.8**	**25.3-30.4**	**9.8**	**8.6-11.2**
High school	2 218	23.4	**66.6**	**64.1-69.0**	**25.1**	**22.9-27.5**	**8.3**	**6.9-10.0**
Graduate/Posgraduate	1 973	21.4	**72.2**	**69.5-74.8**	**20.6**	**18.2-23.3**	**7.1**	**5.9-8.7**
Socioeconomic level								
Low	3 565	33.3	**55**	**52.2-57.7**	**34.3**	**31.7-37.0**	**10.7**	**9.4-12.2**
Medium	3 614	34.1	**62.2**	**59.9-64.5**	**28.1**	**26.0-30.3**	**9.7**	**8.5-11.1**
High	3 617	38.3	**68.7**	**66.4-70.8**	**23.1**	**21.2-25.0**	**8.3**	**7.1-9.6**
Employment‡								
Unemployed	3 345	29.6	**56.9**	**54.6-59.2**	**32**	**29.9-34.1**	**11.1**	**9.9-12.6**
Student	704	7.2	**75.1**	**71.1-78.6**	**18.9**	**15.6-22.8**	**6**	**4.3-8.2**
Retired	539	4.7	**65.5**	**60.1-70.5**	**24.2**	**19.9-29.1**	**10.3**	**7.6-14.0**
Formal employee	1 726	18.6	**73.3**	**70.5-75.8**	**19.3**	**17.1-21.8**	**7.4**	**6.0-9.2**
Informal employee	3 156	32.3	**57.2**	**54.7-59.7**	**32.1**	**29.8-34.4**	**10.7**	**9.3-12.2**
Social security								
IMSS	3 867	38.7	67.4	65.2-69.5	23.8	21.9-25.8	8.8	7.9-9.9
ISSSTE	863	8.2	70.6	66.2-74.7	22.6	18.8-26.8	6.8	5.0-9.2
Pemex, Semar	169	1.5	71.6	62.9-78.9	21.1	14.4-29.9	7.3	4.0-13.0
Without affiliation	5 840	56.5	57.1	55.0-59.1	32.5	30.7-34.4	10.4	9.3-11.6
Private	57	0.7	79.5	59.6-91.1	12.3	4.6-29.0	8.2	3.7-17.2
Region§								
Mexico City	1 200	8.2	**69.2**	**64.8-73.3**	**24.8**	**21.2-28.8**	**5.9**	**4.4-7.9**
North-Border	1 036	10.0	**65.8**	**61.4-70.0**	**26.4**	**21.9-31.3**	**7.8**	**6.3-9.7**

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Central-Pacific	1 101	13.5	**63**	**57.5-68.1**	**25.9**	**21.5-30.8**	**11.1**	**8.4-14.6**
Central-North	1 072	11.5	**54.2**	**49.8-58.6**	**34.5**	**30.5-38.7**	**11.3**	**9.4-13.4**
Center	1 954	13.5	**61.2**	**57.6-64.8**	**27.2**	**24.6-29.9**	**11.6**	**9.3-14.3**
North-Pacific	1 095	10.5	**62.2**	**57.3-66.9**	**26.1**	**22.6-29.9**	**11.7**	**9.1-14.8**
State of Mexico	1 061	14.4	**63.6**	**59.5-67.4**	**28.6**	**25.4-32.1**	**7.8**	**5.7-10.7**
South-Pacific	1 154	13.4	**56.9**	**51.9-61.8**	**33.2**	**28.7-38.0**	**9.9**	**7.6-12.8**
Peninsula	1 123	10.7	**67.6**	**63.3-71.5**	**25.5**	**21.6-29.9**	**6.9**	**5.5-8.6**
Chronic disease#								
No	8 486	85.8	62.1	60.4-63.7	28.4	27.0-29.9	9.5	8.6-10.4
Yes	2 310	19.9	63.0	60.1-65.8	27.4	24.9-30.1	9.6	8.1-11.2
Covid-19 Symptoms&								
Symptomatic	904	8.9	**72.2**	**68.2-75.9**	**18.7**	**15.7-22.1**	**9.1**	**7.1-11.6**
Paucisymtomatic	779	7.3	**63.9**	**59.4-68.3**	**23.3**	**19.9-27.1**	**12.8**	**10.0-16.1**
Asymtomatic	9 113	89.5	**61.1**	**59.6-62.7**	**29.6**	**28.2-31.0**	**9.3**	**8.5-10.2**

Ensanut: *Encuesta Nacional de Salud y Nutrición,* CI: Confidence Interval. IMSS: *Instituto Mexicano del Seguro Social,* ISSSTE: *Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado*, Pemex: *Petróleos Mexicanos*, Semar: *Secretaría de Marina*. *Rural <2 500 inhabitants, urban 2 500 to 100 thousand and metropolitan >100 thousand.‡ Includes only 16 and older. Formal employees defined as those employed and with private o social health insurance. § Diabetes, obesity, hypertension, cardiovascular disease, chronic obstructive pulmonary disease, cancer or HIV. # North-Border: Chihuahua, Coahuila, Nuevo León, Tamaulipas; Central-Pacific: Colima, Jalisco, Michoacán; Central-North: Aguascalientes, Durango, Guanajuato, Querétaro, San Luis Potosí, Zacatecas; Center: Hidalgo, Tlaxcala, Veracruz; North-Pacific: Baja California, Baja California Sur, Nayarit, Sinaloa, Sonora; South-Pacific: Guerrero, Morelos, Oaxaca, Puebla; and Peninsula: Campeche, Chiapas, Quintana Roo, Tabasco, Yucatán. & Symptomatic defined as the presence of one major symptom (headache, cough or fever) and one minor (sore throat, runny nose, conjunctivitis, muscle or joint pain, chest pain, loss of smell or taste), pauci-symptomatic if any symptom was reported, including diarrhea or vomit. Bold letters represent *p* value<0.05.

North-Pacific (0.94), followed by males living in the in South-Pacific (0.77), males living in the Central-Pacific (0.72), males living in the North-Border (0.71), males living in the State of Mexico (0.70) and females living in the North-Pacific (0.69).

Discussion

From August to November 2020 in Mexico, the acceptance for Covid-19 vaccination was 62.3%, refusal 28.2% and hesitancy 9.5%. We found that older adults, females, and workers in the informal sector reported higher refusal and hesitancy. In contrast, higher education and higher socioeconomic status were associated with lower refusal and hesitancy. Refusal and hesitancy were higher in groups at a higher risk of Covid-19 mortality, in particular people over 60 years of age.

The acceptance rate of the Covid-19 vaccine in this study (62%) was lower compared to the average acceptance rate in Mexico reported in a global survey conducted in 19 countries in June 2020 (76.2%) and lower than the global average (71.5%).[14] However, as the global survey was not nationally representative, we cannot rule out the possibility of selection bias. Another nationally representative survey among Mexican adults conducted in November 2020 reported an acceptance of 82%; how-

ever, this figure included both answers, "definitely will get vaccinated" and "unsure, but probably will get vaccinated", which in our case were considered hesitant.[15] It is important to consider the different time frames of the surveys. It has been documented that the acceptance of Covid-19 vaccine can change over time.[16] Since the information regarding the vaccines' effectiveness and safety changes over time, the differences in results across surveys could be explained by collection dates.

The prevalence of Covid-19 vaccine refusal increased with age, and individuals aged 60 years and older had the highest odds of refusal and hesitancy. This is different to other countries where the elders are more likely to accept the Covid-19 vaccines.[14,16,17] This finding is particularly worrisome, considering the burden of morbidity and mortality experienced by older adults, particularly men, in Mexico.[1] A previous study reported that the main determinant for refusal in the elderly is the perception of Covid-19 severity,[18] which suggests that Mexican elders could be having a lower perception of disease severity, although the true underlying cause cannot be explored with our data. We also observed a higher refusal and hesitancy in women compared to men, a finding that was previously reported and explained as potentially linked to a difference in the perceived safety of the vaccines.[3]

Table II

ADJUSTED MULTINOMIAL LOGISTIC MODEL FOR REFUSAL AND HESITANCY COMPARED TO ACCEPTANCE FOR COVID-19 VACCINES IN PARTICIPANTS 16 YEARS OF AGE AND OLDER. ENSANUT-COVID-19, 2020, MEXICO

	Rejection		Doubt	
	RPR	95%CI	RPR	95%CI
Age				
16-29	Ref.		Ref.	
30-39	**1.27**	**1.03-1.56**	1.34	0.96-1.85
40-49	**1.21**	**1.01-1.46**	1.31	0.97-1.78
50-59	1.12	0.91-1.39	**1.44**	**1.07-1.92**
60 and older	**1.46**	**1.16-1.83**	**1.54**	**1.10-2.16**
Sex				
Male	Ref.		Ref.	
Female	**1.17**	**1.03-1.32**	**1.36**	**1.14-1.63**
Location size*				
Rural	Ref.		Ref.	
Urban	0.89	0.72-1.12	0.94	0.72-1.24
Metropolitan	0.87	0.71-1.08	1.01	0.76-1.34
Education				
Elementary school	Ref.		Ref.	
Middle school	**0.69**	**0.58-0.82**	0.82	0.64-1.05
High school	**0.71**	**0.58-0.87**	**0.72**	**0.56-0.93**
Graduate/Posgraduate	**0.62**	**0.49-0.79**	**0.63**	**0.45-0.87**
Socioeconomic level				
Low	Ref.		Ref.	
Medium	**0.80**	**0.67-0.96**	0.89	0.71-1.12
High	**0.73**	**0.60-0.88**	0.76	0.58-1.00
Employment‡				
Formal employee	Ref.		Ref.	
Unemployed	**1.51**	**1.24-1.84**	1.37	0.98-1.92
Student	1.05	0.77-1.45	0.99	0.63-1.57
Retired	0.96	0.68-1.34	1.15	0.77-1.71
Informal employee	**1.72**	**1.43-2.09**	**1.59**	**1.17-2.17**
Region§				
Mexico city	Ref.		Ref.	
North-Border	1.10	0.79-1.53	1.34	0.88-2.04
Central-Pacific	1.16	0.82-1.65	**2.17**	**1.36-3.47**
Central-North	**1.60**	**1.17-2.18**	**2.38**	**1.54-3.68**
Center	1.05	0.8-1.39	**1.94**	**1.25-3.02**
North-Pacific	0.90	0.64-1.27	**1.88**	**1.13-3.14**
State of Mexico	1.11	0.83-1.5	1.29	0.77-2.13
South-Pacific	1.16	0.86-1.57	**1.62**	**1.01-2.59**

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Peninsula	0.83	0.61-1.14	1.02	0.65-1.61
Covid-19 symptoms#				
Symptomatic	Ref.		Ref.	
Paucisymtomatic	**1.38**	**1.02-1.87**	**1.66**	**1.13-2.45**
Asymtomatic	**1.87**	**1.49-2.34**	1.16	0.86-1.56

Ensanut: *Encuesta Nacional de Salud y Nutrición*, CI: Confidence Interval, RPR: Relative Probability Ratio. *Rural <2 500 inhabitants, urban 2 500 to 100 thousand and metropolitan >100 thousand. ‡ Formal employees defined as those employed and with private o social health insurance. § North-Border: Chihuahua, Coahuila, Nuevo León, Tamaulipas; Central-Pacific: Colima, Jalisco, Michoacán; Central-North: Aguascalientes, Durango, Guanajuato, Querétaro, San Luis Potosí, Zacatecas; Center: Hidalgo, Tlaxcala, Veracruz; North-Pacific: Baja California, Baja California Sur, Nayarit, Sinaloa, Sonora; South-Pacific: Guerrero, Morelos, Oaxaca, Puebla; and Peninsula: Campeche, Chiapas, Quintana Roo, Tabasco, Yucatán. # Symptomatic define as the presence of one major symptom (headache, cough or fever) and one minor (sore throat, runny nose, conjunctivitis, muscle or joint pain, chest pain, loss of smell or taste), pauci-symptomatic if any symptom was reported, including diarrhea or vomiting. Bold letters represent *p* value<0.05.

We observed that Covid-19 vaccine acceptance was higher than the mortality risk in all age groups, indicated by a low mortality: acceptance ratio. However, we also noted that the groups at higher risk of Covid-19 mortality—those 60 years and older—showed the highest ratios in all regions. If individuals at higher risk of complications refuse or hesitate to get vaccinated, Covid-19 fatalities in Mexico will continue to rise as new waves of infection happen. Unfortunately, the information available in Ensanut 2020 Covid-19 was limited and did not include reasons for refusal and hesitancy. Future studies will be needed to further identify the reasons behind vaccination hesitancy and refusal.

While the Ensanut 2020 Covid-19 survey did not explore the reasons for refusal and hesitancy, we made the comparison with the stance towards influenza vaccine to explore if it was a general refusal towards vaccines. Influenza vaccines are well known by the population, as national campaigns for influenza vaccination are organized every year since 2014.[19] When compared to the influenza vaccine, the acceptance of Covid-19 vaccination was lower (62.3 vs. 68.1% in influenza) and hesitancy was higher (9.5% compared to 3.5% in influenza). Particularly participants 60 years and older reported a higher acceptance for influenza (69%) than Covid-19 (53.9%) (figure 1). This result suggests that specific aspects of the Covid-19 vaccines could explain the low vaccination acceptance and does not reflect a general refusal stance towards all vaccines. This is positive, as targeted information and communication could increase acceptance towards Covid-19 vaccines.[9] Beliefs and perceptions about the Covid-19 vaccines should

Table III
Mortality: acceptance ratio for Covid-19 vaccines by region, age group and sex. Ensanut-Covid-19, 2020

		Male						Female			
16-29	30-39	40-49	50-59	60+	Region	16-29	30-39	40-49	50-59	60+
0.01	0.06	0.14	0.45	0.94	North-Pacific	0.01	0.03	0.09	0.28	0.69
0.01	0.06	0.12	0.34	0.71	North-Border	0.00	0.03	0.07	0.21	0.49
0.00	0.04	0.09	0.22	0.72	Central-Pacific	0.00	0.02	0.04	0.12	0.41
0.00	0.05	0.10	0.35	0.55	Central-North	0.00	0.02	0.05	0.15	0.37
0.00	0.06	0.12	0.44	0.66	Center	0.00	0.02	0.06	0.18	0.38
0.01	0.06	0.18	0.48	0.62	Mexico city	0.00	0.03	0.05	0.14	0.34
0.01	0.06	0.13	0.34	0.70	State of Mexico	0.00	0.02	0.06	0.14	0.39
0.00	0.05	0.13	0.38	0.77	South-Pacific	0.00	0.02	0.06	0.19	0.35
0.00	0.05	0.14	0.49	0.64	Peninsula	0.00	0.02	0.05	0.17	0.49

Mortality was calculated using the total Covid-19 deaths reported by the Epidemiological Surveillance System of Mexico (SISVER) one month after the mean date of the survey application in each region. A mortality:acceptance ratio of zero is the best scenario (higher acceptance than mortality), a ratio over one is the worst scenario (higher mortality than acceptance). North-Border: Chihuahua, Coahuila, Nuevo León, Tamaulipas; Central-Pacific: Colima, Jalisco, Michoacán; Central-North: Aguascalientes, Durango, Guanajuato, Querétaro, San Luis Potosí, Zacatecas; Center: Hidalgo, Tlaxcala, Veracruz; North-Pacific: Baja California, Baja California Sur, Nayarit, Sinaloa, Sonora; South-Pacific: Guerrero, Morelos, Oaxaca, Puebla; and Peninsula: Campeche, Chiapas, Quintana Roo, Tabasco, Yucatán.
Ensanut: *Encuesta Nacional de Salud y Nutrición*
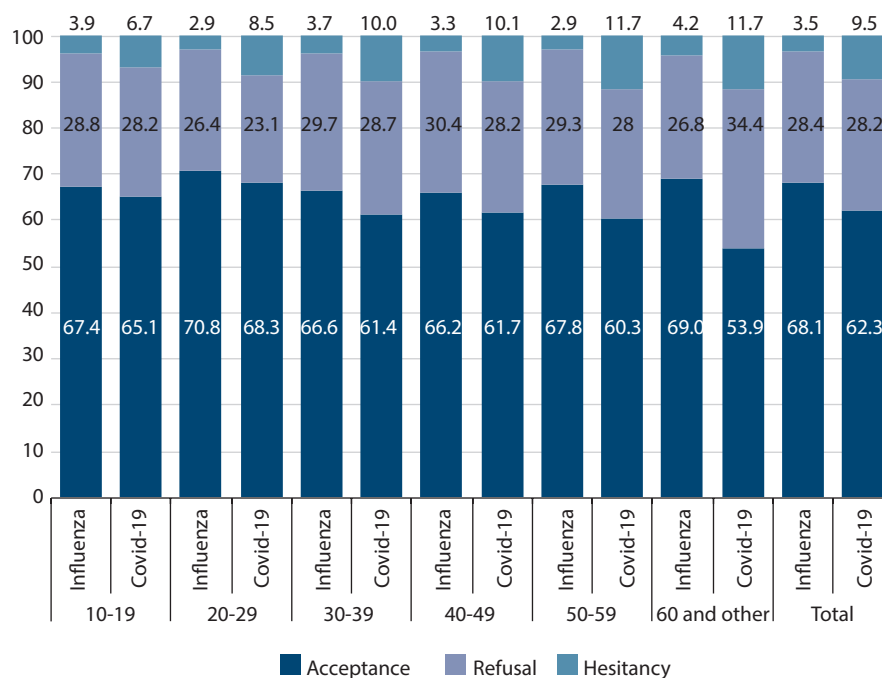
Ensanut: *Encuesta Nacional de Salud y Nutrición*

Figure 1. Comparison of acceptance, refusal and hesitancy to Covid-19 and influenza vaccines by age group. México Source: Ensanut 2020 Covid-19, 2020

be addressed in the groups at higher risk of refusal and hesitancy, as identified by Ensanut 2020 Covid-19, providing clear messages about efficacy, safety, and benefits of Covid-19 vaccines which have been reported as determinants for refusal or hesitancy.[6]

Unemployed and informal employees had higher refusal (32.0 and 32.1%, respectively) and hesitancy (11.1 and 10.7%) compared to formal employees (19.3% refusal and 7.4% hesitancy). A low vaccine uptake in this group could further increase health inequalities and perpetuate them. In Mexico, 60% of workers participate in the informal sector,[20] meaning a lower opportunity to do home-office and a higher exposure to SARS-CoV-2 coupled without social and health security. Thus, beyond defining a targeted information campaigns, it will be necessary to identify key strategies to facilitate vaccination for informal workers, ensuring easy access to the vaccines.

Readers should be aware of the limitations of our study. The two most critical limitations stem from the cross-sectional nature of the study. First, Covid-19 vaccine acceptance is dynamic, as reported in other countries.[16] The willingness to accept the vaccine is influenced by factors that might change over time, particularly in the case of Covid-19, a novel virus known only a few months before the survey. However, previous studies have shown that willingness to accept a vaccine is a good predictor of actual vaccination behavior[21] and is useful information until new one becomes available. Second, the question in the survey was about a generic, hypothetical vaccine. By early 2021, five different vaccines have been approved in Mexico.[22] Acceptance can be different by vaccine.

Developing a safe and effective vaccine is just a step in the immunization process. In addition to the challenges related to vaccine access and distribution, the population's willingness to be vaccinated is crucial. In Mexico, 38% of the population refuses or hesitates to receive a Covid-19 vaccine, particularly among vulnerable groups: older people, unemployed and informal workers. The refusal and hesitancy of Covid-19 vaccine could jeopardize herd immunity and delay the population benefits of the vaccine, such as a reduction in the number of hospitalizations and deaths. It could also create pockets of unvaccinated individuals amongst the most vulnerable populations, that will carry the burden of potential disease outbreaks. Our study contributes to identify vulnerable groups to further explore the specific barriers by qualitative or mixed-method research and create evidence-based campaigns and well-targeted interventions to facilitate acceptance could yield important public health and social benefits.

Acknowledgements

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