ClinicoEconomics and Outcomes Research

Dovepress
Taylor & Francis Group

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ORIGINAL RESEARCH

The Burden of Obesity in Saudi Arabia: A Real-World Cost-of-Illness Study

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Background: The rising prevalence of obesity in the Kingdom of Saudi Arabia (KSA) poses a significant public health challenge. Estimates of the economic cost of obesity are crucial for prioritizing healthcare interventions, guiding policy choices, and justifying budget allocations aimed at reducing obesity prevalence. This study aimed to estimate the cost of obesity in the KSA in 2022.

Methods: A prevalence-based cost-of-illness approach was used to determine the cost of obesity. This analysis encompasses 29 diseases, namely obesity and twenty-eight diseases attributable to obesity. Both direct and indirect costs were considered. The annual cost of treatment for each obesity-attributable disease was obtained from the hospital records of one tertiary hospital in the KSA. Data on direct non-medical costs were obtained from the patient survey. The human capital approach was used to estimate the indirect costs of morbidity and mortality.

Results: The total economic burden of obesity (2022 values) was estimated at US$116.85 billion from a societal perspective and US $109.67 billion from a healthcare system perspective. From a societal perspective, the total direct medical cost accounted for the largest portion of the total cost (94%). In terms of direct medical costs, the cost of treating diseases attributable to obesity was substantially greater than the cost of treating obesity itself. According to the sensitivity analysis, the total cost ranged from 3.4% of the country's Gross domestic product (GDP) when the unit cost of treatment was reduced by 74% to 9.5% of the country's GDP when the prevalence of obesity and its comorbidities was reduced by 5%.

Conclusion: Obesity imposes a substantial economic burden on the healthcare system and society in the KSA. Interventions aimed at promoting healthier lifestyles to reduce the prevalence and incidence of obesity and its comorbidities are highly warranted to alleviate the impact of obesity in the country.

Keywords: body mass index, cost-of-illness, economic burden, obesity, Saudi Arabia

Introduction

Obesity (body mass index ≥ 30 kg/m^2) leads to a substantial economic impact worldwide.[1] People with obesity are at increased risk of a number of medical conditions, which can lead to further morbidity and mortality.[2] Globally, obesity is a major driver of rising medical costs,[3] as people with overweight/obesity require more healthcare services, resulting in increased healthcare spending.[4] A systematic review reported that the total annual expenditure was 36% higher for people with obesity than for

Received: 3 November 2024
Accepted: 14 March 2025
Published: 21 March 2025

those with a normal weight.[5] Additionally, obesity contributes to productivity loss through missed workdays, early retirement, disability, premature death, and reduced caregiver productivity,[6] placing further strain on global economies.

Obesity has become a serious public health issue in the Kingdom of Saudi Arabia (KSA). At present, the obesity rate in the KSA is among the highest in the world, making the country among the worst affected countries globally.[7] Owing to changes in lifestyle patterns, including food patterns and physical activities, the prevalence of obesity in the KSA has increased dramatically during the last three decades.[8] According to the World Health Organization (WHO), the prevalence of obesity in the KSA in 2016 was 30.8% and 42.3% among adult males and females, respectively.[9] Moreover, while obesity was the 5th leading risk factor contributing to the disease burden in 1990, it has escalated to the 2nd leading risk factor in 2019 as reported by the public health authority in the KSA.[10]

To date, few economic costs of obesity studies in the KSA have been identified.[11–13] In the first study, the cost of three diseases (type II diabetes mellitus, chronic liver disease, and liver cancer) attributable to obesity among the working-age population in the KSA was estimated from a healthcare system perspective. On the basis of the United Kingdom's (UK) microsimulation model and the annual mean healthcare expenditure of the UK, the cost of obesity in the KSA was estimated to be approximately US$3.5 billion in 2020 and US$128 billion in 2040.[11]

Another study assessed direct medical costs and indirect costs due to absenteeism and presenteeism attributable to overweight and obesity in the KSA in 2019.[12] Six diseases (coronary heart disease, stroke, type II diabetes mellitus, breast cancer in women, colon cancer, and asthma) were included in the analysis. To estimate the economic cost of obesity, the total direct and indirect costs of these diseases in the KSA were multiplied by the obesity-attributable fraction (OAF). The unit cost of treatment as well as the unit cost of absenteeism and presenteeism associated with the six diseases were obtained from a previous study,[14] which derived such costs from 27 European countries and then extrapolated them to the KSA by taking into account the difference in healthcare expenditure per capita. Accordingly, the economic cost of obesity in the KSA was estimated to be international $19.3 billion in 2019. Of these, $15.5 billion accounted for the indirect cost, representing approximately 1% of the total country's gross domestic product (GDP), whereas 3.8 billion accounted for the direct healthcare cost, representing 4.3% of the total healthcare expenditure.

Another study[13] estimated the direct medical costs, direct non-medical costs, and indirect costs due to absenteeism, presenteeism, and premature mortality attributable to overweight and obesity in the KSA from 2019 to 2060. To estimate the direct medical cost, the OAF derived from the Organization for Economic Cooperation and Development (OECD) report[4] was multiplied by the total health care expenditure in the KSA, which was derived from the WHO's healthcare expenditure database.[15] Twenty-eight obesity-related diseases were considered in the analysis. For the direct non-medical cost, the average travel cost to/from the health facility was obtained from the KSA Household Income and Expenditure Survey, whereas the average number of hospitalizations, average length of hospitalization, and average number of outpatient visits by person with obesity were obtained from previous studies in high-income countries.[16,17] For indirect cost, the excess presenteeism rate was obtained from a previous study in the KSA,[18] whereas the excess absent day was obtained from a previous study in other countries.[19] With respect to the cost of premature mortality, obesity-attributable mortality was obtained from the global burden of disease study.[20] The study revealed that the cost of obesity was US$19.16 billion (US$ 5.02 billion for the direct cost vs US $14.15 billion for the indirect cost), representing 2.4% of the total country's GDP in 2019.

To date, most studies have failed to employ local data on treatment costs, the number of hospital visits/hospitalizations, and OAF.[11–13] Moreover, although obesity is a risk factor for several comorbidities, the number of comorbidities included in the previous analyses was limited.[11,12] Furthermore, none of the previously mentioned studies included the cost of treating obesity itself in their analyses.[11–13] Two previous studies[11,12] did not include the indirect cost of premature mortality, which contributed to a significant part of the total costs.[21] In addition, some important cost components were not included in these studies. These costs include direct non-medical costs (eg, equipment and housekeeping costs), out-of-pocket expenditures (OOPEs) related to treatment, the productivity loss of caregivers, and informal care costs.

Hence, this study aimed to comprehensively estimate the economic cost of obesity in the KSA in 2022. Both the direct and indirect costs of obesity and its related diseases were estimated from the healthcare system and societal perspectives. Given the similarities in the obesity epidemic and sociocultural conditions among Gulf Cooperation Council (GCC) countries, the results from this study could provide valuable evidence for understanding the health and economic benefits of obesity control programs in this region and could be beneficial for policy prioritization and agenda setting.

Methods

Study Design

This study adopted prevalence-based cost-of-illness (COI) approach. Findings from this approach are essential for prioritizing healthcare interventions, raising awareness on the economic burden of obesity on the society, and justifying the policy and budget allocation aimed at reducing prevalence of obesity. The analysis was conducted from both healthcare system and societal perspectives. The estimates from the healthcare system perspective focused on the costs incurred by the healthcare system in providing healthcare services attributable to obesity (eg, primary care, diagnostics, medicines, medical supplies, surgeries, etc). On the other hand, the estimates from the societal perspective covered all costs, regardless of who bears these costs or pays expenses. Hence, OOPE related to treatment, direct non-medical costs (ie, transportation costs, meals, accommodations, equipment, home renovation, and housekeeping costs), and indirect costs (ie, cost of absenteeism, lost productivity of relatives and informal caregivers, and premature death) were included in this analysis.[1,6]

Cost Estimation

Identification of Obesity-Attributable Diseases

We comprehensively searched the literature that documented obesity-related outcomes. In addition, experts from the endocrinology center, who provide obesity care at the King Fahad Medical City (KFMC), were consulted to validate the list of comorbidities included in the estimates. Finally, this study included 28 chronic diseases attributable to obesity in addition to obesity itself in the estimates. Obesity-attributable diseases were classified into seven main groups: 1) type II diabetes mellitus (DM);[2,22] 2) cardiovascular diseases (CVDs), which comprised ischemic heart diseases (IHDs),[2,22] stroke,[2,22] and hypertensive heart diseases;[2,22] 3) cancers, which consisted of breast,[2,22] uterine/endometrial,[23,24] ovary,[2,24] colorectal,[2,22] esophagus adenocarcinoma,[2,25] stomach,[23,24] liver,[22,23] gallbladder,[23,25] pancreas,[2,25] prostate,[2,24] kidney,[2,24] thyroid,[23,25] lymphoma,[25,26] multiple myeloma,[23,24] meningioma,[23,27] and leukemia;[24,25] 4) musculoskeletal disorders, which included osteoarthritis[2] and back pain;[2] 5) gastrointestinal disorders, which were composed of gastro-esophageal reflux disease (GERD),[28] nonalcoholic fatty liver,[22,29] and gallbladder disease;[2,22] 6) respiratory diseases, which comprised asthma[2,25] and sleep apnea;[30] and 7) depression.[2]

Estimating the Obesity Attributable Fraction (OAF)

The first step in calculating the costs of obesity was to estimate OAFs. OAFs were estimated using the following formula:

$$OAF_i\ (\%) = 100 \times [P\ (RR_i - 1)/1 + P\ (RR_i\text{-}1)]^{31}$$

where RR_i is the relative risk (separately for morbidity and mortality) of disease$_i$ attributable to obesity, while P is the prevalence of obesity among the adult population (18 years and over) in the KSA. Data on the RRs for all obesity-associated diseases included in this study were obtained from meta-analyses and cohort studies[2,22–29,32,33] (see Table 1). According to the WHO, the prevalence of obesity (BMI ≥30 kg/m^2) in the KSA in 2016 was 30.8% and 42.3% among adult males and females, respectively.[9] The year 2016 was chosen to account for the latency time between the year of exposure (to obesity) and the year of the event (the year of occurrence of disease attributed to obesity or the year of death due to any disease attributed to obesity).[21] Therefore, the authors adopted a six-year latency time.

Estimation of Direct Costs

Direct Medical Costs of Diseases Attributable to Obesity

To obtain the number of morbidity cases of each disease attributable to obesity, OAF$_i$ was multiplied by the number of morbidity cases of the corresponding disease$_i$ (ie, OAF$_i$ × number of people affected by disease$_i$ in 2022). In this study, the number of people affected by each disease was obtained from the 2019 GBD[34] with the assumption that the prevalence of all comorbidities has remained unchanged since 2019 (see Table 2). The number of morbidity cases of each disease attributable to obesity was then multiplied by the annual cost per patient of that disease (ie, attributable cases × annual cost per case), resulting in the direct cost of each disease attributable to obesity. Data on the average

Table 1 Relative Risks of Obesity-Attributable Diseases

No	Disease	ICD-10	Morbidity RR		Source	Mortality RR		Source
			Male	Female		Male	Female	
1	Esophagus cancer	C15	1.21	1.20	[21]	1.39	1.35	[25]
2	Gastric cancer	C16	1.80	1.80	[23]	1.04	1.04	[24]
3	Colorectal cancer	C18-21	1.95	1.66	[21]	1.29	1.05	[22]
4	Liver cancer	C22	1.80	1.80	[23]	1.47	1.47	[2]
5	Pancreas cancer	C25	2.29	1.60	[21]	1.07	1.09	[25]
6	Breast cancer	C50	NA	1.13	[21]	NA	1.15	[22]
7	Uterine/Endometrial cancer	C54-55	NA	7.10	[23]	NA	1.77	[24]
8	Ovary cancer	C56	NA	1.28	[21]	NA	2.62	[24]
9	Prostate cancer	C61	1.05	NA	[21]	1.45	NA	[24]
10	Kidney cancer	C64-65	1.82	2.64	[21]	1.59	1.59	[24]
11	Meningioma	C70-72	1.50	1.50	[23]	1.50	1.50	[27]
12	Gallbladder cancer	C23-24	1.30	1.30	[23]	1.16	1.34	[25]
13	Thyroid cancer	C73	1.10	1.10	[23]	1.22	1.14	[25]
14	N.H. Lymphoma	C82-85	1.40	1.34	[26]	1.09	1.13	[25]
15	Multiple myeloma	C90	1.50	1.50	[23]	1.20	1.20	[24]
16	Leukemia	C91-95	1.09	1.13	[25]	1.66	1.66	[24]
17	Type II DM	E11-14	6.47	12.41	[21]	2.16	2.16	[22]
18	Depression	F32-34	1.31	1.67	[21]	NA	NA	-
19	HHD	I11	1.84	2.42	[21]	2.03	2.03	[22]
20	IHDs	I20-25	1.72	3.10	[21]	1.39	1.39	[22]
21	Stroke	I60-69	1.51	1.49	[21]	1.39	1.39	[22]
22	Asthma	J45	1.43	1.78	[21]	1.41	1.40	[25]
23	GERD	K21	2.00	2.00	[28]	NA	NA	-
24	NAFL	K76	3.53	3.53	[29]	1.82	1.82	[22]
25	Gallbladder disease	K82	1.43	2.32	[21]	1.82	1.82	[22]
26	Osteoarthritis	M15-19	4.20	1.96	[21]	NA	NA	-
27	Sleep apnea	G47.3	3.77	3.77	[30]	NA	NA	-
28	Back pain	M54	2.81	2.81	[21]	NA	NA	-

Abbreviations: DM, diabetes mellitus; GERD, gastro-esophageal reflux disease; HHD, hypertensive heart disease; ICD, International classification of diseases; IHDs, Ischemic heart diseases; NA, Not available/applicable; NAFL, Nonalcoholic fatty liver; NH, Non-Hodgkin; RR, Relative risk.

annual treatment cost per person for each obesity-related disease were derived from the institutional business center (ie, Department of Finance) at KFMC, Riyadh, KSA, which covered information on adult patients (18 years old and over) seeking care at the facility during the year 2022. Patients with obesity-associated diseases were identified from the database via the International Classification of Disease (ICD-10), as shown in Table 1. The KFMC is one of the largest

Table 2 OAF, Morbidity Cases, Mortality Cases and YPLL Attributable to Obesity in KSA

Disease	ICD-10	Morbidity				Mortality				YPLL	
		OAF (%)		Attributable cases		PAF (%)		Attributable cases			
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Esophagus cancer	C15	6	8	22	17	11	13	16	10	317	215
Gastric cancer	C16	20	25	189	114	1	2	4	2	78	37
Colorectal cancer	C18-21	23	22	2,732	1,063	8	2	90	11	2,190	287
Liver cancer	C22	20	25	135	160	13	17	14	9	219	204
Pancreas cancer	C25	28	20	142	61	2	4	8	6	182	121
Breast cancer	C50	NA	5	NA	2,455	NA	6	NA	54	0	1,654
Uterine/Endometrial cancer	C54-55	NA	72	NA	3,644	NA	25	NA	79	0	1,234
Ovary cancer	C56	NA	11	NA	403	NA	41	NA	101	0	2,570
Prostate cancer	C61	2	NA	297	NA	12	NA	18	NA	198	0
Kidney cancer	C64-65	20	41	605	1,262	15	20	29	13	665	326
Meningioma	C70-72	13	17	434	435	13	17	35	17	1,022	554
Gallbladder cancer	C23-24	0	17	0	33	5	13	5	12	104	292
Thyroid cancer	C73	3	4	182	559	6	5	4	4	90	95
Non-Hodgkin Lymphoma	C82-85	11	13	402	437	3	5	7	7	159	173
Multiple myeloma	C90	13	17	66	48	6	8	6	4	131	82
Leukemia	C91-95	3	5	13	15	17	22	75	72	2,428	2,610
Type II diabetes mellitus	E11-14	63	83	968,908	774,984	26	33	632	468	13,295	9,493
Depression	F32-34	9	22	67,759	167,538	NA	NA	NA	NA	NA	NA
Hypertensive heart disease	I11	21	38	1,520	3,614	24	30	69	166	1,519	3,788
Ischemic heart diseases	I20-25	18	47	107,363	114,353	11	14	2,833	1,800	62,905	35,096
Stroke	I60-69	14	17	33,203	36,810	11	14	1,029	1,019	21,072	19,457
Asthma	J45	12	25	33,012	53,751	11	15	70	77	1,598	1,841
Gastro-esophageal reflux disease	K21	24	30	594,479	590,004	NA	NA	NA	NA	NA	NA
Nonalcoholic fatty liver	K76	44	52	3,193,281	2,152,230	20	26	129	161	2,513	2,887
Gallbladder disease	K82	12	36	9,606	84,241	20	26	28	44	498	795
Osteoarthritis	M15-19	50	29	419,642	189,142	NA	NA	NA	NA	NA	NA
Sleep apnea	G47.3	46	54	745,699	348,197	NA	NA	NA	NA	NA	NA
Back pain	M54	36	43	541,007	388,409	NA	NA	NA	NA	NA	NA
Total		39	44	6,720,698	4,913,976	12	16	5,100	4,137	111,182	83,811

Abbreviations: ICD,International classification of diseases; OAF, obesity attributable fraction; NA, Not available; YPLL, years of potential life lost.

governmental medical complexes in Riyadh, KSA (with a total capacity of 1,200 beds producing 30,000 inpatient days and 500,000 outpatient visits annually). The average annual medical costs of treating each comorbidity are displayed in Supplementary Table S1.

Direct Medical Cost of Obesity Treatment

For estimating the direct medical cost of obesity treatment, the authors estimated the number of people with obesity in 2022 by reducing the total number of patients by 1.6% annually from 2030 to 2022, as reported by the World Obesity Atlas.[7] As such, it was estimated that there were 17,852,993 individuals living with obesity (BMI ≥ 30 kg/m²) in the KSA in 2022 (9,182,588 men or 51% and 8,670,405 women or 49%).[7] While a significant increase in the demand for bariatric surgery has been observed recently,[35,36] mainly due to rising prevalence of obesity and its related comorbidities in the KSA along with the awareness of benefit and advancement in bariatric surgery,[37] the authors employed a conservative annual growth rate of 10% to estimate the number of bariatric surgeries performed in the country in 2022, based on the number of surgeries performed in 2019. As such, 71,874 bariatric surgeries were considered in the estimation of bariatric surgery costs. To estimate the cost of bariatric surgery, the number of bariatric surgeries performed in 2022 was multiplied by the annual cost of bariatric surgery per person, which covers the costs of surgical procedures and the management of complications.

In this analysis, the direct medical costs of treating obesity (excluding bariatric surgery) were estimated under the assumption that only 2% of the people living with obesity received obesity treatment, as reported in the literature.[38,39] This assumption was validated by consultation with experts from the endocrinology center (providing obesity care) at the KFMC. To estimate the direct cost of obesity, the number of people living with obesity was multiplied by the annual cost per patient (ie, obesity cases × annual cost per case). Data on annual treatment costs per person living with obesity and per bariatric surgery were derived from the KFMC database.

In addition, the annual OOPE for medical treatment per person was obtained from the patient's interview using an interviewer administered questionnaire and then multiplied by the total number of patients living with obesity in the KSA in 2022, resulting in the total OOPE for obesity treatment in the country. The eligibility criteria for the patients' interviews were as follows: 1) aged ≥ 18 years, 2) BMI ≥ 30 kg/m^2, and 3) received obesity care at the KFMC from January to June 2022. The six-month period was chosen as a balanced and practical approach, providing sufficient time to capture a representative sample of patients seeking obesity care at KFMC throughout a year. Patients with the following conditions were excluded from the interview: individuals with disabilities, individuals with cognitive impairments or terminal conditions, and pregnant women. The samples were chosen using a convenience sampling method. Written informed consent was obtained from all eligible patients prior to the interviews. Over six months (January to June 2022) of the data collection process, 116 participants were interviewed. To maintain a standardized interview process, ensure consistent data collection, and minimize potential biases, the interviews were carried out by trained interviewers using a structured questionnaire. Of these, 83 (72%) were female. The average participant age was 40.4 years (SD: 6.4), and the average BMI was 44.86 kg/m^2.

Direct Non-Medical Costs

To estimate the direct non-medical costs associated with obesity, the total number of people living with obesity in the KSA in 2022 was multiplied by the annual direct non-medical cost per person. The direct non-medical costs associated with obesity included meals, transportation, accommodations, housekeeping, and any other requirements for patients, relatives and caregivers during hospital visits or stays. Furthermore, the costs of any home renovations (eg, replacement of the old railings/floor or reconstruction room/bathroom, etc)., housekeeping or equipment required by patients living with obesity to adjust to their health status (eg, walking aids, beds, chairs, supporting sticks, wheelchairs, home exercise equipment, etc). were also included. In this study, the annual direct non-medical costs per person with obesity were derived from face–to-face interviews, as mentioned previously.

Indirect Costs

The human capital approach[40] was applied to estimate indirect costs attributable to obesity. The cost of patient absenteeism and the cost of lost productivity by relatives or caregivers for patients with obesity were estimated by multiplying daily wages (based on GDP per capita for patients and relatives and the average income for caregivers) by the average number of days of work lost, which were derived from the patient's interview, as mentioned previously. For the cost of premature mortality, the number of deaths from 23 obesity-associated morbidities and life expectancy at the

time of death were derived from the WHO database[41] with the assumption that the number of deaths of all comorbidities has remained unchanged since 2019 (see Table 2). The OAF was subsequently multiplied by the total number of deaths from each disease (OAF_i × number of people who died due to obesity-related disease$_i$ in 2022) to obtain the number of deaths from that disease attributable to obesity. The difference between age at death and life expectancy was considered the number of lost years. To estimate the cost of premature mortality, the number of deaths attributable to obesity by age and sex from each disease$_i$ was multiplied by the corresponding present value of lifetime earnings (PVLE) (attributable deaths × PVLE). The PVLE was estimated based on the KSA's 2022 GDP of US$30,436,[42] with an average growth rate of 1.14% per annum,[43] both derived from the World Bank dataset. A discount rate of 3% was applied, as recommended by the WHO guidelines.[44]

Currency and Conversion Rate

All costs are reported in Saudi Riyals (SAR) and converted to an equivalent value in United States dollars (US$) in 2022 using the mid-2022 conversion rate reported by the Saudi Central Bank (1US$ = 3.750 SAR) and purchasing power parity (PPP) using the 2022 implied PPP conversion rate (1PPP = 1.878 SAR) provided by the International Monetary Fund.[45]

Sensitivity Analysis

To assess the impact of parameter uncertainty, sensitivity analyses were performed on key inputs, including the prevalence of obesity, the prevalence of obesity-associated diseases and the costs of treating obesity-associated diseases. These scenarios aim to provide policymakers with a range of potential scenarios to assess the economic burden of obesity. First scenario involved reducing the prevalence of obesity and its comorbidities by 5%. This hypothetical scenario is based on policies aimed at lowering obesity rates, as discussed in the literature.[46,47] In fact, it demonstrated the economic benefit if the prevalence of obesity declined according to the target. Other scenarios are related to reducing the annual per-patient cost of treating obesity-related diseases by 30% and 74%. The basis for this assumption comes from a comparison between the historical cost of treating diabetes, which was derived from the previous study in the KSA (SAR 12,682 per patient annually in 2010 values, equivalent to SAR 16,118 in 2022)[48] and the cost of treating diabetes at KFMC, a tertiary hospital in the KSA in 2022 (SAR 62,000 per patient annually), which resulted in a 74% reduction. We then applied this same 74% reduction to the annual treatment costs of all obesity-related diseases, obtained from the KFMC data. Additionally, a 30% reduction in treatment costs was applied in a sensitivity analysis as another hypothetical assumption, given the uncertainty surrounding the treatment costs of obesity-related diseases nationwide.

Ethical Approval

This study was approved by the Institutional Review Board (Ethical Approval Committee) of the KFMC Hospital, Riyadh, Saudi Arabia, under number H-01-R-012 (IRB log number: 21–403) on October 31, 2021. Additionally, the IRB at Mahidol University (MU-DT/PY-IRB) approved this study.

Results

Morbidity and Mortality Cases Attributable to Obesity

As displayed in Table 2, 11.6 million morbidity cases (6.7 million cases among men and 4.9 million cases among women) and 9,237 mortality cases (5,100 cases among men and 4,137 cases among women) were attributable to obesity. This corresponded to an OAF of 41% for morbidity (39% for men and 44% for women) and 13% for mortality (12% for men and 16% for women) from the 28 diseases considered in this analysis for people aged 18 years or over. The mortality cases attributable to obesity resulted in 194,993 years of potential life loss (111,182 years among men and 83,811 years among women). In other words, each individual with obesity in the KSA lost an average of 21 potential years of life as a result of obesity.

Table 3 Total Obesity Costs in KSA in 2022 (US$ Million)

Cost component	Direct costs			Indirect costs				Total economic burden
	Medical	*Non-medical*	*Subtotal*	*Mortality*	*Morbidity (Patient's productivity loss)*	*Morbidity (Relative's productivity loss)*	*Subtotal*	
Male	57,520	443	57,963	2,727	543	204	3,474	61,437
Female	52,266	418	52,684	2,027	513	193	2,732	55,416
Total	**109,786**	**861**	**110,647**	**4,754**	**1,055**	**369**	**6,205**	**116,852**

Abbreviation: *US$: United States Dollar.*

Direct Costs

The total direct cost was estimated at US$110.6 billion (SAR 415 billion; PPP 221 billion), as shown in Table 3. The direct medical costs of obesity and its attributable morbidity cases were estimated at US$ 109.7 billion (SAR 411.28 billion; PPP 219 billion) from the healthcare system perspective and US$ 109.8 billion (SAR 411.70 billion; PPP 219.22 billion) from the societal perspective, as demonstrated in Supplementary Table S2. From the healthcare system perspective, the cost of managing obesity-related morbidities accounted for the largest portion (98%) of the total direct medical costs. In contrast, patients' OOPE contributed 0.10% of the total direct medical costs, whereas the direct non-medical cost was estimated at US$ 0.86 billion, representing 0.78% of the total direct cost, as shown in Supplementary Table S3.

Indirect Costs

As shown in Table 3, the total indirect cost was estimated at US$ 6.2 billion (SAR 23.3 billion; PPP 12.4 billion). The premature mortality cost was estimated to be US$ 4.8 billion (SAR 17.8 billion; PPP 9.5 billion), accounting for 77% of the indirect costs. According to the interviews, individuals living with obesity in the KSA reported an average of 13.6 hospital-related absence days and 10.7 non-hospital-related absence days (ie, an average of 24.3 absence days annually per patient). Furthermore, relatives (informal caregivers) of people living with obesity reported 9.12 hospital-related absence days and 0.015 non-hospital-related absence days while the patients were outside the hospital (ie, an average of 9.133 absence days annually per patient). This translated into US$ 1.055 billion (SAR 4.0; PPP 2.1) and US$ 0.396 billion (SAR 1.5; PPP 0.792) for the productivity losses of patients and their relatives, respectively.

Total Costs

Table 3 provides an overview of healthcare and societal costs attributable to obesity. Overall, the estimated economic impact of obesity in the KSA during the year 2022 from a societal perspective was US$ 116.85 billion (SAR 438 billion; PPP 233 billion). From the healthcare system perspective, the cost of obesity has been estimated at US$ 109.7 billion (SAR 411 billion; PPP 219 billion). Moreover, the subgroup analysis showed that the cost incurred by men was slightly higher than that incurred by women.

Costs per Disease Groups

A breakdown of the disease categories considered in this analysis revealed that cardiovascular diseases (CVDs), gastrointestinal (GIT) diseases, and type II diabetes mellitus were the major contributors to the economic burden of obesity in the KSA. Specifically, CVDs accounted for US$ 43 billion (37%), GIT diseases for US$ 30.3 billion (26%), and T2DM for US$ 29.4 billion (25%), as shown in Table 4. Collectively, these conditions contribute to 88% of the overall societal economic burden of obesity in the KSA. A detailed breakdown of the contributions of each disease is provided in Supplementary Table S4.

Table 4 Costs per Disease Groups

Disease Group	Cases (Thousand)	Direct cost (US$ Million)	Deaths	Indirect Cost (US$ Million)	YPLL	Share of Total Cost (%)
Type II Diabetes mellitus	1,744	28,832	1,100	562	22,789	25
Cardiovascular diseases	297	39,504	6,916	3,521	143,838	37
Cancers	16	2,390	711	425	18,235	2
Musculoskeletal disorders	1,538	5,063	–	–	–	4
Gastrointestinal diseases	6,624	30,097	362	165	6,692	26
Respiratory diseases	1,181	281	148	81	3,439	0
Other disorders	235	1,224	–	–	–	1
Obesity	1,7853	3,257	–	1,452	–	4
Total	29,488	110,647	9,237	6,205	194,993	100

Abbreviations: YPL, years of potential life lost; US$, United States Dollar.

Table 5 Results of Sensitivity Analysis

Scenario	Total Cost (US$ Million)	% Change	% GDP
Base case	116,852	NA	10.5
Reducing the prevalence of obesity and its associated diseases by 5%	105,218	10	9.5
Utilizing the prevalence of obesity in 2019	84,672	28	7.6
Reducing the cost of treating obesity-associated diseases by 30%	84,632	27.6	7.6
Reducing the cost of treating obesity-associated diseases by 74%	37,382	68	3.4

Abbreviation: US$, United States Dollar.

Sensitivity Analysis

When the prevalence of obesity and its comorbidities was reduced by 5%, the total societal cost during the year 2022 would decrease to US$105.2 billion (SAR 394.6; PPP 210), equivalent to a 10% reduction in total cost considering the prevalence used in the base-case analysis. Moreover, if the prevalence of obesity (19.2% among men and 21.4% among women) reported by the World Health Survey 2019 in the KSA was incorporated into the estimates, the total societal cost during the year 2022 would decrease to US$84.7 billion (SAR 317.5; PPP 169), equivalent to a 28% reduction in total cost considering the base-case prevalence. Similarly, when the annual per-patient cost of treating obesity-related diseases was reduced by 30%, the total societal cost would decrease to US$84.6 billion (SAR 317.4; PPP 169), equivalent to a 27.6% reduction in the total cost given the current treatment costs. Besides, when the annual per-patient cost of treating obesity-related diseases was reduced by 74%, as reported by a previous study conducted in the KSA,[48] the total societal cost decreased to US$37.4 billion (SAR 140; PPP 74.6), equivalent to a 68% reduction in the total cost given the current treatment costs, as presented in Table 5.

Discussions

This study clearly showed that obesity has substantial health and economic impacts in the KSA. Approximately 11.6 million morbidities (42%) and 9,237 deaths (13%) occurred in the KSA from the 28 diseases attributable to obesity. The total economic burden of obesity in the KSA was estimated at US$ 116.85 billion from a societal perspective and US $ 109.7 billion from a health care perspective. From a societal perspective, these accounted for 10.5% of the national GDP of the KSA in the year 2022 (US$1.108 trillion; PPP 2,151 trillion).[45,49] According to a previous systematic review,

the overall costs of obesity ranged from 0.05% to 2.42% of nations' GDP worldwide.[21] In comparison, our estimates of the costs of obesity in the KSA are significantly high relative to those observed in other countries. For example, when compared to the USA,[50] which is also a high-income country with a similar obesity prevalence, our estimates were comparable (126.1 billion US$ reported in the USA vs 116.85 billion US$ in our study). Therefore, the high costs in the KSA are more likely attributed to the high obesity prevalence rather than cultural factors.

At first glance, the costs estimated in the present study tended to be significantly higher than those estimated by previous studies performed in the KSA.[11–13] However, it should be noted that only three[11] and six diseases[12] were included in the previous estimates. In addition, the costs of premature mortality were not considered in these previous studies.[11,12] Compared with the most comprehensive estimate for 2019 (US$ 21 billion; PPP 41.8 billion in 2022 values),[13] in which the cost of obesity was estimated at 2.4% of GDP, the estimates in the current study were still higher. Nevertheless, the following differences in terms of methodology approach and sources of information between this study and the previous study should be considered: 1) the previous study did not include any direct medical costs or direct non-medical costs associated with obesity treatment; 2) in the previous study, the number of lost working days by the population living with obesity and their relatives was obtained from previous studies, which were conducted in other countries with different demographic characteristics, cultural norms, and patterns of healthcare delivery; and 3) in the previous study, the total healthcare expenditures of the KSA were derived from the WHO health expenditure database, 2018.[15] Notably, after 2018, many therapies and interventions became available to people with obesity or its comorbidities, which has sharply increased healthcare costs since then. On the other hand, the direct medical costs in the current study were derived from one tertiary hospital in the KSA, which tended to be higher than the national average. As shown in the sensitivity analysis, the unit cost of treatment is the most influential factor in the total cost estimates. When the annual cost of treating obesity-related comorbidities per patient was reduced by 74%, the total cost estimated from our study would represent 3.4% of the national GDP, which is similar to the previous study but slightly higher.[12] Compared with those in other countries, the economic costs of obesity in the KSA are relatively high. This could be due to the high prevalence of obesity in the country. Another possible reason is that the cost per hospital bed in the KSA is markedly higher than that in many high-income countries.[51,52]

The dominance of direct costs observed in the current study is consistent with the findings of previous studies in other high-income countries.[53,54] However, in contrast to previous studies conducted in the KSA, where indirect costs represented the largest proportion of the total, our findings indicate that indirect costs comprise only 5.3% of the overall obesity costs. This discrepancy likely stems from the high direct healthcare costs in our study, driven by a large number of patients with obesity-related diseases and elevated unit cost of treatment. When the unit cost of treatment is reduced by 74%, the indirect costs account for 17% of the total costs. Furthermore, the number of morbidity cases attributable to obesity estimated in our study was significantly higher than the number of mortality cases attributable to obesity (11.6 million vs 9,237). This is partly because the OAF for mortality is lower than that for morbidity as a result of the lower RR for mortality.

In addition, the direct medical cost of obesity-associated morbidities represented the largest share of the total cost and was substantially higher than that of obesity treatment (US$ 107.4 billion vs US$ 2.28 billion), possibly because obesity-related diseases are costly and quite prevalent in the KSA. Moreover, the current situation in the KSA was incorporated into our analysis, where only 2% of people with obesity received obesity treatment (pharmacological treatment) and only 71,874 patients received bariatric surgery. On the other hand, we assumed that all individuals with obesity-associated diseases received the needed treatment.

In our analysis, individuals living with obesity in the KSA missed an average of 24.3 workdays per year, whereas relatives missed an average of 9.1 workdays per year. These results are significantly higher than the number of work days lost to patients in other high-income countries, which are only 10.2 days in Portugal,[55] 6.13 days in the USA,[56] 5.19 days in Germany,[57] and 11 days in the UK.[58] These findings could be justified by the relatively high mean BMI in the current study as well as the differences in working patterns and lifestyle habits (eg, eating and exercise).

It should be noted that while OOPEs accounted for only 0.10% and equipment and home renovation costs accounted for only 0.02% of the total societal costs of obesity, we believe that these cost items were underestimated. Owing to some cultural barriers and social norms, the costs borne by families of individuals with obesity and those who experienced its

consequences remain invisible and are rarely reported by patients or their relatives during the survey process. The mean OOPE in the present study (US$314/patient/year) was lower than that reported from high-income countries such as the USA (US$737.6/patient/year)[59] and from middle-income countries such as China (US$480/patient/year).[60] This may be due to the different pricing and coverage methods across countries. For example, in the USA, patients may be uninsured and have different sources of coverage, hence reporting higher OOPE. Furthermore, since this study surveyed patients within the hospital, it may have led to them not reporting the costs of any kind of traditional or medically unapproved products, such as herbs or remedies, even though an explicit question related to these items was included in the survey.

This study provides a comprehensive assessment of the economic burden of obesity in the KSA by considering both healthcare costs and the broader societal impacts, reflecting a wider economic impact. Furthermore, this study quantifies the economic burden of obesity and 28 associated chronic diseases, covering a wide range of comorbidities (eg, cancers, gastrointestinal, musculoskeletal, respiratory, mental disorders, etc). This extensive inclusion of obesity-related diseases expands beyond commonly studied conditions like type II DM and cardiovascular diseases, offering new insights into the broader spectrum of diseases influenced by obesity. Specifically, the integration of local data on healthcare costs and OOPE expenditures enhances the relevance of the findings. The study also incorporates indirect costs, such as lost productivity and premature death, providing a more holistic view to the overall economic burden of obesity in the KSA.

Nonetheless, this study has certain limitations. First, the cost of overweight was not estimated. Recent evidence has indicated that the potential burden of overweight is expected to be significantly negligible compared with that of obesity.[61,62] Second, the cost of presenteeism was not estimated. The issue of presenteeism is inherently subjective and quite challenging to measure compared with absenteeism, especially in the absence of a validated and appropriate instrument to do so.[63] However, previous studies estimated that the cost of presenteeism in the KSA was US$13.8 billion (0.8% of the national GDP in 2019).[12] Third, due to data unavailability, the number of people affected by each disease and the corresponding death toll in 2019 were used to estimate the costs for 2022 with the assumption that such these figures remain unchanged. Given the global and Saudi Arabian trends of increasing morbidity and mortality from non-communicable diseases, our results may underestimate the actual cost of obesity in 2022. However, considering the short 3-year gap, we believe the impact of this difference is minimal. In addition, it should also be noted that the annual treatment costs were derived from a single tertiary hospital, which might be relatively high and even higher than those in some high-income countries.[51] Therefore, the findings of this study should be interpreted with some caution. The results from sensitivity analysis should also be used as supplement. Finally, the cost of obesity among certain populations, such as children and adolescents, has not been estimated, despite its high prevalence among these groups in the KSA.[64,65]

Conclusions

The economic costs of obesity in the KSA are considerably higher than those in many other countries worldwide. Urgent action is required through effective policies and interventions to decrease the prevalence of obesity and reduce its economic burden on the country. The focus should be on addressing obesity through healthcare interventions such as lifestyle management, pharmacotherapy, and surgical options. Behavioral counseling for physical activity and/or healthy diets, and digital health intervention such as telemedicine, web-based, mobile phone application, text messaging are also recognized as the effective interventions among adults. Increasing taxes on sugar-sweetened beverages can further discourage unhealthy consumption patterns. At the same time, prioritizing effective interventions for children and adolescents is crucial for preventing obesity in adulthood. For children, school-based intervention targeting physical activity only and physical activity in combination with other interventions were likely to effective in children.

Data Sharing Statement

Most of the data generated and/or analyzed during the study are included in this article. The complete datasets are available from the corresponding author(s) upon reasonable request.

Consent to Participate

The current study complies with the Declaration of Helsinki. The participant information sheet and informed consent form were provided to/ and signed by all participants before the interview.

Acknowledgment

This study was supported by funding from Prince Sattam bin Abdulaziz University (project number PSAU/2023/R/1444). This work was conducted as part of the Doctor of Philosophy Program in Social, Economic and Administrative Pharmacy of MAN through a scholarship provided by Health Technology Assessment International (HTAi), Alberta, Canada, and Mahidol University, Bangkok, Thailand.

The views, findings, interpretations, and conclusions expressed in this document cannot be attributed to, nor do they represent, the views of Prince Sattam bin Abdulaziz University, Health Technology Assessment International (HTAi), or Mahidol University.

Additionally, the authors express their sincere gratitude to Mr. Sharif Suleiman for his constructive input and valuable suggestions.

Author Contributions

All authors made a significant contribution to the work reported including the conception, study design, execution, acquisition of data, analysis and interpretation; revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work. MAN is responsible in drafting the manuscript.

Funding

This study was supported by funding from Prince Sattam bin Abdulaziz University (project number PSAU/2023/R/1444).

Disclosure

MAN, ZSA, MT, SS, ST, UC, AMA, LSA, IAA, AIA, and MMA do not work for, consult, own shares in, or receive funding from any organization that would benefit from this article and have disclosed no relevant affiliations beyond their academic appointments.

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