Economic impacts of overweight and obesity: current and future estimates for eight countries

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ABSTRACT

Background: Obesity is a growing public health challenge worldwide with significant health and economic impacts. However, much of what is known about the economic impacts of obesity comes from high-income countries and studies are not readily comparable due to methodological differences. Our objective is to demonstrate a method for estimating current and future national economic impacts of obesity and apply it across a sample of heterogeneous contexts globally.

Methods: We estimated economic impacts of overweight and obesity for eight countries using a cost-of-illness approach. Direct and indirect costs of obesity from 2019 to 2060 were estimated from a societal perspective as well as the effect of two hypothetical scenarios of obesity prevalence projections. Country-specific data were sourced from published studies and global databases.

Results: In per capita terms, costs of obesity in 2019 ranged from US$17 in India to US$940 in Australia. These economic costs are comparable to 1.8% of gross domestic product (GDP) on average across the eight countries, ranging from 0.8% of GDP in India to 2.4% in Saudi Arabia. By 2060, with no significant changes to the status quo, the economic impacts from obesity are projected to grow to 3.6% of GDP on average ranging from 2.4% of GDP in Spain to 4.9% of GDP in Thailand. Reducing obesity prevalence by 5% from projected levels or keeping it at 2019 levels will translate into an average annual reduction in 5.2% and 13.2% in economic costs, respectively, between 2020 and 2060 across the eight countries.

Conclusion: Our findings demonstrate that the economic impacts of obesity are substantial across countries, irrespective of economic or geographical context and will increase over time if current trends continue. These findings strongly point to the need for advocacy to increase awareness of the societal impacts of obesity, and for policy actions to address the systemic roots of obesity.

INTRODUCTION

Between 1975 and 2016, the prevalence of obesity increased in every country in the world.1 Overweight and obesity contribute to numerous noncommunicable diseases (NCDs), including cardiovascular disease, diabetes and cancer.2 Obesity-related NCDs account for over 5 million deaths globally each year, with over half occurring under the age of 70.3 The COVID-19 pandemic also revealed obesity as a significant factor in infectious disease morbidity and mortality.4

Key questions

What is already known?

► Estimates of the economic impacts of obesity as a percentage of gross domestic product (GDP) range from 0.13% in Thailand (Pitayatienanan et al) to 9.3% in the USA (Milken Institute, 2018) with most estimates for high-income countries.

► Most studies use a health system perspective rather than a societal perspective.

► Cost of obesity studies vary considerably in the types of outcomes reported, diseases included for the measurement of healthcare costs, age groups included and methods for estimating direct and indirect costs.

► Scant evidence is available on the economic impacts of obesity that are comparable across income contexts for policy and advocacy.

What are the new findings?

► We estimate obesity costs between 0.8% and 2.4% of gross domestic product (GDP) in 2019 in the eight countries in the study.

► Our projections reveal an increasing trend in obesity costs as a percentage of GDP over time, estimated to reach 2.4% of GDP in Spain and up to 4.9% in Thailand in 2060.

► The economic impacts of obesity are substantial and reach a similar magnitude in low-income and middle-income countries as in high-income contexts.

► Maintaining or reducing the prevalence of obesity can reduce the economic impacts of obesity in the future.

What do the new findings imply?

► Quantifying the economic impacts of obesity will help stakeholders understand the importance of addressing obesity through systemic solutions and is a tool for national and international advocates to encourage policy actions.

► There is need for a concerted increase in national efforts to combat the global rise in obesity prevalence and overcome the existing policy inertia that has hampered progress on obesity policy implementation.
Obesity is a complex chronic disease process resulting from the interaction of various factors including genetic susceptibility, high energy-dense nutrition, low physical activity and stress.2

The multifactorial and chronic nature of overweight and obesity leads to economic impacts for individuals and nations. Most evident are the direct healthcare costs associated with treating obesity-attributable diseases. Individuals living with obesity are significantly more likely to use home healthcare services, have more outpatient visits, be prescribed more medications, be admitted to a hospital and undergo surgery than individuals with lower weight.3 4 Finally, individuals with obesity experience higher costs of care and longer hospital stays.5 8

The economic impacts of obesity include indirect costs resulting from lost or reduced productivity and human capital. Studies from multiple countries show that individuals with obesity miss more days of work (absenteeism) than individuals without obesity, and work at less than full capacity when they are at work (presenteeism).9 Obesity also increases the chances of unemployment and has a negative impact on wages.10 11 Finally, premature deaths from obesity-attributable diseases imply a loss of potential future contributions to the economy. As with economic studies of other diseases, studying the economic costs of obesity does not imply and should not be misconstrued as meaning that individuals living with obesity create or are responsible for costs or economic losses. Rather, an increasingly obesogenic environment, both directly and through individual epigenetic changes, leads to an increased prevalence of obesity and its associated economic impacts. Although difficult to measure, weight bias also imposes economic and other costs,12 further underscoring the importance of not blaming individuals experiencing obesity.

Obesity has been shown to have substantial economic impacts in some countries, with estimates of the costs of medical care and reduced productivity ranging from 0.13% of GDP in Thailand to 9.3% in the USA.13 14 A review of the literature identified 59 studies of economic impacts of obesity published since 2010, a full list of which can be found in the online supplemental appendix. However, most of these studies come from high-income countries, use a healthcare system perspective, and vary considerably in types of outcomes reported, obesity-related diseases included, age groups included, types of costs and methodologies employed in estimating direct and indirect costs.

This study aims to estimate the current and future economic impacts of obesity using a modelling framework that can be applied to different national contexts around the world and be updated over time. It also assesses the effect of two hypothetical future obesity prevalence scenarios on economic impacts and presents results for eight countries selected to represent a range of geographies and income levels and for which adequate data was available. Cross-country analyses of the economic impacts of obesity are an important way to dispel myths and misunderstandings about the prevalence and causes of obesity, as well as factors that can reduce it. Our review of country studies and methodologies highlights the need to estimate the current and projected economic impacts of obesity across diverse countries in a comparable manner. It is especially important to understand the presence of obesity in low-income and middle-income countries (LMICs) but we found only one cross-country study that included countries that are not high income.15 Hence, this study seeks to fill that gap. Quantifying the magnitude of economic impacts of obesity helps policy-makers and other stakeholders better understand the scope of the challenge, supports prioritisation and resource allocation efforts, as well as providing a crucial tool for national and international advocates to urge policy-makers to respond with effective policies.16

**METHODS**

We employed a cost-of-illness approach17 18 to estimate the economic impacts of overweight and obesity in eight countries from a societal perspective in 2019 (baseline) and projected impacts in 2060. This approach translates the adverse effect of obesity into monetary terms,17 which is useful for understanding the impact of obesity for policy prioritisation and agenda setting. In addition, it is useful for facilitating cross-national comparisons of obesity consequences across different contexts.19 Overweight is defined as a body mass index (BMI) of 25 kg/m² to 29.9 kg/m² in adults and obesity as a BMI of 30 kg/m² and above; while for children, overweight is defined as weight 1–2 standard deviations (SD) above the median weight and obesity as more than 2 SD above the median.1 Hereafter, we will use the term ‘obesity’ to refer to both overweight and obesity. The countries in this study—Australia, Brazil, India, Mexico, Saudi Arabia, South Africa, Spain and Thailand—were selected to represent diverse geographic and economic national contexts and based on general data availability. We included 28 obesity-related diseases (online supplemental appendix 1: table 1) from the Global Burden of Disease (GBD) Study with evidence of obesity risk linkages.3

Under the cost-of-illness approach, the economic impacts of an illness are divided into direct costs and indirect costs (figure 1). In this study, direct costs consist of medical costs and non-medical costs (specifically, the travel and time required to receive care). Indirect costs include economic loss from premature mortality and productivity losses from absenteeism and presenteeism. Other relevant cost components such as long-term disability and early retirement costs9 were not included as it was not feasible to measure these across countries. Also, in some societies there may be costs associated with weight bias (eg, lower academic achievement, reduced emotional support, reduced likelihood of promotion) and in others there may be a premium associated with obesity,20 however, the magnitude and direction of these impacts have not been studied across countries.12
We searched PubMed and Google Scholar for peer-reviewed studies and grey literature on the economic impacts of obesity in LMICs, published between 1 January 2010 and December 2019. The PubMed search strategy included MeSH terms for overweight, obesity, world regions and economics, as well as the name of each LMIC (as defined by the World Bank) and synonyms for LMIC status. We identified 59 studies on the economic impacts of obesity, a full list of which can be found in online supplemental appendix 4. Data for model parameters are from peer-reviewed literature and publicly available global databases (see table 1). Data on obesity prevalence and obesity attributable deaths were drawn from the NCD Risk Factor Collaboration (NCD-RisC) study and 2019 GBD Study, respectively. Data on national healthcare expenditure were drawn from the WHO Global Health Expenditure Database. Annual/daily wage data, GDP and employment rates were sourced from the World Bank’s World Development Indicators database. Parameters such as population, life expectancy and background death rates were drawn from the United Nations Population Division. The remaining model parameters—average travel cost; average inpatient and outpatient consultations; hospitalisation days; absenteeism days and presenteeism rate—were sourced from peer-reviewed studies. Where country-specific data were not available, we applied data from another country in the same income group (table 1).

**Estimation of direct costs at baseline**

Direct costs are typically divided into medical and non-medical costs in the cost-of-illness literature. Direct medical costs measure healthcare goods and services consumed due to obesity-attributable diseases and include curative, rehabilitative and preventative care, ancillary services, and medical goods. To estimate the direct medical cost or obesity-attributable healthcare expenditures, we identified studies from our literature search that reported the proportion of health expenditure attributable to obesity or obesity-attributable fractions (OAF) for a country. We found the OAFs from the Organisation for Economic Co-operation and Development (OECD) report (for the 52 countries in the report) to be the most appropriate because they are based on the GBD study and include the same number of obesity-related diseases as this paper (online supplemental appendix 1: table 1). All eight countries in this study were included in the OECD report except for Thailand. The direct medical costs in 2019 were calculated by multiplying the total health expenditure (THE) of a country by the proportion of health expenditure attributed to obesity (OAF).

\[
\text{Direct Medical Cost} = \text{OAF} \times \text{THE}
\]

To estimate OAF for countries not included in the OECD report (Thailand) and for projections, a simple linear regression of OAFs on total obesity prevalence was conducted using the 52 countries in the OECD report. The 52 countries account for about 95% of total health expenditure globally. There is a significant positive association between OAF and obesity prevalence \(\beta=0.094, F=12.92, p=0.001\) (online supplemental appendix 1: figure 1). The regression outputs from the estimated equation were used to estimate the OAFs for all countries. We also apply the regression outputs to estimates of projected obesity prevalence to calculate future OAFs as explained subsequently. We used the estimated OAFs from the regression outputs in computing direct medical costs in 2019 for all eight countries instead of the raw values from the OECD report to prevent discordance.
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**Continued**
between current and future direct medical costs and to allow for useful comparisons across years (see the Methods section in online supplemental appendix for more details).

Direct non-medical costs measure the additional costs incurred during the process of seeking care, such as travel to health facilities or doctor appointments, costs incurred by informal caregivers (ICGs), food and lodging during inpatient care, and home modifications. This study includes an estimation of travel expenses and ICG costs only as there are not reliable data about other direct non-medical costs from which to develop cross-country estimates.

Travel costs were estimated separately for inpatient (hospitalisation) and outpatient care. We calculated this by multiplying the average travel cost (ATC) per trip (proxied by country-specific daily average transportation expenditure per capita) by the population with obesity. The formulae for these components are:

\[ \text{Inpatient Travel Costs} = \text{ATC} \times N_a \times \text{Population with Obesity} \]  
\[ \text{Outpatient Travel Costs} = \text{ATC} \times N_o \times \text{Population with Obesity} \]

where ATC is the average travel cost to and from health facilities; \( N_a \) and \( N_o \) are the average number of inpatient and outpatient consultations by the population with obesity compared with the normal weight population, respectively; and Population with Obesity = Obesity Prevalence \( \times \) Total Population.

ICG costs were estimated for inpatient care and include both travel and time costs during inpatient care. ICG travel cost is calculated the same as inpatient travel cost. ICG time costs denote the income loss of ICGs for time spent tending to a hospitalised family member or friend suffering from an obesity-attributable disease. We calculate this as the average wage lost from the time spent in the hospital.

\[ \text{ICG Time Costs} = \frac{\text{Average Daily Wage} \times N_d}{\text{Employed ICGs for Pop. with Obesity}} \]  

where Employed ICGs for Pop. with obesity = Employment rate \( \times \) Working Age Pop. \( \times \) Obesity Prevalence; \( N_d \) is the average number of hospitalisation days by the population with obesity compared with the normal weight population.25 Productivity loss from inpatient/outpatient care for the population with obesity is assumed to be included within the indirect cost from absenteeism described below.

### Estimating indirect costs at baseline

Indirect costs represent the economic loss due to premature mortality and morbidity and includes the following components: economic loss from premature mortality, missed days of work (absenteeism) and reduced productivity while at work (presenteeism). For absenteeism and presenteeism costs, we assume the same employment rates by BMI status. While it is plausible that the population with obesity may have a lower employment rate compared with the population without obesity, the existing evidence is mixed and inconclusive.26-33

Economic loss from premature mortality is calculated as the number of years of potential life lost by individuals (by age group and sex cohort) who died from obesity multiplied by the economic value of a life year. To quantify the number of years of potential life lost due to obesity, we estimate how many people in each age and sex cohort would have been alive in future years (based on life expectancy) if they had not died from obesity-attributable diseases, while taking into account background death rates from other causes. Background
death rates are drawn from country-specific life tables (table 1).34 We used GDP per capita as a proxy for the economic value of a life year (VLY) to capture economic loss from premature mortality. Other proxies that have been used in estimating cost of premature mortality include wages and the value of a statistical life year (see online supplemental appendix 1: box 1). Our choice of GDP per capita is driven by an inclination to value the economic contribution of every individual in the society across the lifecourse irrespective of employment status. This brings an equity lens to how economic contributions are counted. Furthermore, as part of sensitivity analysis for the upper bound of premature mortality cost, we adjust GDP per capita with a GDP multiplier (online supplemental appendix 1: table 2) for the gains in health or GDP per capita with a GDP multiplier (online supplemental appendix 1: table 2) for the gains in health or GDP per capita with a GDP multiplier (online supplemental appendix 1: table 2) for the gains in health or

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The estimated model is then applied to forecast future obesity prevalence using projected estimates of population growth and urbanisation (see online supplemental appendix 1 for more details).

Future OAF of health expenditure: As earlier explained, we obtained estimates of OAFs for 52 countries from the OECD report. We then estimated a simple linear regression of these OAFs on obesity prevalence. The regression outputs (coefficient and intercept) together with projected obesity prevalence estimates were then used to generate future estimates of OAFs.

Future Obesity-attributable mortality: We calculated all-cause mortality (total deaths) from 2020 to 2060 using the annualised rate of change of projections for obesity-related disease mortality from Foreman and colleagues. We then calculated population attributable fraction (PAF) of obesity mortality for each future year by sex, cause and age group. We used the calculated PAF to generate obesity-attributable deaths for projected years by sex, age group and cause. For more details, see online supplemental appendix 1.

Hypothetical scenarios: In addition to estimating future economic costs based on projected obesity prevalence, we also estimated the impact on the projected economic costs using two scenarios of lower prevalence in the future. Projections are not predictions, hence future obesity prevalence and other model parameters may diverge from projected estimates, which are based largely on historical trends. Therefore, in addition to estimating future economic costs based on projected prevalence, we also developed two hypothetical scenarios for economic impacts of obesity keeping in mind that no country has been able to reduce obesity prevalence and there have been indications of stabilisation in only a handful of countries. The two hypothetical scenarios are: (1) a 5 percentage point reduction in projected obesity prevalence (by sex and age group) for each year and (2) holding obesity prevalence (by sex and age group) constant at 2019 levels.

Currency conversions
All costs are in 2019 constant US dollars. Data for GDP per capita, wages and travel costs were collected in local currency units where possible, adjusted for inflation to 2019 values, and converted to US$ using average annual exchange rates. Purchasing power parity (PPP) costs were also calculated, using PPP conversion factors drawn from the World Bank World Development Indicators Database.

RESULTS
Current economic impacts of obesity
Total obesity costs per capita range from US$17 in India to US$940 in Australia. Obesity results in an impact comparable to 1.76% of GDP on average across the eight countries, ranging from 0.80% of GDP in India to 2.42% in Saudi Arabia (figures 2 and 3). Table 2 provides a comparison of total costs and costs per capita in US dollars, PPP dollars and as a percentage of GDP.

Table 3 shows economic impacts by cost components and figure 4 shows total costs by country. Medical costs make up 90% of direct costs on average across all countries. Time cost of informal caregivers constitute more than 90% of direct non-medical costs on average across all countries. The cost of premature mortality constitutes a substantial proportion of indirect costs (about 56%–92%) across all countries. We did a sensitivity analysis which values the life expectancy gains from avoiding premature mortality at a multiple of GDP, following recommendations from the Lancet Commission on Investing in Health. This results in total costs of 2.59% of GDP on average across the eight countries, ranging from 1.70% of GDP in India to 4.16% in South Africa (table 3). These results, which place a higher value on premature mortality costs, represent a 57% increase in total costs on average across the eight countries, ranging from a 19% increase in Australia to a 163% increase in South Africa.

Obesity prevalence, wage and employment data were disaggregated by sex for all eight countries. Economic impacts of obesity are typically higher for males compared with females (figure 5). This difference is driven by obesity prevalence, wages and sex differences in employment.
## Future economic impacts of obesity

Table 4 and figures 6–8 summarise estimated future costs based on projections of model parameters to 2060. Obesity costs across all countries are projected to increase due to rising obesity prevalence, population changes and economic growth. Between 2020 and 2060, obesity costs are projected to double in Spain and increase by 19-fold in India. As a percentage of projected GDP, total costs in 2060 are estimated to be an average of 3.57% across the eight countries, ranging from 2.43% in Spain to 4.88% in Thailand. See online supplemental appendices 2 and 3 for additional figures and tables.

### Hypothetical scenarios

Our first hypothetical scenario depicts projected economic impacts if there is a 5 percentage points reduction in obesity prevalence from the projected levels (by sex and age). Using this prevalence scenario with all other projected parameters remaining unchanged, we estimate a slight reduction in obesity’s economic cost trajectory compared with baseline projections. As a percentage of projected GDP, total costs in 2060 will range from 2.32% in Spain to 4.70% in Thailand (figure 9). Compared with baseline projections, this scenario implies an average annual savings of approximately 5.18% across all eight countries between 2021 and 2060 (table 5).

Our second hypothetical scenario projects obesity’s economic impacts while holding obesity prevalence constant. This is consistent with the WHO NCD Global Monitoring Framework target #7 to halt the rise in obesity. Keeping obesity prevalence at 2019 levels from 2020 to 2060 is equivalent to an average annual reduction in prevalence ranging from 9% to 22% across countries compared with baseline prevalence projections (table 5). As a percentage of projected GDP, total costs in 2060 will range from 1.44% in India to 4.14% in Mexico, translating to average annual savings of 13.18% compared with baseline projection costs (figure 10).

### DISCUSSION

This study uses cost-of-illness methodology to assess the economic impacts of obesity in eight countries from a societal perspective. We estimate obesity costs between 0.80% and 2.42% of GDP in 2019 in the eight countries. To put this into context, annual GDP growth rate in 2019 averaged 1.6% among the eight countries, ranging between −0.12% (Mexico) and 5% (India). It is therefore reasonable to view the economic impact of obesity as a significant hindrance to economic development. However, these estimates are still conservative. Our sensitivity analysis shows that putting a higher value on gains in life expectancy from avoiding premature mortality would yield a higher economic loss from obesity.

While our results are in a comparable range to the most recent multicountry study of obesity’s economic impact (OECD), they are higher than earlier studies in some of the countries as we include the impacts of obesity on more diseases. For example, Pitayatienanan et al estimate healthcare costs (outpatient and inpatient visits only) in Thailand for 13 obesity-related diseases in 2009 as 5.5 billion Thai baht (approximately US$220 million in 2019), compared with our estimate of US$1.3 billion in obesity-attributable healthcare expenditure for 26 obesity-related diseases. In Brazil, Bahia et al estimate the obesity-attributable public healthcare expenditures for 14 diseases in 2010 US$ as 221 million compared with our estimate of US$14 billion in combined public and private obesity-attributable healthcare expenditure for 26 obesity-related diseases. In addition, some of the difference in results can be attributed to a rise in obesity prevalence during the interim (an increase of 11% in Thailand and 8% in Brazil between the periods of these two studies and 2019). With regard to societal impacts more broadly, we also use GDP per capita to proxy the economic value of a life year for premature mortality while some studies use minimum or average wage in each country. Differing sources, availability and granularity of data could also contribute to differences in cost estimates.
Our findings reveal that the societal impacts of obesity are substantial for countries at different income levels. While high-income countries are known to experience high economic costs from obesity, this study finds that a similar magnitude of impact may be present in LMICs consistent with existing evidence on the double burden of malnutrition. Differences in economic impact across countries are partly explained by differences in obesity prevalence and obesity-attributable mortality. India has the lowest total obesity prevalence, obesity-attributable mortality, and cost per GDP per cent of the eight countries. On the other hand, Saudi Arabia, with the highest cost per GDP per cent, has the highest total obesity prevalence and also has the highest obesity-attributable mortality among the eight counties. Other factors that drive differences in total costs between countries include the income levels/economic strength (GDP/capita), wage differences, employment rates, national health-care expenditure and the age distribution of obesity-attributable mortality.

Estimates of obesity’s economic impacts that are limited to only direct healthcare costs underestimate the full economic effect of overweight and obesity. Our findings indicate that indirect costs of obesity account for a larger proportion of total cost (65% on average across countries) compared with direct costs. However, direct medical costs still impose immediate and sometimes unsustainable burdens on health systems. Examination of the variation in costs by sex in 2019 also generally confirms with existing evidence on the double burden of malnutrition. Differences in economic impacts across countries are partly explained by differences in obesity prevalence, obesity-attributable mortality, and cost per GDP per cent of the eight countries.

Table 3  Current Burden Results, 2019 (in 2019 US$)

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<tr>
<th>Country</th>
<th>Direct medical costs (billions)</th>
<th>Direct non-medical costs (millions)</th>
<th>Total direct costs (billions)</th>
<th>Absenteeism costs (billions)</th>
<th>Presenteeism costs (billions)</th>
<th>Premature mortality costs (billions)</th>
<th>Total indirect costs (billions)</th>
<th>Total costs per capita (US$)</th>
<th>Total costs as per cent of GDP</th>
<th>Total costs (billions)*</th>
<th>Total costs as per cent of GDP*</th>
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*With GDP multipliers. See online supplemental appendix 3: table A1 for complete table. GDP, gross domestic product.
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<td>2.62</td>
<td>0.04</td>
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<td>2.96</td>
<td>3.21</td>
<td>5.83</td>
<td>98</td>
<td>1.60</td>
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</table>

Table 4: Baseline projections, years 2020, 2030, 2040, 2050 and 2060 (in 2019 US$)

Continued
Table 4  Continued

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<th>Direct medical costs (US$ billions)</th>
<th>Direct non-medical costs (US$ billions)</th>
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<th>Presenteeism costs (US$ billions)</th>
<th>Premature mortality costs (US$ billions)</th>
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<th>Total costs per capita (US$)</th>
<th>Total costs as a per cent of GDP</th>
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<td>2020 11.36 0.29 11.65 1.85 6.07 10.16 18.08 29.73 636 2.11</td>
<td>2030 13.06 0.29 13.35 1.89 6.21 13.20 21.30 34.65 750 2.17</td>
<td>2040 14.20 0.28 14.48 1.79 5.85 17.56 25.20 39.68 877 2.20</td>
<td>2050 15.02 0.27 15.30 1.71 5.60 24.43 31.73 47.03 1078 2.28</td>
<td>2060 15.84 0.30 16.14 1.84 6.02 37.29 45.14 61.28 1493 2.43</td>
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<td></td>
<td></td>
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<tr>
<td>Thailand</td>
<td>2020 1.44 0.33 1.77 0.42 0.55 4.53 5.49 7.27 104 1.30</td>
<td>2030 2.13 0.43 2.56 0.53 0.70 8.74 9.98 12.54 178 1.65</td>
<td>2040 3.00 0.52 3.52 0.63 0.82 18.13 19.58 23.10 335 2.23</td>
<td>2050 3.98 0.59 4.58 0.72 0.93 39.16 40.81 45.38 688 3.22</td>
<td>2060 5.09 0.66 5.75 0.79 1.03 85.89 87.71 93.47 1515 4.88</td>
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</table>

GDP, gross domestic product.

indicate a slightly higher cost for males compared with females reflecting differences in obesity prevalence, wages, and employment, which vary by country.

Our projections reveal an alarming trend across all eight countries as the total costs of obesity in 2019 constant US$ is projected to rise at an average rate of between 1.8% and 6.6% and cost/GDP is projected to rise at an average rate of 0.4%–3.3% from 2019 to 2060. This is partly due to a projected rise in obesity prevalence with an average growth rate ranging from 0.7% to 3.0% in the same period (online supplemental appendix 3: table A7). We project that the prevalence of obesity will increase to about 57% of the population in India and to about 93% of the population in Saudi Arabia in 2060 (figure 8). These estimates are similar to estimates by Kilpi et al who adapted the UK Foresight model to estimate that obesity prevalence will rise to 92% in men and 75% in women by 2050 in Saudi Arabia.43 In another related study of 10 countries in Latin America, obesity prevalence in 2050 is estimated to increase to 90% of males in Cuba and Panama and to 85% of females in Chile, Cuba, Nicaragua, Panama, Peru and Uruguay.44

Our hypothetical scenarios demonstrate that economic costs to society can be reduced with lower obesity levels. The scenarios underscore the need to take urgent action to reduce potential economic impacts in the future. This will not be achieved if current levels of underinvestment in treatment and the social determinants of obesity continue. Overall, our findings make the case for a concerted increase in national efforts to combat the global rise in obesity prevalence and overcome the existing policy inertia that has hampered progress on obesity policy implementation.45 WHO’s ‘best buy’ interventions offer an initial set of cost-effective actions for countries to employ, including community wide public education and awareness for physical activity and taxes on sugar-sweetened beverages,46 front-of-package labeling and other nutrition profiling schemes. However, many other opportunities to alter the obesogenic environment through food systems, transportation and subsidies have not been widely implemented and evaluated, leaving much room for future study.16 Efforts to address the economic impacts of obesity must not be left to individuals but focus on altering the complex environmental factors leading to obesity, as well as treatment. The involvement of individuals with obesity in the policy decision-making process and in guiding research is also imperative in achieving equitable allocation and distribution of resources, and for pursuing policies that reduce weight bias.47

This study has several limitations. To produce comparable estimates across countries, we used data that are available across both data-rich and data-poor geographical contexts. For some of the parameters, such as absenteeism and presenteeism rates associated with obesity, due to data limitations, we assumed the same value for countries in similar income groups which is a
inequities across populations. Work, and what is measured by GDP introduces many
ences in labour markets, type of and compensation for
for obesity-related diseases. Also, we recognise that differ-
ces in labour markets, type of and compensation for
work, and what is measured by GDP introduces many
inequities across populations. We handle these issues
with clear and replicable methodology that allows other
data inputs to be selected. Individual country studies
are the appropriate place to make adjustments for these
differences and we suggest here some of the parameters
that should be sourced locally whenever possible. Also,
while cost-of-illness studies have played a significant role
in public health by supporting advocacy for and formu-
lation of healthcare policies, their usefulness in decision
making for prioritisation and resource allocation needs to be augmented by a consideration of both costs and
benefits.

Our estimates of future obesity prevalence are based
on an assumption that historical and current trends
relating obesity to age, sex, and nutrition continue,
and current trends demonstrate that economic costs will
rise over time. The COVID-19 pandemic has especially
affected people living with obesity, thus further bringing
obesity to the attention of national policy makers. The
findings of this study will be helpful to further strengthen
political commitment for national obesity control efforts
in these countries. This is greatly needed to achieve levels
of investment commensurate to the economic impact.
Future analyses will further extend this methodology to
other countries and will estimate the effect of COVID-19
on these results.

CONCLUSION

Our findings suggest that there are enormous economic
impacts associated with obesity across countries irrespec-
tive of geography or income level. There is tremendous
variation across countries in the level and impacts of
obesity and current trends demonstrate that economic costs will
rise over time. The COVID-19 pandemic has especially
affected people living with obesity, thus further bringing
obesity to the attention of national policy makers. The
findings of this study will be helpful to further strengthen
political commitment for national obesity control efforts
in these countries. This is greatly needed to achieve levels
of investment commensurate to the economic impact.
Future analyses will further extend this methodology to
other countries and will estimate the effect of COVID-19
on these results.

Contributors AO contributed to methodology development, data analysis,
interpretation of results and writing of manuscript. RN conceived study and
contributed to methodology, interpretation of results and writing of manuscript. GS
conducted literature search, data collection, created figures/tables and contributed

Table 5 Annual cost reductions in hypothetical scenarios 1 and 2 between 2020 and 2060

<table>
<thead>
<tr>
<th>Country</th>
<th>Scenario 1: reduction in projected overweight and obesity prevalence by 5%</th>
<th>Scenario 2: keeping overweight and obesity prevalence among men, women, boys and girls at 2019 levels through 2060</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average annual cost reduction (billions of 2019 US$)</td>
<td>Percentage cost reduction (%)</td>
</tr>
<tr>
<td>Australia</td>
<td>2.42</td>
<td>4.61</td>
</tr>
<tr>
<td>Brazil</td>
<td>3.83</td>
<td>4.35</td>
</tr>
<tr>
<td>India</td>
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<td>9.77</td>
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<td>Mexico</td>
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<td>3.76</td>
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<tr>
<td>Saudi Arabia</td>
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<tr>
<td>Spain</td>
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<td>5.21</td>
</tr>
<tr>
<td>Thailand</td>
<td>1.57</td>
<td>5.92</td>
</tr>
</tbody>
</table>

Figure 10 Hypothetical scenario of constant* obesity prevalence, total costs (in billions of 2019 constant US$), total costs as a per cent of GDP and obesity prevalence, 2019–2060. GDP, gross domestic product.
to interpretation of results and writing of manuscript. JR coconceived the study and provided guidance on scope and interpretation of results. JW reviewed the paper and provided guidance on interpretation of results.

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Competing interests A0, RN and GS report the research was supported by a grant from the World Obesity Federation which received an unrestricted grant from Novo Nordisk; JR reports grants from Novo Nordisk, during the conduct of the study; JW reports grants, personal fees and consultancy fees to his institution from AstraZeneca and Novo Nordisk, personal fees and consultancy fees paid to institution from Boehringer Ingelheim, Napp, consultancy fees paid to institution from Astellas, Janssen, Mundipharma, Lilly, Sanofi, Saniona, Rhythm Pharmaceuticals and Wilmington Healthcare, outside the submitted work.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

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REFERENCES


54 Lehohla P. Measuring household expenditure on public transport: in-depth analysis of the National household travel survey 2013 data.