Research Article

Analysis of application of covid-19 vaccine in Mexico city by age and gender groups in the second wave of the pandemic

Abstract

Considering the importance of giving continuity to economic activities that have been partially suspended by the global SARS-CoV-2 virus pandemic, the impact of virus contagions with the application of the vaccine was analyzed in Mexico City, in men and women by age groups in the second wave of the virus, from 28-June-2021 to 01-September-2021. Two Poisson regression panel models were performed by random effects by gender and age groups and the variables: infections, dose, applied vaccine, and diseases. A decrease in contagions was found with the AstraZeneca, CoronaVac, Pfizer, and Sputnik vaccines for men aged 18 to 29 years, AstraZeneca and CoronaVac for women aged 18 to 29; and AstraZeneca and Pfizer for men and women ages 50 to 59, as well as Sputnik for men and women over 60. It is concluded that COVID-19 vaccines act differently according to gender and age group. Furthermore, the vaccine that helped reduce contagions with the greatest impact was AstraZeneca for the group of 50 to 59 years old.

Keywords: SARS-CoV-2, COVID-19, vaccines, efficacy, pandemic

Martha Jiménez,[1] Humberto Ríos,[2] Pilar Gómez,[1] María Elena Tavera,[1] Raúl Junior Sandoval,[1] Francisco Pérez,[3] Ma. de los Ángeles Martínez,[4] Itzel Lourdes García,[1] José Antonio Romero,[1] Naisel Rafael Armenteros,[1] Pablo Antonio Castellanos[1]

[1]Instituto Politécnico Nacional – UPIICSA, México
[2]Instituto Politécnico Nacional – ESE, México
[3]Universidad Autónoma Chapingo, México
[4]Instituto Politécnico Nacional – ESIA TEC, México

Correspondence: Martha Jiménez García, Instituto Politécnico Nacional, UPIICSA, México, Tel 525556242000, Email majimenez@ipn.mx

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Introduction

The appearance of SARS-CoV-2 impacts the world in various aspects, such as public health and the economy[1] so it is necessary to guarantee mass vaccination and support the return of economic activities[2] and the mobility of people.[3] Besides stopping the mortality resulting from the pandemic that has left many orphans and consequently various social problems,[4] vaccination has been considered the only effective and possible solution to stop this devastating pandemic,[5] so less than a year after the collaborative effort and the identification of the viral sequence, the vaccine was obtained.[6] This showed that more efforts are needed to facilitate rapid vaccination coverage,[7] taking the necessary measures since SARS-CoV-2 may not be the last coronavirus to cause a global pandemic;[1] in addition to proposing public policies for immunization against the virus.[8]

Some research related to SARS-CoV-2 infections shows that men have a higher risk of infection than women,[9] in addition to gender, age is important.[10] Hence, it is important to conduct research that includes age and gender.

It is necessary to clarify that Mexico is one of the countries with the highest number of cases of deaths from SARS-CoV-2.[9] It is also one of the 10 countries with the highest mortality, and the number of cases and deaths continues to increase significantly. Similarly, Mexico City is the region with the highest number of reported cases.[11] Thus, the Mexican government decided to start vaccinating its population with adults over 60 years of age.

There are various research works in which some diseases such as hypertension or diabetes were analyzed with the risks associated with SARS-CoV-2.[9,12,13] But the diseases presented in this investigation were not, such as diabetes, pneumonia, hypertension, obesity, and smoking, related to SARS-CoV-2 infections.

In the case of vaccines applied to the population, there are several research works that analyze the effectiveness of the vaccine, some due to the risk of hospitalization for the Pfizer[14,15] or Moderna[16] vaccines in the United States, Israel, and the UK; as well as AstraZeneca in Chile & Brazil[17] CoronaVac in Brazil, Cansino in Mexico and Pakistan[18] or individual research in the United States for Pfizer and Moderna.[19] But there are no studies for Mexico City, this city being a place of high contagion of SARS-CoV-2 in Mexico, that include the type of vaccine and the contagion by said virus by gender and age groups, since the vaccine helps reduce contagion and protects against severe symptoms of the disease.[20]

Therefore, the objective of this research was to analyze the impact of SARS-CoV-2 virus infections and the application of the virus vaccine, applied to the population of Mexico City in men and women by age groups in the second wave presented in this city. In this research, two hypotheses were proposed: 1) AstraZeneca, CoronaVac, Pfizer, Sputnik vaccines help reduces the spread of SARS-CoV-2 in men and women, 2) Diabetes, pneumonia, hypertension, obesity, smoking, and other cases are elements that increase the spreading of COVID-19 in the second wave of contagion by SARS-CoV-2 in Mexico City.

Materials and methods

Study area

The research includes 16 boroughs of Mexico City, with a population of 9,209,944 inhabitants divided into 4,805,017 women and 4,404,927 men.[21]

Research design

Retrospective research was carried out. A descriptive and predictive study was carried out on the effects of the vaccine on the population of Mexico City. The study was not experimental, only

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data from free and open repositories were taken; the study variables were not manipulated or controlled. The study was carried out with data from Mexico City, as it is the entity with the highest number of infections in Mexico.

Data collection

Open data were taken from the General Directorate of Epidemiology on cases of contagion from the second wave of cases by COVID-19. 16 boroughs of Mexico City were considered for a period of 66 days that included from June 28-21 to 01-Sep-2021,[22] for people in the age groups 18 to 29, 30 to 39, 40 to 49, 50 to 59, and the group over 60, for men and women. In total, 116,066 records of women and 106,316 records of men were analyzed. For the data of the doses by type of vaccine in the locations of Mexico City, the notices of the page of the Secretary of Health of Mexico City published on twitter were taken.[23]

Data analysis

The data was classified by gender (men and women) and by age groups. Likewise, a grouping was made by the 16 localities of Mexico City and a count by date and by locality. Then, the data was graphed to know its trend by locality.

Contagion models in the second wave of COVID-19 when the vaccine was already applied

To know the variables that influence the infections of people with COVID-19 in health factors and the type of vaccine applied, two models were made by gender, one for men and one for women. Each model with all age groups with the dependent variable (infections) and the independent variables (dose, AstraZeneca, Pfizer, Sputnik, CoronaVac, Diabetes, Pneumonia, Hypertension, Obesity, Smoking, and Other Case) described in (Table 1) with panel data analysis in Stata version 14 software, through a Poisson regression for random effects, for having count data, plus: 1) The variance is equal to the expected value, 2) The more it increases, the more it approaches the normal distribution, and 3) The events are independent of each other. The assumption of no correlation between the residuals is taken, so a Poisson *log-linear* regression analysis was performed. For this, it was evaluated with the likelihood function presented in equation 1 and the logarithm in equation 2.

$$L(\beta) = \Pi_{i=1}^{n} f_i(yi) = \Pi_i^n = 1 \left[\lambda(\chi_{i,\beta}) \right]^{Y_i} \exp\left[-\lambda(\chi_{i,\beta})\right] \frac{1}{y_i!} = \frac{\left\{ \Pi_{i-1}^{n} \left[\lambda(\chi_{i,\beta})^{yi} \right] \right\} \exp\left[-\Sigma_{i=1}^{n} \lambda(\chi_{i,\beta})\right]}{\Pi_{i=1}^{n} y_i!} \quad (1)$$

$$\log_e L(\beta) = \Sigma_{i=1}^{n} Y_i \log_e\left[\lambda(\chi_{i,\beta})\right] - \Sigma_{i=1}^{n} \lambda(\chi_{i,\beta}) - \Sigma_{i=1}^{n} \log_e(Y_i!) \dots (2)$$

In the *log-linear* Poisson regression models, coefficients with high values (greater than 0.1) were obtained, so the exact approximation coefficients were calculated. That is, the exponent of the coefficient minus one was obtained and multiplied by one hundred; this in order to have an exact interpretation of these coefficients. To ascertain the existence of overdispersion, a χ^2 goodness-of-fit test was developed assuming that the observed data fit the Poisson *log-linear* model. These models were validated using the p value of χ^2 with a probability of error of 1%.

Results

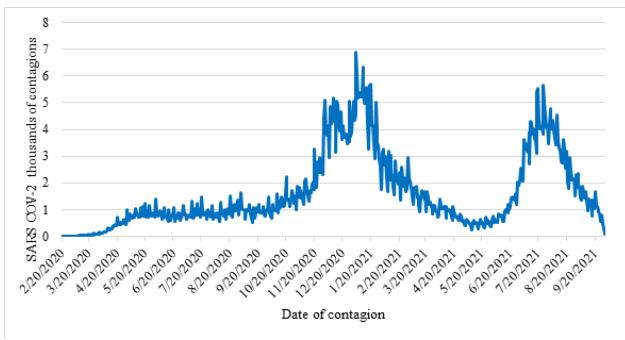The results are presented in two sections, descriptively and model results (Table 1).

Table 1 Variables used in the Poisson regression models.

| Variable	Description
Contagions	Number of registered cases of the population of SARS CoV-2 infections, by locality in Mexico City, by date, by age group, and by gender. Numerical variable that is provided daily by the General Directorate of Epidemiology
Age	5 age groups were considered for people with COVID-19: 1) 18 to 29 years old, 2) 30 to 39 years old, 3) 40 to 49 years old, 4) 50 to 59 years old, and 5) over 60 years old, the decision of these groups was due to the fact that the vaccine was assigned by said age groups
Gender	Women and men were considered, and the results presented are grouped by gender.
Vaccine dose	It is the number of vaccines against SARS CoV-2 that the study population has received, according to official notices from the Health Secretary, by age group, 0= no vaccine, 1= one dose, 2= two doses.
AstraZeneca	Type of vaccine against SARS CoV-2, called AstraZeneca that the study population received, binomial variable, 1=Yes, 0=No
Pfizer	Type of vaccine against SARS CoV-2, called Pfizer that the study population received, binomial variable, 1=Yes, 0=No
Sputnik	Type of vaccine against SARS CoV-2, called Sputnik that the study population received, binomial variable, 1=Yes, 0=No
CoronaVac	Type of vaccine against SARS CoV-2, called CoronaVac that the study population received, binomial variable, 1=Yes, 0=No
Diabetes	Number of patients with diabetes and who have SARS CoV-2, binomial variable, 1=Yes, 0=No
Pneumonia	Number of patients with pneumonia and who have SARS CoV-2, binomial variable, 1=Yes, 0=No
Hypertension	Number of patients with hypertension and who have SARS CoV-2, binomial variable, 1=Yes, 0=No
Obesity	Number of patients with obesity and who have SARS CoV-2, binomial variable, 1=Yes, 0=No
Smoking	Number of patients who smoke and who have SARS CoV-2, binomial variable, 1=Yes, 0=No
Other Case	Number of patients who had contact with someone diagnosed with SARS CoV-2, binomial variable, 1=Yes, 0=No

Descriptive results(Figures 1 & 2)

Model Results

Table 2 shows the Poisson regression model for random effects and type of vaccine applied to the age groups for men and women, with their respective estimated coefficients, the exact approximation coefficient, and its p-value. As well as the p value of Chi square to verify the validity of the model. The rows for the Sputnik vaccine for the age group of 18 to 20 years are only presented in men, since in women this variable was eliminated from the model to avoid collinearity.

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Figure 1 The trend of COVID-19 infections in Mexico City, and two waves of contagion are presented. For this research, only the second wave will be analyzed because it is the one that includes the type of vaccine applied to the population.
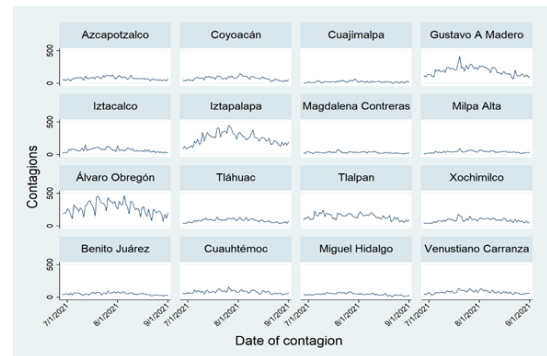
Figure 2 The contagion data for the 16 boroughs of Mexico City, only for the second wave and high contagions are perceived in the Gustavo A. Madero, Iztapalapa, and Álvaro Obregón boroughs, as well as several boroughs with very few infection cases.

Table 2 Poisson regression for random effects by type of COVID-19 vaccine in women and men

		Men			Women		
	Age	**Coeff.**	**Exact Approx. Coeff.**	**P value**	**Coeff.**	**Exact Approx. Coeff.**	***p* value**
cons		4.468		0.000	4.604		0.000
Vaccine dose	18-29	0.159	17.29	0.000	-0.11	-10.44	0.000
AstraZeneca	18-29	-0.426	-34.67	0.000	-0.199	-18.02	0.000
CoronaVac	18-29	-0.31	-26.69	0.000	-0.048	-4.71	0.033
Pfizer	18-29	-0.139	-13.01	0.001	-0.069	-6.69	0.11
Sputnik	18-29	-0.27	-23.65	0.000			
Vaccine dose	30-39	0.075	7.75	0.000	0.052	5.29	0.000
AstraZeneca	30-39	0.067	6.91	0.000	0.077	8	0.000
Vaccine dose	40-49	-0.072	-6.92	0.000	-0.057	-5.5	0.000
AstraZeneca	40-49	0.138	14.8	0.000	0.16	17.32	0.000
Pfizer	40-49	-0.127	-11.89	0.514	-0.148	-13.75	0.465
Vaccine dose	50-59	0.101	10.68	0.000	0.094	9.86	0.000
AstraZeneca	50-59	-1.201	-69.92	0.000	-1.162	-68.71	0.000
Pfizer	50-59	-0.643	-47.42	0.001	-0.642	-47.39	0.001
AstraZeneca	over 60 years old	-0.209	-18.87	0.182	-0.298	-25.74	0.07
Pfizer	over 60 years old	-0.15	-13.89	0.339	-0.21	-18.97	0.199
Sputnik	over 60 years old	-0.685	-49.6	0.003	-0.653	-47.97	0.007
Diabetes		0.01	1.05	0.000	0.009	0.88	0.000
Pneumonia		0.013	1.28	0.000	0.006	0.57	0.000
Hypertension		0.005	0.45	0.000	0.004	0.4	0.000
Obesity		0.006	0.63	0.000	0.007	0.72	0.000
Smoking		0.01	1.05	0.000	0.007	0.65	0.000
Other case		0.005	0.47	0.000	0.005	0.47	0.000
Log likelihood = -5155.0714			Prob > chi^2=0.000		Log likelihood = -5381.0167 Prob > chi^2=0.000		

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Discussion

Our findings indicated that in the population of men aged 18 to 29 years, from Mexico City, who were vaccinated with AstraZeneca, CoronaVac, Pfizer, and Sputnik, COVID-19 infections decreased by 34.67%, 26.69%, 13.01%, and 23.65% respectively. Similarly, infections for women of the same age group decreased by 10.44% for those who had at least one vaccine dose and decreased by 18.02% and 4.71% for women who were vaccinated with AstraZeneca and CoronaVac, respectively. Moreover, it was found that the vaccine that had the greatest impact on reducing infections was AstraZeneca for the group of 18 to 29 years in men and women.

Our findings also indicated that the number of infections by COVID-19 of men aged 40 to 49 years, from the population of Mexico City, decreased by 6.92% for those who received two doses of vaccines. Similarly, for women, contagion decreased by 5.50% for those who had two doses of vaccines. For this age group, the AstraZeneca vaccine did not help reduce infections and Pfizer was not significant.

Our results indicated that the number of infections by COVID-19 in men aged 50 to 59 years in the population of Mexico City decreased by 69.92% and 47.42%, when vaccinated with AstraZeneca and Pfizer, respectively. Similarly, for women of the same age group it decreased by 68.71% and 47.39%, for the AstraZeneca and Pfizer vaccines. Also, for men and women, the vaccine that had the greatest impact in reducing infections was AstraZeneca for the group of 50 to 59 years old.

Our findings indicated that the number of infections by COVID-19 in men over 60 years of age in Mexico City, vaccinated with Sputnik, decreased by 49.6%. Likewise, for women there was a decrease in infections of 47.97% with the Sputnik vaccine. The only vaccine that had an impact in reducing infections for the group over 60 years of age was Sputnik, the other vaccines were not significant.[17] Similarly, Sputnik had an efficiency of 91.6% according to a study by the Gamaleya Research Institute.[18] This is despite other research having argued the efficacy of vaccines.[7] As in the United Kingdom where Pfizer had an effectiveness of 88 to 100% and AstraZeneca 74.5%; or in the United States the effectiveness in preventing hospitalizations in adults aged 65 to 74 was 96% for Pfizer-BioNTech.[14] Although the effectiveness of the vaccine could be influenced by the intake of medicines by the elderly[24] or by the new variants.[17]

The findings indicated that the infections by COVID-19 and their relationship with the vaccines that did not have an impact on the decrease were AstraZeneca for men and women in the group of 30 to 39 years, as well as AstraZeneca for 40 to 49 years. Likewise, the increase in doses for the population group of men from 18 to 29 years old, 30 to 39 years old, and 50 to 59 years old did not reduce the spread of the virus.

Although the population of Mexico in general had the belief that the best vaccine was Pfizer[2,5] the findings presented by age groups and gender in the second wave of COVID-19 showed that other vaccines were more effective. So the effort of the authorization of different brands such as Pfizer, AstraZeneca, and Sputnik V worked in various countries such as the United States, India, Argentina, Mexico, Brazil, Pakistan, and Nepal.[1,26,27] Similarly, not all vaccines against COVID-19 may be equally effective in reducing deaths; regardless of the fact that Mexico has used 6 different vaccines, including Chinese vaccines (Sinovac/Sinopharm)[28] which may be less effective than other licensed vaccines.[29] However, in Mexico City, there has been a different behavior when analyzing by age groups and gender, since, there is contagion decreases, but not all in the same way.

In general terms, our results show that the vaccines have managed to reduce the infections, as they managed to reduce the second wave of SARS-CoV-2, since they are highly protective against diseases related to SARS-CoV-2. There was an effectiveness of the vaccine against severe acute respiratory syndrome infection of 89.11%; against hospitalization related to COVID-19 it was 97.2%; against admission to the intensive care unit 97.4%, and for death 99%.[30]

Our findings showed a very different distribution by vaccine type and age group, as the government decided who should be vaccinated and when;[27] although some people were hesitant to receive the SARS-CoV-2 vaccine,[31] due to lack of education or awareness.[32]

Our results show that in Mexico the vaccine has reduced COVID-19 infections for men and women in all age groups except for the group of 30 to 39 years. Furthermore, the vaccines have had a different impact, but for the most part all of them have managed to reduce contagion. This also complements the effectiveness of the vaccine that has been reported,[16] although they did not analyze it by gender but rather by hospitalizations. Also, other research in which only the Pfizer vaccines in teenagers aged 12 to 18[18] and Moderna[33] were analyzed.

We propose to carry out further research that includes occupation to analyze the mobility of their work area, mainly in the case of medical personnel,[34] since nurses have had a lower risk of death compared to doctors and other health workers. Health.[35]

Conclusion

In the second wave of the SARS-CoV-2 virus in Mexico City, the vaccines that reduced infections were: 1) AstraZeneca, CoronaVac, Pfizer, and Sputnik for men aged 18 to 29, 2) AstraZeneca and CoronaVac for women aged 18 to 29 years old, 3) AstraZeneca and Pfizer for men and women from 50 to 59 years old, 4) Sputnik for men and women over 60 years old.

SARS-CoV-2 infections in Mexico City for the second wave also decreased when two doses were already applied to the population for the group of men and women aged 40 to 49 years.

The AstraZeneca vaccine showed the greatest significant impact in reducing infections of the SARS-CoV-2 virus in the group of 18 to 29 years in men and women, and in 50 to 59 years. For the group of 60 years and older for men and women, it was the Sputnik vaccine.

In the second wave of COVID-19 in Mexico City, diseases such as diabetes, pneumonia, hypertension, obesity, smoking, and having been in contact with people infected with the virus, both for men and women, are negative factors that favor an increase in the spread of the SARS-CoV-2 virus.

The contribution of this work was to carry out an analysis by type of vaccine in age and gender groups in Mexico City, because it is the city with the highest infections in Mexico, to carry out public policies for immunization of the SARS-CoV-2 virus. However, it has the limitation of not including other diseases because they are not representative of the population. On the other hand, other lines of research are being initiated, such as occupation, to analyze mobility by age group and gender and find new predictions to reduce the spreading of the SARS-CoV-2 virus.

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COMMUNITIES" (ANALISIS DE EFECTOS DEL COVID-19 EN EL EMPLEO EN COMUNIDADES RURALES)

Conflicts of interest

Declare if any conflict of interest exists.

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