Temporal and Sociodemographic Analysis of Cancer Mortality of Older Adults in Brazil from 2011 to 2020

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Análise Temporal e de Fatores Sociodemográficos da Mortalidade por Neoplasias da População Idosa no Brasil, no Período de 2011 a 2020

Análisis Temporal y de Factores Sociodemográficos de la Mortalidad por Neoplasias en la Población Anciana en Brasil, en el Período de 2011 a 2020

Felipe Carneiro de Souza[1]; Cleber Nascimento do Carmo[2]

ABSTRACT

Introduction: The rapid increase of the population of older adults in developing countries, combined with changes in the epidemiological profile, underscores the urgent need for public policies focused to this group of individuals. **Objective:** To analyze cancer mortality among older adults in Brazil from 2011 to 2020, and its relationship with some socio-economic data. **Method:** Ecological study. Cancer mortality rates were calculated and standardized, Prais-Winsten regression models were applied, in addition to a cluster analysis. **Results:** The results revealed a growing trend in mortality across all Brazilian states, with Rio Grande do Sul and Distrito Federal standing out with the highest average rates. Cluster analysis identified three distinct groups. The South region, among the regions with better economic conditions, presented high longevity and, consequently, higher cancer mortality rates for older adults. On the other hand, lower rates were found at the North and Northeast Regions, with worst economic indicators, possibly due to lower life expectancy and underreporting. **Conclusion:** These findings emphasize the need for public policies that improve healthcare access and quality of care for older adults throughout Brazil.
Key words: Mortality/trends; Neoplasms/mortality; Aged; Socioeconomic Factors.

RESUMO

Introdução: O aumento rápido da população idosa em países em desenvolvimento, aliado às mudanças no perfil epidemiológico, destaca a necessidade urgente de políticas públicas voltadas para a saúde do idoso. **Objetivo:** Analisar a mortalidade por neoplasias entre idosos no Brasil de 2011 a 2020, e sua relação entre alguns dados socioeconômicos. **Método:** Estudo ecológico. Foram calculadas taxas de mortalidade por neoplasias, padronizadas, e aplicados os modelos de regressão de Prais-Winsten, além de uma análise de agrupamentos. **Resultados:** Os resultados revelaram uma tendência crescente na mortalidade em todas as Unidades Federativas, com destaque para o Rio Grande do Sul e o Distrito Federal, que apresentou as maiores taxas médias. A análise de *clusters* identificou três agrupamentos distintos. Regiões com melhores condições socioeconômicas, como o Sul, apresentaram maior longevidade e, consequentemente, elevadas taxas de mortalidade por neoplasias. Por outro lado, as Regiões Norte e Nordeste, com piores indicadores, apresentaram menores taxas, possivelmente em razão de uma expectativa de vida mais baixa e de subnotificações. **Conclusão:** Esses achados ressaltam a necessidade de políticas públicas que melhorem o acesso à saúde e a qualidade dos cuidados para idosos em todo o Brasil.
Palavras-chave: Mortalidade/tendências; Neoplasias/mortalidade; Idosos; Fatores Socioeconômicos.

RESUMEN

Introducción: El rápido aumento de la población anciana en los países en desarrollo, junto con los cambios en el perfil epidemiológico, destaca la necesidad urgente de políticas públicas centradas en la salud de los ancianos. **Objetivo:** Analizar la mortalidad por neoplasias entre los ancianos en el Brasil de 2011 a 2020, y su relación con algunos datos socioeconómicos. **Método:** Estudio ecológico. Se calcularon las tasas de mortalidad por neoplasias, ellas fueron estandarizadas, y se aplicaron modelos de regresión de Prais-Winsten, además de un análisis de clústeres. **Resultados:** Los resultados revelaron una tendencia creciente en la mortalidad en todos los estados del Brasil, destacando Río Grande del Sur y el Distrito Federal, que tuvo las tasas promedio más altas. El análisis de clústeres identificó tres agrupamientos distintos. Las regiones con mejores condiciones socioeconómicas, como el Sur, mostraron mayor longevidad y, en consecuencia, altas tasas de mortalidad por neoplasias entre los ancianos. Por otro lado, las regiones Norte y Nordeste, con peores indicadores, presentaron tasas más bajas, posiblemente debido a una menor esperanza de vida y subregistro.
Conclusión: Estos hallazgos enfatizan la necesidad de políticas públicas que mejoren el acceso a la salud y la calidad de la atención a los ancianos en todo el Brasil.
Palabras clave: Mortalidad/tendencias; Neoplasias/mortalidad; Anciano; Factores Socioeconómicos.

[1-2]Fundação Oswaldo Cruz (Fiocruz). Rio de Janeiro (RJ), Brasil.
[1]E-mail: felipe.c.souza1005@gmail.com. Orcid iD: https://orcid.org/0000-0002-5816-2083
[2]E-mail: cleber.carmo@gmail.com. Orcid iD: https://orcid.org/0000-0003-4165-2198
Corresponding author: Felipe Carneiro de Souza. Rua Isidro de Figueiredo, 23, 001 – Maracanã. Rio de Janeiro (RJ), Brasil. CEP 20271-100. E-mail: felipe.c.souza1005@gmail.com

INTRODUCTION

Fast increase of the population of older adults is a reality in least developed countries, a challenging demographic change for these countries, that must incorporate populational aging in their public policies and develop social and health strategies to meet this new scenario[1].

While demographic transition occurs, the pattern of diseases and mortality changes concomitantly[2,3]. The epidemiologic profile, influenced by various interconnected alterations of health and disease behaviors along the time is the outcome of social, economic and mainly demographic transformations.

Individuals and social groups have different characteristics but this does not mean there are inequalities in the processes of health and disease. Inequalities are perceptible and quantifiable variations of health conditions or access to health services. When perceived as unfair or somehow resulting from some type of unfairness, they are called inequities[4].

Inequalities are a global reality found in many countries when compared among themselves. They appear in many cultural, social and economic aspects, resulting in disparities in accessing information, healthcare and prevention of health issues and diseases[5].

Cancer is the result of many factors and its association with populational aging is acknowledged[6]. Demographic and epidemiological changes worldwide reveal the rising relevance of oncologic care for the upcoming decades.

For better understanding of the population profile of a community, it is required to monitor socioeconomic indicators. In low-income and developing countries, nearly 10% of deaths are attributed to cancer and this proportion can increase, mainly due to tobacco-related cancers in aging populations[7].

As the sickening process varies individually and contextually (mainly in older than 60 years individuals affected by additional factors of "geriatric syndromes")[8], it is important that the analyzes are grounded on the theoretical understanding of health inequalities. The investigation of social determinants related to death by cancer of older adults and associated sociodemographic factors would favor the analysis of their vulnerability contexts.

The demographic census of 2022 indicate an increase of the Brazilian populational aging, 15.6% of the population is older than 60 years or more compared to 10.8% in 2010[9], emphasizing the pertinence of these analyzes.

Due to the importance of continuous monitoring of the trend of cancer mortality of older adults to guide policies, health services and interventions, the aim of the present study is to characterize the profile of cancer mortality of the older population, the respective contextual factors and follow up the changes of epidemiologic patterns between 2011 and 2020 for individuals older than 60 years of age.

METHOD

Ecologic study to describe and analyze mortality data of the older population between 2011 and 2020. The unit of spatial analysis is the Federative Unit (FU) and the years investigated were the temporal unit.

All the individuals older than 60 years of age or more were enrolled in the study. Data were obtained from the National Health Service (SUS) mortality information system (SIM)[10] through death certificates. In addition, populational data were extracted from the 2010[11] demographic census database.

Contextual variables were collected from the United Nations Development Programme (UNDP), "*Instituto de Pesquisa Econômica Aplicada* (IPEA) and the Ministry of Health[12]. These variables included the Municipal Human Development Index (MHDI), Gini Coefficient, Social Vulnerability Index (SVI) and illiteracy rate (for individuals aged 15 years or more). The most updated data were utilized, for instance, MHDI (IPEA), Gini Coefficient and illiteracy rate (National Household Sample Survey – PNAD) are referred to 2017 and SVI, to 2019.

The number of deaths available at SIM and population according to the 2010 demographic census[11] of "*Instituto Brasileiro de Geografia e Estatística* (IBGE)" were utilized to calculate the mortality rate. Direct standardization was adopted to avoid populational distortion of the results. The reference population for the standardization was obtained from the 2010 Demographic Census[11]. The outcomes analyzed consisted in the rates of mortality by different types of cancer of the older population living at different Brazilian FUs.

Initially, the descriptive analysis of the study variables was performed, involving summary measures and graphical view to organize and describe the characteristics of the dataset. Minimum, maximum, first and third quartiles, median, mean and standard-deviation were calculated for the mortality rates per FU.

Prais-Winsten[13] generalized multiple linear regression models were utilized to estimate time-series, correlating mortality rates (Y) with time in years (X), according to the equation :

$$Y = \beta_0 + \beta_1 X + \beta_2 X^2 + \epsilon$$

Where β_0 corresponds to the intersection between the straight line and the vertical axis; β_1, slope of the line, β_2 corresponds to the quadratic term of the regression whose statistical significance indicates better representation of the data by non-linear relation and ϵ, the random error term. For these analyzes, the variable time (in years) was centralized to avoid autocorrelation of the ordered data. For each model analyzed, the value of the determination coefficient given by R-square (R^2) statistics, the value of *p* – calculated by Student's *t* test – and level of statistical significance were considered[14].

At last, the analysis of mortality data group was performed for each FU. The socioeconomic variables were considered for the analysis, in addition to minimum, maximum values, mean of the rates calculated per FU and respective standard deviation for the period in question. The objective was to differentiate geographic and demographic patterns of mortality of older adults to provide elements to develop more effective public policies targeted to this population.

Level of statistical significance of 5%, software WPS[15] Spreadsheets for tabulation and calculations and software R[16] version 4.2.3 to estimate regression models (packages "*prais*" and "*sandwich*") were utilized for the study analyzes and the packages "*dplyr*", "*stringr*", "*cluster*", "*ggplot2*", "*readxl*" and "*factoextra*" for groups analyzes.

The review and approval by the Ethics Committee were waived because only public, deidentified data were utilized in compliance with Directive 510/2016[17] of the National Health Council.

RESULTS

The results of the analyzes of the data collected (Table 1) reveal wide variation of cancer mortality rates from 2011 to 2020. The FU of Maranhão had the lowest rate for any year of the time period – 34.6 deaths per 100 thousand inhabitants – while Distrito Federal, the highest, 136.1 deaths per 100 thousand inhabitants. The highest mean and median was observed at Distrito Federal and the lowest, at Maranhão. The minimum standard deviation was identified at Piauí, 5.6 and the maximum, at Roraima, 20.7.

Of the 27 models adjusted, each one corresponding to one FU, 24 presented coefficient of determination (R^2) higher than 0.9, a satisfactory explanation of the variability of the data. This result means that these 24 models were able to explain correctly the variation observed. However, at the FUs of Acre, Amazonas and Pará, the coefficient of determination was lower than 0.9, oscillating between 0.7 and 0.9, suggesting a moderate explanation for the variability of the data.

For a 5% level of statistical significance, all *p* values associated with the 27 models adjusted were lower than 0.05, indicating that all of them were statistically significant, rejecting the null hypothesis and providing substantial evidences that the results achieved were not random.

All the models presented positive values of angular coefficient of a linear adjusted regression (Table 2) expressed as β1. The highest value was observed for the adjusted model of the FU of Roraima (β1 = 6.507) and the lowest value for Piauí (β1 = 1.732). All these coefficients presented *p* lower than the significance level of 5%. This fact supports the affirmation that there is a rising trend of mortalities for the 27 models adjusted.

After the application of the silhouette method, which provides a representation of how well each unit fits in its own group compared to the others, it has been determined that three clusters would be utilized to group the data of the 27 FUs as shown in Figure 1.

Cluster 1 was the group with the lowest mean of deaths of older adults, 63.2 deaths per 100 thousands inhabitants/year. In contrast, the group with the highest mean was cluster 2, 85.5 deaths per 100 thousands inhabitants/year.

Cluster 2 presented the highest mean of MHDI, 0.788, the lowest illiteracy rate, 4.2% and lowest SVI, 0.206. Cluster 3 had the lowest Gini coefficient, 0.487. Table 3 portrays these results for each FU.

Cluster 1 had the lowest MHDI, 0.716 and the highest inequality income index measured by Gini coefficient, 0.539. The same cluster presented the highest illiteracy rate, 11.9% for the population older than 15 years of age and the highest SVI, 0.302.

DISCUSSION

The mean mortality rates of two FUs (Rio Grande do Sul and Distrito Federal) calculated for each year of the period 2011-2020 were higher than 100. The lowest means were found for the FUs of the North and Northeast regions. It has been observed a rising trend for all the datasets of the 27 FUs, including Distrito Federal, after the application of the Prais-Winsten[13] regression. The cluster analysis was divided in three groups, formed by 14, 11 and two FUs, respectively. Most of the FUs of the North and Northeast regions were gathered on cluster 1 and most of the FUs of the South, Southeast and Midwest regions, in cluster 2.

Among the five FUs with highest β1 coefficient of their models, three were at the North region (Roraima, Rondônia and Amapá), one, at the Midwest region and one at the South region (Santa Catarina) and all these FUs

Table 1. Cancer mortality rates for older than 60 years of age or more per FU – 2011/2020: minimum, maximum, first, third quartile, median, mean and standard deviation

FU	Min.	Max.	1Q	3Q	Median	Mean	SD
Acre	50.0	83.5	65.7	77.0	73.1	70.8	10.0
Alagoas	39.4	66.0	48.2	60.4	53.5	53.8	8.8
Amapá	53.2	95.1	67.1	77.5	72.9	73.8	12.5
Amazonas	65.1	87.9	70.4	82.7	78.0	76.9	7.5
Bahia	43.7	68.6	48.7	63.6	54.0	55.7	8.9
Ceará	56.3	79.5	61.4	75.5	68.3	68.3	8.2
Distrito Federal	95.9	136.1	102.8	123.7	111.4	113.4	14.0
Espírito Santo	69.7	98.9	74.6	91.7	82.1	82.9	10.5
Goiás	55.2	87.6	64.6	83.1	73.9	73.4	11.3
Maranhão	34.6	55.1	39.5	52.0	45.7	45.4	7.4
Mato Grosso	62.1	94.8	67.4	84.2	76.2	76.6	11.1
Mato Grosso do Sul	62.0	91.1	69.7	86.1	77.5	77.8	10.0
Minas Gerais	58.3	82.3	64.2	77.2	70.8	70.8	8.3
Pará	43.7	68.3	51.6	64.2	59.4	57.9	8.7
Paraíba	49.2	69.9	56.2	62.6	59.7	59.5	5.8
Paraná	77.7	102.7	83.4	97.3	89.9	90.2	8.9
Pernambuco	57.1	76.5	60.9	71.7	66.8	66.1	6.7
Piauí	48.7	67.0	54.2	61.4	60.1	58.3	5.6
Rio de Janeiro	67.8	85.2	73.4	82.0	78.0	77.4	5.9
Rio Grande do Norte	58.9	78.9	61.2	73.9	68.2	68.3	7.5
Rio Grande do Sul	87.5	112.7	94.7	107.3	100.5	100.4	8.5
Rondônia	47.8	99.3	64.5	87.0	79.6	76.3	16.5
Roraima	56.0	109.2	67.1	104.9	77.0	83.1	20.7
Santa Catarina	79.4	112.6	86.8	107.3	96.3	96.0	12.4
São Paulo	73.3	98.5	79.3	92.6	85.9	85.7	8.3
Sergipe	52.5	73.5	58.2	67.3	64.6	63.6	6.7
Tocantins	52.8	72.0	58.7	70.3	62.3	63.2	7.2

Captions: FU = Federative Units; min. = minimum; max. = maximum; 1Q = first quartile; 3Q = third quartile; SD = standard-deviation.

are in cluster 2 or cluster 3. As high the slope, higher is the speed of growth of the rising trend of the mortality standardized rates, even if the mean rates observed for the period investigated were not among the highest, what happened for the three FUs of the North region. If the speed of growth of the standardized rates for all FUs remained equal, these three FUs will eventually reach the FUs with the highest rates for the period.

In despite of potential sub-notification that may have partially compromised the data obtained from the Computer Department of SUS (DATASUS) as already quoted in other studies[18], it is clear there is a rising proportion of older adults in the Brazilian population and longer life expectancy.

IBGE estimates indicated that life expectancy will exceed 80 years in the decade of 2040[19], changing the demographic profile where health of older adults will be more relevant[20].

SUS will have to make adjustments to assist the rising number of older adults. A 2018 survey with a sample of 60-years old or more individuals obtained from 23 FUs revealed that 46% of the 6,590 older adults investigated sought medical care and 53 of them did not receive assistance[21].

Some types of neoplasms are listed as avoidable deaths[22] and deaths by prostate and breast cancers that can be diagnosed early with preventive exams presented rising trends for the population of 80 years or more in the period 2000-2017[23]. Former studies have already showed the importance of medical follow-up not only as a tool to prevent diseases but also to evaluate the quality of life of an individual[24].

Table 2. Prais-Winsten slope coefficient (beta1), respective *p* values (level of significance of 5%) and trends for each regression model adjusted per FU

FU	Beta1	*p*	Trend
Acre	2.8173	0.006	Rising
Alagoas	2.842	<0.001	Rising
Amapá	3.8162	<0.001	Rising
Amazonas	1.9299	0.012	Rising
Bahia	2.8451	<0.001	Rising
Ceará	2.7511	<0.001	Rising
Distrito Federal	4.4708	<0.001	Rising
Espírito Santo	3.3895	<0.001	Rising
Goiás	3.7392	<0.001	Rising
Maranhão	2.4703	<0.001	Rising
Mato Grosso	3.617	<0.001	Rising
Mato Grosso do Sul	3.1876	<0.001	Rising
Minas Gerais	2.7486	<0.001	Rising
Pará	2.7478	<0.001	Rising
Paraíba	1.8217	<0.001	Rising
Paraná	2.8999	<0.001	Rising
Pernambuco	2.307	<0.001	Rising
Piauí	1.732	<0.001	Rising
Rio de Janeiro	1.9214	<0.001	Rising
Rio Grande do Norte	2.507	<0.001	Rising
Rio Grande do Sul	2.913	<0.001	Rising
Rondônia	5.379	<0.001	Rising
Roraima	6.507	<0.001	Rising
Santa Catarina	4.1407	<0.001	Rising
São Paulo	2.879	<0.001	Rising
Sergipe	2.076	<0.001	Rising
Tocantins	2.244	<0.001	Rising

Caption: FU = Federative Unit

Figure 1. Plot of the three groups produced by the analysis of groups and respective colors (cluster 1 – red; cluster 2 – blue; cluster 3 – green)

Note: Cluster 1: FUs of Acre, Alagoas, Amazonas, Bahia, Ceará, Maranhão, Pará, Paraíba, Pernambuco, Piauí, Rio de Janeiro, Rio Grande do Norte, Sergipe and Tocantins. Cluster 2: FUs of Amapá, Distrito Federal, Espírito Santo, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Paraná, Rio Grande do Sul, Santa Catarina and São Paulo. Cluster 3: FUs of Rondônia and Roraima.

The three FUs of the South Region presented mortality rate/year higher than 100 and better socioeconomic indexes, which brings up the concept that longevity is closely related to better quality of life.

In counterpart, cluster 1, mostly formed by FUs of the North and Northeast regions presented the lowest cancer mortality rates and worst socioeconomic indicators, including the FU with the lowest slope of the regression line adjusted by the model, Piauí, which suggests lower life expectancy and explains lower mortality rates. Because of the clusters disparities, public policies should be focused to improve access to health and quality of the care provided to older adults, particularly at more vulnerable regions.

Sub-notification and low quality of the information may have impacted the data collected. A study showed that six FUs presented inadequate proportion of unspecific causes of cancer deaths for the period 2009-2019, and five of them were at the North and Northeast regions[25], that does not favor cancer surveillance and respective risk factors. This can explain why the FUs of the North regions were spread in three clusters (two of them exclusive of cluster 3 which presented the highest standard deviation for the period). In despite of surveillance monitoring and evaluation tools available for each FU, it is still challenging to keep and strengthen them[26].

An additional observation is the presence of clusters that encompassed geographically distant FUs, while one cluster encompassed FUs of the same region (cluster 3 formed by Rondônia and Roraima). The diversity of mortality and socioeconomic data within the same geographical regions suggests more in-depth studies to investigate these trends thoroughly.

A robust analysis of neoplasms and socioeconomic data was performed, utilizing more than one statistical technique to understand the profile of each FU and highlight regional similarities or differences. The combination of descriptive data with advanced analyzes allows contextualized interpretation, further to the relevance for public health planning.

In addition to the strong points of the study, there were limitations as the utilization of potentially flawed or sub-notified secondary data. The growth trends

Table 3. Municipal Human Development Index, Gini coefficient, illiteracy rate and Social Vulnerability Index (SVI) of Brazil's Federative Units

FU	MHDI	Gini Coefficient	Illiteracy rate	SVI
Acre	0.712	0.545	11.5	0.357
Alagoas	0.679	0.525	17.3	0.329
Amapá	0.732	0.589	4.9	0.234
Amazonas	0.728	0.591	5.9	0.329
Bahia	0.71	0.59	12	0.279
Ceará	0.73	0.547	13.4	0.262
Distrito Federal	0.842	0.593	2.3	0.26
Espírito Santo	0.78	0.506	5.1	0.206
Goiás	0.765	0.477	5.4	0.242
Maranhão	0.685	0.526	15.8	0.348
Mato Grosso	0.77	0.463	6	0.215
Mato Grosso do Sul	0.762	0.464	4.6	0.179
Minas Gerais	0.784	0.493	5.6	0.195
Pará	0.694	0.506	8.2	0.285
Paraíba	0.717	0.548	15.7	0.316
Paraná	0.797	0.481	4.2	0.176
Pernambuco	0.722	0.551	12.7	0.329
Piauí	0.694	0.529	15.6	0.281
Rio de Janeiro	0.791	0.519	2.4	0.276
Rio Grande do Norte	0.728	0.523	12.9	0.285
Rio Grande do Sul	0.793	0.481	2.8	0.201
Rondônia	0.721	0.447	6.5	0.178
Roraima	0.746	0.526	5.6	0.273
Santa Catarina	0.817	0.414	2.4	0.126
São Paulo	0.831	0.526	2.4	0.231
Sergipe	0.699	0.551	13.7	0.297
Tocantins	0.74	0.495	9.4	0.251

Captions: FU = Federative Units; MHDI-M = Municipal Human Development Index; IR = illiteracy rate; SVI = Social Vulnerability Index

and variability of mortality rates of each FU were not thoroughly investigated as well for the period analyzed.

Due to the target population selected for the current investigation, it is possible that some profiles of neoplasms found in younger populations and their potential relation with similar contextual determinants may have been overlooked. Another possible limitation was to consider aging as a homogenous phenomenon, neglecting the significant variations of populational aging among social groups in the same population and interfering in the construction of the study profile.

Other studies can potentially be developed from the current findings, for instance, an in-depth investigation of socioeconomic determinants of access to health, analysis of the quality of mortality data of each neoplasm or longitudinal and future estimates of cancer mortality trends.

This study can be an important resource for the application of the recently published National Policy of Palliative Care[27], whose goals are to create multidisciplinary teams able to disseminate palliative practices to other healthcare teams of the health assistance network, promote qualified information and palliative care education and ensure the access to required medications and inputs for those in palliative care. The articulation of the findings of the current investigation with the palliative care policy may stimulate ample decision-making focused to cancer surveillance.

CONCLUSION

The results revealed a rising trend of cancer mortality for older adults at Brazil's Federative Units, standing out Rio Grande do Sul and Distrito Federal that presented the highest mean rates for 2011-2020. The cluster analysis showed complexity of regional variations identifying three different groups. Cluster 2 encompassed FUs with highest mortality rates, but not necessarily worst health systems because this cluster had the best socioeconomic levels. However, the FUs of the North and Northeast regions (mostly included in cluster 1), overall, had the lowest mortality rates together with worst socioeconomic indicators, which may reflect low quality of life and possible sub-notification of deaths.

CONTRIBUTIONS

Felipe Carneiro de Souza contributed substantially to the study design, acquisition, analysis and interpretation of the data, wording and critical review. Cleber Nascimento do Carmo contributed substantially to the study design, wording and critical review. Both authors approved the final version to be published.

DECLARATION OF CONFLICT OF INTERESTS

There is no conflict of interests to declare.

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Associate-Editor: Jeane Tomazelli. Orcid iD: https://orcid.org/0000-0002-2472-3444
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