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Original Article

Impact of vaccination on COVID-19 morbidity and mortality among aged people

Impactos da vacinação na morbimortalidade por COVID-19 entre pessoas idosas

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ABSTRACT

Objective: to correlate COVID-19 incidence and mortality rates in elderly people before and after vaccination. **Methods:** an ecological study with data collected from the official platforms of the State Data Analysis System Foundation and the Prefeitura Municipal de Araraquara (Araraquara City Hall). The data was analyzed using a regression model with a negative binomial distribution and a logarithmic link function. We analyzed 3,188 COVID-19 records in people aged 60 or over, of which 3,137 were eligible for analysis. **Results:** there was a significant reduction in the incidence of the disease among vaccinated-aged people. No significant differences were observed in the mortality coefficient; however, there was a 67.7% decline in deaths when comparing the periods. **Conclusion:** the findings indicate a correlation between the vaccination of older individuals and the reduction in COVID-19 incidence and mortality rates, thereby demonstrating and underscoring the significance of adhering to vaccinations. **Contributions to practice** include the expansion of the theoretical framework regarding the significance of vaccination in reducing morbidity and mortality from COVID-19, particularly in the elderly population. This is especially important considering the endemicity of the disease and the unlimited availability of false information.

Descriptors: COVID-19; Immunization Programs; Health of the Elderly; Public Health; Vaccination.

RESUMO

Objetivo: correlacionar os coeficientes de incidência e mortalidade por COVID-19 em pessoas idosas antes e depois da vacinação. **Métodos:** estudo ecológico com coleta de dados realizada nas plataformas oficiais da Fundação Sistema Estadual de Análise de Dados e da Prefeitura Municipal de Araraquara. Os dados foram analisados por meio de modelo de regressão com distribuição binomial-negativa com função de ligação logarítmica. Foram analisados os 3.188 registros da COVID-19 em pessoas idosas com 60 anos ou mais, dos quais 3.137 foram elegíveis para análise. **Resultados:** constatou-se significativa redução na incidência da doença dentre pessoas idosas vacinadas. Não foram observadas diferenças significativas no coeficiente de mortalidade, entretanto, houve um declínio de 67,7% nos óbitos quando comparados os períodos. **Conclusão:** os resultados sugerem a existência de relação entre a vacinação de pessoas idosas e a redução dos coeficientes de incidência e mortalidade por COVID-19, comprovando e reforçando a importância da adesão às vacinas. **Contribuições para a prática:** amplia o arcabouço teórico sobre a relevância da vacinação para a redução da morbimortalidade por COVID-19, especialmente na população idosa, sendo essencial diante de um cenário de endemização da doença e acesso ilimitado a informações falsas.

Descritores: COVID-19; Programas de Imunização; Saúde do Idoso; Saúde Pública; Vacinação.

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Introduction

The elderly population, defined in Brazil as individuals aged 60 or over, is a risk group susceptible to developing the severe form of COVID-19, with a higher risk of death[1-2]. Elderly people are at greater risk of complications resulting from infection with Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), especially because they are more likely to have low immunity and comorbidities, conditions which, when associated with infection with the virus, increase the chances of death[3].

In the first year of the pandemic, in 2020, elderly people were the group most susceptible to progressing to the severe form of COVID-19, and around 80% of recorded deaths occurred among elderly people, representing a higher mortality rate than in young and adult patients[1]. In addition, the elderly population has the highest coefficients of lethality and incidence of the disease compared to the general population[4].

In this context, vaccination has become fundamental for protecting and reducing the risk of clinical complications among the elderly. In Brazil, the National Vaccination Plan of the Brazilian National Immunization Program (PNI, in Portuguese) has been subdivided, prioritizing groups with greater vulnerability to COVID-19. The first phase began in the country on January 18, 2021, prioritizing risk groups, especially elderly people[5].

At the beginning of the COVID-19 immunization campaign, Brazil was facing an increase in cases and deaths due to the spread of the Gamma variant (P.1), identified in March 2021 in the state of Amazonas. This increase in infections and deaths has translated into high bed occupancy rates inwards and Intensive Care Units (ICUs). Furthermore, this new variant was associated with the second wave of the COVID-19 pandemic, being more transmissible than the initial variant and associated with an increase in overall mortality and cases among younger people[6]. Thus, the rapid spread of the virus associated with the emergence of the Gamma variant increased cases, hospitalizations, deaths, overcrowding of ward and ICU beds, and the consequent collapse of the health system[7].

Subsequently, the positive effects of vaccination became evident in the country, especially between July and November 2021, with a reduction in the incidence of cases, severity, and mortality from the disease. Vaccination protects against the severe form of the disease in elderly people and reduces cases and deaths from COVID-19. In this context, it is estimated that 19.8 million deaths were avoided worldwide during the first year of vaccination[8-9].

Given the elderly population's greater risk of COVID-19 severity, strategies to reduce contamination and, consequently, the risk of complications and deaths have become fundamental. Although the international literature shows the positive impact of vaccination on reducing the incidence and mortality of COVID-19 among elderly people, Brazil still lacks studies that analyze the effects of vaccination on this population group to improve health policies, especially in the face of the disease's endemicity[8-10].

This study, therefore, aimed to correlate COVID-19 incidence and mortality rates in elderly people before and after vaccination.

Methods

This ecological study, presented by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines, was conducted in the city of Araraquara, located in the state of São Paulo. The estimated elderly population is 45,445 inhabitants[11].

A total of 3,137 COVID-19 records were eligible, reported among individuals aged 60 and over, before the start of vaccination of this age group, which began on May 6, 2021, up to three months after vaccination, covering the period from February 12, 2020, to August 6, 2021. It should be noted that the date of a confirmed COVID-19 case corresponds to the onset of symptoms reported by the user when taking the test. In the period following the start of vaccination, elderly

people who received at least one dose of the AstraZeneca and CoronaVac vaccines were considered.

The data on notified cases in the municipality was obtained by searching the official website of the State Data Analysis System Foundation, which is accessible on the São Paulo State Government website[12]. Information related to the municipality's demographic composition was taken from the official website of the Araraquara City Hall, maintaining the same population numbers for the years 2020 and 2021. Information on the immunization schedule was also obtained from the city's official website.

Data collection took place in January 2022, after which a database was built using Excel spreadsheet software. During the analysis period, 3,188 notifications of COVID-19 in elderly people were made. After applying the study's eligibility criteria, 3,137 disease records were kept. Fifty-one records without valid information on sex and outcome (death) were excluded.

The epidemiological (confirmed COVID-19 case and outcome) and sociodemographic (gender) variables were analyzed. At first, a descriptive analysis of the incidence of COVID-19 was carried out, considering the sociodemographic variable.

To compare the periods before and after vaccination to the number of daily COVID-19 cases and deaths, a regression model with a negative binomial distribution with a logarithmic link function[13] was used, considering that the response consisted of a count with overdispersion (variance greater than the mean). To estimate an incidence coefficient, an offset parameter of log(population/100,000) was used for the incidence of cases and log(cases/100) for deaths.

Simulations were carried out to estimate the number of cases and deaths avoided based on the forecast number of cases if the intervention had not been implemented. The total number of cases and deaths observed after the intervention was subtracted from the estimates of predicted cases and deaths. In the simulations, 10,000 replications were carried out using the bootstrap method. The simulated samples were summarized by median and percentiles (2.5; 97.5). A significance level of 5% was adopted for the analyses. The statistical analyses and graphs were drawn up using the R software, version 4.0.4.

The research used secondary data from publicly accessible electronic addresses and did not require an opinion from the Research Ethics Committee, by Resolution 466/12 of the National Health Council.

Results

During the investigation period, 3,137 cases of COVID-19 were reported. Between February 12, 2020, the onset of symptoms of the first case of COVID-19 reported in the municipality, and May 5, 2021, 2,331 cases were reported among elderly people, of which 55.6% were female. In the period of vaccination of the elderly population, May 6 to August 6, 2021, 806 cases were reported, of which 57.2% occurred in women.

When comparing the percentage variations in the incidence coefficient during the periods for individuals aged 60 and over, there was an increase of 5.7% in the COVID-19 incidence coefficient in the female population, while in the male population, there was a decrease of 3.1%. About the general sample of people aged 60 and over, there was an 81.1% decrease in the COVID-19 incidence coefficient (Table 1).

Table 1 – Incidence of COVID-19 among people aged 60 and over in Araraquara. São Carlos, SP, Brazil, 2024

Variables	Incidence of COVID-19 cases per 100,000 inhabitants			
	Before		After	
	Coefficient	95% CI*	Coefficient	CI 95%
Gender				
Female	2.634	2.172–3.195	2.784	2.246–3.451
Male	2.226	1.831–2.706	2.158	1.726–2.698
Total	2.359	1.973–2.82	0.445	0.269–0.736

*CI: confidence interval

Note: incidence coefficient per 100,000 inhabitants and 95% CI estimated by regression models with negative binomial distribution

The pre-and post-vaccination trends are similar for both females (Figure 1A) and males (Figure

1B). Regarding the daily COVID-19 incidence coefficient, no disparities were observed between women and men. It is notable that in females the peak reached a higher value, with more than 20 cases recorded in a single day before vaccination (Figure 1A), while in males it was just over 15 cases (Figure 1B).

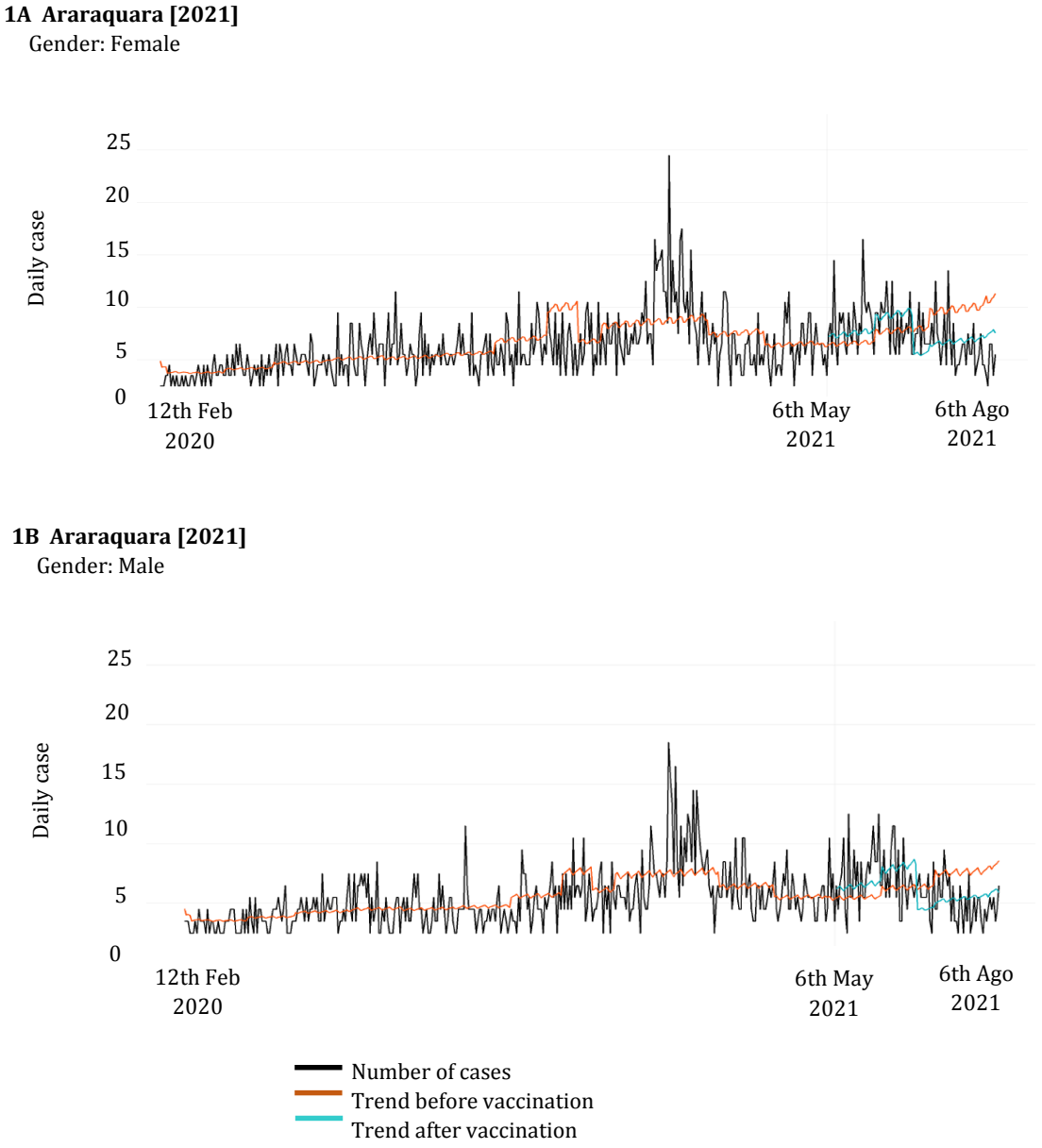

Figure 1 – Daily COVID-19 cases in Araraquara by sex among people aged 60 and over. São Carlos, SP, Brazil, 2024

During three months after the start of vaccination, 806 cases of COVID-19 were recorded among individuals aged 60 and over, projecting that, without vaccination, 1,283 cases could have been recorded. The simulation conducted indicates that 477 cases of COVID-19 were prevented between May 6 and August 6, 2021.

From the start of the pandemic in 2020 until August 6, 2021, 319 deaths were reported in the age group analyzed. Of this total, 281 deaths occurred before the start of vaccination of elderly people, while 38 occurred after the start of vaccination of this group.

The presence of many "zeros" is due to the occurrence of cases during the period but the absence of deaths. Deaths peaked in the period before vaccination began in the population analyzed, followed by a decline in the period before vaccination. Furthermore, after May 6, 2021, there was a drop in the number of daily deaths (Figure 2).

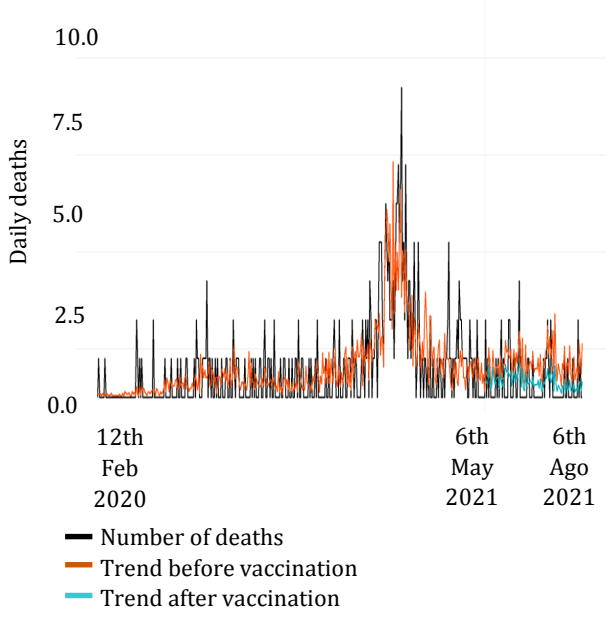

Figure 2 – Daily deaths from COVID-19 in Araraquara among people aged 60 and over. São Carlos, SP, Brazil, 2024

When analyzing the percentage variation in the COVID-19 incidence coefficient among elderly people, a 67% decrease was observed when comparing the periods before and after vaccination. However, although it is not possible to identify a statistically significant difference in the incidence coefficients using the model used, this reduction is clinically relevant, given the direct reduction in severe cases and deaths.

No significant discrepancies were observed concerning the trend in deaths before and after vaccination, and it was not possible to model mortality by sex, since many daily cases were zero, which made it impossible to calculate the ratio of the number of deaths to the number of cases.

There were 38 deaths three months after vaccination; it is estimated that there would have been 83 deaths in this period if vaccination had not taken place. Therefore, in this group, 45 deaths were avoided in the period from May 6 to August 6, 2021, according to the simulation.

Discussion

This study revealed that, after vaccinating elderly people, there was an 81.1% reduction in the incidence rate of COVID-19 cases in the municipality of Araraquara. In this context, it is clear that COVID-19 vaccines have played an essential role in containing the pandemic, reducing the severity of the disease and mortality. It is estimated that more than 19 million deaths were avoided worldwide in the first year of COVID-19 vaccination, representing 63% of the total deaths estimated for the period. It has also been estimated that 45% of deaths could have been avoided in low-income countries if they had reached 20% of the established vaccination coverage[9].

In this context, administering booster doses of COVID-19 vaccines is associated with greater protection of individuals[12-13]. While the efficacy of the second dose of COVID-19 vaccines may only offer short-term protection to the individual, considering the Delta and Omicron variants, a third dose may provide greater protection against symptomatic infection and severe cases[14]. The third dose of the Pfizer vaccine, administered on average 10 months after the second

dose, was found to be 95.3% more effective against COVID-19 than the second dose[15].

The concern about the need to reduce SARS--CoV-2 infection in this population is that the aging process is associated with a decrease in immunity and the development of comorbidities that make elderly people more vulnerable to infections[16]. Comorbidities play a fundamental role in the evolution of the clinical condition of elderly patients with COVID-19, especially hypertension, diabetes, obesity, cardiovascular diseases, and diseases of the respiratory system[3,17].

Due to their immune deficiency, elderly people are subject to a lower immune response capacity to infections, and, in this context, vaccines are less effective in this population. The reduced response to immunization is due to decreased adaptive immune response, inflammation, and dysregulation in cytokine production. However, despite their reduced efficacy in elderly people, vaccines are essential for protection against the disease since they can protect against complications, hospitalizations, and death through cellular immune responses induced against SARS-CoV-2[18].

This shows that vaccination can have an important and positive impact on mitigating COVID-19 outbreaks. Even though they confer limited protection against infection by the virus, the immunizers developed have been able to reduce the number of cases and deaths among elderly people and protect them against the severe form of the disease[9]. Therefore, considering the high risk of complications and death, vaccinating older people is an effective way of reducing hospitalization and mortality.

Internationally, similar findings to this study were found when comparing the periods before and after the start of vaccination among elderly people, with a 79% reduction in the incidence of COVID-19 cases among those aged 65 and over and a 71% reduction among those aged between 50 and 64[19]. There were significant reductions in cases of the disease when comparing the older age groups, 65 to 74 years and 75 years and over, to the 50 to 64 age group, respectively, of 53% and 64% in the incidence of cases when comparing the periods before and after vaccination[20].

The reductions in the incidence coefficients of the disease in the elderly population after vaccination indicate a positive effect of immunization in containing the spread of the disease, even with the lower effectiveness of immunizers due to physiological issues related to immunosenescence[21]. However, given the presence of circulating variants of concern and the endemization of the disease, in a scenario of wide dispersion, adherence to vaccination in this population group is still essential to reduce the spread's speed and the increase in the number of cases.

This study also found that the incidence rate of COVID-19 in the city of Araraquara increased among females after vaccination began, which may be associated with the relaxation of preventive measures, such as wearing a mask, hand hygiene, and physical distancing. This finding diverges from generally observed trends, which indicate greater susceptibility to COVID-19 infection among males[21]. However, estrogen seems to confer a protective effect on females, due to its anti-inflammatory and immunomodulatory effect against COVID-19[22].

On the other hand, concerning the increased prevalence of COVID-19 cases among women found in the municipality of Araraquara, a higher incidence of the disease among women has also been found internationally. This incidence may be associated with gender-related factors, such as the higher number of women among health professionals when employed and residents of long-term care facilities[23-24].

The higher incidence of COVID-19 among women may also be related to the more significant number of contacts established with other people, contributing to the acquisition and spread of the disease. Furthermore, there is evidence of gender patterns with health concerns, with women seeking health services more often; in other words, they are more concerned about the appearance of symptoms, which is reflected in more excellent testing for COVID-19[25-26].

Thus, the lower coefficient of the disease among men may be associated with greater underreporting of cases due to the lower testing of this population group.

However, although our findings show a higher incidence of COVID-19 among women, other records show different gender patterns, indicating a higher incidence of cases in elderly people. The chance of infection with SARS-CoV-2 has been higher among adult women, while in the elderly population, higher incidence rates are found among men[25-26].

In addition, there has been a reduction in mortality from COVID-19 among elderly people in the municipality, comparing the periods before and after vaccination began. In this context, with the progress of immunization of the elderly population, the importance of vaccination for the protection of these individuals was noted, showing that, as vaccination coverage for COVID-19 increases, the mortality rate from the disease tends to reduce.

The analysis of the effect of vaccination against COVID-19 in the international context showed that the overall effectiveness of the vaccines was 79.8% for the prevention of death in elderly people hospitalized for COVID-19 and 72.8% for those without the need for hospitalization in the period from March 11 to October 26, 2021[27]. In this context, it has also been estimated that, in the period from December 1, 2020 to September 30, 2021, a vaccination program against COVID-19 prevented 154,000 deaths among elderly people aged 65 and over and 66,000 deaths in the 50-64 age group[28].

The rapid increase in vaccination coverage among elderly people has reduced mortality[29]. The occurrence of deaths among unvaccinated older people aged 75 and over was 132 times higher when compared to those who had received two doses of the vaccine, considering the AstraZeneca and CoronaVac immunizers[30]. Furthermore, an estimate of the impact of vaccination on elderly people found that the proportion of deaths in individuals aged 80 and over fell from 25% in the period between the 1st and 6th weeks after immunization to 12.4% in the 19th week[29].

Study limitations

This study has limitations related to the under-reporting of COVID-19 cases and deaths in the period. However, these limitations did not affect the study results, which showed the positive effect of vaccination in reducing COVID-19 cases, severity, and deaths, strengthening the arguments against anti-vaccine discourse.

Contributions to practice

The results of this study expand the theoretical framework on the importance of vaccination in reducing COVID-19 morbidity and mortality in the elderly population, reinforcing the need to continue and expand immunization campaigns as an essential public health strategy. In addition, the study contributes to health education and communication, combating misinformation with robust scientific data on the benefits of vaccination.

In a scenario of COVID-19 endemicity, the results strengthen immunization policies and resource allocation, prioritizing the vaccination of at-risk groups. The information obtained is valuable for public health managers, guiding the development of evidence-based long-term strategies.

In addition, the evidence regarding vaccination against COVID-19 in the elderly population contributes to care practices, reinforcing nursing's role in health education and guidance for elderly people and their families, ensuring greater adherence to immunization campaigns, and tackling misinformation.

Conclusion

The results of this study add to the literature on the positive effects of vaccination in reducing the incidence of COVID-19 in the elderly population, as evidenced by the significant drop in the incidence of the disease after vaccination in the age group analyzed. With the mortality coefficient, there was no statisti-

cally significant difference; however, clinically, the decline in the number of deaths observed in the period is relevant. The results show that there is a relationship between vaccination of the elderly population and a reduction in the COVID-19 incidence and mortality coefficients.

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Authors' contribution

Conception and design or analysis and interpretation of the data; writing of the manuscript or relevant critical review of the intellectual content; final approval of the version to be published and responsibility for all aspects of the manuscript: Poli P, Uehara SCSA. Interpretation of data; drafting of the manuscript; final approval of the version to be published; and responsibility for all aspects of the manuscript: Ribeiro AC.

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