How have changes in cancer mortality impacted life expectancy and lifespan disparity? An analysis by age, sex and cancer sites in Brazil (2000-2016)

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Abstract:

During the 20th century, both the incidence rate and the mortality due to cancer experienced substantial increases in Brazil. Currently, cancer is one of the leading causes of death in the country. However, since the turn of the century, improvements in cancer mortality have started to occur, resulting in gains in life expectancy. Although the decline of cancer mortality has already been translated in gains in life expectancy, its implications for the increase life expectancy by cancer sites, and on the pattern of lifespan disparity is still unknown in Brazil. Therefore, we analyze how changes in cancer mortality by age, sex, and cancer sites impacted life expectancy and lifespan disparity between 2000 in 2016. In addition, our results will provide a better understanding of how changes in the age-pattern of mortality by cancer sites can drive patterns of lifespan disparity.

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1 – INTRODUCTION

Cancer is one of the leading causes of death worldwide (Fitzmaurice et al. 2015, McGuire 2015). In 2012, there were 14.1 million new cases and more than 8 million cancer deaths (McGuire 2015). Despite its global impact, there are marked differences of the distribution of cancer across regions: more than 60% of cancer new cases, and for about 70% of cancer deaths are now occurring in low-middle-income countries (McGuire 2015). The disorderly urbanization process, the air pollution, the high prevalence of chronic infection diseases and unhealthy lifestyle habits diffusion are the main reasons for the high neoplasm incidence in these countries (Caldwell 1986, Guerra et. al. 2005, Chrisman et al. 2009, Goss et al 2013, McGuire2015, Strasser-Weippl et. al. 2015, Fitzmaurice et. al. 2015).

Moreover, on average, 70% of cancer patients in developing countries are diagnosed at the late stage of illness, when treatment is no longer effective (McGuire 2015). Clearly, these statistics present a warning impact of cancer in the developing world, with substantial implications for health systems and budges.

The cancer mortality also presents important differentials among sexes, with neoplasms mortality rates significantly higher for men than for women (McGuire 2015, Siegel et al. 2017). Among men, lung, prostate, colorectum, stomach and liver cancer are the major cause of mortality; while for women breast, colorectum, lung, cervix, and stomach are the leading causes of death (McGuire 2015). The larger sex disparity for mortality reflects differences in the composition and distribution of cancers; e.g. liver cancer, which is highly fatal, is 3 times higher in men than in women. In middle-income regions such as Latin America and the Caribbean, breast cancer is a leading cause of cancer death in women, whereas prostate and lung cancers make similar contributions to cancer mortality in men (Boing et. al. 2007, McGuire 2015, Strasser-Weippl et. al. 2015).

The most common age pattern of cancer deaths shows an increasing mortality with age, with a great proportion of deaths around ages 50 or 60 (Vaupel and Yashin 1999, Siegel et al, 2017). However, the age-specific mortality by cancer is also changing over time. For some cancer sites, recent mortality reductions had been greater at younger than at older ages. Lung cancer is a good example of it. Implementation of tobacco control policies has a larger impact on lung cancer mortality at younger ages, leading to a higher proportion of lung cancer deaths at older ages over time (Torre et

al. 2014). A similar impact of smoking policies on age pattern of mortality by lung cancer has been observed in developing countries (Wünsch Filho et al 2010, Souza et. al. 2018).

According to McGuire (2015) and Fitzmaurice et. al. (2015), the cancer incidence and mortality in developing countries will continue to grow in the coming decades. Trends in cancer mortality and incidence also increase the concern of cancer implications in the developing world. Deaths from cancer in these regions are projected to grow to 6.7 million in 2015 and 8.9 million in 2030 (McGuire, 2015). However, in some developing countries, particularly in middle-income countries, as the case of Brazil, improvements in the access to preventive health services related to chronic conditions have been already documented, and these advances have been translated into important reductions in which breast and stomach cancer mortality (Wünsch Filho et al 2010, Souza et. al. 2018, Balabram et al. 2013).

The high burden of neoplasms on population health motivates several studies that seek to compare the impact of cancer in different countries of the world simultaneously (Torre et al. 2014, Fitzmaurice et. al. 2015, Cao et. al. 2017, McGuire 2015) and more specifically in developed regions (Boyle and Ferlay 2005, Crimmins and Beltran-Sánchez 2011, Siegel et. al. 2017, Ferlay et. al. 2015) and in developing countries (Kanavos 2006, Strasser-Weippl et. al. 2015, Goss et al 2013). In general, these studies disclose that substantial progress has been made in recent years with regard to prevention and treatment for certain neoplasms. Cao et. al. (2017) show that declines in cancer deaths contributed to on average 10% of the gain in life expectancy at age 40, which reductions on lung cancer mortality contributed the most for gains among men, and breast cancer for women. However, despite this progress, cancer burden in developing countries is increasing owing to a growing aging population as well as the diffusion of risk factors like smoking, obesity, and unhealthy dietary patterns.

In Brazil, both cancer incidence and mortality increased progressively throughout the 20th century. (Wunsch Filho et al. 2002, Boing et al. 2007). However, more recent studies have shown a certain stability of the effects of cancer mortality in relation to total mortality in the last decades in the country. According to Calazans and Queiroz (2017), mortality by cancer reduced 2.5% per year the number of years lived in adulthood between the years of 2000 and 2010. However, we expect some variations about this percentage given to substantial advances in mortality from lung, stomach and

breast cancers, as previously mentioned (Instituto Nacional de Cancer Jose Alencar Gomes da Silva 2017, Wünsch Filho et al 2010, Souza et al. 2018, Balabram et al. 2013).

Although improvements in survival by some cancer sites deaths have been observed in Brazil, given the different impacts of these changes over ages, it is relevant to understand the effect of them not only on the number of years lived (e.g. life expectancy) but also on the number of years lost due to cancer death (e.g. lifespan disparities). Variation measures, in addition to providing a different dimension of population health, are related to changes in life expectancy; populations that have been experiencing biggest reductions in life disparities have been the highest life expectancy (Vaupel et al. 2011). Therefore, this study aims to analyze gains in life expectancy due to mortality changes by cancer sites parallel with changes in life disparity, in Brazil between 2000 and 2016. We believe that changes in age-specific mortality by cancer over time, particularly due to reductions in premature deaths, will affect the variation in age-at-death. This analysis complements studies of gains in life expectancy by changes in cancer death by revealing which cancer sites has the largest impact in variation in lifespans. This is relevant because reductions in lifespan variation by site of cancer can increase gains in life expectancy. In other words, reducing variation in age-at-death among individuals will reduce heterogeneity in age-at-death and consequently, gains in the average number of years lived.

It is also important to mention here that life disparity is a measure that is greatly affected by changes in age patterns of mortality: progress in reducing premature deaths reduces variation in lifespans, whereas progress in reducing deaths at older ages increases variation in lifespans (Vaupel and vanRaalte, 2011). Therefore, we expect that cancer sites that have been experiencing great reductions in premature mortality such as lung and breast cancer has lower variation in lifespan.

2 – DATA AND METHODS

Database

Despite recent efforts to improve the vital records system, Brazil still has problems in covering death registries. Thus, in order to overcome this problem, life tables calculated by the World Health Organization for Brazil between 2000 and 2016, were used. These tables already correct the level of general mortality in the country.

The number of total deaths by sex, age and cause of death was extracted from the Mortality Information System of the Brazilian Ministry of Health (DATASUS/MS). In addition to using information on the total number of neoplasms, corresponding to the codes from C00 to D48 from the International Classification of Diseases (ICD-10), we also use information for some specific types of cancer: malignant neoplasms of digestive organs (ICD-10 C15-C26), malignant neoplasms of respiratory and intrathoracic organs (ICD-10 C30-C39), malignant neoplasms of breast (ICD-10 C50-C50), malignant neoplasms of genital organs (ICD-10 C51-C58 for females and ICD-10 C60-C63 for males) and malignant neoplasms of lymphoid, hematopoietic and related tissue (ICD-10 C81-C96). These five groups of cancers account for more than 75% of neoplastic deaths during the period analyzed.

Methods

We calculate multiple decrement life tables to evaluate the effect of each cancer site on life expectancy at birth (e_0^0) (Preston et al. 2001). Also, to measure lifespan disparity, we estimate e-dagger at age zero ($e_0^\dagger$) (Vaupel and vanRaalte, 2011). This is the weighted average of remaining life expectancy at each age, weighted by the number of life table deaths at each age. Lifespan disparity is also useful to investigate compression of mortality, therefore by analyzing trends in life disparity by cancer site we can measure this process in Brazil and we can also identify differences by cancer site and sex.

3 - PRELIMINARY RESULTS

Age pattern of cancer mortality

The first part of this session is to investigate changes in the age-specific proportion of deaths by the main cancer sites in Brazil between 2000 and 2016 (Figures 1-6).

[Figures 1 about here]

Figure 1 shows that deaths by all cancer sites together are strongly concentrated at older ages for both men and women. Over time, this figure also reveals that the proportion of deaths at ages 30-55

reduced, parallel with an increasing proportion at ages 60-69, suggesting that cancer deaths have been compressed between 2000 and 2016. This result also indicates that premature mortality by cancer has been reducing in Brazil. In order to better understand this pattern, Figures 2-6 display the age-specific proportion of deaths for the main cancer sites.

[Figures 2-6 about here]

Figures 2-6 show that the age-specific proportion of deaths differs substantially by cancer sites. The deaths by cancer in digestive system and respiratory system have similar age-patterns of that of total cancer deaths (Figures 2-3). Whereas, the peak of death distribution by breast cancer (Figure 4) is at younger ages (45-59 years old) than that of the total female cancer deaths (60-69 years old). The distribution of cancer deaths by lymphoid, hematopoietic and related tissue also differs from that of total cancer deaths. Figure 5 shows that deaths by this site of cancer are more spread over ages than other cancer deaths analyzed here. Cancer deaths by genital organs also have a particular distribution. For men Figure 6 shows that the proportion of genital cancer deaths is nearly exponential with age. Moreover, the distribution of cancer deaths by genital organs is substantially different between men and women: more than 50% of men deaths are concentrated over age 75, while among women this percentage is around 20%. It is important to mention here that part of this sex difference may be driven by the late diagnosis in this type of cancer among men; the stigma, particularly in Brazil, regarding preventive care and regular tests to diagnose cancer in genital organs may be the main reasons.

Figures 1-6, in addition to reveal that the distribution of deaths differ substantially by cancer sites and sex, they also show greater reductions in the proportion of deaths at younger ages, parallel to an increasing concentration of deaths at older ages between 2000 and 2016. This result suggests that mortality by cancer in Brazil has been compressed over time, and the magnitude of this compression differ by cancer sites and by sex. There are two possible reasons for this compression: *i)* aging of the age structure of deaths by cancer, and *ii)* declines in premature cancer deaths due to preventive care and effective medical treatment, particularly for some cancer sites.

Life expectancy and lifespan disparity

In order to investigate the impact of changes in cancer mortality on life expectancy, Figures 7 and 8, respectively for men and women, display life expectancy at birth for all causes of death, and the life expectancy at birth after each cancer site was suppressed. Despite the expected increase in life expectancy over time, our figures also show gains in life expectancy in the absence of cancer deaths in each analyzed year. Note that curves are nearly paralleled over time, suggesting small variation in the relative gains in life expectancy by cancer over time: in each year, life expectancy at birth increase of about 2 years in the absence of cancer for both sexes. For males, Figure 7 discloses important gains in life expectancy due to cancer of genital organs, followed by cancer of respiratory and intrathoracic organs. While for women, Figure 8 shows that the gains in life expectancy due to cancer of digestive organs and breast plays an important role in increasing life expectancy.

[Figures 7-8 about here]

Figures 9 and 10 show the trend in lifespan disparity by cancer sites, respectively for men and women. Both figures reveal great reductions in lifespan disparity between 2000 and 2016: for women, the variation in age at death by all sites of cancer reduced 1.7 years; while for men it reduced less, of about 1.2 years. This result suggests higher compression for women than for men. Reducing premature mortality by breast cancer may play an important role in this sex difference.

Another important finding of this study is that reductions in the variation in age at death by cancers is higher than reductions for the overall mortality between 2000 and 2016 in Brazil. It suggests that the process of compression of deaths is more pronounced by cancer deaths than for the overall mortality.

[Figures 9-10 about here]

4 – DISCUSSION AND OUTLOOK

Our preliminary results suggest that mortality by cancer has been compressed in Brazil. In addition they indicate that this process is more pronounced by cancer deaths than for the overall mortality.

These results are relevant mainly because changes in lifespan disparity over time are closely related to gains in life expectancy. Reducing lifespan disparity may lead to higher gains in life expectancy. The reason is: as the age at death become more homogeneous or in other words, as the variation in lifespan reduces, more gains in life expectancy are expected. Thus, one strategy to increase life expectancy for all causes of death is by reducing the variability in lifespans. As we showed important variation in lifespans by cancer, by reducing the variation in age of deaths by cancer, gains in total life expectancy can be achieve. Moreover our analyses by cancer sites shed some light on which sites of cancer may drive more gains in lifespans.

It is also important to mention here that, over the last decades, several policies for the prevention and early diagnosis of the disease have been designed in the country and these results bring new evidence on the efficiency of these policies for the reduction of premature cancer mortality in Brazil.

Despite the relevance of these findings, it is still necessary to better quality to what extent these changes are associated with the variation in life expectancy and of lifespan over time. Thus, we intend to decompose both the variation in life expectancy and the variation of lifespan between the years 2000 and 2016, by age and cancer side using the continuous decomposition developed by (Horiuchi, Wilmoth and Pletcher 2008). These two methodological exercises will help to answer to what extent the aging of mortality due to cancer has been contributing to the gains in life expectancy and to the compression of general mortality over time in Brazil.

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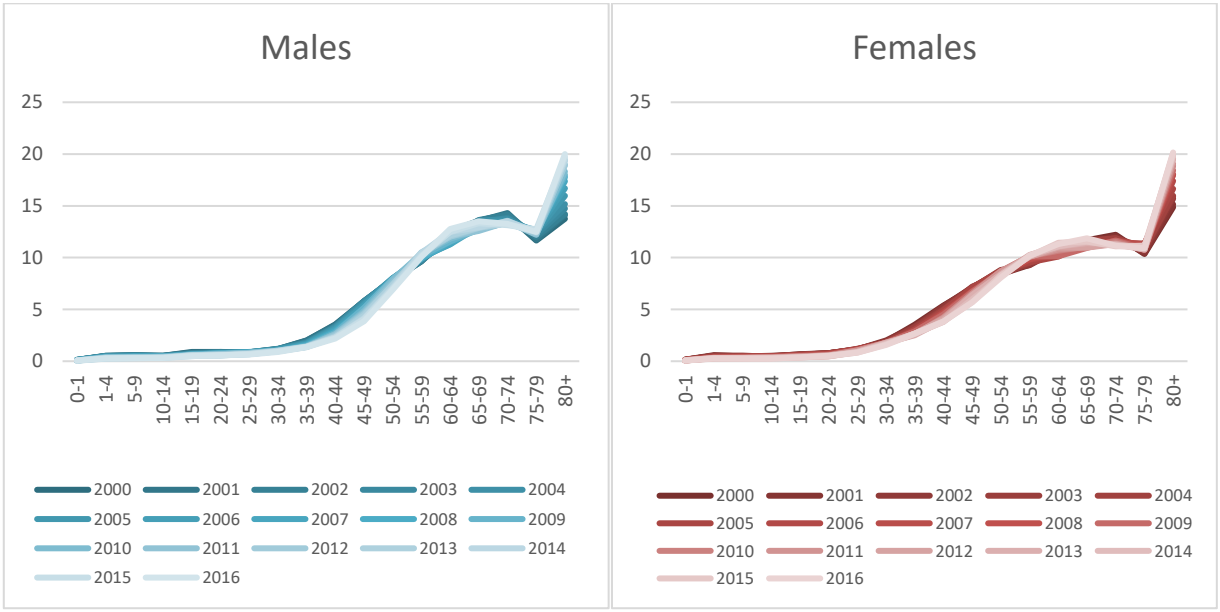
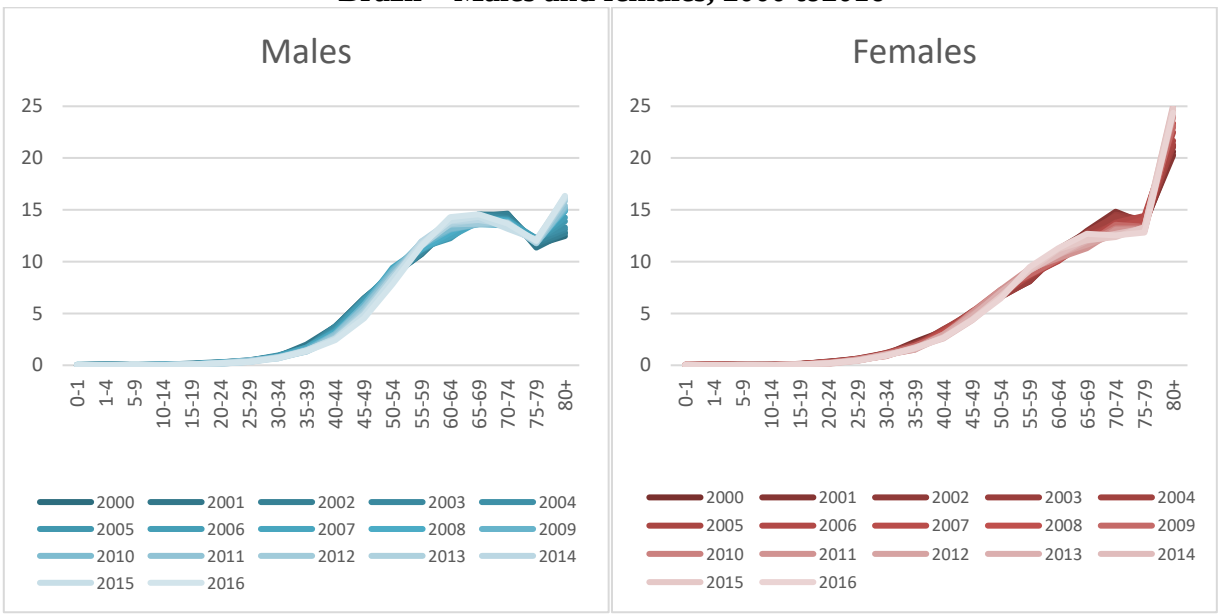
Figures

FIGURE 1 – Age-specific proportion of deaths by neoplasms in Brazil – Males and females, 2000 to 2016



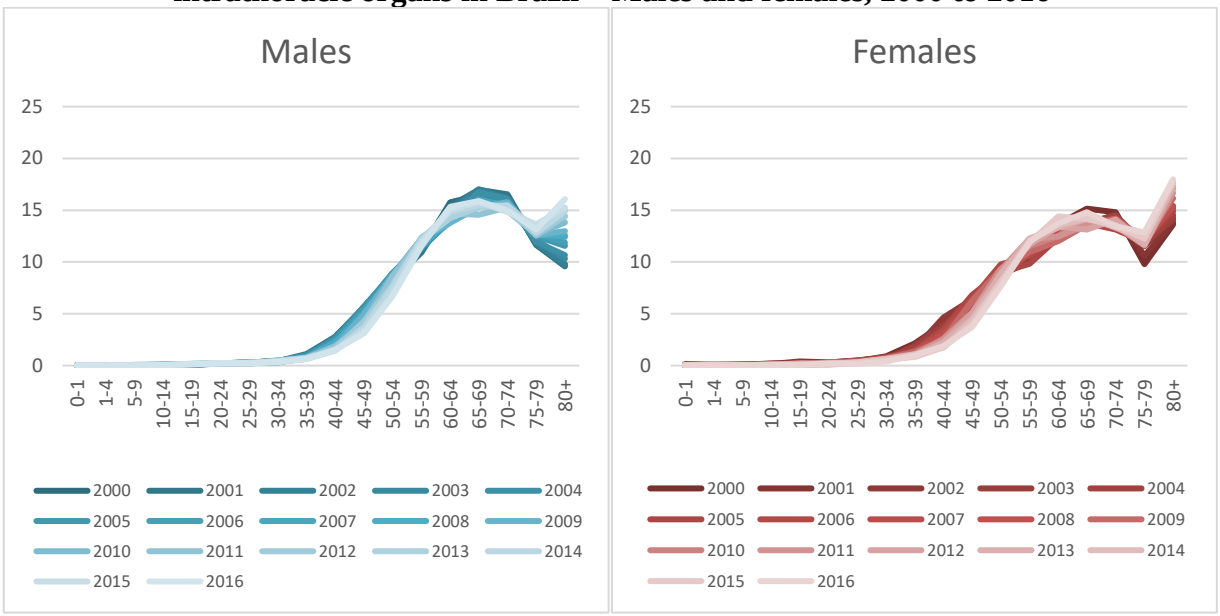
Source: Global Health Observatory data (GHO/WHO) and Mortality Information System of the Brazilian Ministry of Health (DATASUS/MS)

FIGURE 2 - Age-specific proportion of deaths by malignant neoplasms of digestive organs in Brazil – Males and females, 2000 to2016



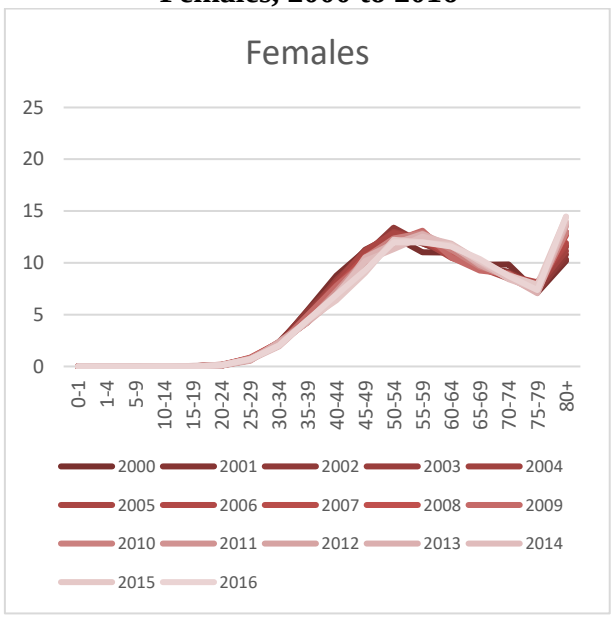
Source: Global Health Observatory data (GHO/WHO) and Mortality Information System of the Brazilian Ministry of Health (DATASUS/MS)

FIGURE 3 - Age-specific proportion of deaths by malignant neoplasms of respiratory and intrathoracic organs in Brazil – Males and females, 2000 to 2016



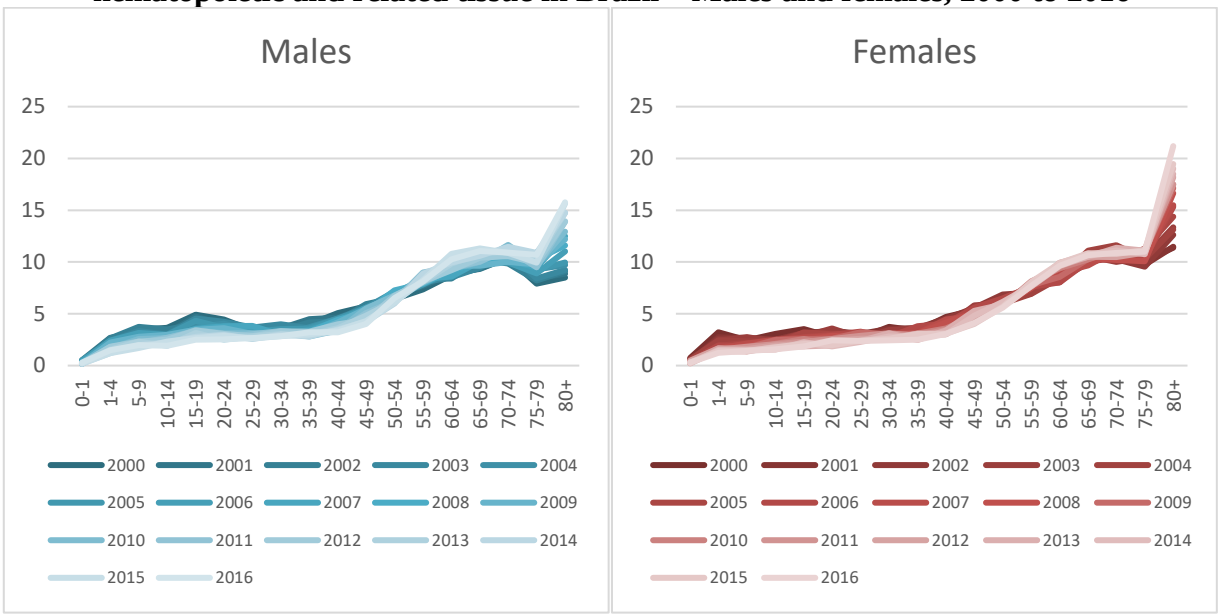
Source: Global Health Observatory data (GHO/WHO) and Mortality Information System of the Brazilian Ministry of Health (DATASUS/MS)

FIGURE 4 - Age-specific proportion of deaths by malignant neoplasms of breast in Brazil – Females, 2000 to 2016



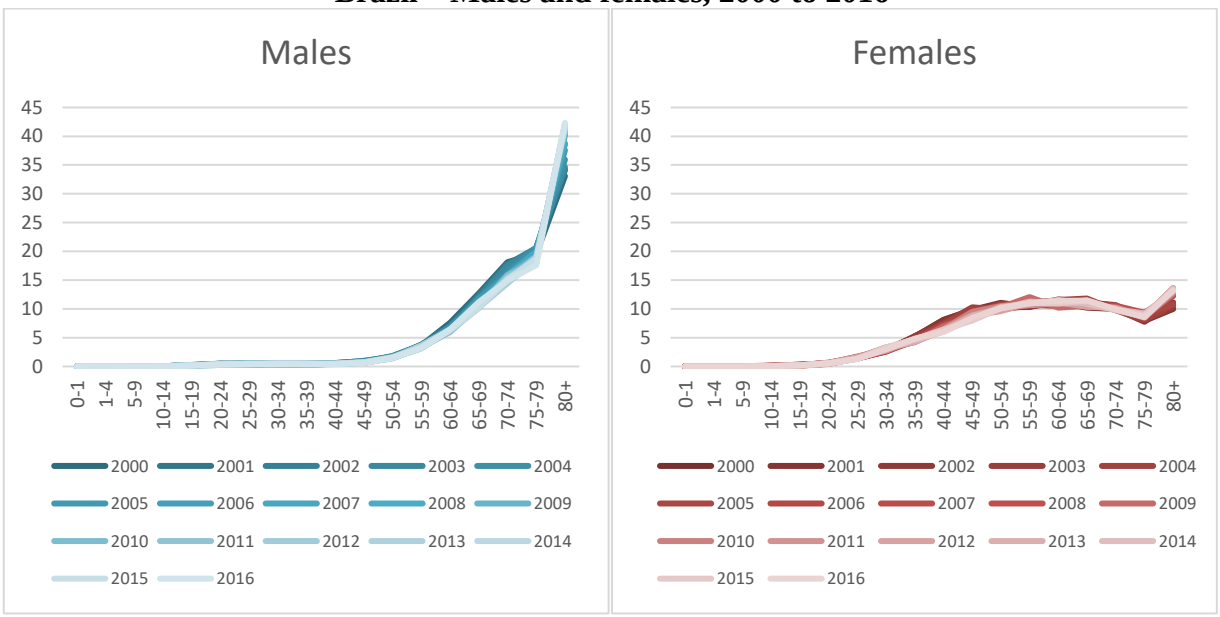
Source: Global Health Observatory data (GHO/WHO) and Mortality Information System of the Brazilian Ministry of Health (DATASUS/MS)

FIGURE 5 - Age-specific proportion of deaths by malignant neoplasms of lymphoid, hematopoietic and related tissue in Brazil – Males and females, 2000 to 2016



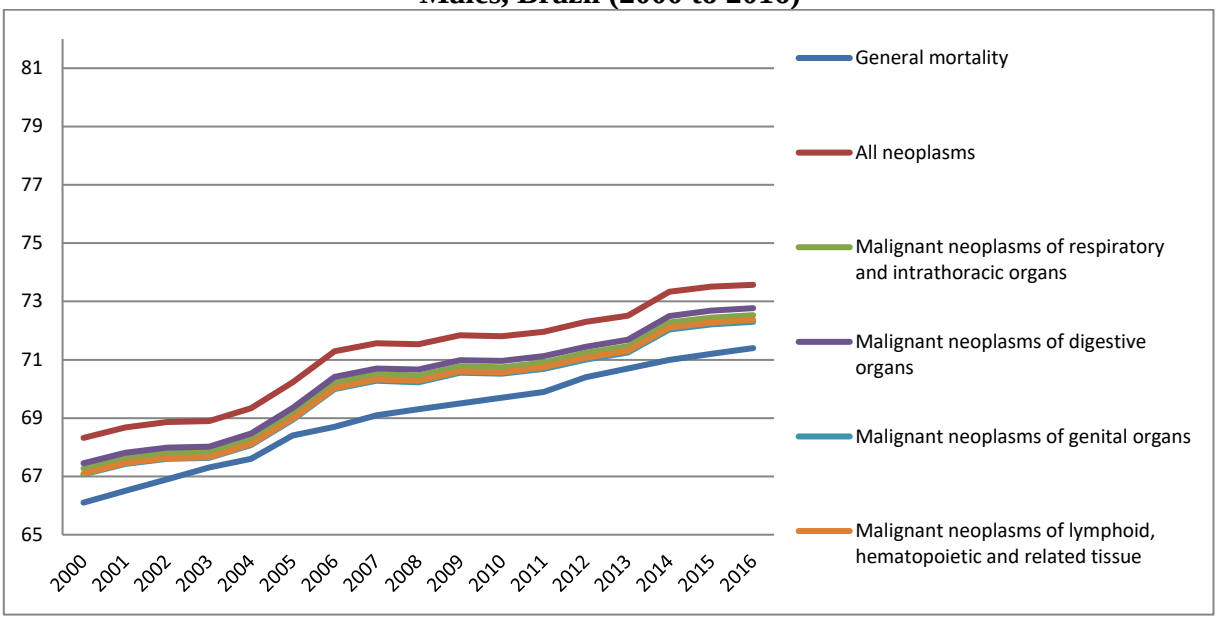
Source: Global Health Observatory data (GHO/WHO) and Mortality Information System of the Brazilian Ministry of Health (DATASUS/MS)

FIGURE 6 - Age-specific proportion of deaths by malignant neoplasms of genital organs in Brazil – Males and females, 2000 to 2016



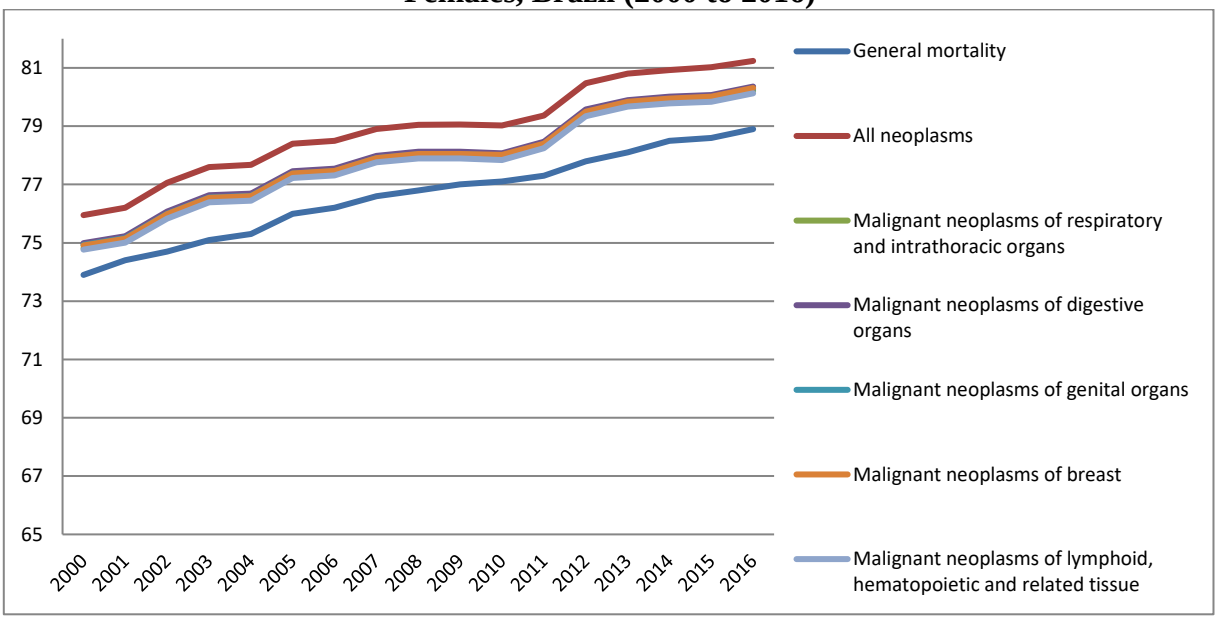
Source: Global Health Observatory data (GHO/WHO) and Mortality Information System of the Brazilian Ministry of Health (DATASUS/MS). Note: The scale of the graphs for the mortality by malignant neoplasms of genital organs is different from the scale of the other graphs

FIGURE 7 – Life expectancy at birth for total mortality and by suppressing each cancer site - Males, Brazil (2000 to 2016)



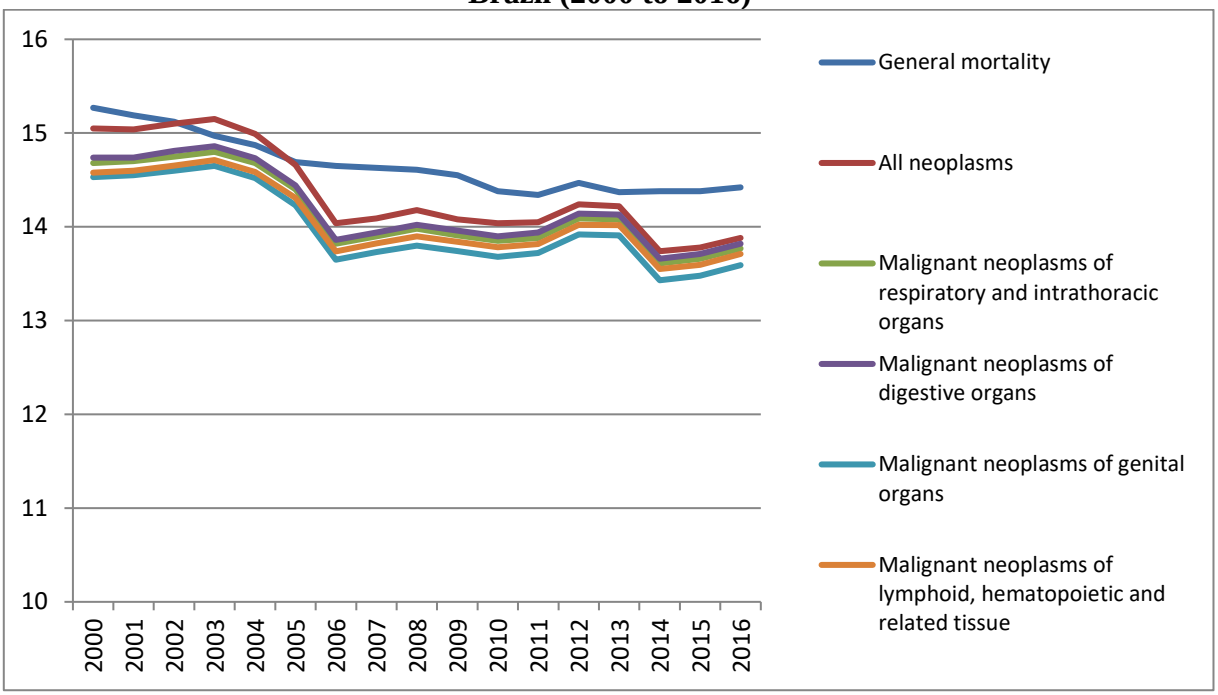
Source: Global Health Observatory data (GHO/WHO) and Mortality Information System of the Brazilian Ministry of Health (DATASUS/MS)

FIGURE 8 – Life expectancy at birth for total mortality and by suppressing each cancer site - Females, Brazil (2000 to 2016)



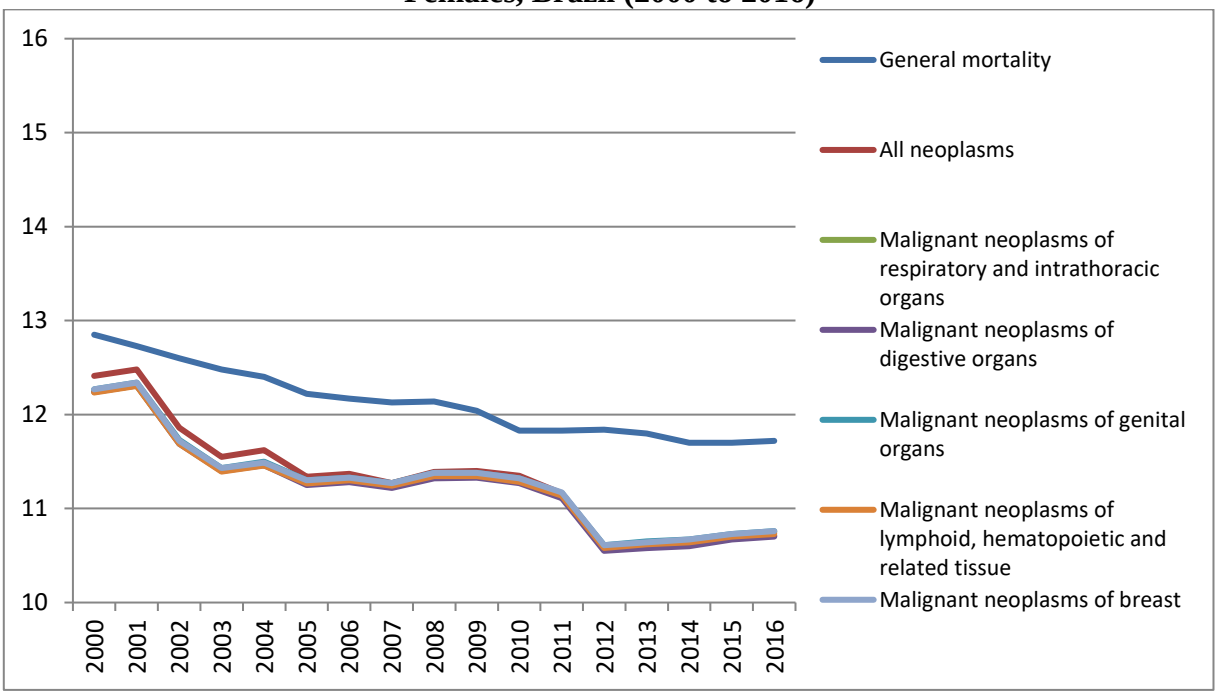
Source: Global Health Observatory data (GHO/WHO) and Mortality Information System of the Brazilian Ministry of Health (DATASUS/MS)

FIGURE 9 – E-dagger at birth for total mortality and by suppressing each cancer site - Males, Brazil (2000 to 2016)



Source: Global Health Observatory data (GHO/WHO) and Mortality Information System of the Brazilian Ministry of Health (DATASUS/MS)

FIGURE 10 – E-dagger at birth for total mortality and by suppressing each cancer site - Females, Brazil (2000 to 2016)



Source: Global Health Observatory data (GHO/WHO) and Mortality Information System of the Brazilian Ministry of Health (DATASUS/MS)