

COVID-19 in Arapongas city – State of Paraná – Brazil: evolution and effects of vaccination between March 2020 and June 2023

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Abstract: *The COVID-19 pandemic, caused by the SARS-CoV-2 virus, had strong impacts that go beyond the health aspect. This research, carried out with data from Arapongas - PR, Brazil, covers the period from March 2020 to June 2023, and aims to show the evolution of COVID-19 and highlight the role of vaccination in reducing the lethality rate. Between March 2020 and June 2023, 41,305 cases and 644 deaths by COVID-19 were recorded. In the first half of 2021, the lethality rate for the period was 2.91%, and in the first half of 2023, the rate was 0.31%. The reduction in the lethality rate coincided with the increase in vaccination rates, since, by June 2023, 93.17% of the population had received at least one dose of the vaccine and 84.73% the second dose or single dose. If the lethality rate had remained at the level recorded until the first half of 2021, the city would have recorded 426 more deaths from COVID-19, reaching 1070 deaths, an increase of 66.15%. Despite hesitancy fueled by misinformation and social media, the vaccination campaign (COVID-19) was highly effective. Of the 644 deaths related to COVID-19, 73.9% were unvaccinated. No deaths were recorded among individuals under 60 years of age who received the fourth dose, 2nd booster or bivalent vaccine, and for individuals aged 60 or over, five deaths were recorded among those who received the fourth dose or 2nd booster, and no deaths for those who received the bivalent vaccine. The conclusions affirm the potential of vaccines to save lives and the need for ongoing public health initiatives to prevent and treat diseases, carry out vaccination campaigns and combat fake news.*

Keywords: *Arapongas; COVID-19; Pandemic; Public-institutional partnership; Vaccination.*

COVID-19 na cidade de Arapongas - Estado do Paraná – Brasil: evolução e efeitos da vacinação entre março de 2020 e junho de 2023

Resumo: *A pandemia da COVID-19, causada pelo vírus SARS-CoV-2 teve fortes impactos que vão além do aspecto sanitário. Esta pesquisa, feita com dados de Arapongas - PR, Brasil, abrange o período de março de 2020 a junho de 2023, e tem como objetivo mostrar a evolução da COVID-19 e ressaltar o papel da vacinação na redução da taxa de letalidade. Entre março de 2020 e junho de 2023 foram registrados 41305 casos e 644 óbitos por COVID-19. No primeiro semestre de 2021 a taxa de letalidade do período era de 2,91%, e no primeiro semestre de 2023, a taxa era de 0,31%. A redução da taxa de letalidade coincidiu com o aumento das taxas de vacinação, uma vez que, até junho de 2023, 93,17% da população tinha recebido pelo menos uma dose da vacina e 84,73% a segunda dose ou dose única. Se a taxa de letalidade tivesse se mantido no patamar registrado até o primeiro semestre de 2021, a cidade teria registrado mais 426 óbitos por COVID-19, alcançando 1070 óbitos, um aumento de 66,15%. Apesar da hesitação alimentada pela desinformação e pelas redes sociais, a campanha de vacinação (COVID-19) foi altamente eficaz. Das 644 mortes relacionadas à COVID-19, 73,9% foram de não vacinados. Nenhuma morte foi registrada entre indivíduos com menos de 60 anos que receberam a quarta dose, 2º reforço ou vacina bivalente, e para os indivíduos com 60 anos ou mais, foram registradas cinco mortes entre aqueles que receberam a quarta dose ou o 2º reforço, e nenhum óbito para os que receberam a vacina bivalente. As conclusões afirmam o potencial das vacinas para salvar vidas e a necessidade de iniciativas contínuas de saúde pública na prevenção e no tratamento de doenças, na realização de campanhas de vacinação e no combate às notícias falsas.*

Palavras-chave: *Arapongas; COVID-19; Pandemia; Parceria Público-institucional; Vacinação.*

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Introduction

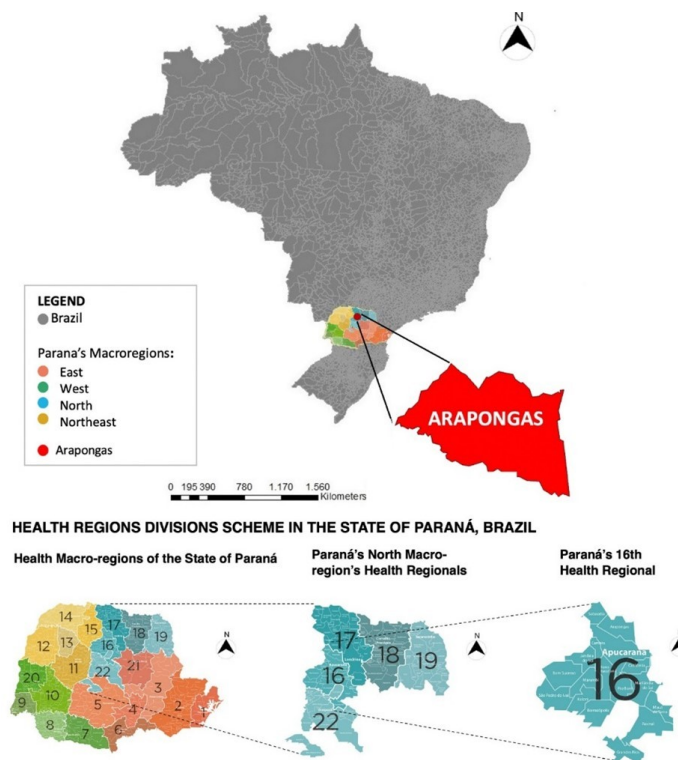
The COVID-19 pandemic, caused by the SARS-CoV-2 virus had strong impacts that go beyond the health aspect. In the end of 2019, within a few weeks, the epidemic outbreak of COVID-19, unleashed in the Chinese city of Wuhan, spread rapidly to other countries, due to the high transmissibility of the SARS-CoV-2 virus (ZHU et al., 2020).

Brazil is located in South America, with an estimated population of more than 200 million inhabitants. The Brazilian Unified Health System (“Sistema Único de Saúde” SUS) provides universal and free access to a comprehensive set of healthcare services for the population (BOTEGA et al., 2020). According to Correa-Galendi et al. (2020), about 70% of the population is exclusively insured with SUS and private insurance offers supplementary coverage.

The first COVID-19 case in Brazil was confirmed by the Brazilian Ministry of Health on February 25, 2020. This event also represented the first case of COVID-19 in the South American region, with a population of over 640 million people (RODRIGUEZ-MORALES et al., 2020).

The State of Paraná, located in the south of Brazil, is divided into four health macro-regions: macro-regional east, macro-regional west, north macro-regional and northwest macro-regional. The city of Arapongas is in the north of the State of Paraná (Figure 1). The health macro-regions in the State of Paraná are subdivided into twenty-two “Health Regionals”. The 16^a Health Regional comprises 17 cities with an estimated population of 390,543 inhabitants. Arapongas is the second biggest city of the 16^a Health Regional with an estimated population of 124,810 inhabitants in 2020, 126,545, in 2021 and 119,138 in 2022 and 2023 according to IBGE (2023).

Figure 1. Location of State of Paraná and Arapongas city in Brazil and Health Regions Divisions Scheme in the State of Paraná.



Fonte: Autores.

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On March 11, 2020, COVID-19 was classified as “pandemic” by the “World Health Organization” (WHO). In March 20, 2020, without the register of COVID-19 cases in Arapongas, but as prevention measures, the City Government established some coping measures of social distance to contain the spread of the virus at an early stage, which involved closing activities considered “non essentials” for 15 days starting in March, 22, 2020.

Not only the City Government, but also the Paraná State Government decreed a lot of measures to contain the spread of COVID-19 in Paraná State. One of them started on March 20, in which presential classes in schools and Universities were suspended.

Considering the new demands for specialized technical analyzes caused by the advent of the COVID-19 pandemic, starting in May 2020, and extending until the end of the pandemic period, a public-institutional partnership was signed between Arapongas and the State University of Londrina (UEL) through the Interdisciplinary Center for Public Management (NIGEP). To this end, data provided by the municipal health department and research carried out with other municipalities belonging to the same health region (16th region), were systematized, and periodically analyzed by the technical team of participants in the Extension Project “BRDATA: Brasil em Dados”. Results of these analyzes (including descriptive statistics, R_0 and spatial analyzes carried out using geoprocessing platforms) were presented and discussed in weekly meetings with representatives from both institutions. In addition, the main results were published in weekly bulletins available on social media and the city of Arapongas official website. Results of this partnership helped municipal management in making important decisions such as lockdowns and the reopening of schools and businesses, in order to minimize human and economic costs caused by the pandemic, in addition to strengthening public-institutional links in scientific production and provision of services to the community.

Studies show the evolution of COVID-19 in cities of State of Paraná (SUSUKI et al., 2021; OLAK et al., 2021), the impact of this new disease in the hospitalization (OLAK et al., 2021; PASSARELLI-ARAUJO et al., 2022a; PASSARELLI-ARAUJO et al., 2023) and also the importance and the positive effects of the vaccination to slow down mainly the number of deaths by COVID-19 (PASSARELLI-ARAUJO et al., 2022b; PALUDETTO JUNIOR et al., 2023).

The aim of this research is present the evolution of COVID-19 in Arapongas and the effects of the vaccination in COVID-19 cases and deaths between March 2020 and June, 2023, considering that in May, 5, 2023 the WHO chief declared end to COVID-19 as a global health emergency.

Background of COVID-19 in Arapongas - State of Paraná – Brazil

The first COVID-19 case in Arapongas was registered on March 31, 2020, of a woman 39 years old, who had returned from the State of “Rio Grande do Sul”, in the south of Brazil. The second case was registered on April 01, 2020, of a 34-year-old woman, who in March had contact with people from another State. Both women recovered.

On April 10, 2020, new measures of the city Hall allowed the return of some activities on April 13, 2020, that were previously considered “nonessentials”, and the use of masks became mandatory. Up to April 13, 2020, the city had registered 9 COVID-19 cases, and the first death by COVID-19 of a woman aged 79 years.

On April 16, 2020, bars, restaurants, and convenience stores were allowed to return the presential attendance with some restrictions, and on April 17, 2021, the open markets could also return, and the gyms could reopen on April 27, 2020.

Reaching 146 cases and 3 deaths by COVID-19 until June 23, 2020, bars and restaurants had to decrease the open hours, and were allowed to stay opened for the presential attendance until 22:00. Until July 30, 2021, the city had registered 1345 cases and 33 deaths by COVID-19, and on August, 01, 2020 and August, 02, 2020, all commercial, religious activities and services provision could not work, and essential activities and delivery were kept.

Between June 2020 and December 2020 no decrees were published by the City Government from Arapongas limiting “non-essential” activities, and presential classes were still suspended by the decree of Paraná State Government. Until December 31, 2020, Arapongas had registered 7114 cases and 139 deaths by COVID-19.

Until January 17, 2021, Arapongas had registered 8176 cases and 161 deaths by COVID-19. In this day the National Health Surveillance Agency from Brazil, “ANVISA” authorized the emergency use of the vaccines Oxford/AstraZeneca and Coronavac.

The vaccination (COVID-19) in Arapongas started on January 20, 2021. The order of vaccination was determined by the National Plan for the Operationalization of Vaccination against Covid-19 - NPOVaC (2020) developed by the Ministry of Health from Brazil. The dates of the vaccination according to the NPOVaC were not fixed due to the low availability of vaccines in January 2021. The vaccination advanced following the order of NPOVaC according to the arrival of doses in the city. The number of available doses in Brazil was equally distributed to the cities following to the number of people to be vaccinated, using the population estimation by IBGE. At this stage the vaccination was authorized for people with 18 years or more.

On February 23, 2021, the National Health Surveillance Agency from Brazil, “ANVISA” authorized the definitive record for the Pfizer vaccine, to be applied in people with 16 years or more.

On February 25, 2021, with 10608 cases and 192 deaths by COVID-19, the City Government from Arapongas published a decree in which the main points were: closing of restaurants, bars and similar at 11 pm; maximum capacity of 50% of capacity; ban on live music, concerts, etc; ban on the use of farms, recreational areas, state ban on events with more than 25 people.

On February 27, 2021, with 10733 cases and 198 deaths by COVID-19 in Arapongas, the municipal government started to follow the decree of Paraná State Government, developed with the aim to decrease the raising of COVID-19 cases, in which non-essential activities were suspended until March 08, 2021.

On March, 31, 2021, the National Health Surveillance Agency from Brazil, “ANVISA” authorized the emergency use of the Janssen vaccine, for people with 18 years or more, and in June, 11, 2021, the National Health Surveillance Agency from Brazil, “ANVISA” authorized people with 12 years or more to be vaccinated with the Pfizer vaccine (until this date just people with 16 years or more were allowed to receive the Pfizer vaccine).

On September 2, 2021, with 21384 cases and 559 deaths by COVID-19 in Arapongas, the classes returned, and on September 3, 2021, following the instructions of the Ministry of Health from Brazil, the third dose of the vaccine (Pfizer) started to be applied in elderly over 70 years old and in people with comorbidities over 18 years old.

On September 24, 2020, with 22249 cases and 566 deaths by COVID-19 in Arapongas, the teenagers between 12 and 17 years with comorbidities started to be vaccinated, and the vaccination

for teenagers without comorbidities with 17 years started on September 29, 2021, for those with 16 years on October 4, 2021, and those with 15 years on October 19, 2021.

On October 6, 2021, the health professionals also started to receive the third dose of the vaccine, and on October 13, 2021, the third dose started to be applied in elderly over 60 years old.

On November 4, 2021, 14 years old teenagers without comorbidities started to be vaccinated, those with 13 years on November 10, 2021, and those with 12 years on November 12, 2021. On November 29, 2021, people with 40 years or more that had received two doses of Coronavac, Pfizer or Astrazeneca started to receive the third dose, and on November 25, 2021, the third dose started for those with 18 years or more (in both cases, after completing five months after the second dose). On December 21, 2021, the interval between the second and third dose decreased from five to four months.

On December 13, 2021, people with 40 years or more that had received the only dose (Janssen) started to receive the booster shot.

Until December 31, 2021, Arapongas had registered 23551 COVID-19 cases, 575 deaths by COVID-19 and 22928 recovered from the disease.

On January 08, 2022, all that had received the only dose (Janssen) at least two months ago, could have the booster shot, and on January 18, 2022, has started the vaccination for those between 5 and 11 years, prioritizing children with permanent disabilities, comorbidities or who live with people with a high degree of immunosuppression. On January 27, 2023, started the vaccination of kids with eleven years old, without comorbidities, followed by the vaccination of kids with ten years old (January 31, 2023), and until January 31, 2023, Arapongas had 99672 vaccinated with one dose, 85533 with the second dose, 25429 the booster dose and 3395 the only dose.

On February 07, 2023, started the vaccination of kids with 9 years old, followed by 8 years old (February 11, 2023), 6 and 7 years old (February 14, 2023) and 5 years old (February 18, 2023).

On March 03, 2023, started the application of the fourth dose against COVID-19 for immunosuppressed people over 18 years old, on March 10, 2023, the use of masks in Arapongas became optional, both in open and closed environments, and on March 10, 2023, started the application of the fourth dose in elderly people aged 80 years or older.

On April, 4, 2023 started the application of the fourth dose in elderly people aged 60 years or older, in May, 30, 2023, the application of the booster dose for teenagers between 12 and 17 years old, in June, 6, 2023 the fourth dose for people over 50 years old and all health professionals, and in June, 21, 2023 the fourth dose for people over 40 years old, and in all the situation the fourth dose should be applied respecting the period of at least four months after the third dose.

On August 08, 2023, started the vaccination for kids with four years old and the fourth dose for people with 35 years old or more, on August 26, 2023, the vaccination for kids with three years old and the fourth dose for people with 30 years old or more.

On October 26, 2023, the fourth dose was released for all those with 18 years old or more. With the arrival of the "Pfizer baby", on November 24, 2023, started the vaccination for babies with six months and comorbidities, and on January 16, 2023, started the vaccination for kids between six months and two years old without comorbidities.

On February 28, 2023, started the vaccination with the bivalent vaccine, focused on people aged 70 and over; population living in long-term care facilities for the elderly; people over 12 years of age who are immunocompromised; indigenous, riverside and quilombola communities over 12 years old; according to the recommendation of the Ministry of Health.

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In March, 03, 2023, the bivalent vaccine, was available for people aged 70 and over, and in March, 14, 03, 2023 was extended to pregnant and postpartum women and health workers, in April, 04, 2023 also included the group of comorbidities (severe hemoglobinopathy; diabetes mellitus; severe chronic lung diseases; chronic kidney disease; hypertension that is difficult to control or with complications/target organ damage; severe obesity; Down syndrome; liver cirrhosis; chronic neurological disease and cardiovascular disease) from 12 to 59 years old.

On April 25, 2023, following the new regulations of the National Immunization Program (PNI), made official by the Ministry of Health – and also through the Department of Health of the State of Paraná (Secretaria da Saúde do Estado do Paraná - SESA), the application of the booster dose with the bivalent vaccine against COVID-19 for people over 18 years old. People who had taken at least two doses of previous vaccines could receive the bivalent vaccine (respecting the last dose interval of four months).

On May 5, 2023, the OMS declared the end of COVID-19 as a public health emergency. Until June 30, 2023, Araçongas had registered 41305 cases, 644 deaths, 111002 had received the first dose of the vaccine (93.17% of the population), 100940 the second dose or single dose (84.73% of the population), 53652 the third dose or 1st booster (45.03% of the population), 18637 the fourth dose or 2nd booster (15.64% of the population) and 9105 the bivalent vaccine (7.64% of the population).

Data

The data used in this research were the confirmed COVID-19 cases in Araçongas and additional information of the cases as age, death and data about the vaccination in the city. The period considered covers March 2020 until June 2023. All the data was provided by the City Health Secretary of Araçongas and the project was approved by the ethical committee under nº 44128621.3.0000.5231.

Statistical Analysis

The statistical analyses were performed using summary tables and graphs to identify the evolution of COVID-19 and the effects of the vaccination in Araçongas. All the analyses were conducted in software R (R CORE TEAM, 2023).

Results

The months considered in this research (March 2020 until June 2023) were separated in seven periods.

- Period 1 - March 2020 until June 2020
- Period 2 - July 2020 until December 2020
- Period 3 - January 2021 until June 2021
- Period 4 - July 2021 until December 2021
- Period 5 - January 2022 until June 2022
- Period 6 - July 2022 until December 2022
- Period 7 - January 2023 until June 2023

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On Table 1 is presented the number of COVID-19 cases, deaths, vaccine doses applied, lethality (number of deaths/number of cases x 100) and on Table 2 the respective cumulative numbers.

Table 1. Number of cases, deaths (by COVID-19), vaccine doses applied and lethality in the periods considered (absolute numbers, total by 100000 inhabitants and the respective percentage)

Variable	March - June	July - December	January - June	July - December	January - June	July - December	January - June	Total	Total (by 100000)	%
	2020		2021		2022		2023			
Nº of cases in the period	250	6864	12992	3445	13975	2803	976	41305	34669.88	34.67%
Nº of deaths in the period	9	133	378	55	56	10	3	644	540.55	0.54%
Fisrt dose	-	-	46655	55427	7430	690	800	111002	93170.94	93.17%
Second dose or single dose	-	-	15293	72384	11214	1371	678	100940	84725.28	84.73%
Third dose or 1st booster	-	-	-	13005	35523	4403	721	53652	45033.49	45.03%
Fourth dose or 2nd booster	-	-	-	-	9350	8337	950	18637	15643.20	15.64%
Bivalent vaccine	-	-	-	-	-	-	7642	7642	6414.75	6.41%
Lethality (%)	3.60%	1.94%	2.91%	1.60%	0.40%	0.36%	0.31%	1.56%	1.56%	1.56%

Fonte: Autores.

Table 2. Cumulative number of cases, deaths (by COVID-19), vaccine doses applied and lethality in the periods considered (absolute numbers, total by 100000 inhabitants and the respective percentage)

Variable	March - June	July - December	January - June	July - December	January - June	July - December	January - June	Total	Total (by 100000)	%
	2020		2021		2022		2023			
Cumulative number of cases	250	7114	20106	23551	37526	40329	41305	41305	34669.88	34.67%
Cumulative number of deaths	9	142	520	575	631	641	644	644	540.55	0.54%
Fisrt dose	-	-	46655	102082	109512	110202	111002	111002	93170.94	93.17%
Second dose or single dose	-	-	15293	87677	98891	100262	100940	100940	84725.28	84.73%
Third dose or 1st booster	-	-	-	13005	48528	52931	53652	53652	45033.49	45.03%
Fourth dose or 2nd booster	-	-	-	-	9350	17687	18637	18637	15643.20	15.64%
Bivalent vaccine	-	-	-	-	-	-	7642	7642	6414.75	6.41%
Lethality (%)	3.60%	2.00%	2.59%	2.44%	1.68%	1.59%	1.56%	1.56%	1.56%	1.56%

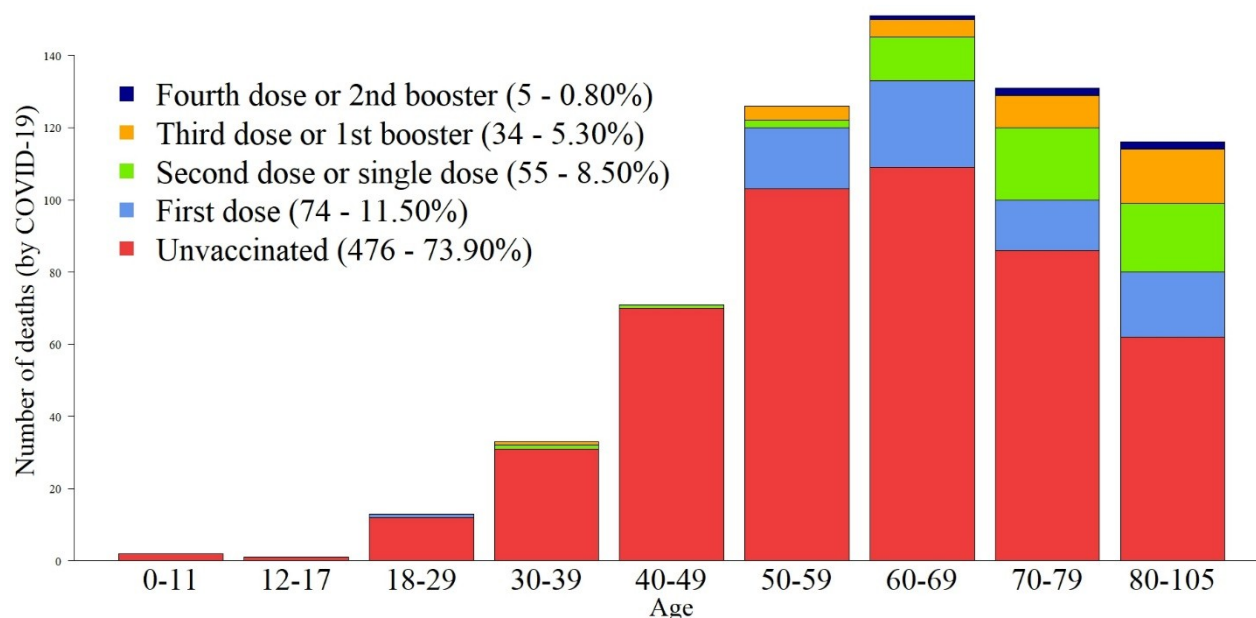
Fonte: Autores.

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On Figure 2 is presented the number of deaths (COVID-19) by age, between March 2020 and June 2023, according to the vaccinal situation (COVID-19)

Figure 2. Number of deaths by COVID-19 according to the vaccinal situation (COVID-19)



Fonte: Autores.

On Table 3 is presented the number of deaths (by COVID-19) according to age (under 60 years old or 60 years or older) and vaccinal situation (COVID-19).

Table 3. Deaths by COVID-19 according to age and vaccinal situation (COVID-19)

Vaccinal situation	Individuals under 60 years old		Individuals aged 60 years or older		Total deaths	
Unvaccinated	219	89.02%	257	64.57%	476	73.91%
First dose	18	7.32%	56	14.07%	74	11.49%
Second dose or single dose	4	1.63%	51	12.81%	55	8.54%
Third dose or 1st booster	5	2.03%	29	7.29%	34	5.28%
Fourth dose or 2nd booster	0	0.00%	5	1.26%	5	0.78%
Bivalent vaccine	0	0.00%	0	0.00%	0	0.00%
Total	246	100.00%	398	100.00%	644	100.00%

Fonte: Autores.

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Final Considerations

Between March 2020 and June 2023 Arapongas city had registered 41305 cases and 644 deaths by COVID-19. The lowest lethality (0.31%) was registered between January 2023 and June 2023, period in which 93.17% of the population had received the first dose of the vaccine, 84,73% the second dose or the only dose, 45.03% the third dose or 1st booster, 15.64 the fourth dose or 2nd booster and 7,64% the bivalent vaccine.

The vaccination started in January 2021, and between January 2021 and June 2021 the general lethality was 2.59%. The lethality constantly decreased after this period and until June 2023 the general lethality was 1.56%. If the lethality had been maintained 2.59% from January 2021 until June 2023, instead of 644 deaths (540.54 deaths by 100000) the city would have registered 1070 deaths (897.95 deaths by 100000), an increase of 426 deaths (66.15%) as shown on Table 4.

Tabela 4. Cumulative number of cases, deaths, lethality, hypothetical lethality, and hypothetical number of deaths (by COVID-19) in the period considered.

Variable	March - June 2020	July - December	January - June 2021	July - December	January - June 2022	July - December	January - June 2023	Total	Total by 100000	%
Cumulative number of cases	250	7114	20106	23551	37526	40329	41305	41305	34669.88	34.67%
Cumulative number of deaths	9	142	520	575	631	641	644	644	540.54	0.54%
Real Lethality (%)	3.60%	2.00%	2.59%	2.44%	1.68%	1.59%	1.56%	1.56%	0.0156 or 1.56%	1.56%
Hypothetical lethality*	3.60%	2.00%	2.59%	2.59%	2.59%	2.59%	2.59%	2.59%	0.0259 or 2.59%	2.59%
Hypothetical cumulative number of deaths*	9	142	520	610	972	1045	1070	1070	897.95	0.90%

*Considering the lethality 2.59% from January 2021 until June 2023.

Fonte: Autores.

From the total number of deaths by COVID-19 in Arapongas (644), 476 (73.90%) were unvaccinated. There were no deaths of individuals under 60 years that received the Fourth dose or 2nd booster and the bivalent vaccine, and for those with 60 years or more, 5 deaths of individuals that received the Fourth dose or 2nd booster and no deaths for those that had the bivalent vaccine. This reinforces the importance of the COVID-19 vaccination, mainly for those with 60 years or more.

The eradication of various diseases (vaccine-preventable) was possible around the world mainly due to vaccination, through successful immunization programs (SATO, 2018). According to Domingues and Teixeira (2013) the “Programa Nacional de Imunizações do Brasil (Brazilian National Immunization Program – PNI)” is recognized for promoting the free vaccination, and it has been getting increasingly complex, both by expanding the number of vaccines provided as by the diversification of immunization schedule, but as pointed by DUBÉ et al. (2015), the “National Immunization Program” can also be considered as one of the causes of its crisis, because as diseases

no longer circulate, they become unknown and there is a reduction in the population's engagement. Thus, fertile ground is created for vaccine hesitation, articulated, at the present time, through social networks. The fake news also impacted the hesitance in vaccination. In GALHARDI et al. (2022), they concluded that this “phenomenon” was crucial in discouraging the adherence of segments of the Brazilian population to social distancing and vaccination campaigns.

The COVID-19 vaccination in Brazil started following the order established by the National Plan for the Operationalization of Vaccination against Covid-19 - NPOVaC (2020) that had many updates, with the last edition (13^a edition) published in May 2022 (NPOVaC, 2022). Even the vaccine being considered by most of the population and the scientific community the main solution to overcome this pandemic, there was also some hesitance by part of the population in having the COVID-19 vaccine.

According to the Meta Analysis published by FAJAR et al. (2022), in which 56 articles were analyzed, the factors associated with higher risk of vaccination hesitancy were being a woman, being a 50-year-old or younger, being single, being unemployed, living in a household with five or more individuals, having an educational attainment lower than an undergraduate degree, having a non-healthcare-related job and considering COVID-19 vaccines to be unsafe, and the factors associated with lower risk of hesitancy to COVID-19 vaccination were living with children at home, maintaining physical distancing norms, having ever tested for COVID-19, and having a history of influenza vaccination in the past few years.

The COVID-19 vaccination was very important in Arapongas as in other cities in Brazil, mainly avoiding deaths, that could have been higher (1070) compared to the 644 deaths by COVID-19 recorded until June 2023.

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