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The increasing burden of cancer attributable to high body mass index in Brazil

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ABSTRACT

Background: Body mass index (BMI) has been constantly increasing over the last decades in most parts of the world, most notably in transitioning nations such as Brazil. High BMI (> 22 kg/m^2) is associated with an increased risk of 14 types of cancer. We estimated the extent to which reducing high BMI could lower cancer incidence in Brazil, nationally as well as at regional and state levels.

Methods: We calculated fractions of cancer incidence in 2012 attributable to high BMI as well as projections for attributable cases in 2025 using BMI data from representative national surveys and relative risks published in meta-analyses. Estimates of cancer incidence were retrieved from GLOBOCAN and the Brazilian National Cancer Institute.

Results: We found that 15,465 (3.8%) of all new cancer cases diagnosed in Brazil in 2012 were attributable to high BMI, with a higher burden in women (5.2%) than in men (2.6%). The cancer sites contributing most to the number of attributable cases were breast (n = 4777), corpus uteri (n = 1729), and colon (n = 681) in women, and colon (n = 1062), prostate (n = 926), and liver (n = 651) in men. The highest population attributable fractions (PAFs) for all cancers were found in the richer states of the country, located in the south (1.5% men/3.4% women) and the southeast (1.5% men/3.3% women).

Conclusions: Cancer cases attributable to high BMI will reach 29,490, which will be 4.6% of all cancers in Brazil in 2025; the extent will be greater in women (6.2% or 18,837) than in men (3.2% or 15,702). This information is a tool to support policy makers for future cancer prevention strategies in Brazil.

1. Introduction

Fourteen million new cancer cases (excluding non-melanoma skin cancers) were diagnosed worldwide in 2012. By 2025, the number of new cancer cases is projected to increase by 37% worldwide, and even higher increases are expected in countries with low (46%) to medium human development (41%) [1]. Brazil is an illustrative example of the cancer prevention challenges in transitioning nations. Being the fifth largest country in the world in both area and population (e.g. 8,515,767 km^2 and around 200 million inhabitants), this country is facing rapid population growth as well as socioeconomic and environmental transformations [2]. At the same time it confronts health challenges from countries in transition (e.g. infections and malnutrition) and from the highly developed world (e.g. overconsumption of ultra-processed foods, obesity, and diabetes), leading to persistent and massive health inequalities [2]. Furthermore, describing the burden of cancer in these 'two worlds' (i.e. within-country) is important to inform cancer prevention strategies in transitioning countries.

In Brazil, more than 470,000 new cancer cases occurred in 2012, and around 640,000 cases are expected by 2025 based only on expected changes in population structure [1]. The increase in the prevalence of risk factors associated with westernization may also lead to further

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increases in the burden of cancer. In fact, obesity prevalence – defined as body mass index (BMI) ≥30 kg/m^2 – has constantly increased over the last decades [3], reaching 17.4% in men and 25.2% in women aged ≥20 years in 2013. There is convincing evidence that overweight and obesity are associated with an increased risk of at least 14 types of cancer, namely breast (postmenopausal), colon, corpus uteri, gallbladder, kidney, liver, multiple myeloma, esophagus (adenocarcinoma), ovary, pancreas, prostate (advanced stage), rectum, stomach/cardia, and thyroid [4–14]. The incidence of these cancers represented almost half of all cancer cases diagnosed in Brazil in 2012 [1]. Therefore, reducing overweight and obesity may have a substantial impact on cancer prevention in Brazil.

In this study, we estimated the extent to which reducing high BMI could lower cancer incidence in Brazil, nationally as well as at regional and state levels. We also present projections of the potentially preventable cancers due to high BMI for the year 2025.

2. Materials and methods

In order to quantify the extent to which high BMI contributes to cancer incidence in Brazil, we estimated fractions of cancers in 2012 and 2025 attributable to high BMI (> 22 kg/m^2) in Brazil. Population attributable fractions (PAFs) were calculated according to sex, age, cancer site, and geographic area. Regarding the geographic areas, three levels of analysis were considered: (1) country level: Brazil; (2) regional level: five sets of states (north, northeast, midwest, southeast, and south); (3) state level: 26 states (e.g. Sao Paulo, Rio de Janeiro) and one federal district (Distrito Federal). All data input and scripts used in our study are available at https://osf.io/sve7y/.

2.1. Data input

2.1.1. BMI distribution

We obtained BMI data from the National Household Budget Survey [15] and the National Health Survey [16] conducted in 2002 and 2013, respectively. Both surveys were nationally representative and collected height and weight data from the adult population aged ≥20 years. Both body weight (in kg) and height (in cm) were objectively measured by trained researchers using portable electronic scales and stadiometers [15–17].

For country-level analyses, we estimated BMI distribution (mean and standard deviation, SD) and the prevalence of overweight (25.0–29.9 kg/m^2) and obesity (≥30 kg/m^2) by sex and age group (20–34, 35–44, 45–54, 65–74, and ≥75 years) for the years 2002 and 2013 [15,16]. For regional- and state-level analyses, data on BMI distribution and prevalence of overweight and obesity in 2002 and 2013 were estimated by sex only (i.e. PAFs for these geographical areas were not estimated by age group due to absence of cancer incidence data – see Section 2.1.3. *Estimated cancer incidence*) [15,16].

2.1.2. Relative risk estimates

We included in our study only cancer sites with probable, convincing and sufficient evidence that they are associated with high BMI as reported by the World Cancer Research Fund (WCRF) Continuous Update Project [4–14] and the International Agency for Research on Cancer (IARC) [18]. We used meta-analyses from these sources to retrieve RR estimates per 1 kg/m^2 BMI increment and their 95% confidence intervals (95%CIs) for the association between high BMI and cancers of the breast (postmenopausal), colon, corpus uteri, gallbladder, kidney, liver, multiple myeloma, esophagus (adenocarcinoma), ovary, pancreas, prostate (advanced stage), rectum, stomach (cardia), and thyroid (Table S1).

2.1.3. Estimated cancer incidence

For country-level analyses, we retrieved estimates of new cancer cases in Brazil in 2012 by sex, age group (20–34, 35–44, 45–54, 65–74, and ≥75 years), and cancer site from the GLOBOCAN project [1]. These estimates were generated by modelling age-, sex-, and site-specific incidence/mortality ratios from 11 population-based cancer registries (PBCRs) across Brazil, which covered 13% of the population between 2003 and 2007 (i.e. classified as high-quality regional data according to GLOBOCAN 2012 [1]). We also obtained from GLOBLOCAN the number of cancer cases predicted for 2025 due to expected changes in population structure [1].

For the regional- and state-level analyses, we retrieved the estimated number of cancer cases in 2012 by sex and cancer site from the Brazilian National Cancer Institute (NCI) [19]. These estimates were modelled using data from 19 PBCRs across Brazil (fulfilled using data derived from 260 hospital-based cancer registries, HBCRs) and mortality statistics systems [19]. These estimates have been officially used to inform policy makers and cancer-prevention strategies in Brazil [19].

To obtain separate estimates for cancers of the colon, rectum, and stomach/cardia and esophageal adenocarcinoma we applied sex-specific adjustment factors for these subtypes in Brazil as reported in Cancer in Five Continents Volume X (CI5 X) [20–22]. For prostate cancer, we obtained the proportion of cases in advanced stage (stage 3 or 4) from the HBCR from Sao Paulo (i.e. 27% of 7000 cases diagnosed in 2012) [23]. Breast cancer (postmenopausal) was defined as cases aged ≥45 years (Table S2).

2.2. Data analysis

2.2.1. Calculation of PAF

PAFs by sex and age group were calculated on the country level, and PAFs by sex were calculated at the regional and state levels using the following equation [24]:

$$\mathrm{PAF} = \frac{\int \mathrm{RR}(x)\mathrm{P}(x)\mathrm{d}x - \int \mathrm{RR}(x)\mathrm{P}^*(x)\mathrm{d}x}{\int \mathrm{RR}(x)\mathrm{P}(x)\mathrm{d}x}$$

where P(x) is the population distribution of BMI (mean and SD), P*(x) is the counterfactual distribution of BMI, RR(x) is the relative risk of cancer associated with BMI (per 1 kg/m^2 increment), and dx indicates that the integration was done with respect to the BMI level. We used a log-logit function to represent each RR value across BMI units [25]. The counterfactual distribution of BMI was defined as mean 22 kg/m^2 and SD 1 kg/m^2 (i.e. the mid-point of normal-weight category). We thereby defined high BMI as any BMI level > 22 kg/m^2. No increased cancer risk was assumed below this value. The same reference group and approach were used in a recent study that estimated the global burden of cancer attributable to high BMI [25].

2.2.2. Number of cancer cases attributable to BMI

To obtain the number of cancer cases attributable to high BMI, we applied PAF estimates from 2002 to cancer cases in 2012, assuming a 10-year lag period. This 10-year lag period has been consistently used in the PAF literature [25–27] to account for the latent period for the development of cancer. The precise latent period between high BMI and cancer is not well established, but previous prospective studies have found beneficial effects of weight loss on cancer incidence after 10 years of follow up [28,29].

For country-level analyses, we applied PAF estimates by sex and age group from 2002 to cancer cases in 2012 (e.g. PAF calculated for 35–44-year-olds in 2002 were applied to cancer cases among 45–54-year-olds 2012). Then we summed up the age-specific number of cases attributable to high BMI (numerator) and divided by the total number of cases ≥35 years old (denominator, except in the case of breast cancer where the denominator was considered cases ≥45 years old) to obtain age-weighted PAFs. For regional- and state-level analyses, we calculated the number of cancer cases attributable to high BMI, applying PAF estimates by sex from 2002 to cancer cases ≥35 years old in 2012. This version of PAF (not age-weighted) was also estimated at country level