Regional inequalities in mortality from colorectal cancer and its indirect economic impact in Brazil from 2001 to 2030: a human capital approach study

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Summary

Background Brazil contributes to 41% of colorectal cancer (CRC) deaths in Latin America. CRC is the second most incident cancer among males and females in Brazil, with wide regional variation. We aimed to estimate the years of potential life lost (YPLL) and the productivity lost due to mortality from CRC by region, between 2001 and 2030.

Methods We estimated the indirect costs of mortality from CRC using the Human Capital Approach. Mortality data (2001–2016) were obtained from the national Mortality Information System. Economic data were obtained from the Continuous National Household Sample Survey. Productivity lost was calculated for those aged over 15. Results for 2016–2030 were estimated based on the observed data (2001–2015).

Findings We estimated 635,253 deaths from CRC between 2001 and 2030, corresponding to 12·6 million YPLL and Int$22·6 billion in productivity losses. From 2001–2005 (observed) to 2026–2030 (estimated), CRC deaths are expected to increase by 181% and 165% among males and females, respectively. The largest relative increases among males will be observed in the North region, with productivity losses increasing 9·7-fold. Among females, North and Northeast regions will experience the highest increases in productivity lost, 8·7 and 10·3-fold respectively.

Interpretation CRC productivity loss will increase substantially by 2030, primarily due to increasing incidence and mortality, as a consequence of the epidemiological transition and health services access, especially in the North and Northeast regions. Implementing primary prevention, screening, early diagnosis and ensuring timely access to treatment is essential to reduce the economic impact of CRC overall and reduce regional inequities.

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Keywords: Cost of illness; Human capital approach; Indirect costs; Lost productivity; Mortality; Cancer; Colorectal

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Disclaimer: This summary is available in Portuguese in the Supplementary Material.

Research in context

Evidence before this study

We searched Pubmed, Scopus and Scielo databases, in English, Portuguese and Spanish, using the following expression: ((((((cost of illness) OR (Human capital approach)) OR (indirect costs)) OR (lost productivity)) AND (mortality)) AND (cancer)) AND (colorectal) AND Brazil). The only study found, was from the same authors of this article, forecasting the productivity losses for all cancers in Brazil; regional variations were not examined. Colorectal cancer will be one of the cancer types that will contribute the most to productivity losses in Brazil, but the magnitude of this impact on Brazilian regions remains unknown.

Added value of this study

This study provides robust evidence on unequal economic and societal impact of colorectal cancer across Brazilian regions. The highest relative increases in productivity losses, were observed in the North and Northeast regions compared to other regions of the country. This study highlights the relationship between cancer mortality and economic consequences, drawing attention to the societal implications of CRC.

Implications of all the available evidence

This study highlights the public health and economic challenges posed by colorectal cancer in Brazil, revealing marked disparities across regions. Increasing mortality rates and productivity losses, particularly pronounced in the North and Northeast, reflecting regional inequalities in healthcare access and infrastructure. It is crucial to address these regional inequalities to mitigate colorectal cancer's indirect economic impact and improve health equity. Our results emphasize the need for promoting healthy lifestyles, setting up screening programs, early diagnosis and providing timely treatment access.

Introduction

Brazil has the 5th highest mortality rate from colorectal cancer (CRC) among countries in Latin America, contributing to 41% of the CRC deaths in the region.[1] The main factors responsible for the high burden of the disease in Brazil are demographic transition, absence of organized screening programs for the general population and surveillance programs for higher-risk groups, and westernization of lifestyle[2,3] – which has occurred at differing rates in the various regions of Brazil.[4] Brazil has five major geographical regions which markedly differ culturally, economically, demographically and in health services access.[5]

As well as the individual impacts, CRC morbidity and mortality among working-age people have major economic impacts on society due to both the high costs of treatment and losses of productivity caused by the exit of affected individuals from the labor market.[6] Indirect costs such as productivity losses can exceed the direct costs related to the diagnosis, active treatment, and follow-up care of cancer survivors.[6] In Brazil, as in developed countries, early-onset CRC is on the rise, which has the potential to further exacerbate productivity losses and increase the economic burden associated with the disease.[7]

Assessing the economic impact of deaths from CRC – along with measures of incidence, mortality, and survival – can assist health service managers and policymakers by highlighting potential economic benefits from cancer prevention and control strategies, as an additional measure of the cancer burden.[8] For CRC in Brazil, this assessment becomes even more relevant given the estimated increase in mortality over the coming years,[3] and the limited public health system resources allocated to cancer treatment, especially in the North and Northeast regions of the country. Currently, data on the indirect regional economic impact of CRC mortality in Brazil are lacking. For this reason, the aim of this study is to estimate the years of potential productive life lost (YPLL) and value of lost productivity due to mortality from CRC in Brazil and regions between 2001 and 2015 and estimate these until 2030.

Methods

Study setting

Brazilian geographical regions present demographic, economic, and social inequalities. Table 1 presents government-sourced contextual indicators to characterize the study setting, not the input used in calculations. Respectively, the Southeast and South regions have the highest population densities (91·8 inhabitants/km^2 and 51·9 inhabitants/km^2); the highest proportion of the population with access to basic sanitation services (88% and 66%); and the highest percentage of individuals covered by private health insurance (36% and 25%).[9] The North and Northeast regions have the highest proportions of families depending on government income transfer programs (North: 7·5%; Northeast: 9·7%).[9] In both regions, approximately 39% of families experience some level of food insecurity.[9] Around 90% of the population in these areas relies exclusively on the Unified Health System (UHS).[9]

The UHS is a publicly funded national health system, which provides universal and free coverage for the entire population – even for those who have private health insurance. Approximately 75% of Brazilians rely exclusively on this system. The UHS provides access to a full range of medical services, including cancer treatment.

Indicators	Brazil	North	Northeast	Southeast	South	Midwest
Population, area, economic structure, and labor market						
Population (2022)						
Males	98,532,431	8,663,119	26,417,802	40,859,823	14,584,204	8,007,483
Females	104,548,325	8,691,765	28,240,713	43,980,290	15,353,502	8,282,055
Territorial areas (km^2)	8,515,767	3,853,676	1,554,292	924,621	576,774	1,606,404
Population density (inhabitants/km^2)	23·8	4·5	35·2	91·8	51·9	10·1
Resident population – household situation (2022) (%)						
Rural	12·59	21·51	22·3	5·55	11·73	8·65
Dependency ratio[a] (2023)	55·5	69·0	62·6	49·9	51·6	52·3
Urbanization ratio[b]	78·4	62·5	65·2	89·3	77·2	84·4
People aged 14 or older are employed according to (% by column):						
Sex and race/skin color[c]						
White males	24·1	11·5	14·2	26·8	39·5	19·6
Other race/ethnicity males	32·2	47·7	43·8	28·3	16·2	36·8
White females	19·7	8·8	10·9	22·5	32·0	16·2
Other race/ethnicity females	22·7	30·4	29·8	21·0	11·5	26·1
Age-group						
14–29 years	27·0	29·9	26·9	25·7	28·2	29·0
30–49 years	49·5	49·1	50·8	49·1	48·8	49·4
50–59 years	15·9	14·9	15·3	16·7	15·8	14·6
60 years or older	7·6	6·1	7·0	8·4	7·2	7·0
Income distribution						
Per capita household income by classes (2023 minimum wage[d]) (%)						
Without income	1·2	1·1	1·7	1·1	0·9	0·8
More than zero up to ¼	8·1	13·2	16·9	4·2	2·8	3·2
More than ¼ up to ½	17·8	25·6	27·7	13·1	10·6	13·3
More than ½ up to 1	30·0	31·3	31·3	29·1	28·3	31·2
More than 1 to 2	26·2	18·9	15·2	31·0	35·5	29·7
More than 2 to 3	7·6	5·0	3·2	9·5	10·8	9·6
More than 3 to 5	5·2	3·1	2·4	6·5	6·9	6·9
More than 5	3·9	1·8	1·6	5·5	4·2	5·4
Source of income						
Employment (%)	74·2	76·3	65·7	75·3	75·6	79·3
Retirement and pension (%)	17·5	13·3	21·4	17·4	17·6	13·9
Benefits of government social programs (%)	3·7	7·5	9·7	2·1	1·6	2·5
HDI (2017)	0·760	0·730	0·710	0·795	0·777	0·789
GDP per capita (R$)	49,638	33,123	25,401	63,327	55,942	65,651
Gini index	0·567	0·547	0·587	0·537	0·543	0·573
Living conditions						
Proportion of people living with simultaneous access to the three basic sanitation services: water supply through a general network, garbage collection and sewage through a collection network (%)	66·1	27·9	46·3	88·0	66·1	59·3
Education						
Illiteracy rate of the population aged 15 and over (%)[e]						
Males	3·6	4·5	7·6	1·8	1·6	2·6
Females	3·4	3·7	6·6	2·1	1·9	2·5
Health						
Number of clinics of primary care per 10,000 inhabitants (2024)	9·5	6·5	7·1	10·8	12·6	8·4
Number of specialized clinics per 10,000 inhabitants (2024)	9·5	4·6	7·4	10·8	12·2	11·1
Number of CT scans per 10,000 inhabitants (2024)	0·3	0·2	0·2	0·3	0·4	0·5
Number of respiratory, urinary and digestive endoscopes in use per 10,000 inhabitants (2024)	1·2	0·7	0·9	1·4	1·6	1·3
Number of hospital beds in the public health system (UHS) per 10,000 inhabitants (2024)	14·6	14·4	17·0	12·4	16·0	15·5
Physicians per 10,000 inhabitants (2024)	23·7	13·0	16·5	29·2	27·1	25·3
Nurses per 10,000 inhabitants (2024)	17·1	14·6	16·5	18·1	16·8	17·9
Oncologists per 10,000 cancer cases (2024)	1·7	0·8	1·1	2·1	1·8	1·8
Total fertility rate[f]	2·3	3·1	2·6	2·1	2·2	2·2

(Table 1 continues on next page)

Indicators	Brazil	North	Northeast	Southeast	South	Midwest
(Continued from previous page)						
Proportion of beneficiaries of private health plans (2024)	25·3	11·3	13·4	36·4	24·9	22·9
Proportion of households with people living in food insecurity (2024)	27·6	39·7	38·8	23·0	16·6	24·3
Mild	18·2	23·7	23·9	16·2	11·8	16·4
Moderate	5·3	8·3	8·6	3·8	2·7	4·3
Severe	4·1	7·7	6·2	2·9	2·0	3·6

[a]Population considered economically inactive (0–14 years and 65 years and older) over the potentially active population (15–64 years old). [b]Percentage of the urban population in relation to the total population. [c]Other race/ethnicity: included Black/Brown/Yellow/Indigenous/Unknown. [d]Reference minimum wage R$ 1320·00 (US$ ppp: 2·44). [e]Person who cannot read or write a simple note in the language they know (Portuguese). [f]Probable average number of children a woman would have at the end of her reproductive period (45 years old).

Table 1: **Key sociodemographic, economic, income, education, and health indicators according to Brazil and its geographical regions.**[9]

The UHS is organized into three levels of care – primary, secondary, and tertiary. At the primary care level, individuals receive basic health services, including opportunistic screening for breast and cervical cancers. If screening tests are positive or the patient presents signs or symptoms suggestive of disease, they are referred to secondary level for further diagnostic investigation. Once diagnosed, they are referred to tertiary level, where specialized, high-complexity treatment is provided.

Study design and data sources

This population-based study calculated YPLL and productivity lost from CRC mortality in individuals aged above 15 years old for the remainder of their lifetime. In Brazil, it is common that people continue to work after the formal state-endorsed retirement age, established by the Brazilian Social Security system (65 years for men and 60 years for women during most of the study period; increasing to 62 years for women after the 2019 pension reform). Official data show that the proportion of Brazilians aged 60 or over working was 22·6% in 2022.[10] Thus, YPLL was estimated based on life expectancy rather than statutory retirement age. Analyses were carried out for the period between 2001 and 2030 and were stratified by sex to take into account differences in CRC mortality trends,[11] and economic indicators such as workforce participation Thus, YPLL was estimated based on life expectancy rather than statutory retirement age (Supplementary Table S1).

Data on CRC (ICD 10: C18-21) mortality by age, sex and region between 2001 and 2015 were obtained from the Brazilian Ministry of Health's Mortality Information System (SIM).[12] Population data were obtained from the last demographic census (2010) and the annual estimates made by the Brazilian Institute of Geography and Statistics (IBGE).[12]

Economic data were obtained from the National Continuous Household Sample Survey, also conducted by IBGE; data on the average annual population wage – including formal and informal (not officially registered work, without taxation or social security contributions), labor force participation rates, and unemployment rates were obtained by sex (sex assigned at birth), and age-group for the period between 2001 and 2015.[10] The data were available for all ages, and included earnings from formal and informal work of those working after formal state-endorsed retirement.

Mortality projection

The number of CRC deaths for 2016–2030 was projected using the Age-Period-Cohort (APC) model from the NordPred package in R software version 3·6·0 based on the 2001–2015 observed data. This tool is widely applied for long-term forecasting of cancer incidence and mortality. Its application requires a minimum of fifteen consecutive years of data, corresponding to at least three 5-year observation periods. The goodness-of-fit was evaluated using two statistical post-estimation parameters: (i) the deviance *p*-value, assuming as the null hypothesis that the model provides an adequate fit to the data at the 5% significance level; (ii) compare deviance to degree of freedom, in which, for a correctly specified model, these statistics divided by their degree of freedom should be close to one; values much larger than one suggests overdispersion (Supplementary Table S2).

Deaths defined as neoplasms of other digestive organs and ill-defined locations in the digestive tract (C26) were reallocated proportionally to neoplasms of specific digestive organs (C15–25), by sex, 5-year age-group and region.[13] Crude and age-adjusted mortality rates (world population) were calculated by the direct method using the population proposed by Segi and adapted by Doll et al.[14]

Estimated productivity loss

We employed the Human Capital Approach (HCA) to estimate the productivity lost from CRC deaths among those working. The productivity lost was calculated based on YPLL, defined as the sum of the years between the occurrence of death and the life expectancy age, as follows[2]:

$$YPLL = \sum_{i=1}^{M} a_i .\ d_i = \sum_{i=1}^{M} (e_i - idm_i + 0,5).\ d_i$$

where i represent the age group; M – upper limit of the age group; a_i – remaining years of life up to age group i at death; d_i – number of deaths occurring in age group i; e_i – life expectancy in age group i; and idm_i – mean age in age group i. The life expectancy was obtained from the Brazilian Institute of Geography and Statistics Life Tables.

Productivity losses were adjusted by the unemployment rate and labor force participation rate for 2016. Losses for the last three quinquennia (2016–2020, 2021–2025, 2026–2030) were projected based on data for 2016 (the most recent year of available data), allowing for annual wage growth of 2·4%, a discount rate of 3·0%, and adjusting for the labor force participation and unemployment rate (by sex and age group) for 2016.[15] Sensitivity analysis was performed using an alternative scenario of 0·0% wage growth, due to the COVID-19 pandemic impact on the economy as a whole. The values calculated in national currency (Real–R$) were converted to international dollars (Int$) by applying Purchasing Power Parity (PPP), to allow comparisons between countries.[2,16] All analyses were performed in the statistical package STATA version 15·1.

Ethical statement

The study used secondary data that are publicly available, unrestricted, and de-identified. Therefore, under Brazilian regulations, this research is exempt from registration and review by the Brazilian system of Research Ethics Committees and the National Commission for Research Ethics, and no ethics approval number applies, in accordance with the Brazilian National Health Council (CNS) Resolution No. 510/2016 (Art. 1, sole paragraph; and the definition of “publicly accessible information” in Art. 2, item VI).

Role of funding sources

This study was funded by the MSD Independent Oncology Policy Grant Program. The sponsor was not involved in the study design, collection, analysis or interpretation of data; in the writing of the manuscript or in the decision to submit the manuscript for publication.

Results

We estimated 635,253 (52% among males) deaths from CRC among individuals older than 15 years, between 2001 and 2030. These deaths corresponded to 12,635,613 YPLL (44·9% among males) and Int$22·6 billion in productivity lost (74·1% in males) from CRC mortality between 2001 and 2030.

Tables 2 and 3 present the national and regional numbers of deaths and their respective mortality rates (crude and age-adjusted) according to sex. The number of CRC deaths in the last quinquennium (2026–2030, estimated) is estimated to be almost three times higher than in 2001–2005 (observed)–57,631 vs 157,027. Among males, numbers of deaths and ASR were estimated to increase, respectively, 181% and 28% between the first and last period: from 26,453 deaths (ASR: 10·80/100,000) in 2001–2005 to 79,421 deaths (ASR: 13·82/100,000) in 2026–2030. In females, number of deaths and ASR were estimated to increase, respectively, 165% and 12% in the same period: from 31,178 deaths (ASR: 10·11/100,000) to 82,606 deaths (ASR: 11·27/100,000). On average for the period studied (2001–2030), the South and Southeast regions accounted for 78% of total deaths among males (ranging from 81% in 2001–2005 to 77% in 2026–2030), and 75% among females (ranging from 80% in 2001–2005 to 75% in 2026–2030).

Figs. 1 and 2 present the growth in YPLL over time. Nationally, among males, the YPLL in the last quinquennium (2026–2030) were predicted to be 3·2 times higher than in the first quinquennium (2001–2005; 459 thousand to 1·5 million YPLL). The YPLL in the North region was predicted to increase six-fold between the first and last quinquennium, the highest increase observed. Among females, nationally, YPLL in 2026–2030 were estimated to be three times higher than in 2001–2005 (598 thousand years to 1·8 million years). Regionally, North and Northeast regions showed similar increases: 4·6-fold higher in 2026–2030 compared to 2001–2005.

Figs. 3 and 4 present the productivity lost growth rates overall and by region. Comparing the first (2001–2005, observed) and the last (2026–2030, estimated) quinquennia in Brazil as a whole, productivity lost was estimated to increase five-fold among males (Int$ 1·02 billion to Int$ 5·3 billion) and six-fold among females (Int$ 307·4 million to Int$ 1·9 billion). Regionally, the largest increases from first to last quinquennia were estimated in the North (9·7-fold) among men and Northeast (10·3-fold) among females. The results of the sensitivity analyses are shown in Supplementary Table S3. Supplementary Tables S4 to S9 present the number of deaths, crude and age-adjusted rates, and productivity losses, stratified by age group, sex, and region.

Discussion

CRC was estimated (2022) the second most commonly diagnosed neoplasm and the third leading cause of cancer death in the Brazilian population.[1,17] In addition to the intangible costs relating to cancer deaths, mortality among working individuals results in a significant economic impact. Our study estimated 635,253 deaths from CRC between 2001 and 2030 among individuals older than 15 years, resulting in 12·6 million YPLL and Int$22·6 billion in productivity lost. The Southeast and South regions account for 74% of the total YPLL

	Period	Absolute number of deaths (95% CI)	Crude mortality rate (95% CI)	ASR mortality (95% CI)	YPLL (95% CI)	Productivity losses - Int$ (95% CI)
Brazil	2001–2005	26,453 (26,135–26,773)	8·37 (8·27–8·47)	10·80 (10·67–10·93)	458,882 (327,992–589,772)	1,022,288,933 (609,848,691–1,429,353,264)
	2006–2010	34,709 (34,344–35,076)	10·07 (9·96–10·18)	11·97 (11·84–12·10)	627,598 (430,631–824,566)	1,284,782,323 (684,264,522–1,847,548,043)
	2011–2015	44,530 (44,117–44,945)	11·99 (11·88–12·10)	12·50 (12·38–12·62)	827,654 (548,989–1,106,319)	1,881,987,660 (1,042,660,786–2,704,506,522)
	2016–2020	54,915 (54,456–55,376)	13·87 (13·75–13·98)	13·15 (13·04–13·26)	1,031,663 (658,605–1,404,720)	3,157,865,369 (1,774,722,170–4,741,219,415)
	2021–2025	66,600 (66,095–67,107)	16·00 (15·88–16·13)	13·58 (13·48–13·69)	1,252,609 (774,585–1,730,633)	4,151,646,443 (2,492,609,598–6,210,561,072)
	2026–2030	79,421 (78,869–79,975)	18·34 (18·21–18·47)	13·82 (13·72–13·92)	1,476,505 (887,925–2,065,086)	5,277,245,197 (3,069,895,185–7,701,711,526)
	2001–2030	**306,628 (305,543–307,715)**	**13·46 (13·42–13·51)**	**12·93 (12·88–12·98)**	**5,674,912 (4,674,481–6,675,343)**	**16,775,815,924 (12,993,532,005–21,449,416,941)**
North	2001–2005	611 (563–661)	2·65 (2·44–2·86)	4·31 (3·96–4·67)	12,190 (9231–15,149)	27,940,421 (17,713,535–39,479,954)
	2006–2010	847 (790–906)	3·21 (3·00–3·44)	4·87 (4·54–5·21)	17,895 (14,067–21,724)	36,945,640 (21,817,902–51,890,942)
	2011–2015	1305 (1235–1377)	4·38 (4·15–4·62)	5·87 (5·55–6·20)	28,272 (21,587–34,958)	65,259,861 (42,289,757–90,508,211)
	2016–2020	1880 (1795–1966)	5·68 (5·43–5·94)	7·11 (6·79–7·44)	41,999 (31,251–52,747)	127,583,131 (76,987,901–178,885,273)
	2021–2025	2541 (2443–2641)	7·03 (6·76–7·31)	8·10 (7·78–8·41)	57,858 (42,456–73,260)	192,804,269 (120,266,138–267,831,798)
	2026–2030	3252 (3141–3365)	8·40 (8·12–8·69)	8·72 (8·42–9·02)	74,170 (54,287–94,053)	271,704,667 (174,059,310–379,308,249)
	2001–2030	**10,436 (10,236–10,638)**	**5·58 (5·47–5·68)**	**7·01 (6·87–7·15)**	**232,384 (192,800–271,969)**	**722,237,990 (549,964,651–914,332,868)**
Northeast	2001–2005	3032 (2925–3141)	3·58 (3·45–3·71)	4·55 (4·39–4·72)	54,640 (43,450–65,831)	117,066,269 (77,627,389–158,531,152)
	2006–2010	4262 (4135–4391)	4·63 (4·49–4·77)	5·64 (5·47–5·81)	79,334 (58,496–100,173)	160,360,352 (99,607,449–225,265,036)
	2011–2015	6041 (5889–6195)	6·11 (5·96–6·27)	6·57 (6·40–6·73)	115,257 (82,942–147,572)	257,908,007 (152,898,657–358,628,336)
	2016–2020	7900 (7726–8076)	7·56 (7·39–7·73)	7·65 (7·48–7·83)	153,256 (104,813–201,700)	465,377,380 (271,620,212–665,940,182)
	2021–2025	9929 (9734–10,126)	9·10 (8·92–9·28)	8·45 (8·28–8·62)	193,338 (126,223–260,452)	644,919,845 (372,545,967–961,650,403)
	2026–2030	12,009 (11,795–12,225)	10·67 (10·48–10·86)	8·92 (8·76–9·08)	230,896 (143,357–318,435)	839,014,615 (442,481,722–1,227,492,879)
	2001–2030	**43,173 (42,766–43,582)**	**7·17 (7·11–7·24)**	**7·34 (7·27–7·41)**	**826,722 (680,135–973,309)**	**2,484,646,469 (1,867,685,885–3,205,852,069)**
Southeast	2001–2005	15,618 (15,374–15,864)	11·27 (11·09–11·44)	14·06 (13·83–14·28)	267,046 (186,693–347,400)	596,734,791 (361,230,038–844,275,310)
	2006–2010	20,272 (19,993–20,553)	13·55 (13·37–13·74)	15·27 (15·05–15·48)	360,535 (242,172–478,899)	737,012,145 (421,630,044–1,067,490,525)
	2011–2015	25,165 (24,855–25,477)	15·76 (15·56–15·95)	15·55 (15·35–15·74)	459,721 (295,530–623,912)	1,043,759,408 (594,091,034–1,577,763,962)
	2016–2020	30,642 (30,299–30,987)	18·07 (17·87–18·28)	15·95 (15·77–16·13)	562,556 (346,827–778,285)	1,716,970,659 (908,935,580–2,503,588,630)
	2021–2025	36,888 (36,512–37,266)	20·80 (20·58–21·01)	16·22 (16·05–16·39)	674,765 (402,518–947,012)	2,214,766,566 (1,205,575,905–3,271,746,111)
	2026–2030	43,807 (43,397–44,219)	23·78 (23·56–24·01)	16·36 (16·20–16·52)	789,512 (459,126–1,119,897)	2,772,463,854 (1,425,187,084–4,135,846,394)
	2001–2030	**172,392 (171,579–173,207)**	**17·61 (17·53–17·69)**	**15·79 (15·71–15·86)**	**3,114,136 (2,554,046–3,674,226)**	**9,081,707,423 (7,144,185,944–11,441,988,810)**
South	2001–2005	5775 (5627–5925)	12·17 (11·85–12·48)	14·95 (14·56–15·34)	99,038 (68,650–129,427)	221,033,305 (130,042,672–317,161,108)
	2006–2010	7298 (7131–7467)	14·20 (13·88–14·53)	15·74 (15·37–16·10)	130,507 (86,230–174,784)	267,841,343 (150,650,132–381,538,388)
	2011–2015	9223 (9035–9413)	16·79 (16·45–17·14)	16·21 (15·88–16·54)	168,853 (108,710–228,997)	385,304,047 (229,039,994–570,806,467)
	2016–2020	11,489 (11,279–11,701)	19·76 (19·40–20·13)	16·86 (16·54–17·17)	210,648 (129,517–291,779)	647,786,240 (373,900,644–947,575,334)
	2021–2025	14,070 (13,838–14,304)	23·24 (22·86–23·63)	17·41 (17·11–17·70)	256,568 (151,682–361,454)	851,141,503 (467,790,180–1,262,608,750)
	2026–2030	17,004 (16,749–17,261)	27·17 (26·77–27·58)	17·90 (17·62–18·18)	304,547 (172,330–436,763)	1,086,087,650 (607,217,530–1,607,694,955)
	2001–2030	**64,859 (64,360–65,360)**	**19·36 (19·21–19·51)**	**16·80 (16·67–16·93)**	**1,170,162 (952,407–1,387,917)**	**3,459,194,088 (2,682,806,083–4,385,628,587)**
Midwest	2001–2005	1421 (1348–1496)	6·37 (6·04–6·71)	9·36 (8·86–9·86)	26,129 (18,755–33,503)	59,814,406 (36,569,255–86,488,060)
	2006–2010	2031 (1943–2121)	8·07 (7·72–8·42)	10·78 (10·31–11·26)	39,341 (27,798–50,884)	82,766,305 (47,868,031–117,566,193)
	2011–2015	2795 (2692–2900)	9·93 (9·56–10·30)	11·56 (11·13–12·00)	55,559 (38,274–72,844)	129,660,091 (70,012,056–188,973,794)
	2016–2020	3676 (3558–3796)	11·96 (11·57–12·35)	12·63 (12·22–13·04)	74,249 (49,779–98,719)	230,104,138 (127,660,910–334,724,579)
	2021–2025	4689 (4555–4825)	14·20 (13·79–14·61)	13·44 (13·05–13·82)	94,957 (62,554–127,360)	318,580,637 (181,096,079–464,197,950)
	2026–2030	5760 (5612–5910)	16·43 (16·01–16·86)	13·81 (13·45–14·17)	116,002 (75,504–156,499)	423,462,928 (249,120,789–604,646,513)
	2001–2030	**20,372 (20,093–20,653)**	**11·68 (11·52–11·84)**	**12·43 (12·26–12·60)**	**406,237 (334,417–478,057)**	**1,244,388,505 (937,872,224–1,577,627,791)**

ASR: age standardized rate· Int$: international dollars; CI: Confidence Interval. The bold line is being used to highlight the entire study period (30 years), in contrast to the other lines, which represent specific periods within the study.

Table 2: **Deaths, age-standardized mortality rate (ASR), years of potential life lost (YPLL) and economic impact related to premature colorectal cancer mortality among males in Brazil.**

	Period	Absolute number of deaths (95% CI)	Crude mortality rate (95% CI)	ASR mortality (95% CI)	YPLL (95% CI)	Productivity losses - Int$ (95% CI)
Brazil	2001–2005	31,178 (30,832–31,526)	9·51 (9·40–9·61)	10·11 (10·00–10·23)	598,636 (421,654–775,619)	307,455,839 (161,943,333–463,686,034)
	2006–2010	39,157 (38,770–39,546)	10·85 (10·74–10·96)	10·57 (10·46–10·68)	792,322 (547,697–1,036,947)	403,468,610 (203,733,148–626,702,813)
	2011–2015	48,515 (48,084–48,948)	12·22 (12·11–12·33)	10·68 (10·58–10·78)	1,020,292 (680,346–1,360,238)	644,020,529 (351,826,733–986,876,063)
	2016–2020	57,941 (57,470–58,414)	13·68 (13·56–13·79)	10·85 (10·76–10·94)	1,248,194 (808,100–1,688,288)	1,162,448,126 (677,027,737–1,681,476,171)
	2021–2025	69,228 (68,713–69,745)	15·53 (15·42–15·65)	11·05 (10·97–11·14)	1,507,766 (949,123–2,066,409)	1,486,361,632 (857,783,967–2,199,883,372)
	2026–2030	82,606 (82,043–83,171)	17·79 (17·66–17·91)	11·27 (11·19–11·36)	1,793,492 (1,091,134–2,495,849)	1,858,548,161 (1,100,392,784–2,714,462,974)
	2001–2030	**328,625 (327,502–329,750)**	**13·58 (13·54–13·63)**	**10·85 (10·81–10·89)**	**6,960,702 (5,772,919–8,148,485)**	**5,862,302,898 (4,470,249,626–7,343,848,169)**
North	2001–2005	702 (651–755)	3·18 (2·95–3·42)	4·87 (4·50–5·24)	16,012 (11,644–20,379)	9,735,156 (5,004,876–15,062,208)
	2006–2010	1040 (977–1105)	4·07 (3·82–4·32)	5·92 (5·55–6·29)	23,658 (18,000–29,316)	13,078,007 (7,132,799–19,521,986)
	2011–2015	1417 (1344–1492)	4·78 (4·54–5·04)	6·17 (5·84–6·50)	34,123 (25,491–42,755)	23,921,073 (14,124,724–34,857,967)
	2016–2020	1902 (1817–1989)	5·75 (5·49–6·01)	6·79 (6·48–7·10)	45,856 (34,188–57,523)	45,745,580 (28,836,010–62,320,498)
	2021–2025	2443 (2347–2541)	6·72 (6·46–6·99)	7·08 (6·80–7·37)	59,270 (43,603–74,936)	63,390,590 (40,318,437–89,213,979)
	2026–2030	3045 (2937–3155)	7·76 (7·49–8·04)	7·18 (6·92–7·44)	73,854 (53,347–94,361)	84,970,200 (51,696,785–117,319,756)
	2001–2030	**10,549 (10,348–10,752)**	**5·67 (5·57–5·78)**	**6·60 (6·47–6·73)**	**252,771 (213,544–291,998)**	**240,840,605 (186,745,229–301,149,736)**
Northeast	2001–2005	4057 (3933–4183)	4·58 (4·44–4·72)	4·99 (4·84–5·15)	78,195 (55,785–100,606)	39,773,324 (21,688,967–58,852,772)
	2006–2010	5441 (5297–5587)	5·57 (5·43–5·72)	5·71 (5·56–5·87)	113,688 (81,212–146,164)	60,062,578 (31,243,099–91,182,751)
	2011–2015	7707 (7535–7881)	7·19 (7·03–7·35)	6·62 (6·47–6·77)	166,013 (117,310–214,715)	106,895,667 (56,749,495–153,484,298)
	2016–2020	10,049 (9853–10,247)	8·80 (8·63–8·97)	7·56 (7·41–7·72)	226,704 (157,630–295,777)	219,286,508 (134,436,638–314,407,135)
	2021–2025	12,757 (12,536–12,980)	10·64 (10·45–10·82)	8·34 (8·19–8·49)	294,477 (200,916–388,038)	308,156,166 (171,714,483–455,617,005)
	2026–2030	15,639 (15,394–15,886)	12·57 (12·37–12·77)	8·88 (8·73–9·03)	363,403 (241,561–485,245)	407,944,716 (242,135,889–592,402,270)
	2001–2030	**55,650 (55,188–56,114)**	**8·53 (8·46–8·61)**	**7·36 (7·29–7·42)**	**1,242,480 (1,025,982–1,458,978)**	**1,142,118,959 (855,487,386–1,452,812,062)**
Southeast	2001–2005	18,509 (18,243–18,777)	12·71 (12·53–12·90)	12·62 (12·43–12·80)	351,416 (245,545–457,287)	178,174,064 (95,066,677–273,459,053)
	2006–2010	22,619 (22,325–22,915)	14·28 (14·09–14·46)	12·83 (12·66–13·00)	450,442 (305,857–595,028)	224,843,324 (113,076,784–344,199,151)
	2011–2015	27,242 (26,919–27,567)	15·77 (15·58–15·96)	12·71 (12·55–12·86)	565,419 (366,629–764,210)	352,325,511 (185,808,972–527,739,945)
	2016–2020	31,994 (31,644–32,346)	17·50 (17·30–17·69)	12·73 (12·58–12·88)	678,986 (425,010–932,961)	623,747,833 (359,378,925–902,524,681)
	2021–2025	37,774 (37,394–38,156)	19·79 (19·59–19·99)	12·89 (12·75–13·03)	808,227 (489,625–1,126,830)	780,055,562 (438,163,513–1,132,216,168)
	2026–2030	44,688 (44,274–45,104)	22·61 (22·40–22·82)	13·12 (12·99–13·26)	950,485 (555,291–1,345,678)	956,387,594 (555,629,316–1,419,505,008)
	2001–2030	**182,826 (181,988–183,666)**	**17·44 (17·36–17·52)**	**12·84 (12·78–12·90)**	**3,804,976 (3,141,845–4,468,107)**	**3,115,533,888 (2,373,507,318–3,884,398,684)**
South	2001–2005	6382 (6226–6540)	12·97 (12·65–13·29)	12·93 (12·61–13·25)	120,493 (83,441–157,546)	60,735,524 (32,883,088–90,334,311)
	2006–2010	7819 (7646–7994)	14·59 (14·27–14·91)	13·07 (12·78–13·37)	153,988 (104,057–203,920)	75,831,534 (38,564,909–118,276,768)
	2011–2015	9238 (9050–9428)	15·86 (15·54–16·19)	12·65 (12·38–12·91)	188,412 (121,857–254,966)	114,751,731 (62,635,357–173,960,154)
	2016–2020	10,906 (10,702–11,112)	17·68 (17·35–18·01)	12·46 (12·21–12·70)	225,078 (140,700–309,456)	199,773,430 (113,499,119–290,242,230)
	2021–2025	12,835 (12,613–13,059)	19·95 (19·60–20·30)	12·37 (12·14–12·60)	266,247 (160,511–371,984)	246,336,270 (143,991,767–357,038,994)
	2026–2030	15,185 (14,944–15,428)	22·80 (22·43–23·16)	12·45 (12·23–12·67)	312,951 (179,458–446,444)	300,513,656 (171,000,235–424,675,355)
	2001–2030	**62,365 (61,876–62,856)**	**17·63 (17·49–17·77)**	**12·56 (12·45–12·66)**	**1,267,170 (1,046,153–1,488,187)**	**997,942,145 (765,067,418–1,257,713,880)**
Midwest	2001–2005	1530 (1454–1608)	6·81 (6·47–7·16)	9·42 (8·94–9·90)	32,598 (22,785–42,411)	19,083,283 (10,156,880–28,801,095)
	2006–2010	2239 (2147–2333)	8·74 (8·38–9·10)	10·67 (10·22–11·12)	50,554 (35,864–65,245)	29,651,643 (14,738,399–46,836,969)
	2011–2015	2909 (2804–3016)	10·00 (9·64–10·37)	10·68 (10·28–11·07)	66,324 (45,627–87,021)	46,088,278 (22,652,698–69,420,479)
	2016–2020	3565 (3448–3684)	11·20 (10·83–11·57)	10·57 (10·22–10·92)	82,102 (54,850–109,353)	82,005,900 (46,760,046–119,072,218)
	2021–2025	4355 (4226–4486)	12·70 (12·32–13·08)	10·55 (10·23–10·87)	100,246 (65,008–135,485)	105,158,715 (60,150,395–152,579,631)
	2026–2030	5286 (5144–5430)	14·47 (14·08–14·87)	10·52 (10·23–10·81)	120,197 (75,509–164,885)	131,316,344 (76,112,112–192,746,085)
	2001–2030	**19,884 (19,608–20,162)**	**11·06 (10·90–11·21)**	**10·49 (10·34–10·64)**	**452,021 (375,329–528,713)**	**413,304,162 (309,185,630–511,063,837)**

ASR: age standardized rate. Int$: international dollars; CI: confidence interval. The bold line is being used to highlight the entire study period (30 years), in contrast to the other lines, which represent specific periods within the study.

Table 3: **Deaths, Age-standardized mortality rate (ASR), years of potential life lost (YPLL) and economic impact related to premature colorectal cancer mortality among females in Brazil.**

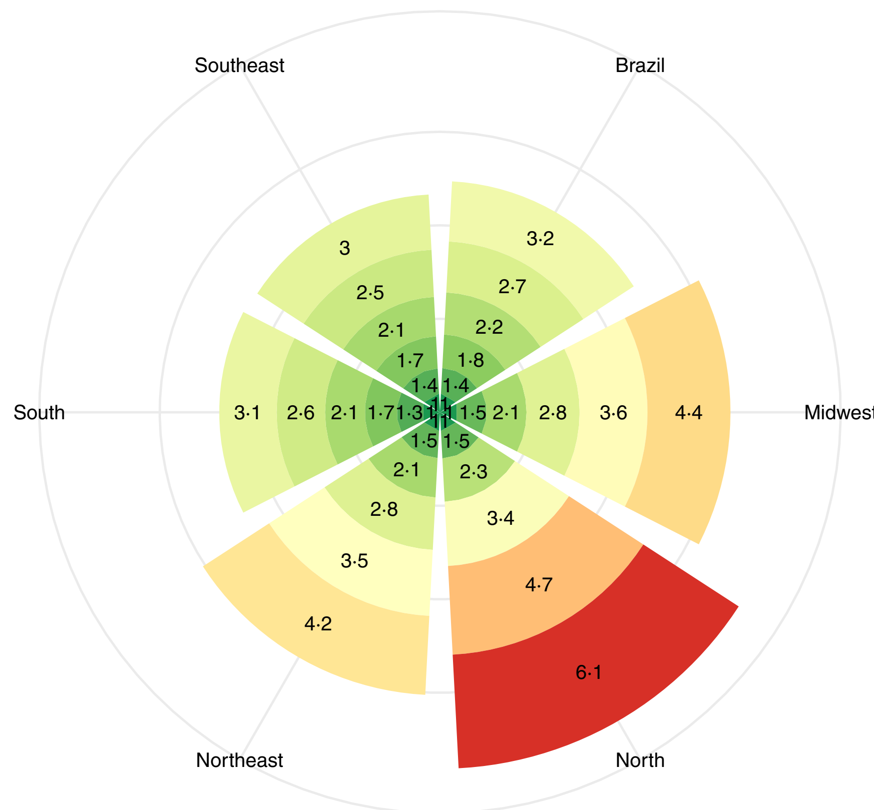

Fig. 1: YPLL growth ratio among males by quinquennium compared to the first quinquennium (inner circle – 2001–2005), Brazil and regions.

and the productivity losses, while the highest relative increases were estimated to occur in the North and Northeast regions.

Significant regional differences in productivity lost were observed in our study. The Southeast, South, and Midwest regions had the highest mortality rates and the highest economic impact compared to the North and Northeast regions. Besides differences in lifestyle behaviors, the Southeast and South regions are in a more advanced stage of demographic transition compared to the other regions, with a higher proportion of the population over 60 years of age, the highest incidence of CRC, and consequently the highest total productivity lost. However, the highest productivity costs per death (2001–2030) were observed in the North region, for males and females, as well as the highest YPLL per death (22 YPLL for males and 24 YPLL for females) compared to the Brazilian average of 18 and 21 YPLL, respectively.

The North and Northeast regions of Brazil have poorer socioeconomic and infrastructure indicators compared to the other regions of the country.[9] Although North and Northeast regions presented lower total economic impact compared to other regions, the highest relative growth of YPLL and productivity loss are estimated in these regions. However, the accelerated pace of westernization (these regions are expected to attain the behavior patterns seen in the most economically developed regions of the country in the coming decade), probably also plays a major role.[18]

The high incidence rates, seen in the South and Southeast regions, are likely related to behavioral risk factors, population ageing and the absence of organized population-based screening and surveillance programs for high-risk groups.[5] Population-based 5-year net survival in Brazil is low compared to high-income countries and other countries in Latin America and Caribbean.[19] Patients diagnosed during 2010–2014 had 5-year net survival of 48·3% (CI 95% 46·7%–49·9%) for colon cancer and 42·4% (40·1%–44·6%) for rectal cancer.[19] These figures are driven, in part, by the high percentage of cases diagnosed at an advanced disease stage. Data from hospital-based cancer registries (HBCR) from 2010 to 2019 demonstrate that the highest proportions of advanced-stage CRC at diagnosis are found in the North, Central-West, and Northeast regions. This is most likely a consequence of low density of primary care teams which are responsible for the referral of patients presenting CRC signs and symptoms to diagnostic services (secondary care) and treatment (tertiary care) in a timely manner.[5,20]

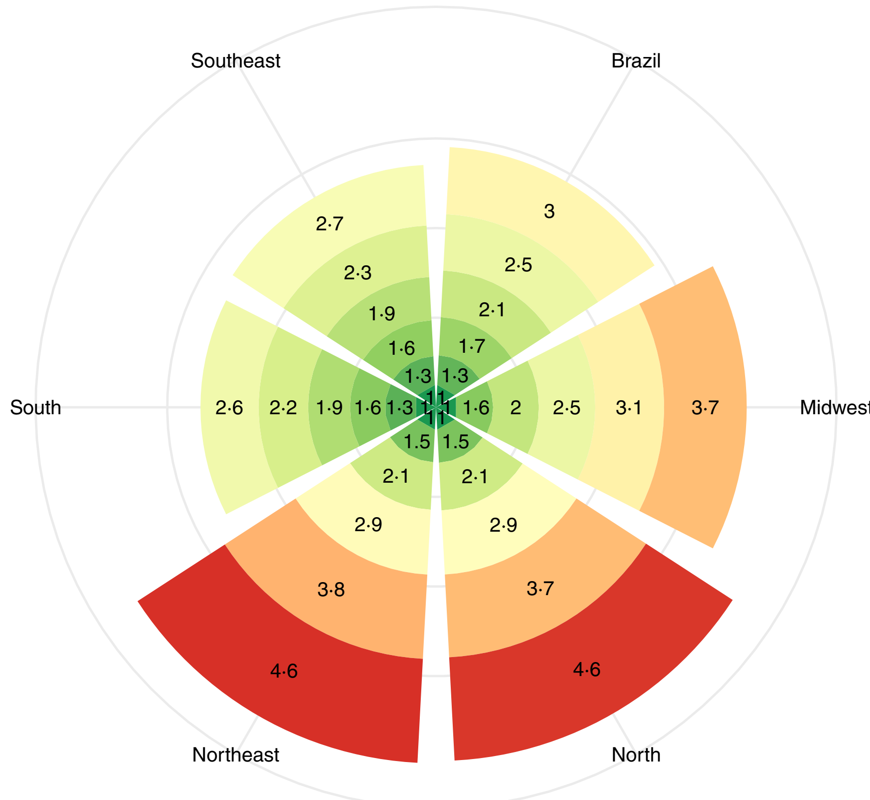

Fig. 2: YPLL growth ratio among females by quinquennium compared to the first quinquennium (inner circle – 2001–2005), Brazil and regions.

Evidence from randomized controlled trials supports the efficacy of CRC screening in CRC mortality reduction.[21] However, in Brazil, a nationwide organized population-based screening program is considered unfeasible, due to capacity challenges in endoscopy, both in relation to equipment and trained health professionals, the UHS prioritizing individuals with clinical suspicion by initial signs and symptoms.[4] Given the continental size of the country, feasibility is challenged by the infrastructural differences between regions. Data are scarce regarding screening coverage, with only a few local initiatives implementing structured pilot screening projects.[22]

Given the heterogeneity in the public health care structure in the country, it is important to highlight that screening should only be implemented in municipalities that have at least: (i) logistical conditions to implement an organized population-based program with a call-recall system; (ii) sufficient facilities and specialists to perform colonoscopies on all screen-positive individuals; and (iii) are able to implement a quality-assurance program for colonoscopies.[23] In locations with a lower incidence of colorectal cancer and that do not meet the aforementioned prerequisites, the strategy of referring primary care patients with presenting CCR signs and symptoms to secondary care for diagnostic investigation should be prioritized.[4]

In the present study we found that the largest relative increases in mortality and productivity loss are projected to occur in the North and Northeast regions, reinforcing the need to improve access to early diagnosis and treatment in these regions. Individuals diagnosed with CRC should be assured of timely and appropriate treatment in order to reduce CRC mortality, and, indirectly, mitigate the impacts of productivity loss. More deprived regions (Northeast and North) and cities distant from large urban centers are the least supported by the health system. Time between diagnosis and treatment is set nationally by the “60-day law” and monitored by the oncology panel.[24] According to this panel, in 2019, 27% of cases diagnosed in the UHS took more than 60 days to start treatment, the longer delays observed in the North (34%) and Northeast (30%) regions compared to the South (23%).[24] However, improvements are needed in the whole country. Even in the wealthiest Brazilian municipality (São Paulo, in the Southeast region), there is evidence of delays in seeking medical assistance due to a lack of knowledge on the

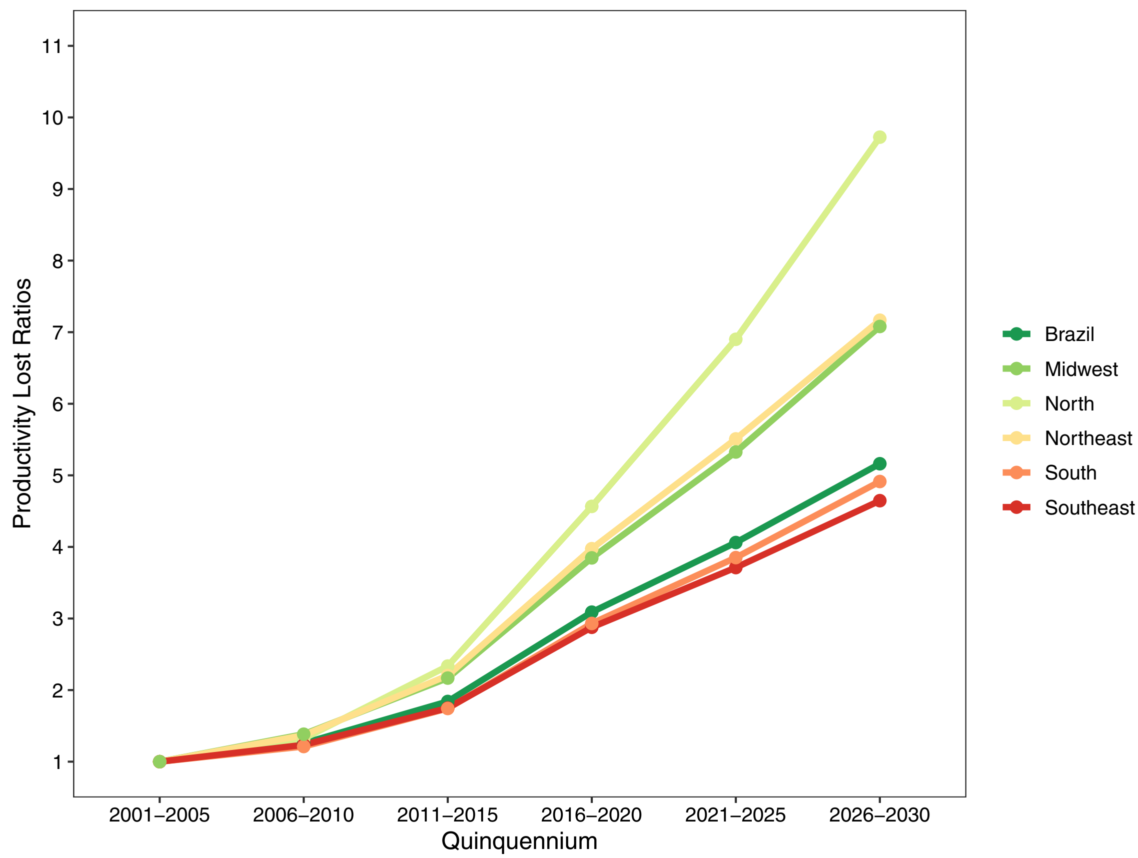

Fig. 3: Productivity lost ratios among males by quinquennium compared to the first quinquennium (2001–2005), Brazil and regions.

warning signs of the disease, as well as prolonged times until diagnostic confirmation after the initial consultation and the start of treatment.[25] Therefore, strategies to raise awareness among primary care physicians and the population, accompanied by better access to timely colonoscopy for diagnostic investigation and a more efficient referral system, could potentially reduce these delays and positively impact the outcomes of these patients.

In addition, healthy lifestyle promotion should be encouraged as a primary prevention strategy for reducing CRC morbidity and mortality in Brazil, since the combination of unhealthy eating habits, physical inactivity, overweight, alcohol consumption, and smoking are the main risk factors for sporadic cases of CRC.[2,3] Notably, nutritional intake in Brazil has been worsening in recent decades, with a reduction in the consumption of healthy foods and an increase in the consumption of processed and ultra-processed foods.[26] Concomitantly, there was an increase in the prevalence of alcohol consumption[27] and physical inactivity.[28] Smoking is the only risk factor for which prevalence has been decreasing in recent decades.[29] Promoting healthy lifestyles as public policy remains a challenge, but should be considered a potentially cost-effective primary strategy to prevent and control CRC, as well as other cancers and non-communicable diseases in general.

This study estimates productivity lost due to mortality from CRC in Brazilian regions over a three-decade period, with projections of the economic impact up to 2030. The Human Capital Approach is the most widely-used method to estimate productivity loss from cancer. Economic and mortality data were obtained from reliable data sources; IBGE, responsible for the National Household Sample Survey Continuous – from which we obtained the economic data – follows a robust method in its surveys, ensuring data quality. Regarding mortality data, Brazil started to register deaths from all causes in a unified way in 1979. Since then, the mortality information system has been improving, placing Brazil among the countries with good coverage and quality of mortality registration.[30]

Our study has some limitations: the losses associated with unpaid work undertaken by people with cancer, and paid or unpaid work undertaken by caregivers of people with cancer that is lost, were not included due to a lack of data. Costs related to CRC

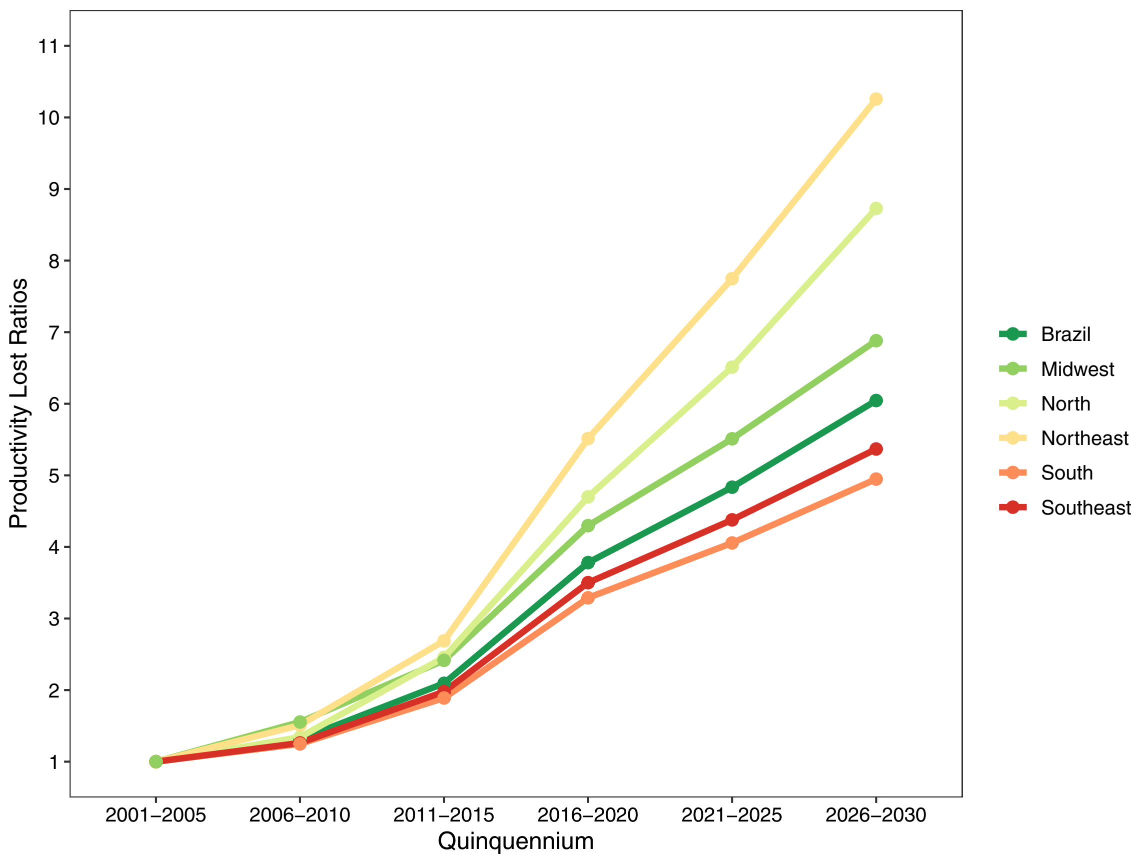

Fig. 4: Productivity lost ratios among females by quinquennium compared to the first quinquennium (2001–2005), Brazil and regions.

morbidity (e.g., temporary work absences during treatment and presenteeism) are also not included; thus, the economic losses related to morbidity and mortality (total indirect cost) will be even higher than those identified in our study. We used national age- and sex-specific mean wages, as detailed data were unavailable, which may have led to underestimation of productivity loss in affluent regions and overestimation in less affluent ones. Although the NordPred prediction method takes into account both changes in population and risk factors, the number of cases can be underestimated due to the changing role of risk factors across time. Furthermore, economic forecasts can be impacted by changes in political and economic conditions, which can affect employment and wages. Data were available only for sex; therefore, the role of gender and gendered behaviors in CRC risk profiles could not be inferred from the available data.

Our findings showed that CRC mortality will increase by 2030, resulting in 12·6 million YPLL and Int$22·6 billion in productivity lost during 2001–2030. The highest relative growth in YPLL and productivity lost are estimated to be observed in the North and Northeast regions, possibly linked to the westernization process that has now impacted behavioral patterns in the South and Southeast regions of Brazil. Strategies to mitigate the economic impact of CRC in Brazil in the coming decades must include: (i) promoting the reduction of social and regional inequalities related to access to timely diagnostic investigation of CRC; (ii) decreasing the prevalence of risk factors, by promoting healthy eating habits, practice physical activity, awareness about alcohol consumption, smoking cessation and reduce overweight; (iii) introduction and gradually scale-up a population-based screening program; (iv) ensuring early diagnosis for individuals with suspicious signs and symptoms and surveillance for those at high CRC risk; and (v) ensuring equitable access to evidence-based treatments for all stages of disease.

Contributors

JEMS: data curation, methodology, analysis, validation, writing – original draft, review and editing.

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LBLS: data curation, methodology, analysis, validation, writing – review and editing.

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LFLM: data curation, methodology, analysis, validation, writing – review and editing.

PH: conceptualization, methodology, validation, writing – review and editing.

MCC: conceptualization, data curation, funding acquisition, methodology, project management, analysis, supervision, validation, writing – original draft, writing – review and editing.

Data sharing statement

The data used in this study are available for download at: https://datasus.saude.gov.br/transferencia-de-arquivos/, https://sidra.ibge.gov.br/pesquisa/estimapop/tabelas and https://www.ibge.gov.br/estatisticas/sociais/trabalho/9171-pesquisa-nacional-por-amostra-de-domicilios-continua-mensal.html?=&t=microdados.

Declaration of interests

AM is Member of the Brazilian Ministry of Health's working group on colorectal cancer prevention and screening; MCC discloses a grant from MSD; all other authors have no conflicts of interest to declare.

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IARC disclaimer: Where authors are identified as personnel of the International Agency for Research on Cancer/World Health Organization, the authors alone are responsible for the views expressed in this article and they do not necessarily represent the decisions, policy or views of the International Agency for Research on Cancer/World Health Organization.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2026.101383.

References

1 Ferlay J, Lam F, Laversanne M, et al. Global cancer observatory: cancer today (version 1.1). Available from: https://gco.iarc.who.int/today/; 2024. Accessed December 11, 2024.
2 Pearce A, Sharp L, Hanly P, et al. Productivity losses due to premature mortality from cancer in Brazil, Russia, India, China, and South Africa (BRICS): a population-based comparison. *Cancer Epidemiol*. 2018;53:27–34.
3 de Souza DLB, Jerez-Roig J, Cabral FJ, de Lima JRF, Rutalira MK, Costa JAG. Colorectal cancer mortality in Brazil: predictions until the year 2025 and cancer control implications. *Dis Colon Rectum*. 2014;57:1082–1089.
4 *INCA. Detecção Precoce do Câncer*. Rio de Janeiro: Instituto Nacional de Câncer – INCA; 2021:72.
5 Dantas AAG, de Oliveira NPD, Costa GAB, et al. Multilevel analysis of social determinants of advanced stage colorectal cancer diagnosis. *Sci Rep*. 2024;14:9667.
6 Barchuk A, Bespalov A, Huhtala H, et al. Productivity losses associated with premature mortality due to cancer in Russia: a population-wide study covering 2001-2030. *Scand J Public Health*. 2019;47:482–491.
7 Siegel RL, Torre LA, Soerjomataram I, et al. Global patterns and trends in colorectal cancer incidence in young adults. *Gut*. 2019;68:2179–2185.
8 Hanly PA, Sharp L. The cost of lost productivity due to premature cancer-related mortality: an economic measure of the cancer burden. *BMC Cancer*. 2014;14:224.
9 Instituto Brasileiro de Geografia e Estatística. Estatísticas: condições de vida, desigualdade e pobreza. Instituto Brasileiro de Geografia e Estatística. Available from: https://www.ibge.gov.br/estatisticas/multidominio/condicoes-de-vida-desigualdade-e-pobreza.html; 2025. Accessed February 12, 2025.
10 Instituto Brasileiro de Geografia e Estatística. Pesquisa Nacional por Amostra de Domicílios Contínua - PNAD Contínua. Available from: https://www.ibge.gov.br/estatisticas/sociais/trabalho/17270-pnad-continua.html?=&t=o-que-e; 2020. Accessed February 18, 2021.
11 Instituto Brasileiro de Geografia e Estatística. Tábuas Abreviadas de Mortalidade. Available from: https://www.ibge.gov.br/estatisticas/sociais/populacao/9125-tabuas-abreviadas-de-mortalidade.html?=&t=o-que-e; 2023. Accessed February 23, 2021.
12 Minstério da Saúde. DATASUS. Tab net. Available from: https://datasus.saude.gov.br/informacoes-de-saude-tabnet/; 2022. Accessed August 9, 2022.
13 de Souza Giusti ACB, de Oliveira Salvador PTC, Dos Santos J, et al. Trends and predictions for gastric cancer mortality in Brazil. *World J Gastroenterol*. 2016;22:6527–6538.
14 dos Silva IS. *Cancer epidemiology: principles and methods*. Lyon: International Agency for Research on Cancer; 1999:442.
15 OECD Economic Surveys: Brazil 2018. Available from: https://www.oecd-ilibrary.org/economics/oecd-economic-surveys-brazil-2018_eco_surveys-bra-2018-en;jsessionid=Kt2tOy7-LPHj7uXVqOYOYu_R.ip-10-240-5-45; 2018. Accessed February 18, 2021.
16 Leal J, Luengo-Fernandez R, Sullivan R, Witjes JA. Economic burden of bladder cancer across the European Union. *Eur Urol*. 2016;69:438–447.
17 de Santos MO, de da Lima FCS, Martins LFL, Oliveira JFP, de Almeida LM, De Camargo Cancela M. Estimated cancer incidence in Brazil, 2023-2025. *Rev Bras Cancerol*. 2023;69:e213700.
18 De Camargo Cancela M, Bezerra de Souza DL, Leite Martins LF, et al. Can the sustainable development goals for cancer be met in Brazil? A population-based study. *Front Oncol*. 2022;12:1060608.
19 Allemani C, Matsuda T, Di Carlo V, et al. Global surveillance of trends in cancer survival 2000–14 (CONCORD-3): analysis of individual records for 37 513 025 patients diagnosed with one of 18 cancers from 322 population-based registries in 71 countries. *Lancet*. 2018;391:1023–1075.
20 Ribeiro U Jr, Safatle-Ribeiro AV, Sorbello M, et al. Implementation of an organized colorectal cancer screening program through quantitative fecal immunochemical test followed by colonoscopy in an urban low-income community: guidance and strategies. *Clinics*. 2023;78:100278.
21 Jodal HC, Helsingen LM, Anderson JC, Lytvyn L, Vandvik PO, Emilsson L. Colorectal cancer screening with faecal testing, sigmoidoscopy or colonoscopy: a systematic review and network meta-analysis. *BMJ Open*. 2019;9:e032773.
22 Guimarães DP, Mantuan LA, de Oliveira MA, et al. The performance of colorectal cancer screening in Brazil: the first two years of the implementation program in Barretos Cancer Hospital. *Cancer Prev Res*. 2020;14:241–252.
23 CanScreen5, a global repository for breast, cervical and colorectal cancer screening programs. *Nat Med*. 2023;29:1135–1145.
24 Instituto Nacional de Câncer. Relatório do intervalo entre diagnóstico e início do tratamento do câncer no SUS. Rio de Janeiro: INCA. Available from: https://www.inca.gov.br/publicacoes/relatorios/relatorio-do-intervalo-entre-diagnostico-e-inicio-do-tratamento-do-cancer-no; 2020. Accessed December 11, 2024.
25 Valle TD, Turrini RNT, de Poveda VB. Intervening factors for the initiation of treatment of patients with stomach and colorectal cancer 1. *Rev Lat Am Enfermagem*. 2017;25:e2879.
26 Instituto Brasileiro de Geografia e Estatística. Pesquisa de Orçamentos Familiares 2017-2018: análise do consumo alimentar pessoal no Brasil. Rio de Janeiro (RJ): instituto Brasileiro de Geografia e Estatística (IBGE), Coordenação de Trabalho e Rendimento. Available from: https://www.ibge.gov.br/estatisticas/sociais/saude/24786-pesquisa-de-orcamentos-familiares-2.html?edicao=28523&t=publicacoes; 2020. Accessed March 31, 2021.
27 Murray CJL, Aravkin AY, Zheng P, et al. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2020;396:1223–1249.

28 da Silva RCF, Bahia LR, da Rosa MQM, et al. Costs of cancer attributable to excess body weight in the Brazilian public health system in 2018. *PLoS One*. 2021;16:e0247983.
29 Ministério da Saúde. Observatório da Política Nacional de Controle do Tabaco. Dados e números da prevalência do tabagismo Rio de Janeiro (RJ): Instituto Nacional de Câncer José Alencar Gomes da Silva (INCA); 2021. Available from: https://www.inca.gov.br/observatorio-da-politica-nacional-de-controle-do-tabaco/dados-e-numeros-prevalencia-tabagismo; 2018. Accessed March 18, 2021.
30 Laurenti R, de Mello Jorge MHP, Gotlieb SLD. Underlying cause-of-death mortality statistics: considering the reliability of data. *Rev Panam Salud Publica Pan Am J Public Health*. 2008;23:349–356.