ORIGINAL ARTICLE

OBJN
Online Brazilian Journal of Nursing
ISSN: 1676 - 4285 | www.objnursing.uff.br

Submission: 08-Dec-2025
Approved: 08-Feb-2026

FACTORS ASSOCIATED WITH THE CLINICAL OUTCOMES OF OLDER ADULTS WITH COVID-19 ACCORDING TO VACCINE AVAILABILITY: AN OBSERVATIONAL STUDY

FATORES ASSOCIADOS À EVOLUÇÃO CLÍNICA DE PESSOAS IDOSAS POR COVID-19 SEGUNDO DISPONIBILIDADE VACINAL: ESTUDO OBSERVACIONAL

FACTORES ASOCIADOS A LA EVOLUCIÓN CLÍNICA DE PERSONAS MAYORES POR COVID-19 SEGÚN DISPONIBILIDAD VACUNAL: ESTUDIO OBSERVACIONAL

Luiz Hiroshi Inoue[1] ORCID: 0000-0002-7226-9661
Wanessa Cristina Baccon[1] ORCID: 0000-0001-9750-3576
Francielle Renata Danielli Martins[1] ORCID: 0000-0002-8578-9615
Guilherme Kenzo Acutu[1] ORCID: 0000-0002-5940-8110
Márcia Lorena Alves dos Santos[1] ORCID: 0000-0002-1098-1944
Giovana Alves Santos Rodrigues[1] ORCID: 0000-0002-5586-4688
Maria Aparecida Salci[1] ORCID: 0000-0002-6386-1962
Lígia Carreira[1] ORCID: 0000-0003-3891-4222

[1] Universidade Estadual de Maringá, Maringá, PR, Brazil.

How to cite: Inoue LH, Baccon WC, Martins FRD, Acutu GK, Santos MLA, Rodrigues GAS, et al. Factors associated with the clinical outcomes of older adults with COVID-19 according to vaccine availability: an observational study. Online Braz J Nurs. 2026;25(1):e20266878. https://doi.org/10.17665/1676-4285.20266878

RESUMO

Objetivo: Identificar a associação de fatores sociodemográficos e clínicos com a evolução clínica de pessoas idosas hospitalizadas em UTI no estado do Paraná, segundo a disponibilidade vacinal contra Covid-19. **Método:** Estudo observacional analítico, de base populacional, com dados secundários de idosos hospitalizados por COVID-19 em UTI. As razões de chances condicionais foram estimadas, a homogeneidade entre estratos foi avaliada pelo teste de Breslow-Day (5%), e a independência condicional pelo teste de Mantel-Haenszel, com estimativa da razão de chances comum. **Resultados:** Associaram-se a maiores chances de alta hospitalar: faixa etária (OR = 1,97), sexo feminino (OR = 1,20) e cor/raça branca (OR = 1,22). Pessoas idosas com grau de escolaridade $\leq$ 9 anos de estudo (OR = 0,63), com fatores de risco (OR = 0,69), diabetes (OR = 0,82), imunodeficiência (OR = 0,57), doença hepática (OR = 0,50), doença hematológica (OR = 0,56), pneumopatia (OR = 0,61) e uso de suporte ventilatório (OR = 0,30) apresentaram menores chances de alta hospitalar. **Conclusão:** A vacinação associou-se a maiores chances de alta hospitalar segundo faixa etária, sexo, cor da pele branca e maior escolaridade. Comorbidades como diabetes mellitus, imunodeficiência, doença hepática, pneumopatias e uso de suporte ventilatório reduziram essa chance.
Descritores: Covid-19; Enfermagem em Saúde Pública; Esquemas de Imunização; Saúde do Idoso; Unidade de Terapia Intensiva.

ABSTRACT

Objective: To identify the association of sociodemographic and clinical factors with the clinical outcomes of older adults hospitalized in intensive care units (ICUs) in the state of Paraná, according to the availability of COVID-19 vaccination. **Method:** Analytical observational, population-based study using secondary data from older adults hospitalized with COVID-19 in ICUs. Conditional odds ratios were estimated, homogeneity between strata was assessed using the Breslow-Day test (5%), and conditional independence was evaluated using the Mantel-Haenszel test, with estimation of the common odds ratio. **Results:** The following were associated with higher odds of hospital discharge: age group (OR = 1.97), female sex (OR = 1.20), and White race/color (OR = 1.22). Older adults with $\leq$ 9 years of schooling (OR = 0.63), risk factors (OR = 0.69), diabetes (OR = 0.82), immunodeficiency (OR = 0.57), liver disease (OR = 0.50), hematological disease (OR = 0.56), chronic lung disease (OR = 0.61), and use of ventilatory support (OR = 0.30) had lower odds of hospital discharge. **Conclusion:** Vaccination was associated with higher odds of hospital discharge according to age group, sex, White skin color, and higher educational level. Comorbidities such as diabetes mellitus, immunodeficiency, liver disease, chronic lung disease, and the use of ventilatory support reduced this likelihood.
Descriptors: COVID-19; Public Health Nursing; Immunization Schedules; Health of the Elderly; Intensive Care Units.

RESUMEN

Objetivo: Identificar la asociación de factores sociodemográficos y clínicos con la evolución clínica de personas mayores hospitalizadas en UCI en el estado de Paraná, según la disponibilidad de la vacuna contra la Covid-19. **Método:** Estudio observacional analítico, de base populacional, con datos secundarios de adultos mayores hospitalizados por COVID-19 en UCI. Se estimaron las razones de momios (odds ratios) condicionales, se evaluó la homogeneidad entre estratos mediante la prueba de Breslow-Day (5%) y la independencia condicional a través de la prueba de Mantel-Haenszel, con estimación de la razón de momios común. **Resultados:** Se asociaron con mayores probabilidades de alta hospitalaria: el grupo etario (OR = 1,97), el sexo femenino (OR = 1,20) y el color/raza blanca (OR = 1,22). Las personas mayores con un nivel de escolaridad $\leq$ 9 años de estudio (OR = 0,63), con factores de riesgo (OR = 0,69), diabetes (OR = 0,82), inmunodeficiencia (OR = 0,57), enfermedad hepática (OR = 0,50), enfermedad hematológica (OR = 0,56), neumopatía (OR = 0,61) y uso de soporte ventilatorio (OR = 0,30) presentaron menores probabilidades de alta hospitalaria. **Conclusión:** La vacunación se asoció con mayores probabilidades de alta hospitalaria según el grupo etario, sexo, color de piel blanca y mayor escolaridad. Comorbilidades como diabetes mellitus, inmunodeficiencia, enfermedad hepática, neumopatías y el uso de soporte ventilatorio redujeron dicha probabilidad.
Descriptores: Covid-19; Enfermería en Salud Pública; Esquemas de Inmunización; Salud del Anciano; Unidades de Cuidados Intensivos.

Publisher:
Escola de Enfermagem Aurora de Afonso Costa – UFF
Rua Dr. Celestino, 74 – Centro, CEP: 24020-091 – Niterói, RJ, Brazil
Journal email: objn.cme@id.uff.br

Corresponding author:
Luiz Hiroshi Inoue
E-mail: lhinoue17@gmail.com

What is already known:

- COVID-19 has a high case-fatality rate among older adults, significantly worsened by the presence of preexisting comorbidities.
- COVID-19 vaccination has been proven effective in reducing hospitalizations, severe complications, and deaths in the older population.
- Clinical outcomes of ICU patients with COVID-19 changed throughout the pandemic, following epidemiological changes and adjustments in clinical management.

What this article adds:

- Vaccine availability reduced overall mortality, but comorbidities such as liver disease and immunodeficiency remained associated with lower odds of discharge.
- Sociodemographic factors, specifically higher educational level and White skin color, were determinants of increased survival chances in the ICU.
- The magnitude of the association between specific comorbidities (e.g., kidney disease, heart disease, and neurological disease) and ICU outcomes (discharge/death) varied across periods, indicating temporal heterogeneity in clinical vulnerabilities among older adults.

INTRODUCTION

COVID-19, declared a pandemic on March 11, 2020[1], remains a public health problem. Although the world has resumed a certain level of normality after the critical period, the disease has continued to be one of the leading causes of death from respiratory infections, especially among older adults and children, accounting for more than 7 million deaths[2]. In Brazil, more than 716,000 deaths have been recorded, with particular concern for the first months of 2025, during which more than 130,000 cases and hundreds of deaths were reported[1].

Infection with the virus that causes COVID-19 may pose a high health risk for individuals of advanced age and those with preexisting comorbidities, increasing the likelihood of hospitalization, complications, and death in this population[3]. In the United States of America (USA), a study found that adults aged over 65 years accounted for 53% of admissions to Intensive Care Units (ICUs) and 80% of deaths, with a linear increase in mortality as age advanced[4]. In Brazil, a similar study identified an increase of more than 70% in the risk of death among older adults admitted to ICUs and diagnosed with COVID-19[5].

The proportion of deaths among older adults due to COVID-19 in Brazil reached 76% between February and September 2020[6]. Disease severity and lethality may be related to the presence of comorbidities such as arterial hypertension, diabetes mellitus, respiratory diseases, cardiovascular diseases, and obesity, which become risk factors for individuals infected with COVID-19[7].

Beyond individual risk, the hospitalization of older adults in ICUs exposed care-related and organizational challenges: severe clinical conditions requiring ventilatory and hemodynamic support, greater care complexity, and, during periods of high transmission, pressure on beds and healthcare teams, with direct repercussions for resource management and clinical decision-making processes[8].

Recent studies have documented that capacity overload in scarcity scenarios is associated with changes in decisions related to ICU eligibility, raising ethical and care-related implications[9,10]. At the same time, even when the acute outcome is favorable, relevant consequences may persist after critical illness, including functional impairment and the need for post-discharge follow-up, encompassing components of "Long COVID" with physical, cognitive, and psychosocial effects[11]. Among older adults, the literature emphasizes the importance of evaluating outcomes beyond hospital discharge, incorporating functionality and quality of life as central dimensions of care[12].

As a strategy to reduce disease progression, vaccines were developed to prevent complications and death. With the start of vaccination in Brazil in January 2021, older adults were included in priority groups, considering their vulnerabilities and greater susceptibility to infection[13]. According to recommendations from the Ministry of Health, the vaccination schedule prioritized individuals aged 80 years or older and residents of Long-Term Care Facilities (LTCFs)[14]. Two months after the start of vaccination, the first positive results were observed, with a significant reduction in the percentage of deaths among older adults in these institutions[15].

Studies published in 2025 support that vaccination and booster doses reduce hospitalizations and severe outcomes, although evidence indicates waning protection over time, reinforcing the need for monitoring according to time since the last dose and individual risk profile[16,17]. Additionally, studies involving hospitalized patients have reported an association between vaccination and lower risk of ICU admission, reduced mortality, and shorter length of hospital stay[18,19].

Despite advances in understanding the impact of vaccination, knowledge about clinical outcomes and morbidity and mortality among older adults hospitalized in ICUs, specifically in relation to vaccination status, remains limited. Although existing studies include older adults, detailed analyses focused exclusively on this group are scarce.

In this context, it is essential to understand how sociodemographic and clinical factors interact with vaccination status to influence the clinical course of older adults with COVID-19 hospitalized in ICUs. Conducting an association study is justified by the need to identify factors related to more severe outcomes, such as death, even after the introduction of vaccination. Such evidence may contribute to the development of more effective public policies and care strategies, as well as to the monitoring of vaccination effectiveness in vulnerable populations.

Considering the increased susceptibility of older adults to complications, ICU admission, and death due to COVID-19, as well as the effectiveness of vaccination in reducing hospitalizations, the objective of this study was to identify the association of sociodemographic and clinical factors with the clinical outcomes of older adults hospitalized in ICUs in the state of Paraná, according to the availability of COVID-19 vaccination.

METHOD

This was a retrospective analytical observational study based on secondary data, linked to the cohort "Longitudinal Follow-up of Adults and Older Adults Discharged from Hospitalization due to COVID-19," developed through a partnership between the State University of Maringá (UEM) and the Paraná State Health Department (SESA/PR), with financial support from the National Council for Scientific and Technological Development (CNPq). The observational design was adopted because it is appropriate for investigating associations between sociodemographic and clinical characteristics and ICU hospitalization outcomes among older adults with COVID-19, without direct intervention on individuals.

The use of statewide secondary data enabled the inclusion of a large population contingent, increasing the statistical power of the analyses. The analytical approach was based on estimating odds ratios, stratified according to periods of COVID-19 vaccine availability, in order to incorporate relevant temporal variations in the epidemiological and healthcare context. The study was conducted in the state of Paraná, which comprises 399 municipalities and an estimated population of 11,675,661 inhabitants, of whom 1,927,286 are older adults, according to DataSUS projections for 2020[20]. The analyses followed the recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline[21].

Sociodemographic and clinical data were obtained from the Influenza Epidemiological Surveillance Information System (SIVEP-Gripe) database, maintained by the Health Surveillance Secretariat of the Ministry of Health, updated on November 7, 2022. Public-domain data from compulsory notification forms for Severe Acute Respiratory Syndrome (SARS) were used; these forms do not allow individual patient identification[22]. The study period ranged from March 16, 2020, to March 15, 2022.

The study population comprised individuals aged 60 years or older, residing in Paraná, with a final diagnosis of COVID-19, hospitalized and admitted to ICUs within the state. Records with missing information for residence area, education level, and race/color were excluded, as well as deaths due to causes unrelated to COVID-19. Of the 23,297 initial records, the final sample included 11,918 older adults after systematic application of the exclusion criteria, ensuring the robustness of the results.

The explanatory (independent) variables included: age group (60–74 years; ≥75 years), sex (male; female), race/color (White; Black/Asian/Indigenous), education (≤9 years; >9 years), area of residence (urban/peri-urban; rural), use of influenza antivirals, influenza vaccination, presence of risk factors/comorbidities, and use of ventilatory support. Specific comorbidities (diabetes mellitus, immunodeficiencies, chronic liver, hematological, cardiovascular, neurological, or kidney diseases, asthma, and chronic lung diseases) were also analyzed individually. The primary outcome (response variable) was ICU hospitalization outcome, categorized as hospital discharge (recovery) or death.

The stratifying variable was temporal vaccine availability, categorized into three periods: Unavailable: March 16, 2020, to January 18, 2021 (pre-vaccination); Partially available: January 19, 2021, to June 3, 2021 (initial phase and gradual rollout); and Available: June 4, 2021, to March 15, 2022 (full vaccination schedule available for the age group).

For each explanatory variable, conditional odds ratios were estimated within each vaccine availability stratum. Homogeneity of the odds ratios across strata was assessed using the Breslow–Day test (5% significance level). When homogeneity was confirmed, the Mantel- Haenszel test was applied to verify the common association across periods. In cases of heterogeneity (rejection of the Breslow–Day hypothesis), the adjusted Breslow–Day test was used for post-hoc comparisons.

Data were processed using R software (version 4.3.2), with the magrittr, dplyr, and tidyverse packages for data manipulation, and DescTools, vcd, and epiDisplay for stratified 2×2 analyses.

The study was approved by the Research Ethics Committee involving Human Beings (Opinion No. 4,214,589; CAAE: 34787020.0.3001.5225), in accordance with Resolutions 466/2012 and 510/2016 of the National Health Council. As public-domain data without individual identification were used, the requirement for informed consent was waived.

RESULTS

The analyzed data comprise records from a sample of 11,918 older adults hospitalized and admitted to ICUs due to COVID-19 in the state of Paraná, distributed across three periods of vaccine availability: unavailable (n = 4,486), partially available (n = 4,638), and available (n = 2,794).

Across the three periods analyzed, most older adults admitted to ICUs were aged 60 to 74 years, were male, had White skin color, and lived in urban/peri-urban areas within the same municipality where hospitalization occurred. Regarding education, the group with more than nine years of schooling predominated. Most of the study population did not use antivirals, had not received influenza vaccination, and presented at least one risk factor.

With respect to COVID-19 vaccination, it was observed that during the partially available period, a minority of older adults admitted to ICUs had been vaccinated. In contrast, during the available period, most older adults admitted to ICUs had already received the vaccine, as detailed in Table 1.

Table 2 presents the association analysis between sociodemographic and clinical variables and the outcomes of older adults hospitalized in ICUs due to COVID-19, stratified by vaccination periods, based on the Breslow-Day test.

The Breslow-Day test assessed the homogeneity of odds ratios (ORs) across the periods. Significant differences ($p < 0.05$) were observed for age group, cardiovascular disease, neurological disease, and kidney disease, indicating that the magnitude of the association between these variables and the outcome varied according to the vaccination period.

Table 1 - Sociodemographic and clinical characteristics of older adults hospitalized in ICUs due to COVID-19 in the state of Paraná, according to COVID-19 vaccination status (n = 11,918). Maringá, PR, Brazil, 2022

Variables	Unavailable n= 4486 (37.6%)		Partially available n= 4638 (39.0%)		Available n= 2794 (23.4%)	
	Discharge (n %)	Death (n %)	Discharge (n %)	Death (n %)	Discharge (n %)	Death (n %)
Age group (in years)						
60 to 74	996 (22.5)	1697 (37.8)	788 (17.0)	2456 (53%)	510 (18.3)	1025 (36.7)
75 or older	430 (9.6)	1363 (30.4)	195 (4.2)	1199 (25.8)	361 (12.9)	898 (32.1)
Sex						
Female	641 (14.3%)	1234 (27.5)	477 (10.3)	1550 (33.4)	404 (14.5)	848 (30.4)
Male	785 (17.5)	1826 (40.7)	506 (10.9)	2105 (45.4)	467 (16.7)	1075 (38.5)
Race / skin color						
White	1203 (26.8)	2470 (55.1)	831 (17.9)	2990 (64.5)	739 (26.4)	1596 (57.1)
Black/Asian/Indigenous	223 (4.9)	590 (13.2)	152 (3.3)	665 (14.3)	132 (4.8)	327 (11.7)
Education						
$\leq$ 9 years	422 (9.4)	1164 (25.9)	254 (5.5)	1379 (29.7)	253 (9.1)	741 (26.5)
> 9 years	1004 (22.4)	1896 (42.3)	729 (15.7)	2276 (49.1)	618 (22.1)	1182 (42.3)
Area of residence						
Urban / Peri-urban	1382 (30.8)	2953 (65.8)	938 (20.2)	3467 (74.8)	830 (29.7)	1821 (65.2)
Rural	44 (1.0)	107 (2.4)	45 (1.0)	188 (4.0)	41 (1.5)	102 (3.6)
Resides in city of hospitalization						
Yes	910 (20.3)	1858 (41.4)	570 (12.3)	2206 (47.6)	499 (17.9)	1108 (39.7)
No	516 (11.5)	1202 (26.8)	413 (8.9)	1449 (31.2)	372 (13.2)	815 (29.2)
Used antiviral for flu						
Yes	223 (5.0)	473 (10.5)	15 (0.3)	62 (1.3)	7 (0.2)	16 (0.6)
No	1203 (26.8)	2587 (57.7)	968 (20.9)	3593 (77.5)	864 (30.9)	1907 (68.3)
Received Flu Vaccine						
Yes	266 (5.9)	565 (12.6)	138 (3.0)	497 (10.7)	114 (4.1)	249 (8.9)
No	1160 (25.9)	2495 (55.6)	845 (18.2)	3158 (68.1)	757 (27.1)	1674 (59.9)
Received Covid-19 Vaccine						
Yes	0 (0.0)	0 (0.0)	166 (3.6)	704 (15.2)	614 (22)	1286 (46)
No	1426 (31.8)	3060 (68.2)	817 (17.6)	2951 (63.6)	257 (9.2)	637 (22.8)
Has risk factors/comorbidities						
Yes	1206 (26.9)	2701 (60.2)	743 (16.0)	3013 (65.0)	711 (25.4)	1653 (59.2)
No	220 (4.9)	359 (8.0)	240 (5.2)	642 (13.8)	160 (5.7)	270 (9.7)
Diabetes mellitus						
Yes	484 (10.8)	1186 (26.4)	293 (6.3)	1234 (26.6)	281 (10.1)	691 (24.7)
No	942 (21.0)	1874 (41.8)	690 (14.9)	2421 (52.2)	590 (21.1)	1232 (44.1)
Immunodeficiency						
Yes	26 (0.6)	119 (2.6)	17 (0.4)	78 (1.7)	21 (0.7)	77 (2.8)
No	1400 (31.2)	2941 (65.6)	966 (20.8)	3577 (77.1)	850 (30.4)	1846 (66.1)
Chronic Liver Disease						
Yes	14 (0.3)	66 (1.5)	8 (0.2)	46 (1.0)	8 (0.3)	37 (1.3)
No	1412 (31.5)	2994 (66.7)	975 (21.0)	3609 (77.8)	863 (30.9)	1886 (67.5)
Chronic Hematological Disease						
Yes	6 (0.1)	28 (0.6)	6 (0.1)	41 (0.9)	9 (0.3)	28 (1.0)
No	1420 (31.7)	3032 (67.6)	977 (21.1)	3614 (77.9)	862 (30.9)	1895 (67.8)
Asthma						
Yes	43 (1.0)	87 (1.9)	23 (0.5)	86 (1.8)	19 (0.7)	55 (1.9)
No	1383 (30.8)	2973 (66.3)	960 (20.7)	3569 (77.0)	852 (30.5)	1868 (66.9)
Chronic Lung Disease						
Yes	89 (2.0)	299 (6.7)	41 (0.9)	229 (4.9)	53 (1.9)	190 (6.8)
No	1337 (29.8)	2761 (61.5)	942 (20.3)	3426 (73.9)	818 (29.3)	1733 (62.0)
Chronic Cardiovascular Disease						
Yes	803 (17.9)	1777 (39.6)	483 (10.4)	1929 (41.6)	415 (14.9)	1084 (38.8)
No	623 (13.9)	1283 (28.6)	500 (10.8)	1726 (37.2)	456 (16.3)	839 (30.0)
Chronic Neurological Disease						
Yes	88 (2.0)	289 (6.4)	54 (1.7)	204 (4.4)	45 (1.6)	203 (7.3)
No	1338 (29.8)	2771 (61.8)	929 (20.0)	3451 (74.4)	826 (29.6)	1720 (61.6)
Chronic Kidney Disease						
Yes	77 (1.7)	276 (6.2)	31 (0.7)	216 (4.7)	71 (2.5)	180 (6.4)
No	1349 (30.1)	2784 (62.1)	952 (20.5)	3439 (74.1)	800 (28.6)	1743 (62.4)
Use of Ventilatory Support						
Yes	1224 (27.3)	2923 (65.2)	899 (19.4)	3552 (76.6)	762 (27.3)	1830 (65.5)
No	202 (4.5)	137 (3.0)	84 (1.8)	103 (2.2)	109 (3.9)	93 (3.3)

Source: prepared by the authors, 2025.

Table 3 presents the variables for which the Breslow–Day test indicated homogeneity of the odds ratios across the vaccine availability periods, allowing the calculation of the Mantel– Haenszel common odds ratio. This estimate was statistically significant for sex, race/skin color, education, presence of risk factors, diabetes, immunodeficiency, liver disease, chronic lung disease, and use of ventilatory support.

Older women and older adults of White race/skin color had 20% and 22% higher odds of hospital discharge, respectively, compared with older men and those of Black, Asian, or Indigenous race/skin color. It is important to note that sex and race/skin color were analyzed separately in relation to the outcome.

Regarding education, older adults with fewer than 9 years of schooling had 27% lower odds of discharge compared with those with more than 9 years of education. No statistically significant differences in the odds of discharge were observed for the following variables: area of residence (p = 0.24), residence in the same municipality as the hospitalization (p = 0.68), use of antivirals for influenza (p = 0.99), influenza vaccination (p = 0.73), and diagnosis of asthma (p = 0.79).

Table 2 - Factors associated with the outcome of elderly individuals hospitalized in ICUs for Covid-19 in the state of Paraná according to vaccination status, Breslow-Day test (n=11,918). Maringá, PR, Brazil, 2022

Variables (n; %)	Discharge n(%)	Death n(%)	Breslow-Day Test OR (95% CI)	p-value
COVID-19 Vaccine: Unavailable				
Age group (4486; 37.6%)				
60 to 74 years	996 (22.2)	1697 (37.8)	1.86 (1.62-2.13)	<0.001
75 years or older	430 (9.6)	1363 (30.4)		
Chronic cardiovascular disease (4486; 37.6%)				
Yes	803 (17.9)	1777 (39.6)	0.93 (0.81-1.05)	0.02
No	623 (13.9)	1283 (28.6)		
Chronic neurological disease (4486; 37.6%)				
Yes	88 (2.0)	289 (6.4)	0.63 (0.40-0.81)	0.003
No	1338 (29.8)	2771 (61.8)		
Chronic kidney disease (4486; 37.6%)				
Yes	77 (1.7)	276 (6.2)	0.57 (0.43-0.75)	0.05
No	1349 (30.1)	2784 (62.1)		
COVID-19 Vaccine: Partially Available				
Age group (4638; 39.0%)				
60 to 74 years	788 (17.0)	2456 (53.0)	1.97 (1.66-2.35)	<0.001
75 years or older	195 (4.2)	1199 (25.8)		
Chronic cardiovascular disease (4638; 39.0%)				
Yes	483 (10.4)	1929 (41.6)	0.86 (0.74-0.99)	0.02
No	500 (10.8)	1726 (37.2)		
Chronic neurological disease (4638; 39.0%)				
Yes	54 (1.7)	204 (4.4)	0.98 (0.70-1.34)	0.003
No	929 (20.0)	3451 (74.4)		
Chronic kidney disease (4638; 39.0%)				
Yes	31 (0.7)	216 (4.7)	0.51 (0.34-0.76)	0.05
No	952 (20.5)	3439 (74.1)		
COVID-19 Vaccine: Available				
Age group (2794; 23.4%)				
60 to 74 years	510 (18.3)	1025 (36.7)	1.24 (1.05-1.46)	<0.0001
75 years or older	361 (12.9)	898 (32.1)		
Chronic cardiovascular disease (2794; 23.4%)				
Yes	415 (14.9)	1084 (38.8)	0.70 (0.59-0.83)	0.02
No	456 (16.3)	839 (30.0)		
Chronic neurological disease (2794; 23.4%)				
Yes	45 (1.6)	203 (7.3)	0.46 (0.33-0.64)	0.003
No	826 (29.6)	1720 (61.6)		
Chronic kidney disease (2794; 23.4%)				
Yes	71 (2.5)	180 (6.4)	0.64 (0.54-1.15)	0.05
No	800 (28.6)	1743 (62.4)		

Source: prepared by the authors, 2025.

Older adults with preexisting risk factors had 31% lower odds of discharge compared with those without any risk factors. However, the number of deaths among older adults with at least one risk factor during the period when the vaccine was unavailable was approximately 60% higher than during the period when the vaccine was available.

Among older adults admitted to the ICU with preexisting comorbidities such as diabetes, immunodeficiency, liver disease, hematologic disease, and chronic lung disease, the odds of discharge were lower compared with those without these conditions. The most pronounced effects were observed among those with liver disease, hematologic disease, and immunodeficiency, who had 50%, 44%, and 43% lower odds of discharge, respectively. Older adults with diabetes and chronic lung disease showed 18% and 39% lower odds of discharge, respectively. Finally, older adults who required ventilatory support had 70% lower odds of discharge compared with those who did not use this intervention.

DISCUSSION

The results highlight the complex interaction between the availability of COVID-19 vaccines, hospital outcomes among older adults, demographic factors, and preexisting comorbidities. The variation observed across the pre-vaccination, implementation, and full availability periods is consistent with scientific evidence demonstrating the benefits of immunization in reducing morbidity and mortality, particularly among vulnerable populations[15,23–24].

Table 3 - Factors associated with the outcome of elderly individuals hospitalized in ICUs for Covid-19 in the state of Paraná according to Covid-19 vaccination status, Breslow-Day, and Mantel-Haenszel tests (n=11,918). Maringá, PR, Brazil, 2022

Variables	Covid-19 vaccine						Tests		
	Unavailable 4486 (37.6%)		Partially available 4638 (39.0%)		Available 2794 (23.4%)		Breslow-Day	Mantel-Haenszel	
	Discharge n (%)	Death n (%)	Discharge n (%)	Death n (%)	Discharge n (%)	Death n (%)	p-value	OR (95% CI)	p-value
Sex							0.36	1.20 (1.10-1.30)	<0.001
Female	641 (14.3)	1234 (27.5)	477 (10.3)	1550 (33.4)	404 (14.5)	848 (30.4)			
Male	785 (17.5)	1826 (40.7)	506 (10.9)	2105 (45.4)	467 (16.7)	1075 (38.5)			
Race/Color							0.70	1.22 (1.09-1.37)	<0.001
White	1203 (26.8)	2470 (55.1)	831 (17.9)	2990 (64.5)	739 (26.4)	1596 (57.1)			
Black/Asian/Indig.	223 (4.9)	590 (13.2)	152 (3.3)	665 (14.3)	132 (4.8)	327 (11.7)			
Education							0.24	0.63 (0.58-0.69)	<0.001
$\leq$ 9 years	422 (9.4)	1164 (25.9)	254 (5.5)	1379 (29.7)	253 (9.1)	741 (26.5)			
> 9 years	1004 (22.4)	1896 (42.3)	729 (15.7)	2276 (49.1)	618 (22.1)	1182 (42.3)			
Area of Residence							0.99	1.13 (0.92-1.39)	0.24
Urban / Peri-urban	1382 (30.8)	2953 (65.8)	938 (20.2)	3467 (74.8)	830 (29.7)	1821 (65.2)			
Rural	44 (1.0)	107 (2.4)	45 (1.0)	188 (4.0)	41 (1.5)	102 (3.6)			
Resides in City of Hospitalization							0.06	1.01 (0.93-1.10)	0.68
Yes	910 (20.3)	1858 (41.4)	570 (12.3)	2206 (47.6)	499 (17.9)	1108 (39.7)			
No	516 (11.5)	1202 (26.8)	413 (8.9)	1449 (31.2)	372 (13.2)	815 (29.2)			
Use of Flu Antiviral							0.91	1.00 (0.84-1.18)	0.99
Yes	223 (5.0)	473 (10.5)	15 (0.3)	62 (1.3)	7 (0.2)	16 (0.6)			
No	1203 (26.8)	2587 (57.7)	968 (20.9)	3593 (77.5)	864 (30.9)	1907 (68.3)			
Flu Vaccine							0.98	1.02 (0.91-1.14)	0.73
Yes	266 (5.9)	565 (12.6)	138 (3.0)	497 (10.7)	114 (4.1)	249 (8.9)			
No	1160 (25.9)	2495 (55.6)	845 (18.2)	3158 (68.1)	757 (27.1)	1674 (59.9)			
Risk Factors / Comorbidities							0.67	0.69 (0.62-0.78)	<0.001
Yes	1206 (26.9)	2701 (60.2)	743 (16.0)	3013 (65.0)	711 (25.4)	1653 (59.2)			
No	220 (4.9)	359 (8.0)	240 (5.2)	642 (13.8)	160 (5.7)	270 (9.7)			
Diabetes Mellitus							0.91	0.82 (0.75-0.90)	<0.001
Yes	484 (10.8)	1186 (26.4)	293 (6.3)	1234 (26.6)	281 (10.1)	691 (24.7)			
No	942 (21.0)	1874 (41.8)	690 (14.9)	2421 (52.2)	590 (21.1)	1232 (44.1)			
Immunodeficiency							0.26	0.57 (0.43-0.75)	<0.001
Yes	26 (0.6)	119 (2.6)	17 (0.4)	78 (1.7)	21 (0.7)	77 (2.8)			
No	1400 (31.2)	2941 (65.6)	966 (20.8)	3577 (77.1)	850 (30.4)	1846 (66.1)			
Chronic Liver Disease							0.74	0.50 (0.33-0.74)	<0.001
Yes	14 (0.3)	66 (1.5)	8 (0.2)	46 (1.0)	8 (0.3)	37 (1.3)			
No	1412 (31.5)	2994 (66.7)	975 (21.0)	3609 (77.8)	863 (30.9)	1886 (67.5)			
Chronic Hematological Disease							0.75	0.56 (0.35-0.91)	0.01
Yes	6 (0.1)	28 (0.6)	6 (0.1)	41 (0.9)	9 (0.3)	28 (1.0)			
No	1420 (31.7)	3032 (67.6)	977 (21.1)	3614 (77.9)	862 (30.9)	1895 (67.8)			
Asthma							0.58	0.95 (0.74-1.23)	0.79
Yes	43 (1.0)	87 (1.9)	23 (0.5)	86 (1.8)	19 (0.7)	55 (1.9)			
No	1383 (30.8)	2973 (66.3)	960 (20.7)	3569 (77.0)	852 (30.5)	1868 (66.9)			
Chronic Pneumopathy (Lung)							0.91	0.61 (0.52-0.72)	<0.001
Yes	89 (2.0)	299 (6.7)	41 (0.9)	229 (4.9)	53 (1.9)	190 (6.8)			
No	1337 (29.8)	2761 (61.5)	942 (20.3)	3426 (73.9)	818 (29.3)	1733 (62.0)			
Ventilatory Support							0.49	0.30 (0.26-0.36)	<0.001
Yes	1224 (27.3)	2923 (65.2)	899 (19.4)	3552 (76.6)	762 (27.3)	1830 (65.5)			
No	202 (4.5)	137 (3.0)	84 (1.8)	103 (2.2)	109 (3.9)	93 (3.3)			

Source: prepared by the authors, 2025.

The rapid development of vaccines against SARS-CoV-2 and their implementation through mass vaccination campaigns proved to be highly successful strategies for mitigating the effects of the pandemic[23]. Findings from a study conducted in Washington, USA, showed a significant reduction in hospitalizations among individuals aged 65 years or older after vaccine administration; six weeks after the start of vaccination, a substantial decrease in the odds of death was observed in this group[24].

Additionally, a meta-analysis showed that, among older adults, receiving a higher number of doses was associated with a lower risk of infection, hospitalization, and death compared with those who received fewer doses[25]. These findings reinforce the importance of maintaining booster schedules in this population. Another systematic review found that a complete vaccination regimen provided up to 75% protection against symptomatic infection, 63% to 80% protection against hospitalization, and 65% to 81% protection against severe disease, regardless of sex and age[26]. As reported in the literature, although older adults present a naturally reduced immune response, booster vaccination is associated with increased antibody production and improved overall immune capacity[25,27].

An important finding of this study is that, when the vaccine was available, the likelihood of discharge remained higher among individuals aged 60 to 74 years compared with those aged 75 years or older; however, the disparity between these age groups decreased to 24%. This attenuation may be associated with the Brazilian immunization plan, which prioritized the first doses for individuals aged 80 years or older[14]. Evidence supports the notion that vaccination remains a vital tool for protecting this population, overcoming initial concerns regarding the magnitude of the immune response[28–29].

Due to the high lethality rate among older adults residing in long-term care facilities (LTCFs), immunization of this group was prioritized in several countries[14]. COVID-19 proved particularly harmful to institutionalized individuals because of a combination of biological vulnerabilities and structural characteristics of these facilities, such as shared bedrooms and common areas, which hinder social distancing and transmission control[30]. In this con-

text, it is essential to implement complementary measures alongside vaccination to reduce severe outcomes in these settings[14,30,31].

Regarding sociodemographic factors, higher odds of hospital discharge were associated with White skin color, higher education level, younger age within the older age group, and female sex. Concerning race/skin color and education, studies conducted in the United States corroborate that older adults with lower educational attainment and those self-identified as Black have higher odds of unfavorable outcomes, reflecting structural inequalities in access to health care[31].

Finally, aging is associated with a decline in multiple cellular groups, resulting in weaker immune responses compared with younger populations[23]. The immune response capacity of older adults is challenged by immunosenescence. Although vaccines may present lower biological efficacy in this group, the literature indicates that even a single vaccine dose was associated with an 85% reduction in the risk of death in this population, confirming the positive clinical impact of the intervention[28].

Regarding sex, a study conducted in Turkey on vaccine effectiveness identified differences between older men and women, similar to those observed in the present study. Administration of the second dose of the Sinovac vaccine resulted in a substantial reduction in ICU admissions among older women. The study also highlighted that older adults with more than one preexisting comorbidity were less likely to experience favorable outcomes[32].

Concerning clinical factors, this study found poorer discharge outcomes among older adults with chronic diseases, who have a higher intrinsic risk of hospitalization and mortality[13,33]. A study conducted in Italy showed that the incidence of COVID-19 among individuals with chronic diseases increased from 4.1% in 2020 to 7.3% in 2021. In this context, the probability of hospitalization and death increased progressively among individuals with two or more comorbidities compared with those with only one[34].

Furthermore, evidence indicates that individuals with severe and debilitating conditions, such as neoplasms, showed lower vaccine acceptance compared with those with less severe conditions, such as isolated hypertension. Vaccination rates were also proportionally lower among individuals with chronic conditions compared with the general population[34–35].

The results of this study indicated unfavorable outcomes particularly among older adults with liver disease, hematologic disorders, immunodeficiency, and diabetes mellitus. Prospective studies show that liver injury caused by SARS-CoV-2 occurs through ACE2 receptors present in hepatocytes and cholangiocytes. In addition to reducing protein synthesis capacity, infection compromises coagulation factors and metabolic reserve, which interact synergistically with the prothrombotic state characteristic of COVID-19[36].

Older patients with hematologic disorders also constitute a high-risk group. This is due to immunosuppression inherent to the disease itself and to cytotoxic treatments, resulting in lymphocyte depletion and impaired viral clearance[15,23,25]. In addition, the virus infects monocytes and endothelial cells, triggering a cytokine storm, lymphopenia, and activation of the coagulation cascade, leading to thrombosis and disseminated intravascular coagulation in severe cases—complications that are particularly deleterious for an already immunocompromised population[37].

The literature reinforces that older adults with hematologic diseases experience a more severe clinical course. A multicenter analysis involving 569 patients reported an overall mortality rate of 29.3%, with individuals aged over 70 years and those with associated comorbidities presenting a higher probability of death[38]. This vulnerability requires rigorous clinical management strategies, including continuous monitoring of hematological parameters and intensive supportive care plans[39,40].

Regarding diabetes mellitus, the increased risk of death is substantial. Pathophysiological mechanisms include chronic hyperglycemia, which impairs immune function and promotes systemic inflammation. In addition, SARS-CoV-2 may directly affect pancreatic beta cells, worsening glycemic control and contributing to organ damage[41]. However, analyses conducted in Brazil demonstrated that fully vaccinated individuals with diabetes had significantly lower rates of hospital mortality and ICU admission compared with unvaccinated individuals, supporting our findings[42].

Finally, regarding immunodeficiency, data from the World Health Organization indicate that immunocompromised patients (including those with cancer, transplant recipients, and people living with HIV) remain at high risk of death despite therapeutic advances[43]. Although vaccination provides beneficial effects, immunosuppression may attenuate the expected immune response, making the maintenance of additional protective measures essential for these patients.

Regarding the need for mechanical ventilation during ICU hospitalization, a comparative study involving 3,293 fully vaccinated, partially vaccinated, and unvaccinated individuals found that unvaccinated patients were more likely to require invasive ventilatory support, vasopressor use, and longer ICU stays[44]. These data corroborate the findings of the present study, which showed a substantial reduction in ICU admissions during the period of full vaccine availability compared with the periods of unavailability or initial implementation.

Overall, COVID-19 vaccination had a significant impact on reducing mortality among individuals with chronic cardiac, renal, respiratory diseases, and diabetes, highlighting the role of immunization in protecting these vulnerable groups[34]. Evidence indicates that vaccinated patients, even those with comorbidities, had a lower risk of death compared with unvaccinated individuals, positioning vaccination as a crucial protective factor against progression to critical illness[45,46].

The findings emphasize the value of continuous booster vaccination among older adults. Given the increased risk of severe disease, maintaining high levels of immunity through regular booster doses is essential to protect this population[46]. In addition, although unfavorable socioeconomic conditions act as risk indicators, studies suggest that the direct impact of chronic diseases on COVID-19

mortality is more predictive than the indirect effect of poverty[47]. This reinforces that comorbidities remain the primary determinants of unfavorable clinical outcomes.

This study provides evidence to support health managers in formulating data-driven public policies, allowing care strategies to be aligned with the actual characteristics observed. The stratified analysis organized according to the vaccine availability timeline made it possible to demonstrate the association between access to vaccination and the mitigation of severe cases.

The limitations of this study are primarily related to its retrospective observational design and the use of secondary data. These factors limit causal inference and may introduce information bias due to potential incompleteness or inconsistencies in record completion. Additionally, the analysis was based on stratified associations not simultaneously adjusted for multiple confounding factors, which may result in residual confounding.

It is also important to consider that restricting the analysis to ICU patients may have concentrated the sample among individuals with inherently more severe conditions and a higher burden of comorbidities. Finally, the regional nature of the study limits the generalizability of the findings to other geographic contexts.

Despite these limitations, the findings provide relevant insights into the clinical course of older adults in intensive care. For the advancement of this research field, future studies should prioritize the incorporation of individualized vaccination data and the use of multivariate analytical approaches. Prospective studies including clinical frailty measures, severity biomarkers, and identification of viral variants are also recommended, enabling a broader analysis of the interaction between vaccination and the physiological reserve of older adults.

CONCLUSION

The findings of this study demonstrate that, among older adults admitted to ICUs due to COVID-19 in the state of Paraná, sociodemographic factors such as age between 60 and 74 years, female sex, White race/skin color, and higher educational level were associated with greater odds of hospital discharge. In contrast, chronic conditions—such as diabetes mellitus, immunodeficiency, liver disease, and chronic lung diseases—and, particularly, the need for ventilatory support were identified as markers of increased risk of death.

Immunization proved to be a key factor in reducing mortality, although older adults with multiple comorbidities remained more vulnerable. These results reinforce the importance of public vaccination policies targeting priority groups and the need for complementary care strategies for individuals with greater clinical frailty.

However, the interpretation of these findings should consider limitations inherent to the retrospective design and the use of secondary data, which may present incompleteness or underreporting. In addition, the exclusive inclusion of ICU patients limits the generalizability of the results to older adults treated in general wards or outpatient follow-up.

Future research should advance the integration of databases to incorporate detailed individual vaccination histories, as well as specific clinical variables such as laboratory markers and frailty indicators. These advances will enable more robust multivariate analytical models and the assessment of complex interactions between comorbidities and ventilatory support. Furthermore, multicenter studies with post-discharge follow-up are essential to evaluate long-term outcomes, such as functional status and late mortality.

Finally, this study highlights the strategic role of Primary Health Care and Nursing in promoting immunization and addressing vaccine hesitancy. The findings provide evidence to support the improvement of public health policies, reaffirming vaccination as an essential measure for protection and favorable clinical outcomes among older adults hospitalized with COVID-19.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

FUNDING

This study was supported by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brazil (CAPES) – Financing Code 001; the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) through Circular Letter No. 14/2020-GAB/PR/CAPES, dated March 30, 2020; Public Notice No. 07/2020 – Universal Call from the Ministry of Science, Technology, Innovations and Communications (MCTIC); the National Council for Scientific and Technological Development (CNPq); the National Fund for Scientific and Technological Development (FNDCT); the Ministry of Health (MS)/Secretariat of Science, Technology, Innovation and Strategic Health Inputs (SCTIE)/Department of Science and Technology (Decit). Process: 402882/2020-2.

REFERENCES

1. World Health Organization. Q&A on coronaviruses (Covid-19) [Internet]. Geneva: WHO; 2020 [cited 2025 Jan 10]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/q-a-coronaviruses.
2. World Health Organization. Coronavirus (Covid-19) Dashboard [Internet]. Geneva: WHO; 2023 [cited 2025 Jul 25]. Available from: https://covid19.who.int/.
3. Maciel EL, Jabor P, Goncalves Júnior E, Tristão-Sá R, Lima R de CD, Reis-Santos B, et al. Factors associated with COVID-19 hospital deaths in Espírito Santo, Brazil, 2020. Epidemiol. Serv. Saúde. 2020;29(4):e2020413. https://doi.org/10.1590/s1679-49742020000400022.
4. Fhon JRS, Silva LM, Leitón-Espinoza ZE, Matiello F de B, Araujo JS, Rodrigues RAP. Hospital care for elderly COVID-19 patients. Rev Lat Am Enfermagem. 2020;28:e3396. https://doi.org/10.1590/1518-8345.46

49.3396. PMID: 33174997.

5. Cavalcanti BRV da S, Marques AP de O, Marques AP de O, Borba AK de OT, Borba AK de OT, Bezerra AE, et al. Fenótipos da Pandemia por coronavírus em idosos. Braz. J. Hea. Rev. 2021;4(4):17154-9. https://doi.org/10.34119/bjhrv4n4-217.
6. Pan American Health Organization. People over 60 have been hardest hit by COVID-19 in the Americas [Internet]. Washington (DC): OPAS; 2020 [cited 2025 Dec 01]. Available from: https://www.paho.org/en/news/30-9-2020-people-over-60-have-been-hardest-hit-covid-19-americas.
7. Sousa AH da S, Martins SB, Cortez ACL. Influência das comorbidades na saúde dos idosos frente à pandemia da Covid-19: uma revisão integrativa. Res Soc Dev. 2021;10(17):e199101724678. https://doi.org/10.33448/rsd-v10i17.24678.
8. Bex S, Guinness L, Gaudet-Blavignac C, Martin JH, Stirnemann J, Agoritsas T, et al. Association between critical care occupancy and code status decisions during resource scarcity: a retrospective cohort study. BMC Med Ethics. 2025;26(1):156. https://doi.org/10.1186/s12910-025-01299-x. PMID: 41184990.
9. Jain S, Valley TS. Who Receives ICU Care during Times of Strain? Triage and the Potential for Racial Disparities. Ann Am Thorac Soc. 2022;19(12):1973-4. https://doi.org/10.1513/AnnalsATS.202209-766ED. PMID: 36454169.
10. Mendes TO, Somensi RM, Santos RK, Silva AM, Pires RN, Caregnato RCA, et al. COVID-19 and demand for nursing work in intensive care units: retrospective cohort. Online Braz J Nurs. 2024;23:e20246775. https://doi.org/10.17665/1676-4285.20246775.
11. Marques FRDM, Laranjeira C, Carreira L, Gallo AM, Baccon WC, Paiano M, et al. Illness Experiences of Brazilian People Who Were Hospitalized Due to COVID-19 and Faced Long COVID Repercussions in Their Daily Life: A Constructivist Grounded Theory Study. Behav Sci (Basel). 2023;14(1):14. https://doi.org/10.3390/bs14010014. PMID: 38247666.
12. Pesce GB, Covre ER, Souza FCS, Marques FRDM, Salci MA, Vissoci JRN, et al. Aging as an aggravating factor of Long Covid: an integrative review. Rev enferm UFPE on line. 2024;18(1):e257702. https://doi.org/10.5205/1981-8963.2024.257702.
13. Ferreira LS, Darcie Marquitti FM, Paixão da Silva RL, Borges ME, Ferreira da Costa Gomes M, Cruz OG, et al. Estimating the impact of implementation and timing of the COVID-19 vaccination programme in Brazil: a counterfactual analysis. Lancet Reg Health Am. 2023;17:100397. https://doi.org/10.1016/j.lana.2022.100397. PMID: 36439909.
14. Ministério da Saúde (BR). Profissionais de saúde e pessoas idosas institucionalizados serão os primeiros a receber doses de vacina contra a Covid-19 [Internet]. Brasília: Ministério da Saúde; 2021 [cited 2025 Mar 17]. Available from: https://www.gov.br/saude/pt-br/assuntos/noticias/2021/janeiro/profissionais-de-saude-e-idosos-institucionalizados-serao-os-primeiros-a-receber-doses-de-vacina-contra-a-covid-19.
15. Victora PC, Castro PMC, Gurzenda S, Medeiros AC, França GVA, Barros PAJD. Estimating the early impact of vaccination against COVID-19 on deaths among elderly people in Brazil: Analyses of routinely-collected data on vaccine coverage and mortality. EClinicalMedicine. 2021;38:101036. https://doi.org/10.1016/j.eclinm.2021.101036. PMID: 34308302.
16. Xing Y, Bahl A. Waning Protection Against Severe COVID-19 Following Vaccination: A Longitudinal IPTW Analysis of Emergency Department Encounters. Infect Dis Rep. 2025;17(6):142. https://doi.org/10.3390/idr17060142. PMID: 41283346.
17. Rojas-Castro M, Verdasca N, Monge S, De Mot L, Trobajo-Sanmartín C, Duffy R, et al. COVID-19 Vaccine Effectiveness Against Hospitalization in Older Adults, VEBIS Hospital Network, Europe, September 2024-May 2025. Influenza Other Respir Viruses. 2025;19(11):e70191. https://doi.org/10.1111/irv.70191. PMID: 41290396.
18. Maleki B, Sadeghian AM, Ranjbar M. Impact of vaccination against SARS-CoV-2 on mortality risk, ICU admission rate, and hospitalization length in hospitalized COVID-19 patients: a cross-sectional study. BMC Infect Dis. 2025;25(1):144. https://doi.org/10.1186/s12879-025-10530-4. PMID: 39885405.
19. Carazo S, Skowronski DM, Brousseau N, Guay C, Sauvageau C, Racine É, et al. Monovalent mRNA XBB.1.5 vaccine effectiveness against COVID-19 hospitalization in Quebec, Canada: Impact of variant replacement and waning protection during 10-month follow-up. PLoS One. 2025;20(6):e0325269. https://doi.org/10.1371/journal.pone.0325269. PMID: 40460407.
20. Instituto Brasileiro de Geografia e Estatística. Projeções da População [Internet]. Rio de Janeiro: IBGE; 2024 [cited 2025 Sep 05]. Available from: https://www.ibge.gov.br/estatisticas/sociais/populacao/9109-projecao-da-populacao.html.
21. Strengthening the Reporting of Observational Studies in Epidemiology. STROBE Checklists [Internet]. Bern: STROBE; 2022 [cited 2025 May 12]. Available from: https://www.strobe-statement.org/checklists/.
22. Open DataSUS [Internet]. Brasília: Ministério da Saúde; 2022 [cited 2025 Dec 21]. Available from: https://opendatasus.saude.gov.br/dataset/srag-2021-e-2022.
23. Fedele G, Palmieri A, Onder G. The immune response to SARS-CoV-2 vaccination in older people. Lancet Healthy Longev. 2023;4(5):e177-8. https://doi.org/10.1016/S2666-7568(23)00060-0. PMID: 37148886.
24. Lavista Ferres JM, Richardson BA, Weeks WB. Association of COVID-19 vaccination prioritization and hospitalization among older Washingtonians. J Am Geriatr Soc. 2021;69(10):2780-2782. https://doi.org/10.1111/jgs.17315. PMID: 34106460.
25. Zhang L, Jiang L, Tian T, Li W, Pan Y, Wang Y. Efficacy and Safety of COVID-19 Vaccination in Older Adults: A Systematic Review and Meta-Analysis. Vaccines (Basel). 2022;11(1):33. https://doi.org/10.3390/vaccines11010033. PMID: 36679878.
26. Yang XH, Bao WJ, Zhang H, Fu SK, Jin HM. The

Efficacy of SARS-CoV-2 Vaccination in the Elderly: A Systemic Review and Meta-analysis. J Gen Intern Med. 2023:1-9. https://doi.org/10.1007/s11606-023-08254-9. PMID: 37266884.

27. Shabu A, Nishtala PS. Safety outcomes associated with the moderna COVID-19 vaccine (mRNA-1273): a literature review. Expert Rev Vaccines. 2023;22(1):393-409. https://doi.org/10.1080/14760584.2023.2209177. PMID: 37133747.
28. Lopez Bernal J, Andrews N, Gower C, Robertson C, Stowe J, Tessier E, et al. Effectiveness of the Pfizer-BioNTech and Oxford-AstraZeneca vaccines on covid-19 related symptoms, hospital admissions, and mortality in older adults in England: test negative case-control study. BMJ. 2021;373:n1088. https://doi.org/10.1136/bmj.n1088. PMID: 33985964.
29. Salinas-Martínez AM, Rodríguez-Vidales EP, Garza-Carrillo D, Robles-Rodríguez OA, Oca-Luna RM, Marroquín-Escamilla AR. Comparison of the effectiveness of four SARS-COV-2 vaccines in Nuevo Leon, Mexico: A test-negative control study. Aten Primaria. 2023;55(5):102606. https://doi.org/10.1016/j.aprim.2023.102606. PMID: 37002983.
30. Pimentel MH, Pereira F, Teixeira C. Impacto da covid-19 em idosos institucionalizados em estruturas residenciais para pessoas idosas. Revista INFAD de Psicología. 2021;1(1):477-90. https://doi.org/10.17060/ijodaep.2021.n1.v1.2129.
31. Hawkins RB, Charles J, Mehaffey JH. Socio-economic status and COVID-19-related cases and fatalities. Public Health. 2020;189:129-134. https://doi.org/10.1016/j.puhe.2020.09.016. PMID: 33227595.
32. van Diepen S, McAlister FA, Chu LM, Youngson E, Kaul P, Kadri SS. Association Between Vaccination Status and Outcomes in Patients Admitted to the ICU With COVID-19. Crit Care Med. 2023;51(9):1201-1209. https://doi.org/10.1097/ccm.0000000000005928. PMID: 37192450.
33. Summan A, Nandi A, Wahl B, Carmona S, Ongarello S, Vetter B, et al. Estimates of hospitalisations and deaths in patients with COVID-19 associated with undiagnosed diabetes during the first phase of the pandemic in eight low-income and middle-income countries: a modelling study. EClinicalMedicine. 2024;70:102492. https://doi.org/10.1016/j.eclinm.2024.102492. PMID: 38481788.
34. Fortuna D, Caselli L, Berti E, Moro ML. Direct impact of 2 years of COVID-19 on chronic disease patients: a population-based study in a large hard-hit Italian region. BMJ Open. 2023;13(10):e073471. https://doi.org/10.1136/bmjopen-2023-073471. PMID: 37899159.
35. Nham E, Kim Y, Jung J, Kim DW, Jang H, Hyun H, et al. COVID-19 Vaccination Rates in Patients With Chronic Medical Conditions: A Nationwide Cross-Sectional Study. J Korean Med Sci. 2022;37(45):e325. https://doi.org/10.3346/jkms.2022.37.e325. PMID: 36413798.
36. Fu L, Fei J, Xu S, Xiang H, Xiang Y, Hu B, et al. Liver Dysfunction and Its Association with the Risk of Death in COVID-19 Patients: A Prospective Cohort Study. J Clin Transl Hepatol. 2020;8(3):246-254. https://doi.org/10.14218/JCTH.2020.00043. PMID: 33083246.
37. Naimi A, Yashmi I, Jebeleh R, Imani Mofrad M, Azimian Abhar S, Jannesar Y, et al. Comorbidities and mortality rate in COVID-19 patients with hematological malignancies: A systematic review and meta-analysis. J Clin Lab Anal. 2022;36(5):e24387. https://doi.org/10.1002/jcla.24387. PMID: 35385130.
38. Acar IH, Guner SI, Ak MA, Gocer M, Ozturk E, Atalay F, et al. Impact of COVID-19 on Outcomes of Patients with Hematologic Malignancies: A Multicenter, Retrospective Study. Mediterr J Hematol Infect Dis. 2022;14(1):e2022074. https://doi.org/10.4084/MJHID.2022.074. PMID: 36425152.
39. Pagano L, Salmanton-García J, Marchesi F, Busca A, Corradini P, Hoenigl M, et al. COVID-19 infection in adult patients with hematological malignancies: a European Hematology Association Survey (EPICOVIDEHA). J Hematol Oncol. 2021;14(1):168. https://doi.org/10.1186/s13045-021-01177-0. PMID: 34649563.
40. Vijenthira A, Gong I, Fox TA, Booth S, Cook G, Fattizzo B, et al. Outcomes of patients with hematologic malignancies and COVID-19: a systematic review and meta-analysis of 3377 patients. Blood. 2020;136(25):2881-2892. https://doi.org/10.1182/blood.2020008824. PMID: 33113551.
41. Zhang J, Ma Y, To WL, Chow S, To Tang H, Wong HK, et al. Impact of COVID-19 infection on mortality, diabetic complications and haematological parameters in patients with diabetes mellitus: a systematic review and meta-analysis. BMJ Open. 2025;15(3):e090986. https://doi.org/10.1136/bmjopen-2024-090986. PMID: 40147989.
42. Moraes EV de, Pires MC, Costa AAA, Nunes AGS, de Amorim CL, Manenti ERF, et al. Comprehensive statistical analysis reveals significant benefits of COVID-19 vaccination in hospitalized patients: propensity score, covariate adjustment, and feature importance by permutation. BMC Infect Dis. 2024;24(1):1052. https://doi.org/10.1186/s12879-024-09865-1. PMID: 39333931.
43. Turtle L, Thorpe M, Drake TM, Swets M, Palmieri C, Russell CD, et al. Outcome of COVID-19 in hospitalised immunocompromised patients: An analysis of the WHO ISARIC CCP-UK prospective cohort study. PLoS Med. 2023;20(1):e1004086. https://doi.org/10.1371/journal.pmed.1004086. PMID: 36719907.
44. Uzun O, Akpolat T, Varol A, Turan S, Bektas SG, Cetinkaya PD, et al. COVID-19: vaccination vs. hospitalization. Infection. 2022;50(3):747-752. https://doi.org/10.1007/s15010-021-01751-1. PMID: 34984646.
45. Doti JL. The impact of vaccinations and chronic disease on COVID death rates. J Bioecon. 2023;25(3):239-269. https://doi.org/10.1007/s10818-023-09339-5.
46. Cunha LL, Perazzio SF, Azzi J, Cravedi P, Riella LV. Remodeling of the Immune Response With Aging: Immunosenescence and Its Potential Impact on COVID-19 Immune Response. Front Immunol. 2020;11:1748. https://doi.org/10.3389/fimmu.2020.01748. PMID:

32849623.
47. Suthar AB, Wang J, Seffren V, Wiegand R, Griffing S, Zell E. Public health impact of covid-19 vaccines in the US: observational study. BMJ. 2022;377:e069317. https://doi.org/10.1136/bmj-2021-069317. PMID: 35477670.

AUTHOR CONTRIBUTIONS

Study conception: Inoue LH, Baccon WC, Marques FRDM, Salci MA, Carreira L.
Data collection: Inoue LH, Baccon WC, Marques FRDM, Acutu GK.
Data analysis: Inoue LH, Baccon WC, Marques FRDM, Santos MLA.
Data interpretation: Inoue LH, Baccon WC, Marques FRDM, Rodrigues GAS, Salci MA, Carreira L.
All authors are responsible for the textual preparation and critical revision of the intellectual content, for the final published version, and for all ethical, legal, and scientific aspects related to the accuracy and integrity of the study.