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Citation: Alvarez-Najar JP, Iguacel I, Martínez-Jarreta B, Couto-Alfonso S, De Blas I. **Factors influencing COVID-19 vaccination acceptance when knowing potential side effects: a study in Colombia.** Colomb Méd (Cali), 2025; 56(4):e2016609 http://doi.org/10.25100/cm.v56i4.6609

Received: 05 Dec 2024
Revised : 10 Jun 2025
Accepted : 30 Dec 2025
Published: 30 Dec 2025

Keywords
COVID-19; COVID-19 vaccines; vaccination; vaccination hesitancy; body mass index; safety; patient acceptance of health care.

Palabras clave
COVID-19; vacunas contra la COVID-19; vacunación; vacilación a la vacunación; índice de masa corporal; seguridad; aceptación de la atención de salud

ORIGINAL ARTICLE

Factors influencing COVID-19 vaccination acceptance when knowing potential side effects: a study in Colombia

Factores que influyen en la aceptación de la vacunación de COVID-19 al conocer los posibles efectos secundarios: un estudio en Colombia

Juan Pablo Álvarez-Najar,[1,5] Isabel Iguacel,[1,2,3,4] Begoña Martínez-Jarreta,[3,6] Sergio Couto-Alfonso,[1] Ignacio De Blas[2,7].

1 Universidad de Zaragoza, Facultad de Ciencias de la Salud, Zaragoza, Spain. **2.** Universidad de Zaragoza, Instituto de Investigación Agroalimentario de Aragón, Zaragoza, Spain. **3.** Universidad de Zaragoza, Instituto de Investigación Sanitaria Aragón, Zaragoza, Spain. **4.** Centro de Investigación Biomédica en Red de Fisiopatología de la Obesidad y Nutrición, Zaragoza, Spain. **5.** Universidad de los Llanos, Villavicencio, Colombia. **6.** Universidad de Zaragoza, Facultad de Medicina, Zaragoza, Spain. **7.** Universidad de Zaragoza, Facultad de Veterinaria, Departamento de Patología Animal, Zaragoza, Spain.

Abstract

Aim:

To examine the determinants of COVID-19 vaccine acceptance in Colombia, with particular emphasis on individuals' responses to possible side effects.

Methods:

A cross-sectional study was conducted using an anonymous online questionnaire in Colombia between January and March 2023. The ad hoc survey collected sociodemographic data, COVID-19 history, vaccination status, and adverse effects. Descriptive analyses, chi-square tests, and multinomial logistic regression (aOR, 95% CI) were performed (p <0.05).

Results:

The 40.2% of respondents expressed doubts or would have rejected vaccination had they known about possible side effects beforehand. Women were more likely to hold doubts or reject the vaccine after experiencing adverse effects. Participants who experienced side effects were more likely to question their decision to vaccinate. Younger individuals were less likely than older adults to develop negative attitudes after experiencing side effects. Those who had received only one dose were more likely to doubt or reject further vaccination, whereas individuals with multiple doses were less likely to do so. Participants with asymptomatic COVID-19 were less likely to refuse vaccination after learning about potential side effects, possibly because they trusted their immune system more or had a stronger desire to protect others.

Conclusions:

Vaccination hesitancy was associated with female sex, prior adverse effects, and fewer doses, whereas younger age was associated with greater acceptance. These findings highlight the need for targeted risk communication to address safety concerns and strengthen vaccine confidence.

Conflict of interest

The authors declare no conflicts of interest.

Acknowledgments

The authors express their gratitude to all participants for their time and contribution in completing the survey

Funding:

This study did not receive any external financial support.

CRediT authorship contribution statement

II: Conceptualization, Data curation, Formal analysis, Methodology, Writing - original draft, Supervision. **IB:** Data curation, Formal analysis, Methodology, Writing - review & editing. **BM:** Conceptualization, Resources, Supervision, Writing - review & editing. **JPA:** Conceptualization, Writing - review & editing. **SCA:** Writing - review & editing. All authors reviewed and approved the final version of the manuscript.

Data Availability

The raw data underlying the findings of this study are available from the authors upon reasonable request, without restriction (scouto@unizar.es).

Corresponding author

Sergio Couto-Alfonso. Facultad de Ciencias de la Salud, Domingo Miral s/n, 50009 Zaragoza, Spain**. E-mail:** scouto@unizar.es

Resumen

Objetivos:

Este estudio examinó los factores determinantes de la aceptación de la vacuna contra la COVID-19 en Colombia, con especial énfasis en las respuestas de las personas tras experimentar posibles efectos secundarios.

Métodos:

Se realizó un estudio transversal mediante un cuestionario anónimo en línea en Colombia entre enero y marzo de 2023. La encuesta ad hoc recopiló información sociodemográfica, antecedentes de COVID-19, estado de vacunación y efectos adversos. Se realizaron análisis descriptivos, pruebas de chi cuadrado y regresión logística multinomial (ORa, IC95%) (p <0.05).

Resultados:

El 40.2% de los participantes expresó dudas o habría rechazado la vacunación si hubiera conocido previamente los posibles efectos secundarios. Las mujeres tuvieron una mayor probabilidad de presentar dudas o de rechazar la vacuna tras experimentar efectos adversos. Los participantes que presentaron efectos secundarios fueron más propensos a cuestionar su decisión de vacunarse. Las personas más jóvenes tuvieron menor probabilidad de desarrollar actitudes negativas tras experimentar efectos secundarios que los adultos mayores. Quienes habían recibido solo una dosis presentaron una mayor probabilidad de dudar o rechazar futuras vacunaciones, mientras que quienes habían recibido múltiples dosis presentaron una menor probabilidad de hacerlo. Los participantes que cursaron COVID-19 de manera asintomática tuvieron menor probabilidad de rechazar la vacunación tras conocer los posibles efectos secundarios, posiblemente porque confiaban más en su sistema inmunológico o tenían un mayor deseo de proteger a otros.

Conclusiones:

La vacilación hacia la vacunación se asoció con el sexo femenino, la presencia previa de efectos adversos y un menor número de dosis recibidas, mientras que la menor edad se asoció con una mayor aceptación. Estos hallazgos resaltan la necesidad de estrategias de comunicación del riesgo dirigidas a abordar las preocupaciones sobre la seguridad y a fortalecer la confianza en las vacunas.

Remark

1) Why was this study conducted?

To identify the factors influencing COVID-19 vaccine acceptance in Colombia, specifically analyzing how the experience and knowledge of potential side effects affect individuals' willingness to receive further vaccine doses.

2) What were the most relevant results of the study?

Around 40.2% of participants reported they would have doubted or rejected vaccination if they had known the side effects in advance. Women and individuals who experienced adverse effects were more likely to show hesitancy or regret, while younger individuals and those with more vaccine doses were more likely to accept vaccination.

3) What do these results contribute?

These findings provide evidence that personal experience with side effects significantly influences vaccine acceptance and highlight the need for targeted public health strategies to address hesitancy, improve risk communication, and strengthen trust in vaccination programs.

Introduction

The introduction and dissemination of COVID-19 vaccines have prevented millions of deaths globally [1]. Despite the widespread acceptance of COVID-19 vaccines during the initial rollout in December 2020, a noticeable decline in vaccine uptake has been observed since the end of 2022 [2,3]. Initially, many countries achieved vaccination rates exceeding 80% with at least two doses, reflecting broad societal support even without mandatory vaccination policies [4].

Despite the invaluable benefits of COVID-19 vaccines, a significant portion of the population has declined to receive the vaccine or subsequent doses [5]. According to the latest data published by the European Centre for Disease Prevention and Control (ECDC), the average COVID-19 vaccination coverage in the European Union between 1 September 2023 and 15 January 2024 was 11.1% for individuals aged 60 and above (ranging from 0.01% to 65.8%) and 16.3% for those aged 80 and above (ranging from 0.01% to 88.2%) [5].

The current perception of COVID-19 as a mild illness, combined with misconceptions about the necessity, efficacy, and safety of vaccines, has contributed to this decline [6]. According to data published by the Colombian government, in 2023, a total of 36,312,611 people received one dose of the COVID-19 vaccine, while 30,320,238 individuals completed their vaccination with two doses. Although booster doses were recommended for all adults aged 18 years and over, the first booster dose was administered to 14,792,792 individuals, and the second booster dose was received by 2,381,408 individuals [7]. The acceptance of the COVID-19 vaccine among Colombians has not only varied over time but also differs significantly based on sociodemographic and cultural characteristics. Notably, only 6% of the indigenous population in Colombia accepted vaccination during the initial months of the campaign, although this percentage increased following communication efforts by the World Health Organization (WHO) [8].

Given that a significant portion of the public's reluctance towards COVID-19 vaccines stems from concerns about their safety and fears of potential adverse effects, our research aims to investigate the predictors that influence individuals' acceptance of subsequent vaccinations after experiencing and learning about these possible adverse effects. This study is part of a broader research project that earlier analyses explored attitudes toward vaccines and vaccine mandates in Spain, as well as the association between vaccine side effects and body mass index [4,6,9]. However, the present study uses a new, independent analytic dataset and focuses specifically on predictors of willingness to receive subsequent vaccinations after adverse effects, rather than reanalyzing data from prior publications. Although the studies cited above were conducted within the same research topic, the present article reports original data and a distinct research question.

Materials and Methods

Study design and population

The current study follows the same topic and methods as our earlier studies [4,6,9]; however, the participants and data are independent, original, and collected specifically for the present analysis.

Data were collected through an anonymous online survey conducted between January and March 2023. This cross-sectional study involved a convenience sample of adults in Colombia. The questionnaire was created using Google Forms and distributed via social media platforms, including Facebook, Twitter, and WhatsApp. Additionally, in Villavicencio (Colombia), students from the Universidad de los Llanos were invited by email to participate. Respondents accessed the survey link on their electronic devices and completed the questionnaire.

Eligibility criteria included individuals who: (1) were aged 18 years or older, (2) had received at least one dose of a COVID-19 vaccine, (3) voluntarily consented to participate in the online survey, and (4) were able to read and independently complete the self-administered questionnaire.

After excluding participants who did not meet the inclusion criteria (n= 66 reported not having received any vaccine dose), a total of 1,454 individuals were included in the final analysis. A convenience sampling approach was used.

The study protocol was approved by the Ethics Committees in Colombia, specifically Centro de Salud La Candelaria La Capilla (Boyacá), NIT 820003193-1 (14092022), and was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all participants included in the study.

Measures

Participant characteristics and vaccination-related data. The questionnaire was organized into three primary sections. The first collected general background information (sociodemographic variables), the second explored aspects associated with COVID-19 infection, and the third addressed variables related to vaccination.

Participants were asked to report sociodemographic characteristics, including: (1) gender: male or female; (2) age: grouped into 18-24, 25-44, 45-64, and ≥65 years; (3) area of residence: rural or urban; (4) educational attainment: defined as the highest level of education completed. The response categories were coded and recategorized as follows: low education (including preschool, elementary, and middle school), medium (including high school or equivalent), and high (including university studies); (5) social security affiliation: divided in the following categories: contributory scheme (including those participants who contribute to a social security or welfare program through employment), special scheme (including those in the contributory scheme within special sectors such as national police, military forces, army, navy, air force, teaching profession, and workers of the hydrocarbon company Ecopetrol) or subsidized (designed to provide access to healthcare services or other social benefits to low-income individuals such as the unemployed, informal workers, and people in extreme poverty).

Regarding COVID-19, participants reported the number of times they may have been infected (0, 1, 2, or ≥ 3). Additionally, as shown in Table 1, they provided information on the severity of their symptoms based on medical parameters (no infection, asymptomatic, mild, moderate, severe, and critical) [10].

We also collected data on the number of comorbidities, which were recoded into categories of 0, 1-2, or ≥ 3 comorbidities. A list of comorbidities associated with COVID-19 is provided in Table 2 [11].

Moreover, participants reported the number of vaccine doses they had received and whether they experienced any adverse effects following COVID-19 vaccination (yes/no).

Finally, participants answered the following question: "Knowing the possible side effects experienced, would you get vaccinated against COVID-19 again?" Possible responses were: Yes, No, I would have doubts.

Statistical analysis. For descriptive analyses, numbers and percentages were used to detail sample characteristics. Contingency tables as percentages and Pearson's chi-square tests were used to assess the sample characteristics (gender, age, residency, educational level, social security affiliation, possible infection of COVID-19 and effects, comorbidities, doses administered, and possible adverse effects due to vaccination) according to their attitude towards COVID-19 vaccination acceptance, if the possible side effects experienced were known in advance.

Subsequently, we conducted multinomial logistic regression models to examine the predictive factors for vaccination likelihood when possible side effects were known in advance. For statistical purposes, the responses "No" and "I would have doubts" were merged. The reference for all models was the response "Yes".

Table 1. Description of the severity of COVID-19 symptoms.

Severity of COVID-19 symptoms	Description
Asymptomatic	No symptoms.
Mild	Symptoms such as e.g., fever, cough, sore throat, malaise, headache, muscle pain, nausea, vomiting, diarrhea, loss of taste and smell) but do not have shortness of breath, dyspnea, or abnormal chest images.
Moderate	Evidence of lower respiratory disease on clinical assessment or imaging, and who have an oxygen saturation (SpO2) ≥94% in ambient air at sea level.
Severe	SpO2 < 94% in ambient air at sea level, a ratio of arterial partial pressure of oxygen to fraction of inspired oxygen (PaO2/FiO2) < 300 mm Hg, respiratory rate > 30 breaths/min, or pulmonary infiltrates > 50%.
Critical	Respiratory failure, septic shock, and/or multiple organ dysfunction.

Table 2. Comorbidities with a significant risk for COVID-19..

Comorbidities	Examples
Cardiovascular Diseases	Hypertension Heart failure Coronary artery disease History of stroke
Diabetes Mellitus	Both type 1 and type 2 diabetes significantly increase the risk of severe COVID-19 outcomes.
Chronic Respiratory Diseases	Chronic obstructive pulmonary disease (COPD) Asthma (particularly uncontrolled or severe) Interstitial lung disease
Obesity	Obesity (Body Mass Index (BMI) ≥30) is a major risk factor for severe COVID-19, with higher risk associated with higher BMI levels.
Chronic Kidney Disease	Patients with chronic kidney disease or those on dialysis are at increased risk.
Cancer	Active cancer, particularly hematologic malignancies (leukemia, lymphoma) and cancers under treatment
Immunocompromised State	Conditions such as HIV/AIDS, or those resulting from immunosuppressive therapy (e.g., organ transplant recipients, patients on corticosteroids or chemotherapy).
Chronic Liver Disease	Including cirrhosis and chronic hepatitis.
Neurological Conditions	Neurological conditions such as dementia, and other neurodegenerative diseases.
Sickle Cell Disease	Patients with sickle cell disease are at higher risk for severe complications from COVID-19.
Autoimmune Diseases	Rheumatoid arthritis Systemic lupus erythematosus (SLE) Multiple sclerosis Inflammatory bowel disease (Crohn's disease and ulcerative colitis) Psoriasis

Adjusted odds ratios (aORs) and their corresponding 95% confidence intervals (CIs) were calculated for the regression analysis. All statistical analyses were conducted using SPSS version 26.0 (IBM Corporation, New York, NY, USA). Statistical significance was established at an alpha level of 0.05, with *p*-values below 0.05 considered significant. Models included the following variables and adjustments: gender, age, residency, educational level, social security affiliation, number of times infected with COVID-19, COVID-19 effects, number of comorbidities, doses administered, and possible adverse effects experienced with the COVID-19 vaccine.

Results

The Table 3 presents the characteristics of the study sample. Most participants were female (67.2%), aged between 18 and 44 years (80.6%), residing in urban areas (86.2%), with a medium educational level (i.e., upper secondary education) (54.4%), and enrolled in a contributory social security scheme (65.5%). Nearly half of the participants (48.6%) were infected with COVID-19 at least once. Among those infected, 13.9% reported being asymptomatic, 68.8% experienced mild symptoms, 14.7% had moderate symptoms, 2.0% suffered from severe infection, and 0.6% had critical disease. Most participants had no comorbidities (79%), had received 3 doses of the vaccine (38%), and had experienced adverse effects from at least 1 dose (63.5%).

In response to the question of whether they would choose to get vaccinated against COVID-19 again if they had known in advance about the potential side effects, 21.3% stated they regretted their decision, 19% expressed doubt, and 59.8% said they would get vaccinated again.

Being a woman was significantly associated with a higher likelihood of expressing regret (22.5%) or having doubts (20.5%) about getting vaccinated compared to men (18.7% and

Table 3. Sample characteristics according to their attitude towards COVID-19 vaccination acceptance if the possible side effects experienced were known in advance. "Knowing the possible side effects experienced, would you get vaccinated against COVID-19 again?"

Variables	N= 1,454		Response options			*p*-value
			No (n= 309) 21.2%	Doubts (n= 276) 19.0%	Yes (n= 869) 59.8%	
	n		(%)			
Gender						
Female	977	67.2	22.5	20.5	57.0	0.009
Male	477	32.8	18.7	15.9	65.4	
Age (years)						
18-24	591	40.6	17.1	20.1	62.8	0.007
25-44	581	40.0	24.4	17.9	57.7	
45-64	259	17.8	21.6	18.5	59.8	
≥ 65	23	1.6	43.5	21.7	34.8	
Residency						
Rural	201	13.8	20.4	23.9	55.7	0.160
Urban	1253	86.2	21.4	18.2	60.4	
Educational level						
Low	53	3.6	30.2	15.1	54.7	0.317
Medium	791	54.4	19.5	21.0	59.5	
High	610	42.0	22.8	16.7	60.5	
Social security affiliation						
Contributory scheme	953	65.5	20.8	18.4	60.9	0.462
Special scheme	81	5.6	21.0	14.8	64.2	
Subsidized	420	28.9	22.4	21.2	56.4	
COVID-19 infection (number of times)						
0	748	51.4	19.3	19.7	61.1	0.060
1	474	32.6	21.9	20.5	57.6	
2	183	12.6	24.0	15.3	60.7	
≥ 3	49	3.4	19.3	19.7	61.1	
COVID-19 effects						
No infection	748	51.4	19.3	19.7	61.1	0.858
Asymptomatic	98	13.9	19.4	22.4	58.2	
Mild	486	68.8	23.5	17.1	59.5	
Moderate	104	14.7	25.0	20.2	54.8	
Severe	14	2.0	35.7	14.3	50.0	
Critical	4	0.6	25.0	25.0	50.0	
Number of comorbidities						
0	1148	79.0	20.1	19.3	60.6	0.208
1-2	274	18.8	25.2	19.0	55.8	
≥ 3	32	2.2	28.1	9.4	62.5	
Doses administered						
1	126	8.7	44.4	25.4	30.2	<0.001
2	516	35.5	25.6	21.7	52.7	
3	553	38.0	15.0	18.3	66.7	
4	259	17.8	14.7	12.0	73.4	
Adverse effects						
No	530	36.5	19.3	19.7	61.1	0.156
Yes	924	63.5	23.4	18.3	58.4	

* Statistically significant difference given by the chi-square, measured by the p-value <0.05.

15.9%, respectively). Older age was significantly associated with greater regret about getting vaccinated (43.5% regret among those over 65 years old compared to 17.1% among young adults aged 18 to 24 years).

Those residing in urban areas (60.4%) were more likely to be vaccinated again after learning about possible side effects than those in rural areas (55.7%). Similarly, individuals with a higher educational level (60.5%) and those with a special affiliation (64.2%) reported a higher likelihood of getting vaccinated again after knowing the possible side effects experienced, compared to those with a low educational level (54.7%) and those affiliated with the social security under the subsidized scheme (56.4%), respectively.

Those who experienced more severe side effects from the COVID-19 vaccine reported a higher rate of regret about vaccination (35.7%) than those who were asymptomatic (19.4%). Additionally, individuals with three or more comorbidities expressed a higher percentage of

Table 4. Predictor factors about according to their attitude towards COVID-19 vaccination acceptance if the possible side effects experienced were known in advance. "Knowing the possible side effects experienced, would you get vaccinated against COVID-19 again?" Possible responses were: Yes, No, I would have doubts. Results from Multinomial Logistic Regression Models.

N= 1,454	No/I would have doubts vs Yes (reference)		
	aOR	95% CI	*p*-value
Gender			
Female	1.50	1.17-1.93	0.002
Male	1.00	Ref.	
Age (years)			
18-24	0.19	0.07-0.54	0.002
25-44	0.29	0.10-0.78	0.015
45-64	0.32	0.12-0.88	0.027
≥ 65	1.00	Ref.	
Residency			
Rural	1.20	0.85-1.68	0.291
Urban	1.00	Ref.	
Educational level			
Low	0.66	0.32-1.34	0.254
Medium	1.02	0.75-1.34	0.981
High	1.00	Ref.	
Social security affiliation			
Contributory scheme	0.92	0.69-1.21	0.548
Special scheme	0.78	0.45-1.35	0.387
Subsidized	1.00	Ref.	
COVID-19 infection (number of times)			
0	0.82	0.42-1.58	0.553
1	0.90	0.46-1.75	0.754
2	0.89	0.43-1.81	0.752
≥ 3	1.00	Ref.	
COVID-19 effects			
Asymptomatic	0.64	0.50-0.83	0.001
Symptomatic	1.00	Ref.	
Number of comorbidities			
0	0.75	0.33-1.17	0.502
1-2	1.03	0.37-1.98	0.728
≥ 3	1.00	Ref.	
Doses administered			
1	9.51	5.60-16.16	<0.001
2	3.21	2.22-4.64	<0.001
3	1.64	1.15-2.34	0.007
4	1.00	Ref.	
Adverse effects of the vaccine			
No	0.64	0.50-0.83	0.001
Yes	1.00	Ref.	

*Statistically significant results shown in bold font; Models were adjusted for each of the following variables. aOR: adjusted odds ratio.

doubts about being vaccinated (28.1%) than those with no comorbidities (20.1%). People who had received over four doses (73.4%) were significantly more likely to accept the COVID-19 vaccine after learning about the possible side effects, compared to those who had received only one dose (30.2%). In relation to adverse effects, those who experienced them were more likely to regret vaccination (23.4%) than those who did not (19.3%).

Predictor factors regarding their attitude towards COVID-19 vaccination acceptance if the possible side effects experienced were known in advance (reference: yes) are illustrated in Table 4. Findings from multinomial logistic regression analyses, adjusted for potential confounders, showed that women were significantly more likely than men to refuse or express hesitancy toward vaccination after learning about possible side effects (aOR= 1.50, 95% CI: 1.17-1.93). Younger ages were associated with significantly lower odds of rejecting or having doubts about being vaccinated after knowing the possible side effects experienced (aOR= 0.19, 95% CI: 0.07-0.54, for ages 18-24); (aOR= 0.29, 95% CI: 0.10-0.78, for ages 25-44); (aOR= 0.32, 95% CI: 0.12-0.88, for ages 45-64), compared to participants aged 65 years or older.

Participants who reported no symptoms during COVID-19 had significantly lower odds of rejecting or having doubts about being vaccinated after knowing the possible side effects experienced (aOR= 0.64, 95% CI: 0.50-0.83). Those with a lower number of administered

vaccine doses had a higher risk of rejecting or having doubts about being vaccinated (aOR= 9.51, 95% CI: 5.60-16.16 for only one dose administered); (aOR= 3.21, 95% CI: 2.22-4.64 for two doses administered); (aOR= 1.64, 95% CI: 1.15-2.34 for three doses administered) compared to those who received four doses. Finally, those who did not experience adverse effects from the vaccines were less likely to reject or have doubts about being vaccinated after knowing the possible side effects experienced (aOR= 0.64, 95% CI: 0.50-0.83) compared to those who did have adverse effects. No other statistically significant associations were found.

Discussion

The present study aimed to analyze the factors influencing COVID-19 vaccination acceptance when considering potential side effects in Colombia. Data from 1,454 participants were analyzed and collected through an online survey conducted between January and March 2023.

Our results showed that 40.2% of the Colombian population who responded to the questionnaire indicated they would have had doubts or would have rejected the COVID-19 vaccine if they had known the possible side effects they experienced. Being a woman was associated with a higher likelihood of rejecting or having doubts about the vaccine after knowing the possible adverse effects experienced. This finding aligns with previous research indicating greater concern about the safety and efficacy of COVID-19 vaccines among women than among men, with women perceiving more risks than benefits [6,12]. These results can be partially explained by the fact that women have reported more side effects from COVID-19 vaccination compared to men [13]. Indeed, in the present study, those who reported experiencing adverse effects from the COVID-19 vaccine were more likely to reject or have doubts about the vaccine after learning about the possible adverse effects they had experienced, compared to those who did not experience these symptoms. People who experience adverse effects from the COVID-19 vaccine may develop doubts or refuse future doses due to negative reinforcement, heightened risk perception, and reduced trust in the vaccine. Their own negative experiences become more prominent in their decision-making [14].

Similar to our study, in a large sample of UK adults (N= 32,361), young people (ages 18-29) were significantly less likely than older adults (ages 65+) to hold negative attitudes towards vaccines across all four domains [15]. In our investigation, younger participants were also associated with significantly lower odds of rejecting or having doubts about vaccination after learning about possible side effects, compared with participants aged 65 years or older. Regarding the relationship between adverse effects and age, studies have shown that adverse effects from the COVID-19 vaccine seemed to be less prevalent but more serious at older ages compared to younger ages [13,16,17].

Another Latin American study showed that vaccine acceptance rates varied considerably, with approximately 58.4% of respondents accepting vaccination, 17.8% expressing hesitancy, and 23.7% refusing it. Notably, acceptance was significantly higher among males than among females (p <0.05) [18]. Similar studies in the Latin American population have analyzed determinants of COVID-19 vaccine hesitancy across Chile, the broader Latin American and Caribbean region, and Mexico. Collectively, they reveal that while the majority of adults expressed willingness to get vaccinated, a significant proportion exhibited hesitation or fear, mainly driven by concerns about vaccine side effects, perceived effectiveness, and the severity of COVID-19 [19-21].

Sociodemographic factors such as gender, rural residence, economic insecurity, and age shaped attitudes, with young adults and men typically more willing, while women and individuals with economic concerns were more hesitant [20,21]. Fear of adverse effects was prevalent even among those intending to vaccinate, highlighting the paradoxical coexistence of acceptance and anxiety [20,21]. Importantly, factors like trust in government and health authorities, prior vaccine experience (e.g., influenza vaccination), perceived benefits to health and the economy, and targeted informational campaigns influenced both hesitancy and acceptance [19,21]. The studies emphasize the need for nuanced, context-specific communication strategies that address fears and misconceptions, especially among subgroups more prone to hesitancy, to achieve widespread vaccine uptake and accelerate the end of the pandemic [19-21].

Recent Colombian evidence reinforces the interpretation of our findings. A mixed-methods study conducted in eight Colombian cities reported that only a minority of participants expressed a strong intention to initiate or complete the COVID-19 vaccination schedule and showed that acceptance was higher among older adults and those with higher educational levels, as well as among individuals living with people with chronic conditions or adults over 50 years of age [22]. That study also underscored the importance of family support, observing others being vaccinated, and the influence of community and religious leaders, media narratives, and vaccine knowledge as key determinants of vaccination decisions [22]. In contrast, distrust in vaccines, concerns about safety and long-term effects, misinformation, and perceived political or economic interests acted as major barriers to acceptance [23]. Taken together, these results converge with our finding that personal experiences with adverse effects do not operate in isolation but are interpreted within a broader social and institutional context of trust and mistrust towards vaccines and health authorities [22,23].

In our study, individuals who had received only a single dose of the vaccine were more likely to refuse further vaccination or express doubts after learning about the side effects they experienced. In fact, the likelihood of rejecting the vaccine or having doubts decreased with the number of doses they had received, which aligns with their subsequent behavior. Contrary to what might have been expected, individuals who had experienced asymptomatic COVID-19 were less likely to refuse vaccination or express doubts after learning about the potential side effects. Our results could be explained by the fact that people who had asymptomatic COVID-19 may be more willing to get vaccinated because they trust their immune system, have gained more knowledge about the virus, or want to protect others. Their mild experience might also make them less worried about vaccine side effects. Also, it would be important to consider whether those who had symptomatic COVID-19 contracted the virus before or after being vaccinated, as contracting the disease despite vaccination might erode their confidence in the vaccine. Similarly, asymptomatic individuals may attribute the mildness of their infection to the vaccine's protection, thereby reinforcing their preference for continuing vaccination.

Although no other significant relationships were found, our descriptive results suggest a trend among individuals with lower educational attainment and those living in rural areas, who were more likely to reject the vaccine or express doubts after experiencing potential side effects. However, in fully adjusted models, this tendency was not significant. Previous studies have indeed shown higher vaccine hesitancy among groups with lower educational levels [24,25] or among rural community members [26]. However, our study includes individuals who accepted the vaccination and went on to receive it, which sheds light on the potential regret or reconsideration of that decision after experiencing possible side effects. This objective is, therefore, unique and has not been addressed in any previous research to our knowledge.

Implications for public health and the Colombian National Expanded Program on Immunization (PAI). The present findings have direct implications for the design of public health strategies in the post-pandemic period in Colombia [22,23,27]. Given that a substantial proportion of vaccinated individuals would have doubted or refused COVID-19 vaccination had they known in advance about the side effects they experienced, it is insufficient to focus solely on achieving high coverage rates. Instead, policies should also aim to strengthen vaccine confidence through transparent, anticipatory, and bidirectional communication about the benefits and limitations of vaccination, as well as about expected and rare adverse events, to align risk perceptions with the best available evidence [23,27].

First, our results support the need for targeted strategies aimed at groups with higher levels of doubt or regret, particularly women, individuals with fewer doses, and those who have experienced adverse events. Second, evidence from Colombia and other Latin American countries highlights the crucial role of healthcare professionals, community and religious leaders, and other local stakeholders as trusted messengers who can contextualize information,

address fears and misconceptions, and promote informed decision-making [22,23]. Third, the PAI (Programa Ampliado de Inmunización) should incorporate visible mechanisms for listening to and responding to citizens' concerns, including health education, active countering of misinformation, and spaces for public deliberation about vaccine safety [27]. Finally, context-specific interventions, especially in rural and socioeconomically disadvantaged areas, are needed to address structural barriers, cultural and spiritual beliefs, and unequal access to reliable information and vaccination services [22,23,27]. Integrating these elements into the PAI could not only sustain COVID-19 vaccination in the medium term but also rebuild trust in the expanded immunization program [27].

Strengths and limitations. To our knowledge, no previous study has specifically examined potential regret after COVID-19 vaccination in relation to the side effects experienced. While other studies have investigated possible attitudes and intentions regarding vaccination, this study, with a sample of 1,454 Colombians, allows for the examination of predictors of this potential regret. This, in turn, enables better targeting of public policies by providing a clearer understanding of the variables that need to be addressed for effective COVID-19 vaccination.

However, this study does have certain limitations. Firstly, the sample is not random, which limits its representativeness for the Colombian population. Additionally, certain groups may be underrepresented due to the data collection method employed. For instance, males made up only 33.3% of the sample; participants with lower education levels accounted for 23.2%, compared to 50.9% with higher education; and only 3.9% of the sample were older adults (65 years and above). According to 2020 official statistics, 40% of individuals aged 25 to 65 in Colombia had completed tertiary education [28]. Therefore, generalizing these findings may be challenging. While online surveys are convenient and can reach diverse populations quickly, they have drawbacks, such as the difficulty in addressing certain questions that could be clarified in face-to-face interviews. Another limitation of this study is that we did not collect data on whether those who had symptomatic COVID-19 contracted the virus before or after being vaccinated, as contracting the disease despite vaccination might erode their confidence in the vaccine.

Furthermore, a critical limitation is that we did not distinguish between mild and severe vaccine side effects. Our questionnaire only assessed whether participants experienced adverse effects (yes/no), without collecting information on their severity. This distinction is crucial, as severe side effects would likely influence decision-making differently than mild effects, limiting our ability to fully interpret the factors influencing vaccine acceptance.

Additionally, our study did not assess the complete Knowledge, Attitudes, and Practices (KAP) construct regarding COVID-19 vaccination. While we collected information on vaccination practices (number of doses received) and some attitudes (willingness to be revaccinated), we did not systematically evaluate participants' knowledge about the COVID-19 vaccine. A comprehensive KAP assessment would have provided a richer context for interpreting our findings and better understanding factors influencing vaccine acceptance.

Finally, the use of an *ad hoc* questionnaire rather than a standardized, validated instrument is another limitation. Although existing validated questionnaires were reviewed, none comprehensively captured all variables essential to our research objectives, particularly those related to the retrospective evaluation of vaccination decisions following side effects. Consequently, we developed a questionnaire based on existing validated instruments and the scientific literature, encompassing all variables of interest. However, we did not conduct psychometric validation or assess the instrument's internal consistency, which may affect the reliability of our findings. Future research should consider using validated instruments or conducting thorough psychometric testing of newly developed questionnaires.

It is important to consider that the data collection occurred during the post-pandemic period (January-March 2023), when COVID-19 was perceived as a milder illness and vaccination urgency had diminished. This context likely influenced our findings, as participants may have weighed their side effects experiences more heavily when the perceived risk of COVID-19 was lower.

Conclusions

The findings of this study highlight the complex factors influencing COVID-19 vaccination acceptance in Colombia, particularly when individuals are aware of potential side effects. The study reveals that a significant portion of the population, particularly women and those who experienced adverse effects, expressed doubts or regret about their decision to get vaccinated. These results suggest that personal experiences with side effects play a crucial role in shaping individuals' perceptions and willingness to receive further doses. Additionally, the data indicate that younger individuals tend to have fewer reservations about vaccination, even after experiencing side effects. This study provides important insights that could inform public health strategies, emphasizing the need to address concerns related to vaccine safety and effectiveness, particularly among vulnerable groups, to improve vaccination uptake and trust in the process.

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