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RESEARCH ARTICLE

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Modeling the herpes zoster disease burden and its potential health impact on older adults >50 years of age in Brazil

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ABSTRACT

In Brazil, as the older population has grown at a very rapid pace (by 57.4% over 2010), the number of herpes zoster (HZ) infections is expected to increase. As the Brazilian healthcare system constitutes a complex combination of public-private financing, estimating the true impact of HZ is challenging. The objective was to ascertain the disease burden of HZ and estimate its attributable cost in older adults aged ≥50 y who are users of public and private health services. Disease burden was estimated based on the ZOster ecoNomic Analysis model using Brazil-specific inputs, and any information gap was addressed by the Delphi Panel. The incidence estimates were multiplied by the cost per intervention to calculate the economic burden of the disease. In the absence of HZ vaccination, older adults ≥50 y are projected to experience 359,797 and 23,917 cases of HZ and post-herpetic neuralgia (PHN), with frequent and severe outcomes in the advanced age groups. The estimated mean cost of treatment per patient for HZ and PHN was ~7X and 16X more in the ANS population compared with the SUS. The number of hospitalizations (1339–1424) and median length of stay (4–5 d) were comparable between ANS and SUS. Hospitalization increased the treatment cost >10X (ANS: R$12459.67 –16,343.07; SUS: R$357.93 to 525.08). HZ imposes a substantial economic burden on the healthcare system due to high direct medical (R$357.36 million) and indirect costs (R$440.82 million). These results hold valuable insights for healthcare providers, insurers, and policymakers offering a comprehensive overview of the economic impact of HZ while implementing strategies for prevention of disease.

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Introduction

Reactivation of varicella-zoster virus (VZV) due to age-related decline in immunity or immunosuppression results in Herpes zoster (HZ). More than 95% of adults ≥50 y of age (YOA) are seropositive to VZV, putting them at risk of acquiring HZ.[1] Worldwide, across all age groups, especially in the absence of vaccination programs, an increase in the incidence of HZ has been reported with a noteworthy upsurge after 50 YOA, and is 6–8 and 8–12 per 1,000 person-years at 60 and 80 YOA, respectively.[2,3] In the Latin America and Caribbean (LAC) region, while the incidence of HZ for the general population is largely unknown, in high-risk populations it ranged from 6.4 to 36.5 cases per 1,000 patient-years, with most data coming from Brazil.[4]

HZ is a debilitating illness and is associated with a painful, self-limited dermatomal rash that usually resolves within a few weeks.[5] The thoracic region is most frequently affected, followed by the cranial, lumbar, cervical, and sacral regions.[6] However, based on the individual's immune status and if left untreated, people can experience severe, long-lasting, or even life-threatening complications.[5,7] Among various complications, post-herpetic neuralgia (PHN), which usually causes debilitating and long-lasting pain, is the most common. Its risk increases with age: 21% in those 60 to 69 YOA to 34% in those 80 + YOA.[7] PHN is difficult to manage as a consequence of HZ as there is no definitive treatment algorithm, and it is further complicated by comorbidities or susceptibility to cognitive decline that increases the risk of adverse effects or interactions.[7,8] Some of the other complications associated with HZ include conditions associated with ocular (e.g., herpes zoster ophthalmicus), neurological (e.g., encephalitis, myelitis, and aseptic meningitis), and cutaneous system (e.g., disseminated HZ, bacterial superinfection, and pigmentary changes). While deaths due to HZ are uncommon, severe cases of HZ and its complications often might require hospitalization.[4,5,9]

Many patients do not seek medical assistance further complicating its management. The burden of HZ and its complications, therefore, extends beyond individual health, encompassing broader societal consequences such as medical care-associated strain on the healthcare system and productivity losses. In developed countries, it is estimated to incur around US$2.6 billion and up to US$241.5 million annually toward direct and indirect medical costs. Across the globe, as the incidence of HZ is increasing, so is the cost to society and the healthcare system, which is in billions.[10,11]

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Brazil is among the 10 most populous country, and the older population has grown at a very rapid pace, rising by 57.4% over 2010.[12,13] Due to this demographic transition, the number of HZ infections is expected to increase in the aging population. While the burden of HZ might not differ greatly among the various geographical areas, its social and economic impact does. The result of the economic impact can be different even within the same geographical area based on the type of patients assessed.[14] Therefore, estimating the true impact of HZ in older adult populations is challenging because Brazil's healthcare system constitutes a complex combination of public-private financing. This includes SUS, a Unified Health System, which is a free healthcare system for the entire population financed primarily through taxes, and ANS, a regulated National Agency of Supplemental Health operated through private health plans and insurance. It follows the principle of universal coverage via SUS contrasted with supplemental private insurance. Almost 75% of the population depends exclusively on SUS, and ANS has about 25% of its users.[15] This underscores the necessity of comprehensively understanding the burden of HZ to inform evidence-based public health interventions. While some studies have explored HZ epidemiology in Brazil or the broader Latin American region,[4,16] a comprehensive assessment of its economic burden, particularly distinguishing between the public (SUS) and private (ANS) healthcare subsectors using Brazil-specific model inputs and costings, has been notably lacking. This study is among the first to undertake such a detailed analysis. The objective of this study was to fill this critical knowledge gap by ascertaining the prevalence of HZ and to estimate its cost in the older adults aged ≥50 YOA who are users of the public and private health subsector.

Methods

The disease burden attributed to HZ in Brazil was estimated based on GSK's ZOster ecoNomic Analysis ZONA model. We utilized ZONA to simulate cohorts of one million adults using epidemiological and economic inputs from Brazil's public and private subsectors, establishing relevant rates for the disease burden and respective costs for each age group. These rates were then applied to the Brazilian population aged ≥50 YOA in the public and private subsectors. Subsequently, we calculated the annual economic burden caused by this disease.

ZONA model

The ZONA,[17] is a static multi-cohort state-transition model that was previously developed to estimate the disease burden attributed to HZ and was adapted to the Brazil Setting. The model considers various age group cohorts and three different vaccination strategies: no vaccination, vaccination with recombinant zoster vaccine, and Zoster Vaccine Live-attenuated. Older adults begin in the "No HZ" health state and transition between different disease transition events, including HZ, HZ with PHN, non-PHN complications, recovery, recurrent HZ, and death from HZ or natural causes. The model had a 1-y cycle length and followed all subjects over their remaining lifetime. Incidence rates were calculated for each age group within the hypothetical cohort. The incidence estimates were then extrapolated and aligned to each corresponding age group with the population of interest. This methodology thus involved transforming the longitudinal outcomes of a hypothetical cohort into cross-sectional data so that it mirrors the situation in real life. Finally, the estimated annual cases were multiplied by the cost per intervention, thus providing a comprehensive economic assessment of the disease burden.

Model inputs

Inputs used to populate the model, e.g., HZ incidence rates, the proportion of HZ cases with PHN or non-PHN complications, and healthcare resource utilization per HZ case, etc. were derived from several sources and are included in Table S1. A comprehensive literature search was conducted to identify and obtain Brazilian-specific epidemiological data of HZ necessary for populating Zona model. Additionally, Delphi Panels was used to obtain updated and precise information to address any information gaps.

Demographic data

The 2019 population estimates were sourced from the Population Projection of the Brazilian Institute of Geography and Statistics. The collected data were stratified by age groups.

Epidemiology

HZ incidence data were sourced from Curran et al. and ranged from 0.00515 to 0.01081 among individuals older than 50 y.[18] Incidence rate of recurrent HZ was obtained from Tseng et al. (2020) and ranged from 0.01188 to 0.00888.[19] PHN incidence data were sourced from Klein et al. (2019).[20] The proportion of developing non-PHN complications after the initial HZ episodes, i.e., ocular, neurological, cutaneous, and other non-pain complications, were sourced from a Delphi panel. The process and results of this panel will be published separately

Health coverage

Table S1 represents the health insurance coverage stratified according to the age groups for the public and private health systems applied to the population estimates of 2019. Data from the National Health Survey (PNS, 2019) was used.[21]

Hospitalization SUS

SUS hospital admissions data for public services were obtained from the Hospital Information System of the Unified Health System that is financed by the government. Payment for hospitalizations by the SUS occurs on a tripartite basis (states, municipalities and federal level). The costs presented in the SIH-SUS represent federal payments. To calculate the total costs, a correction factor of 2.8 was used, according to the participation of the state and municipal levels.[22]

Hospitalization ANS

In contrast, private services data were obtained from the National Supplementary Health Agency (ANS).[23]

Mortality data

HZ-related deaths were obtained from the National Mortality Information System (SIM), which covers the entire population.[24] To check the quality of data extracted from SIM, the numbers of varicella and HZ data reported by SIM were compared with the global disease burden.[25] SIM data did not underestimate the total number of deaths. As the number of related deaths is collected from the official mortality system, this data was not projected.

Economic data

Unit cost was estimated separately for SUS and ANS.

For SUS, the unit costs of medications were estimated based on the average price of medicines purchased by the government in 2019 from the health price database.[26] The costs of examinations and health professional visits were obtained from official SUS Procedures, Medications, and OPM Table Management System.[27,28]

For ANS, the medicine costs were derived from the regulated market prices considering the maximum price that pharmacies can charge (plus 18% tax). For the costs of the examination and professional visits, the Brazilian Hierarchical Classification of Medical Procedures was used.[29]

Direct Medical Costs of hospitalization were calculated by macro-costing according to the reimbursement amounts in the public and private sectors for 2019, presenting the total cost per year and the average cost per patient per age group for all ICD-10 related to HZ. For outpatient direct costs, values for procedures, care, and medication were considered from the public and private health perspectives. Resource utilization for outpatients' management of each case from SUS and ANS system was estimated from a Delphi panel. For each age group, the costs and number of resources used were multiplied, and the average annual value and the average value per patient for the year 2019 are presented.

Productivity costs for each case of HZ and the PHN included absenteeism and presenteeism. For absenteeism costs, the proportion of sick leave and median length (in days) of work absenteeism, obtained from the Delphi panels, were valued (median hourly wage for an 8-hour workday) and weighted according to the employment to population rate. Productivity costs due to presenteeism, i.e., the productivity lost because an individual keeps on working during the sickness period but cannot perform at maximum capability due to the HZ symptoms, the percentage scale of productivity lost in terms of work impairment (Completely effective: 100%; Not able to work: 0%) reported by Rampakakis et al. was considered.[30] This percentage of impairment (29% for HZ and 49% for PHN) was then valued as a loss of working days over a 6-month, excluding hours due to absenteeism. Median salaries, employment to population rate, and hours worked per week were obtained from the PNAD 2019 survey.[21] The estimation of productivity cost per case is presented in Table S1.

Additionally, different univariate sensitivity analyses of productivity costs were performed. For these, productivity costs were estimated considering the 95% confidence intervals (95% CI) of the median salaries and the CIs for the estimates of work effectiveness obtained from Rampakakis E et al.[30] Finally, a scenario analysis of ± 20% of the days of absence in the case of absenteeism was chosen due to the lack of dispersion measures. All costs were estimated in Brazilian real (R$; 1 R$ = 0.17 US $).

Results

Burden of HZ

Out of the total estimated population of 52.57 million older than 50 YOA, in the absence of HZ vaccination, Brazil older adults are projected to experience an estimated 359,797, 23917, and 76,623 cases of HZ, PHN and other non-PHN complications, respectively. The number of deaths due to HZ were low (n = 196), and 143 deaths were without mention of immunosuppression (Table S1). Of this, 18, 14 and 57 deaths due to HZ occurred in the 50–69, 70–79 and the 80+ YOA group, respectively.

Overall, the highest number of HZ cases was seen in the 50–59 YOA age group. However, the most severe outcomes, including PHN and non-PHN complications, were more frequent in the advanced age groups. Similar observations were noted in the ANS and SUS patients. Across the age subgroups, the number of HZ, PHN, and non-PHN complication cases registered in the SUS system was more than two times that in the ANS system. Figure 1 presents the number of these cases in SUS and ANS patients by age groups. Also, in both ANS and SUS patients, the proportion of PHN (0.11%) and non-PHN (0.28%) cases were most pronounced in the 80+ YOA subgroup.

Direct healthcare resource utilization (HCRU) costs

Figure 2 presents the direct HCRU costs (outpatient, prescription, and hospitalization) across ANS and SUS populations for HZ and PHN patients stratified by age group. The mean expected HZ-related cost per patient ranged from R$1306.5 to 1435.02 and R$187.55 to 197.55, depending on the age group in the ANS and SUS populations, respectively. The mean cost of treatment per patient increased with age and was ~7 times more in the ANS population compared with the SUS population. Across both system and age sub-groups, the costs of antiviral drugs were the primary driver, followed by the costs of other medications (Figure 2a).

The mean expected PHN-related cost of treatment per patient was higher compared with those with HZ only; it ranged from R$2391.18 to 3680.09 and R$202.75 to 308.97, depending on the age group in the ANS and SUS populations, respectively. The cost of treatment was up to 16 times more in the ANS population compared with the SUS population. Across both system and age sub-groups, the costs of other medications were the primary driver (Figure 2b).

The expected treatment cost per patient for non-PHN complications was also significant (Table S2). In the ANS population, the expected treatment cost per patient for neurological complications was higher than for ocular complications, while in the SUS population, it was comparable.

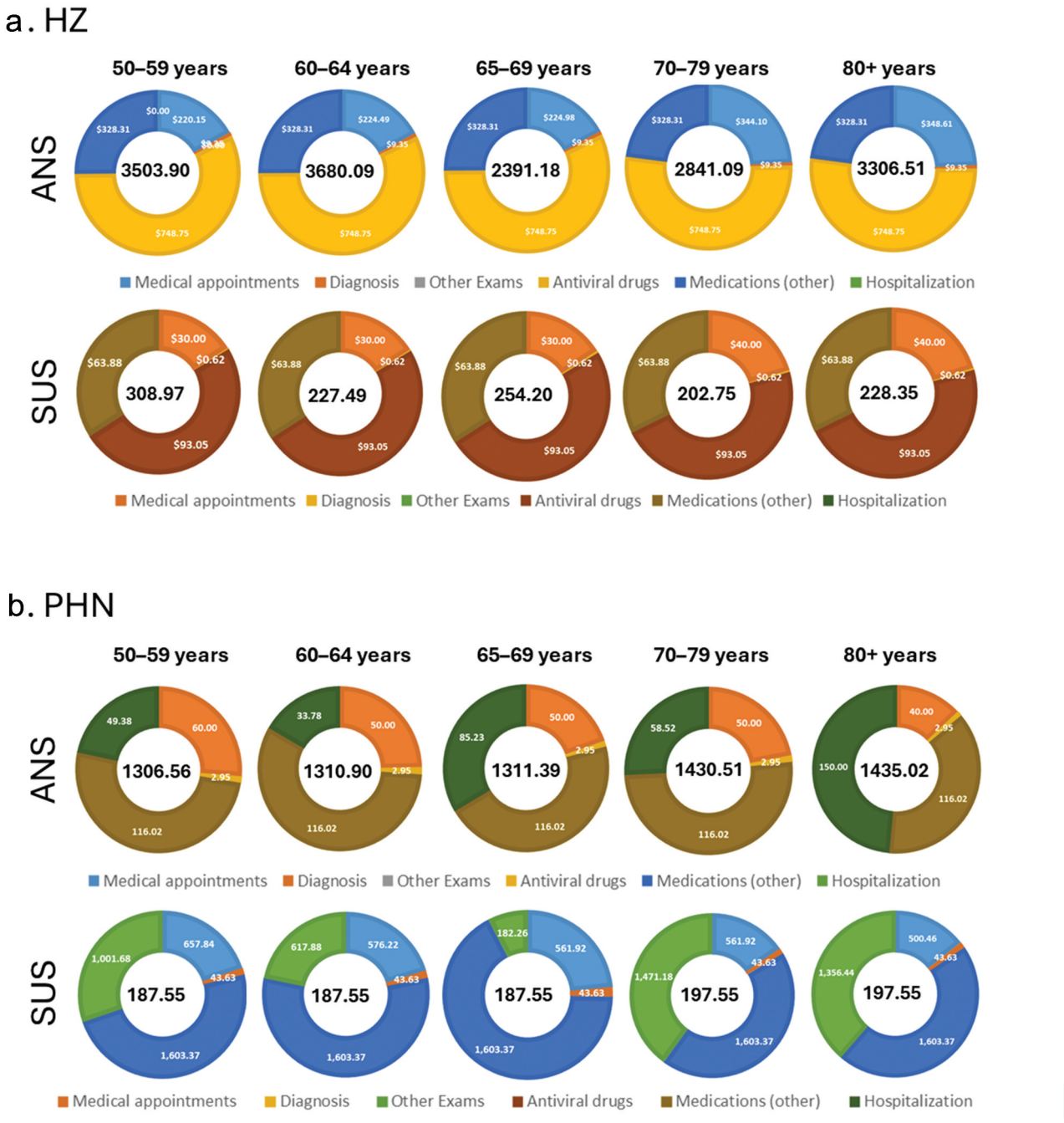

Figure 1. Number of cases of HZ, PHN, non-PHN complications in SUS and ANS by age groups. HZ: Herpes zoster; PHN: Post-herpetic neuralgia; SUS: Unified Health System; ANS: Regulated National Agency of Supplemental Health operated through private health plans and insurance.

Hospitalizations and cost of hospitalizations

Table 1 presents the hospitalizations and costs of hospitalizations for the ANS as well as SUS patients stratified by age groups. The number of hospitalizations registered with primary diagnosis (ANS: 1424; SUS: 1339) and median length of stay (4–5 d) was comparable between ANS and SUS. However, in patients using ANS, the cost of HZ hospitalizations per year was higher when compared with SUS and increased with age (R$42.35 to 60.63 million). Similarly, the average cost of hospitalizations per case was greater in ANS (R$12459.67 to 16,343.07) than for those in the SUS (R$357.93 to 525.08). On the other hand, in the ANS population, the cost of management of hospitalizations of HZ patients without complications was less when compared with the cost per case of the total population, while it was comparable in SUS. In ANS and SUS patients, the annual cost of hospitalizations for HZ patients without complications was R$0.98 to 1.30 million and R$0.03 to 0.09 million. The details of hospitalizations and cost of hospitalizations for HZ patients with non PHN-complications are presented in Table S2.

Economic burden of HZ

Table 2 presents the economic burden (direct and indirect) in millions of HZ, PHN, and non-PHN complications for the ANS

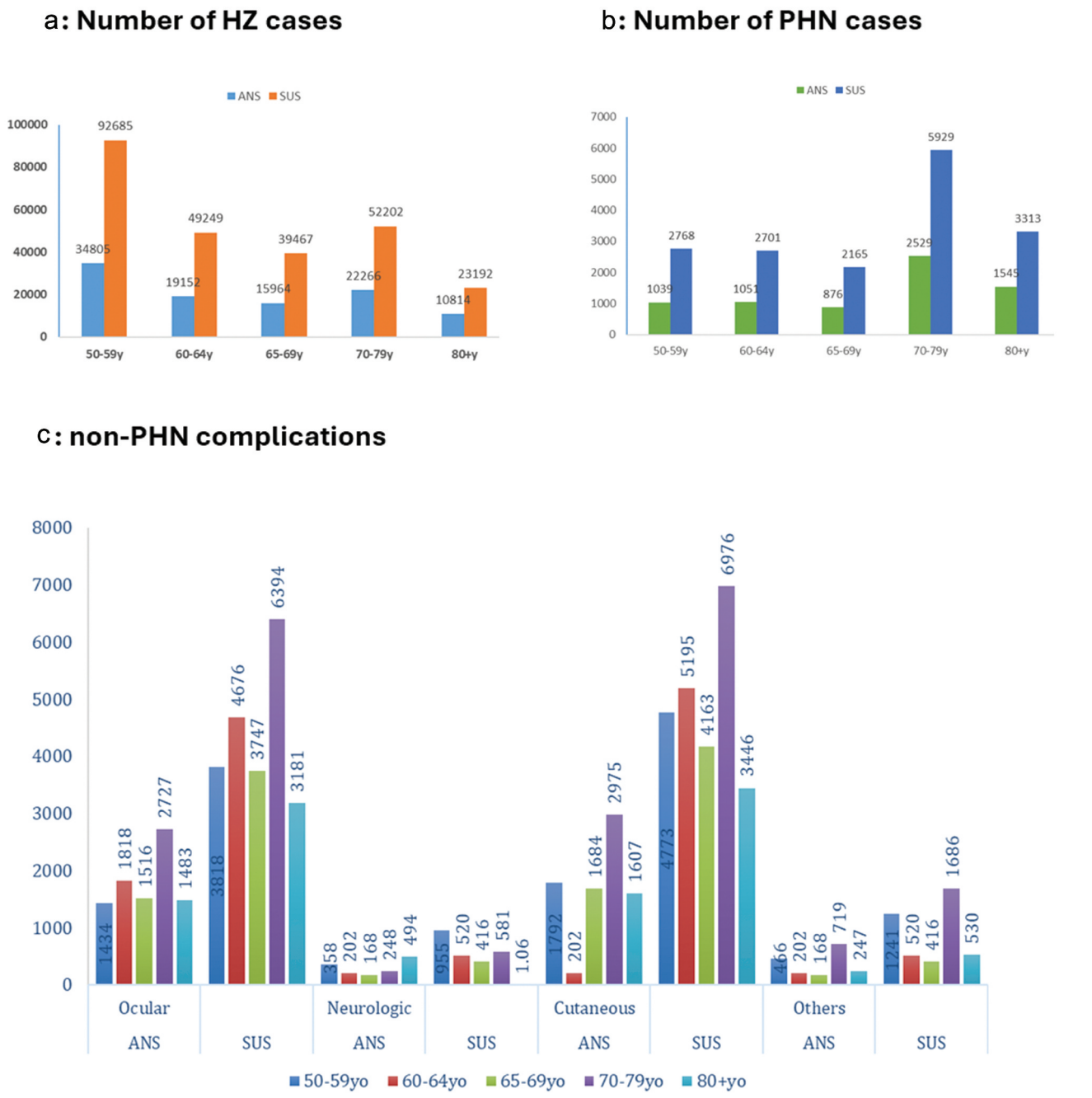

Figure 2. Expected cost per case (R$) of HZ and PHN in ANS and SUS population. HZ: Herpes zoster; PHN: Post-herpetic neuralgia; SUS: Unified Health System; ANS: Regulated National Agency of Supplemental Health operated through private health plans and insurance.

and SUS population. In both ANS and SUS, direct medical costs attributed to HZ were highest in the 50–59 YOA (~R$54 million), while costs associated with PHN and ocular complications were most significant in the 70–79 YOA. The total direct medical costs for HZ and associated conditions are R$190.74 and R $166.61 million for ANS and SUS, respectively. Of these, HZ alone accounts for over 70% of the cost. The productivity costs associated with HZ are higher, amounting to R$410.82 million, while PHN-related productivity costs add another R$30 million.

The overall economic burden of HZ and its sequelae for SUS and ANS combined amounts to R$798.17 million. Table 2 also presents the total economic burden across the ANS and SUS population put together by age group.

Sensitivity analysis results

The results of the univariate sensitivity analysis for productivity costs are summarized in Table S4. Outcome of this analysis shows that there were no relevant variations in the total productivity losses when different parameters, i.e. salary in median, absenteeism in days, and work efficiency were varied.

Discussion

Globally, HZ and its complications, such as PHN, are associated with a substantial economic burden. In Brazil, despite the expected increase in the incidence of HZ as the population ages, studies on the economic burden of illness are

Table 1. Hospitalizations and cost of hospitalizations (R$) with a primary diagnosis of HZ for the SUS and ANS by age groups.

Age Groups, Years	Hospitalizations		Hospitalization days, Mean		Hospitalization days, Median		Cost of hospitalizations/year		Cost of hospitalizations/case	
	T	WOC	T	WOC	T	WOC	T	WOC	T	WOC
ANS										
50–59	290	89	6	4	4	4	4,234,549.81	1,178,679.56	14,601.90	13,243.59
60–69	348	107	5	4	4	4	4,359,456.27	980,765.63	12,527.17	9,166.03
70–79	415	113	6	4	4	4	5,170,764.37	1,284,136.27	12,459.67	11,364.04
80+	371	99	7	5	5	4	6,063,280.68	1,298,063.44	16,343.07	13,111.75
SUS										
50–59	329	146	6	6	5	5	172,751.77	88,320.48	525.08	604,93
60–64	211	89	6	5	5	5	75,523.18	39,014.96	357.93	438,37
65–69	214	98	6	6	5	4	105,897.11	50,669.68	494.85	517,04
70–79	315	130	6	5	4	3	127,103.93	45,276.2	403.50	348,28
80+	270	107	6	5	4	4	119,534.37	29,188.52	442.72	272,79

HZ: Herpes zoster; T: Total HZ population; WOC: HZ without complications; SUS: Unified Health System; ANS: Regulated National Agency of Supplemental Health operated through private health plans and insurance.

Table 2. Direct medical costs and total economic burden (in millions, Brazilian reals) of HZ disease in Brazilian population ≥50 y of age.

	HZ	PHN	Ocular	Neurological	Other complications	Total
			A: Direct medical cost.			
Direct Medical Cost ANS						
50-59y	45.47	3.64	2.84	1.47	0.95	54.38
60-64y	25.11	3.87	3.71	0.85	1.08	34.61
65-69y	20.94	2.09	2.96	0.66	0.90	27.54
70-79y	31.85	7.19	5.86	1.05	1.59	47.54
80+y	15.52	5.11	3.20	1.98	0.86	26.67
All	138.89	21.90	18.57	6.01	5.38	190.74
Direct Medical Cost: SUS						
50-59y	46.29	1.59	3.79	1.27	0.82	53.75
60-64y	24.62	1.38	3.84	0.65	0.97	31.46
65-69y	19.73	1.16	3.75	0.53	1.16	26.33
70-79y	27.68	2.91	4.48	0.75	0.53	36.36
80+y	12.32	1.77	2.83	1.31	0.49	18.72
All	130.65	8.80	18.69	4.51	3.96	166.61

Age groups	Total Direct medical costs (SUS+ANS)	Productivity costs		Total economic burden
		HZ	PHN	
		B: Total economic burden		
50-59yo	108.14	248.18	12.12	368.44
60-64yo	66.06	88.91	8.00	162.97
65-69yo	53.87	43.23	3.89	101.00
70-79yo	83.90	28.13	5.42	117.45
80+yo	45.38	2.37	0.55	48.31
All	357.36	410.82	30.00	798.17

ANS: Regulated National Agency of Supplemental Health operated through private health plans and insurance; HZ: Herpes zoster; PHN: Post-herpetic neuralgia; SUS: Unified Health System; y: years.

inadequate and still needed. Recently, a systematic review described the economic burden of HZ in the LAC region. However, it had its own limitations, as there was a considerable amount of heterogeneity among the included studies, and some did not meet the standards. This also highlighted the need for more studies to ascertain the economic impact in countries of the LAC region.[16] The present study is one of the first that used Brazil-specific model inputs where available and predicted a high economic impact of HZ in Brazilian older adults ≥50 YOA. This information can aid in informed decision-making and enable effective planning for healthcare resource allocation and insurance coverage strategies, both in the private and public healthcare sectors. Also, the epidemiology and the burden of HZ in Brazil is poorly understood. Results of the present study indicate that in the absence of vaccination, 0.70% ($n = 359,79$) older adults are projected to experience HZ and of this, 6.64% ($n = 23,917$) progress to PHN. The estimated number of deaths due to HZ was also low (0.05%). These estimates are lower than those of previous studies,[4] which could be due to underreporting cases or a lack of medical-seeking behavior for less severe cases in this region.

While the absolute number of HZ and PHN cases was higher in the SUS, reflecting its broader population coverage, the mean cost of treatment per patient was substantially greater in the ANS system, indicating a higher per-capita economic burden for individuals utilizing private healthcare. As HZ and its complications mainly affect older adults, the financial impact is generally due to high direct costs (e.g., medical appointments, hospitalizations, etc.) rather than due to indirect costs (e.g., workday loss, deterioration of work capacity, etc.). In the present study, the mean cost per patient for HZ-related treatment was estimated to range from R $1306.5 to R$1435.02 and R$187.55 to R$197.55 in the ANS

and SUS system, respectively. Similarly, among a sub-set of patients with PHN, the mean cost per patient ranged from R $2391.18 to R$3680.09 and R$202.75 to R$308.97, respectively. The costs of antiviral drugs and other medications were the primary driver. In a pooled analysis of studies from Latin America, the overall direct cost per case was US$763.19 for those without PHN to US$1,227.67 for those with PHN. In the same study, the direct cost per case for Brazil was US$1,132.64 for those without PHN to US$1,871.82 for those with PHN.[30] In another population-based study from the US, the cost per case was estimated to be US$910 for those without PHN to $5548 for those with PHN.[31] In the aforementioned studies, higher and considerable differences in the cost per HZ case compared with the present study can be attributed to consideration of additional resources such as the use of ambulance or nursing services, visits to the emergency room or a physiotherapist, etc., while estimating the cost. Thus, if we discount for these variables, which may also have contributed to the higher per-patient costs, our results are most likely to be consistent with previous published studies.[30,31] Also, in line with the literature,[30,31] the costs of care for HZ patients with PHN were substantially higher compared with HZ patients without PHN. While medical appointments and costs of medications accounted for the foremost proportion across the cohorts, hospitalization costs contributed significantly to the overall costs of HZ patients with PHN.

Although hospitalizations due to HZ is uncommon and remained stable over time in Brazil, it can have significant impact on the total burden.[4] In the present study, hospitalization increased the treatment cost by a factor of more than 10 (cost per case: R$12459.67–16343.07). We explored neighboring regions or countries with varying healthcare models and socioeconomic profiles. In contrast, the study from Switzerland showed a 26.9-fold increase, and the average cost of hospitalized patients was CHF 9029.[32] Similarly, the cost of hospitalization was high for patients in Canada (US$14,258) and Germany (EUR 2,984).[33,34] One of the reasons for these differences could be associated to high healthcare costs in developed countries. Other factors, such as severity of disease, presence of comorbidity, length of stay, type of hospital, etc., also influence the cost. Also, HZ is known to significantly increase the length of hospitalization, adding to the cost of the management of the disease. The median length of stay of 4–5 d in the present study was comparable to that reported from a meta-analysis (4.5 d) involving patients over 65 YOA from three studies.[16] Further, in the present study, the annual cost of HZ hospitalizations for patients escalates with age; it ranged from R$42.35 to R $60.63 million and R$0.08 to R$0.17 million for patients visiting ANS and SUS systems, respectively. Notably, individuals aged 80 and above incur the highest costs, suggesting more complex or intensive treatments, which is something also related to the increase in complications. This also underscores the heightened vulnerability of older patients to severe outcomes.

The total direct medical costs for HZ and associated complications were R$357.36 million, of which HZ alone accounted for over 75% of the cost. Indirect costs associated with lost productivity were responsible for an additional R$440.82 million in costs in the older population and reflect the debilitating nature of HZ and PHN among older people of working age. Our results confirmed that HZ imposes a substantial economic burden on the healthcare system as a result of high direct medical and indirect costs. In Brazil, there is great heterogeneity within the public and private healthcare systems, resulting in a disparity in healthcare services utilization and favor those belonging to higher socioeconomic status.[35] Despite this fact, the combined (ANS and SUS) financial impact of HZ reflects its extensive influence on healthcare expenditures within the Brazilian health systems. This data holds valuable insights for healthcare providers, insurers, and policymakers in Brazil, offering a comprehensive overview of the economic impact of HZ and its associated complications for the ANS and SUS patients. Though most HZ cases are concentrated in the 50–59 age group, the more severe outcomes, such as higher incidence of its complications, e.g., PHN, significantly affect the older population, particularly those aged 80 and above. This underlines the urgency of addressing these conditions from a healthcare standpoint and as an economic concern. Beyond the economic costs quantified in our study, HZ significantly impacts patient quality of life, as demonstrated in neighboring Argentina.[36]

Similar modeling approaches are employed internationally to assess both baseline burden and the potential public health impact of vaccination.[37,38] Our baseline HZ burden estimates for Brazil could inform and be compared with other regional vaccine impact models, strengthening the case for similar cost-effectiveness and budget impact analyses tailored specifically to Brazil.

However, some limitations must be considered when interpreting the results. The population projection used might be overestimated as data from the 2022 Census indicated a discrepancy of 11.8 million people in previous estimates. Health service usage estimates were based on residents available at the time of the National Health Survey interview, potentially underestimating prevalence due to respondents' lack of knowledge about health plan ownership. Additionally, hospitalization data from ANS may be underestimated since variables related to causes of hospitalization are not mandatory fields. Regarding mortality data, there may be underreporting of underlying causes; however, to minimize potential underreporting, we also considered associated causes. Furthermore, heterogeneity between public and private health systems, including differences in access, service quality, and data collection, may influence the results.

Recent events like the pandemic may have influenced HZ incidence trends, underscoring the importance of ongoing surveillance and future updates to burden estimates.[39,40] Our study's data largely reflects a pre-pandemic or early-pandemic baseline.

Finally, some epidemiological parameters, such as HZ incidence and complication rates, were based on general population data as specific stratified data for SUS and ANS users in Brazil were unavailable. Underlying health status, health-seeking behaviors, and actual incidence rates may differ between these populations, and applying general epidemiological rates might introduce some bias. Future studies with prospectively collected, stratified epidemiological data would be beneficial to refine these estimates. Despite the good methodology applied, the Delphi panel is recognized as a method that provides point estimates based on expert consensus, which may have limitations in capturing the full spectrum of variability for all parameters. While key Delphi-derived parameters affecting productivity costs were

varied in scenario analyses, comprehensive probabilistic sensitivity analyses on all expert-derived resource utilization estimates were constrained by the nature of these inputs. Key economic and social challenges and burdens that warrant further exploration include chronic underfunding and regional inequalities within the SUS, the increasing burden of non-communicable diseases, the impact of a rapidly aging population (a central theme of our study), and the role of this dual system in contributing to disparities in healthcare access and outcomes.

Conclusions

This study provides the first comprehensive estimate of the substantial economic burden of Herpes Zoster (HZ) in Brazilian adults aged ≥50 y, totaling R$798.17 million annually, with distinct cost profiles observed between the public (SUS) and private (ANS) healthcare systems. These findings underscore HZ as a significant public health and economic concern in Brazil, necessitating targeted strategies for prevention and management. To further build upon these findings and address current limitations, future research should prioritize several key areas. Prospectively collecting data on HZ incidence, complications, and healthcare resource utilization specifically within the SUS and ANS cohorts is paramount to refine model inputs and reduce reliance on Delphi panels for certain parameters. A more holistic understanding of the disease burden would be achieved by investigating the long-term impact of HZ and post-herpetic neuralgia (PHN) on quality of life and indirect costs beyond the initial 6-month period assessed in this study.

Given the considerable economic impact demonstrated, cost-effectiveness analyses of HZ vaccination strategies, including newer adjuvanted recombinant vaccines, are urgently needed. Such analyses, building upon the burden estimates from this study, would be invaluable for informing public health policy and guiding resource allocation in Brazil. Furthermore, studies exploring the impact of socioeconomic disparities on HZ burden and access to care within Brazil could illuminate important equity considerations relevant to health policy. Finally, continuous monitoring of HZ incidence trends will be crucial for future burden reassessments. Addressing these research priorities will be essential for developing comprehensive and equitable strategies to mitigate the impact of HZ in Brazil.

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Disclosure statement

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Ethics

Ethical approval was not required for this study as it involved secondary analysis of previously collected, de-identified data and did not include any interaction with human participants.

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