Obesity prevalence in Mexico: impact on health and economic burden

Ketevan Rtveladze[1],*, Tim Marsh[1], Simon Barquera[2], Luz Maria Sanchez Romero[2], David Levy[3], Guillermo Melendez[4], Laura Webber[1], Fanny Kilpi[1], Klim McPherson[5] and Martin Brown[1]

[1]Micro Health Simulations, Victoria House 7th Floor, Southampton Row, London WC1B 4AD, UK: [2]Instituto Nacional de Salud Pública, Cuernavaca, Morelos, México: [3]Georgetown University, Washington, DC, USA: [4]Fundación Mexicana para la Salud, Tlalpan, México DF: [5]New College, Oxford, UK

Abstract

Objective: Along with other countries having high and low-to-middle income, Mexico has experienced a substantial change in obesity rates. This rapid growth in obesity prevalence has led to high rates of obesity-related diseases and associated health-care costs.

Design: Micro-simulation is used to project future BMI trends. Additionally thirteen BMI-related diseases and health-care costs are estimated. The results are simulated for three hypothetical scenarios: no BMI reduction and BMI reductions of 1% and 5% across the population.

Setting: Mexican Health and Nutrition Surveys 1999 and 2000, and Mexican National Health and Nutrition Survey 2006.

Subjects: Mexican adults.

Results: In 2010, 32% of men and 26% of women were normal weight. By 2050, the proportion of normal weight will decrease to 12% and 9% for males and females respectively, and more people will be obese than overweight. It is projected that by 2050 there will be 12 million cumulative incidence cases of diabetes and 8 million cumulative incidence cases of heart disease alone. For the thirteen diseases considered, costs of $US 806 million are estimated for 2010, projected to increase to $US 1·2 billion and $US 1·7 billion in 2030 and 2050 respectively. A 1% reduction in BMI prevalence could save $US 43 million in health-care costs in 2030 and $US 85 million in 2050.

Conclusions: Obesity rates are leading to a large health and economic burden. The projected numbers are high and Mexico should implement strong action to tackle obesity. Results presented here will be very helpful in planning and implementing policy interventions.

Mexico has experienced a rapid increase in wealth in recent decades, bringing a significant shift in socio-economic status and a geographical shift from rural to urban among its population. This has led to changes in diet that are detrimental to health: an increase in sedentary behaviour and increased access to low-priced highly energy-dense foods. As a result, rapid growth in the prevalence of obesity and obesity-related non-communicable diseases (NCD) has been observed with a lack of prevention programmes to curb this rise. A significant increase in obesity was reported between 2000 and 2006[1] and is expected to impose a substantial burden in terms of disease outcomes and health-care costs. Nutrition-related chronic diseases such as type 2 diabetes and hypertension are associated with increased obesity rates[2]. CVD and type 2 diabetes are now considered the main causes of adult mortality in Mexico[1].

According to the Ministry of Health, the number one leading cause of mortality in 2008 was diabetes (14%), followed by IHD (11%) and stroke (5·6%). When the mortality prevalence of the different types of cancers was combined, it became the third most common cause of mortality[3].

In 2004, NCD caused 75% of the total deaths and 68% of total disability-adjusted life years in Mexico[4]. Overweight and obesity are the main risk factor for a larger burden of NCD. According to a report by the Organisation for Economic Co-operation and Development, for every extra 15 kg, the probability of early death increases by 30%[5]. In 2008, the loss of productivity due to early death that is attributable to overweight and obesity in Mexico was $US 1931 million. The total direct cost estimated for the treatment of these co-morbidities

Corresponding author: Email ketevan.rtveladze@heartforum.org.uk

(CVD, stroke, hypertension, cancer and diabetes mellitus) reached a total of $US 3·2 million, representing 33·2% of the total health-care expenditure in 2008. This is an increase of 61% from the cost in 2000[6].

In the present paper, we map the trajectory of future obesity trends in Mexico to 2050 based a method that utilizes the best data currently available and that is already applied in the UK and the USA[7]. We measure the consequences of these trends on future incidence of disease and health-care costs. In addition, we estimate the impact of reducing obesity rates by 1% and 5% on the incidence of and mortality rates from obesity-related diseases. The estimates are of interest not only in Mexico, as one of the low- and middle-income nations with higher rates of obesity, but also are of interest to other low- and middle-income nations, especially in Latin America.

Design

BMI data

The BMI data (kg/m²) were obtained from the 2000 Mexican Health and Nutrition Survey (Encuesta Nacional en Salud (ESNA))[8] and the 2006 Mexican National Health and Nutrition Survey (Encuesta Nacional de Salud y Nutrición (ENSANUT))[9]. In addition, data from 1993 for males and females[10] and from 1999 for females aged 20–49 only (Encuesta Nacional de Nutrición (ENN) 1999)[11] were utilized to project obesity trends. Adult BMI distributions were distinguished by age and gender in three BMI categories: normal weight ($\leq$24·9 kg/m²), overweight (25·0–29·9 kg/m²) and obese ($\geq$30·0 kg/m²).

Disease data

A review of the epidemiological and academic literature was undertaken to determine the country-specific incidence, survival or case fatality rates and annual medical costs for the following, by age and sex: (i) type 2 diabetes, CHD (or IHD, myocardial infarction), stroke and knee osteoarthritis as obesity-related diseases; and (ii) cancer of the breast, kidney, colon/rectum, oesophagus, endometrium and gallbladder as obesity-related cancers. Relative risks (RR) by BMI for each disease were obtained from a systemic review of the epidemiological literature[12]. These RR were applied to the Mexican population, assuming that the risks do not differ from those in European populations. The population free of disease was assigned a probability of getting a specific disease defined by the RR at the beginning of a particular year. As a consequence, they might recover or be ill and die from the specified disease or from an unspecified cause. The development of disease is defined by survival statistics and life expectancy.

Some of the disease data, such as incidence and prevalence, were provided to us by our collaborators (diabetes, stroke, IHD and hypertension), but much of the requisite data could not be obtained during the duration of the study. Survival for CHD was not available; therefore we used myocardial infarction survival, calculated from case fatality figures and applied it to 1-year CHD survival, assuming that myocardial infarction and CHD have the same survival rate. Mortality both for CHD and stroke is from the WHO mortality and burden of disease estimates[13].

Cancer incidence and mortality data were obtained from the GLOBOCAN Project 2008[14]; survival data were available only for two of them, breast and colorectal. For others, figures from the USA have been used[7]. We applied the US survival figures to Mexico, assuming they are the same within these two countries. No data on the incidence of knee osteoarthritis were available and so US data were used as a proxy to calculate Mexican figures. The disease rates reflect the obesity distribution of the originating country (the USA in this case). When using these data for another country, we removed the effect of the BMI distribution, taking the rates of the healthy individuals, and then used the obesity rates of the receiving country to calculate an estimate of the rates in Mexico.

The Mexican Institute of Social Security (Instituto Mexicano del Seguro Social) provides detailed disease cost data. The costs are presented as unit costs, i.e. the cost of each patient during hospital admission[15]. However, the micro-simulation program only incorporates total costs for health care and per unit costs cannot be entered into the program at this stage. The evaluation methods of other published articles were different. In order to be consistent with the data estimations and to make costs more reliable, the US health-care costs were chosen and applied to Mexico by adjusting the disease ratios. Thus, the diabetes cost[16] was taken as the constant and most reliable number from Mexico. The ratio (e.g. how many times higher one disease cost is than the other) of US health-care costs was applied to each disease. For example, the cost of diabetes in Mexico is $\approx$$US 2 billion; the costs of all diseases in the USA are known. To calculate the unknown cost for CHD in Mexico we take the cost of CHD in the USA ($\approx$$US 132 billion) divided by the US diabetes cost ($US 132 billion/$US 109 billion = 1·211), then multiply this ratio with the Mexican diabetes cost (1·211 $\times$ $US 2 billion). The rough estimate of the CHD costs in Mexico is therefore $US 2·4 billion. All costs are for 2000 and are not inflated to the latest year or discounted. Costs are presented in $US.

Simulation model

We employed the two-stage modelling process developed by the UK Foresight working group[17–19]. In the first module, we fit multivariate, categorical regression models to the cross-sectional BMI data series. We included sex, age and calendar year as covariates and constrained the predicted proportions of the population for each BMI category. The cross-sectional data were used to construct longitudinal trajectories to 2050 by creating pseudo cohorts

within the population. Size and age distributions were based on published projections from the UN population database[20]. We simulated 5 million individuals by sex and age, and scaled up the simulated population to reflect the total population of Mexico. The 95 % confidence interval for the projected prevalence was calculated from the Bayesian posterior distribution of the regression parameters. Further details of the two-part modelling process can be found elsewhere[19].

For the present analyses, we reduced the BMI by a constant percentage across the whole population (1 % and 5 % in this case) to test the potential of the amended BMI prevalence. This is to say that everyone's BMI was reduced by 1 % or 5 % only in 2010, and it is then assumed that the trend will continue from the decreased level. Each simulation consisted of 5 million Monte Carlo[21] trials.

Results

Obesity is projected to increase across all age groups. Particularly high levels are seen in middle-aged men (50–59 years) and older females (≥60 years), as shown in Table 1. As shown in Table 2, obesity rates are expected to increase for both males and females. In 2010, 68 % (41 % overweight and 27 % obese) of the male population is estimated to be overweight or obese (BMI ≥ 25·0 kg/m^2). The rate is expected to increase to 88 % (34 % overweight and 54 % obese) by 2050. An increase is also projected among females, with rates estimated at 74 % (37 % overweight and 37 % obese) in 2010 increasing to about 91 % by 2050 (34 % overweight and 57 % obese).

Using the projected BMI distribution, we simulated the data of thirteen BMI-related diseases. Table 3 shows the cumulative incidence cases in the total population for males and females projected to 2050. It is clear that the disease burden is increasing every year, resulting in a doubling of prevalence rates by 2050. Obesity-related CHD and stroke and the cancers are projected to more than double between 2010 and 2050. For the other obesity-related diseases, between 2010 and 2050, the rates will nearly double for hypertension and knee osteoarthritis; the highest prevalence rate will be seen for diabetes which more than doubles.

Table 4 shows the effect of a 1 % (Scenario 1) and a 5 % (Scenario 2) reduction in the rate of overweight and obesity (from a mean BMI of 28·5 to 28·2 kg/m^2 (−1 %) and to 27·1 kg/m^2 (−5 %)) that starts in 2010 on cancers, CHD and stroke, knee osteoarthritis, type 2 diabetes and hypertension. A reduction in BMI of 1 % across the population will result in 13 051 fewer cumulative cancer cases in 2030 compared with an unchanged 2010 trend and 28 277 fewer cases in 2050. The CHD and stroke cases are reduced by 118 183 cumulative cases in 2030 and by 400 227 cases in 2050. Diabetes cases are reduced by

Table 1 Projected trends in BMI (%) among Mexican adults by gender, age group and BMI group*

Age (years)	2010 BMI ≤ 24.9 kg/m² (normal weight)	2010 BMI = 25.0–29.9 kg/m² (overweight)	2010 BMI ≥ 30.0 kg/m² (obese)	2020 BMI ≤ 24.9 kg/m² (normal weight)	2020 BMI = 25.0–29.9 kg/m² (overweight)	2020 BMI ≥ 30.0 kg/m² (obese)	2030 BMI ≤ 24.9 kg/m² (normal weight)	2030 BMI = 25.0–29.9 kg/m² (overweight)	2030 BMI ≥ 30.0 kg/m² (obese)	2040 BMI ≤ 24.9 kg/m² (normal weight)	2040 BMI = 25.0–29.9 kg/m² (overweight)	2040 BMI ≥ 30.0 kg/m² (obese)	2050 BMI ≤ 24.9 kg/m² (normal weight)	2050 BMI = 25.0–29.9 kg/m² (overweight)	2050 BMI ≥ 30.0 kg/m² (obese)
Males															
20–24	45	35	20	35	35	30	26	34	40	18	33	49	13	32	55
25–29	45	35	20	35	35	30	26	34	40	18	33	49	13	32	55
30–34	25	45	30	18	43	39	12	41	47	8	38	54	6	36	58
35–39	25	45	30	18	43	39	12	41	47	8	38	54	6	36	58
40–44	23	46	31	17	45	38	13	43	44	10	41	49	7	39	54
45–49	23	46	31	17	45	38	13	43	44	10	41	49	7	39	54
50–54	24	40	36	19	35	46	15	30	55	12	25	63	9	22	69
55–59	24	40	36	19	35	46	15	30	55	12	25	63	9	22	69
≥60	28	45	27	24	45	31	20	45	35	16	45	39	13	44	43
Females															
20–24	40	36	24	30	39	31	22	40	38	15	41	44	10	41	49
25–29	40	36	24	30	39	31	22	40	38	15	41	44	10	41	49
30–34	24	39	37	17	38	45	12	37	51	9	35	56	6	34	60
35–39	24	39	37	17	38	45	12	37	51	9	35	56	6	34	60
40–44	17	36	47	14	33	53	10	31	59	8	28	64	6	25	69
45–49	17	36	47	14	33	53	10	31	59	8	28	64	6	25	69
50–54	16	39	45	13	40	47	12	40	48	10	40	50	7	41	52
55–59	16	39	45	13	40	47	12	40	48	10	40	50	7	41	52
≥60	18	37	45	13	35	52	9	33	58	7	31	62	5	29	66

*Projections are based on survey data[8–11].

Table 2 Projected trends in BMI (%) for adult Mexican males and females by BMI group*

	Year	BMI ≤ 24·9 kg/m² (normal weight)	BMI = 25·0–29·9 kg/m² (overweight)	BMI ≥ 30·0 kg/m² (obese)
Males	2010	32	41	27
	2020	25	40	35
	2030	19	38	43
	2040	15	36	49
	2050	12	34	54
Females	2010	26	37	37
	2020	21	36	43
	2030	15	36	49
	2040	12	35	53
	2050	9	34	57

*Projections are based on survey data[8–11].

Table 3 Cumulative incidence cases of various obesity-related diseases from year 2010 to 2050 (per 100 000 of the population in 2010) among Mexican adults according to different scenarios

		Eight cancers		CHD and stroke		Knee osteoarthritis		Type 2 diabetes		Hypertension	
	Year	n	95 % CI	n	95 % CI	n	95 % CI	n	95 % CI	n	95 % CI
Scenario 0	2010	41	39, 43	217	213, 221	623	616, 630	296	301, 291	413	407, 419
	2020	481	475, 487	2456	2443, 2469	6988	6966, 7010	3540	3524, 3556	4819	4801, 4837
	2030	991	983, 999	5074	5056, 5092	13 590	13 560, 13 620	9786	9761, 9811	9786	9761, 9811
	2040	1576	1566, 11 586	8305	8282, 8328	20 541	20 505, 20 577	11 681	11 654, 11 708	15 339	15 308, 15 370
	2050	2264	2252, 2276	12 203	12 176, 12 230	27 925	27 884, 27 966	16 558	16 526, 16 590	21 523	21 487, 21 559
Scenario 1	2010	40	39, 42	212	208, 216	601	594, 608	274	269, 279	397	391, 403
	2020	476	470, 482	2384	2371, 2397	6800	6778, 6822	3292	3277, 3307	4642	4624, 4660
	2030	973	965, 981	4911	4893, 4929	13 264	13 235, 13 293	6804	6783, 6825	9428	9403, 9453
	2040	1546	1536, 1556	7984	7962, 8006	20 068	20 033, 20 103	10 819	10 793, 10 845	14 783	14 753, 14 813
	2050	2225	2213, 2238	11 651	11 625, 11 677	27 304	27 263, 27 345	15 348	15 318, 15 378	20 770	20 735, 20 805
Scenario 2	2010	39	37, 41	193	189, 197	569	562, 576	214	210, 218	354	349, 359
	2020	456	450, 462	2173	2161, 2185	6399	6378, 6420	2690	2676, 2704	4235	4218, 4252
	2030	934	926, 942	4452	4435, 4469	12 582	12 553, 12 611	5739	5720, 5758	8695	8671, 8719
	2040	1501	1491, 1511	7245	7224, 7266	19 009	18 975, 19 043	9245	9421, 9269	13 712	13 683, 13 741
	2050	2150	2139, 2161	10 602	10 577, 10 627	25 850	25 811, 25 889	13 135	13 107, 13 163	19 303	19 269, 19 337

Scenario 0, no BMI reduction; Scenario 1, 1 % reduction in BMI across the population; Scenario 2, 5 % reduction in BMI across the population.

Table 4 Cumulative incidence cases of various obesity-related diseases avoided from year 2010 to 2050 (per 100 000 of the population in 2010) among Mexican adults according to different scenarios

		Eight cancers		CHD and stroke		Knee osteoarthritis		Type 2 diabetes		Hypertension	
	Year	n	95 % CI	n	95 % CI	n	95 % CI	n	95 % CI	n	95 % CI
Scenario 1	2010	1	−2, 4	5	−1, 11	22	12, 32	22	15, 29	16	8, 24
	2020	5	−4, 14	72	52, 92	188	155, 221	248	225, 271	177	149, 205
	2030	18	5, 31	163	135, 191	326	280, 372	546	512, 580	358	319, 397
	2040	30	14, 46	321	285, 357	473	416, 530	862	820, 904	556	507, 605
	2050	39	20, 58	552	508, 596	621	555, 682	1210	1159, 1261	753	695, 811
Scenario 2	2010	2	−1, 5	24	18, 30	54	44, 64	82	72, 90	59	51, 57
	2020	25	16, 34	283	264, 302	589	556, 622	850	828, 872	584	557, 611
	2030	57	45, 69	622	594, 650	1008	962, 1054	1611	1579, 1643	1091	1053, 1129
	2040	75	59, 91	1060	1025, 1095	1532	1476, 1588	2436	2395, 2477	1627	1579, 1675
	2050	114	95, 133	1601	1558, 1644	2075	2009, 2141	3423	3374, 3472	2220	2163, 2277

Scenario 1, 1 % reduction in BMI across the population; Scenario 2, 5 % reduction in BMI across the population.

395 878 cases in 2030 and by 877 311 cases in 2050. With a 5 % reduction in BMI, more cumulative cases are avoided. Cancer cases are decreased by 41 328 in 2030 and by 82 655 in 2050. In 2030 and 2050, respectively 450 981 and 1 160 805 cumulative cases of CHD and stroke are avoided. Diabetes is reduced by 1 168 056 cases in 2030 and by 2 481 845 cases in 2050.

The economic burden of the BMI-related diseases across each of the three scenarios is presented in Table 5. The cancer costs double when projected until 2050. The CHD and stroke costs increase from $US 324 million to $US 557 million and $US 797 million in 2030 and 2050 respectively. All diseases, calculated to cost $US 806 million in 2010, could increase to $US 1·2 billion in 2030 and to

Table 5 Projected health-care costs (in millions of $US) of various obesity-related diseases in year 2010 to 2050 among Mexican adults according to different scenarios

Year	Scenario 0			Scenario 1			Scenario 2		
	Eight cancers	CHD and stroke	All thirteen diseases	Eight cancers	CHD and stroke	All thirteen diseases	Eight cancers	CHD and stroke	All thirteen diseases
2010	50	324	806	50	317	796	49	310	783
2011	53	346	837	52	336	823	51	326	804
2012	54	362	862	54	351	846	53	339	823
2013	56	370	880	56	362	867	55	348	838
2014	57	384	902	58	372	886	56	359	855
2015	58	395	923	59	381	903	58	368	870
2016	60	404	942	60	392	922	60	376	885
2017	62	416	964	62	402	941	61	385	901
2018	64	425	984	63	408	957	62	392	914
2019	65	435	1004	65	420	978	63	401	930
2020	67	445	1025	67	429	997	64	407	943
2021	69	456	1047	68	438	1016	65	414	959
2022	70	463	1066	70	447	1035	66	422	976
2023	72	474	1089	71	457	1055	68	432	995
2024	73	486	1112	73	470	1080	70	443	1015
2025	74	496	1133	74	481	1101	72	452	1034
2026	77	508	1158	75	492	1122	73	462	1053
2027	78	519	1181	77	502	1143	75	471	1073
2028	79	532	1205	78	512	1164	76	482	1093
2029	80	544	1228	79	523	1186	78	493	1114
2030	81	557	1254	81	537	1211	78	506	1137
2031	82	569	1277	82	547	1231	80	516	1157
2032	84	580	1300	83	557	1252	82	526	1177
2033	85	592	1324	84	567	1272	84	537	1199
2034	87	604	1348	85	580	1296	85	548	1220
2035	87	618	1372	86	590	1317	86	559	1240
2036	88	632	1397	87	604	1340	87	570	1260
2037	89	642	1419	88	616	1363	87	583	1281
2038	90	654	1441	90	628	1385	90	596	1305
2039	91	671	1469	91	641	1408	91	607	1325
2040	92	684	1492	92	650	1427	92	617	1345
2041	94	697	1517	94	660	1448	93	628	1365
2042	96	708	1540	96	669	1467	95	637	1382
2043	97	718	1559	97	681	1490	95	646	1400
2044	97	726	1576	98	689	1507	96	656	1417
2045	98	738	1598	99	701	1528	97	666	1435
2046	99	752	1623	101	711	1548	98	675	1452
2047	101	763	1644	102	720	1567	99	682	1466
2048	102	773	1663	103	731	1588	100	694	1486
2049	103	785	1683	103	739	1603	100	703	1501
2050	104	797	1706	104	748	1621	102	709	1514
Total	3263	23 042	51 548	3257	22 057	49 687	3194	20 941	46 917

Scenario 0, no BMI reduction; Scenario 1, 1 % reduction in BMI across the population; Scenario 2, 5 % reduction in BMI across the population.

$US 1·7 billion in 2050. Table 5 also shows that a 1 % reduction in BMI prevalence could save a total of $US 43 million in 2030 and $US 85 million in 2050. A 5 % BMI decrease saves $US 117 million in 2030 and $US 192 million in 2050.

Discussion

Our analysis shows that the prevalence of overweight and obesity and the associated disease and economic burden will increase substantially in Mexico. By 2050, the prevalence of normal weight individuals will decrease to 12 % from 32 % in males and to 9 % from 26 % in females, and more people will be obese than overweight. About 12 million diabetes cases and 8 million heart disease cases are projected in 2050 alone. For the thirteen diseases considered, costs of $US 806 million are estimated for 2010 and projected to increase to $US 1·2 billion and $US 1·7 billion in 2030 and 2050 respectively.

We also found that a 1 % reduction in mean BMI could save a total of $US 43 million in 2030 and $US 85 million in 2050. A 5 % decrease saves $US 117 million in 2030 and $US 192 million in 2050. This shows considerable avoidable health-care costs and future burdens of disease. By translating these costs to per capita terms, these estimates provide measures that can be used in developing cost-effectiveness analysis of interventions to reduce obesity.

Mexico's public health community and policy makers must develop and implement effective public health interventions to halt the increasing trend in obesity

prevalence. All programmes and policies need to be evaluated in order to refine and adapt effective actions that might contribute to controlling the epidemic. A very carefully designed public health strategy involving all social sectors, and with important participation of the state regulating and protecting the population and creating incentives for healthier lifestyles at the family, community, school, work and country levels, is necessary. Our analysis demonstrates that a small reduction in BMI at the national level over the years could tackle the disease burden, generating important savings and benefits for the country. Thus higher priority and investment in developing comprehensive, multisectoral programmes with an evaluation component and process indicators are urgently needed.

In Mexico, as in many other countries, the majority of the health budget is going into treatment (73·5%) rather than prevention and public health (2·7%). In 2006, Mexican total health-care cost for diabetes, CVD and obesity was approximately 40 billion Mexican pesos, which represents 7% of the total health-care budget. Only 4·2% of the total health-care budget is destined for obesity and 55·2% for CVD[22]. It is important to reallocate the budget appropriately and invest in obesity prevention.

As part of the proposed solution to tackle the problem, we projected possible outcomes of two interventions with an impact on mean BMI of the population. We found that a 1% reduction in mean BMI could save a total of $US 43 million in 2030 and $US 85 million in 2050. A 5% decrease saves $US 117 million in 2030 and $US 192 million in 2050. This shows considerable avoidable health-care costs and future burdens of disease. Although it is possible that this reduction can be reached by national prevention programmes at an expense of approximately $US 12 per capita[23], it is likely that an additional fund needs to be considered in order to prevent obesity-related diseases and no actual saving can be made at the initial stage. Still, the priority should remain the health of the population and not saving money.

Since 2007, the Mexican Federal Administration has developed several actions to tackle obesity, for example: (i) 'Unidades de Especialidades Médicas' (UNEMES) in 2007, a primary health clinic system focused on treatment of NCD; (ii) the national agreement for healthy eating, 'Acuerdo Nacional para la Salud Alimentaria. Estrategia contra el Sobrepeso y la Obesidad', in 2010; (iii) the guidelines for food and beverage sales in schools, 'Lineamientos para el Expendio o Distribución de Alimentos o Bebidas', in 2010; and (iv) 'Five Steps for Your Health' ('Cinco pasos por tu salud') in 2010. These all aim to promote healthy eating, lifestyle and early detection of obesity's health consequences. Nevertheless, evaluating the cost-effectiveness of these projects will take longer than planned.

While the projections presented here are based on the best data available, the study has some limitations. First, some of the data parameters were unavailable for Mexico and were interpolated using information from other countries; therefore the results could be under- or overestimated. For six cancers we used the survival rates from the USA. Mexican health-care resources are substantially scarce compared with the USA; the USA has the highest health-care expenditure per capita in the world focusing on early screening, whereas Mexican health care places a greater focus on hospital care, resulting in lower survival rates than in the USA[24,25]. Therefore, in using survival from the USA we may have overestimated cancer survival for Mexico, and possibly underestimated the burden of disease. Despite this, the projected cancer incidence carries a substantial health and economic burden that may be even higher in the actual population and should be a high priority on the health-care agenda. Moreover, there is evidence of different evolutions and patterns of natural history in nutrition-related chronic diseases. Diabetes mellitus prevalence is higher in Mexicans in contrast to European and American populations[26]. Half of the Mexican population with the condition have not been checked, and the ones diagnosed have poor control. The same holds with hypertension, so complications from these diseases are higher than in developed countries[27]. This may underestimate disease prevalence and health-care costs. These aspects have not been considered for the projections.

Second, height is increasing in Mexico due to successful national prevention policies against child undernutrition (e.g. micronutrient programmes for children)[5,28]. This will have a protective effect against obesity which has not been accounted for in the simulation model. However, the expected improvement in height in the next few years probably will be small. Third, a population with higher energy intake also has a higher intake of most nutrients, including Na. A reduction in BMI as a result of healthier diets will also cause reductions in Na intake, thus additional benefits could be expected from intensive policy to promote healthier diets. Fourth, many other effects of obesity were not considered in the analysis. The savings in expenditure due to complications of obesity could be much higher. Finally, aggressive communication campaigns against obesity, a national agreement for healthy nutrition, guidelines for foods at schools and other successful initiatives have been launched recently by the Mexican Government and might contribute to partial reductions in future prevalence[29]. At present, however, these programmes have not been evaluated and it is difficult to argue about their effectiveness.

Conclusion

Obesity rates across Mexico are alarming. The present study serves to highlight the need for better-quality surveillance data and effective public health interventions to curb rising obesity rates. Without these, the costs of obesity will place a huge financial burden on the public health system.

References

1. Barquera S, Campos-Nonato I, Hearnandes-Barrera L *et al.* (2006) Obesity and central adiposity in Mexican adults: results from the Mexican National Health and Nutrition Survey 2006. *Salud Publica Mex* **51**, Suppl. 4, S595–S603.

2. Sánchez-Castillo CP, Velásquez-Monroy O, Lara-Esqueda A *et al.* (2005) Diabetes and hypertension increases in a society with abdominal obesity: results of the Mexican National Health Survey 2000. *Public Health Nutr* **8**, 53–60.

3. Secretaria de Salud (2008) Principales causes de mortalidad general, 2008. Nacional. http://www.sinais.salud.gob.mx/descargas/xls/m_005.xls (accessed January 2012).

4. Stevens G, Dias RH, Thomas KJA *et al.* (2008) Characterizing the epidemiological transition in Mexico: national and subnational burden of diseases, injuries, and risk factors. *PLoS Med* **5**, e125.

5. Organisation for Economic Co-operation and Development (2010) Obesity and The Economics of Prevention: Fit not Fat – Mexico Key Facts. http://www.oecd.org/document/32/0,3746,en_2649_33929_46038752_1_1_1,00.html (accessed June 2012).

6. Secretaría de Salud (2010) *Acuerdo Nacional para la Salud Alimentaria: estrategia contra el sobrepeso y la obesidad*, pp. 12–13. Mexico DF: Sub-Secretaría de Prevención y Promoción de la Salud de la Secretaría de Salud.

7. Wang YC, McPherson K, Marsh T *et al.* (2011) Health and economic burden of the projected obesity trends in the USA and the UK. *Lancet* **378**, 815–825.

8. Olaiz G, Rojas R, Barquera S *et al.* (2003) *Encuesta Nacional de Salud 2000. tomo 2: La salud de los adultos*. Cuernavaca, Morelos: Instituto Nacional de Salud Pública.

9. Olaiz G, Rivera J, Shamah T *et al.* (2006) *Encuesta Nacional de Salud y Nutrición 2006*. Cuernavaca, Morelos: Instituto Nacional de Salud Pública.

10. Arroyo P, Loria A, Fernandez V *et al.* (2000) Prevalence of pre-obesity and obesity in urban adult Mexicans in comparison with other large surveys. *Obes Res* **8**, 179–185.

11. Rivera J, Shamah T, Villalpando S *et al.* (2001) *Encuesta Nacional de Nutrición 1999. Estado nutricio de niños y mujeres en México*. Cuernavaca, Morelos: Instituto Nacional de Salud Pública.

12. Lobstein T & Leach RJ (2010) Workpackage 7: Overweight and Obesity. Report on data collection for overweight and obesity prevalence and related risks. Data documentation for the Dynamic Modelling for Health Impact Assessment (DYNAMO-HIA) Project. http://www.dynamo-hia.eu/object_binary/o3055_BMI_WP7-datareport_20100317.pdf

13. World Health Organization (2008) Health statistics and health information systems. Disease and injury country estimates. Burden of disease. http://www.who.int/healthinfo/global_burden_disease/estimates_country/en/index.html (accessed July 2011).

14. International Agency for Research on Cancer, World Health Organization (2008) The GLOBOCAN Project 2008. http://globocan.iarc.fr/ (accessed July 2011).

15. Instituto Mexicano del Seguro Social (2008) Grupos Relacionados con el Diagnóstico; Costo Medico Tecnico. http://www.imss.gob.mx/profesionales/Documents/GRD_IMSS.pdf (accessed January 2012).

16. Barcelo A, Aedo C, Rajpathak S *et al.* (2003) The cost of diabetes in Latin America and the Caribbean. *Bull World Health Organ* **81**, 19–27.

17. Butland B, Jebb S, Kopelman P *et al.* (2007) *Foresight Tackling Obesities: Future Choices – Project Report*. London: Government Office for Science.

18. Kopelman P, Jebb SA & Butland B (2007) Executive summary: Foresight: 'Tackling Obesities: Future Choices' project. *Obes Rev* **8**, Suppl. 1, vi–ix.

19. McPherson K, Marsh T & Brown M (2007) *Foresight. Tackling Obesities: Future Choices – Modelling Future Trends in Obesity & Their Impact on Health*. London: Government Office for Science.

20. United Nations, Department of Economic and Social Affairs, Population Division, Population Estimates and Projections Section (2010) World Population Prospects, the 2010 Revision. http://esa.un.org/unpd/wpp/index.htm (accessed July 2011).

21. Fishman GS (1995) *Monte Carlo: Concepts, Algorithms, and Applications*. New York: Springer.

22. Neufeld LM (2007) Lecciones aprendidas en la evaluación del Programa Oportunidades. *Salud Publica Mex* **49**, número especial, E242–E244; available at http://redalyc.uaemex.mx/pdf/106/10649091.pdf

23. Secretaría de Salud (2010) *Acuerdo Nacional para la Salud Alimentaria: estrategia contra el sobrepeso y la obesidad*. Mexico DF: Sub-Secretaría de Prevención y Promoción de la Salud de la Secretaría de Salud.

24. World Health Organization (2000) *The World Health Report 2000. Health Systems: Improving Performance*. Geneva: WHO; available at http://www.who.int/whr/2000/en/whr00_en.pdf

25. World Health Organization (2009) Health Expenditure: Health Expenditure per capita. http://www.who.int/whosis/whostat/EN_WHS09_Table7.pdf (accessed December 2012).

26. Centers for Disease Contol and Prevention (2004) *National diabetes fact sheet, United States, 2003*. Atlanta, GA: CDC.

27. Ávila Burgos L, Cahuana Hurtado L & González Domínguez D (editors) (2006) *Cuentas en diabetes mellitus, enfermedades cardio. Fes y obesidad: México 2006*, 1st ed. Cuernavaca, Morelos: Instituto Nacional de Salud Pública, Centro de Investigación en Sistemas de Salud.

28. World Health Organization (2011) *Global Health Observatory. Prevalence of raised blood pressure, ages 25+, age standardized: Both sexes, 2008*. Geneva: WHO; available at http://gamapserver.who.int/mapLibrary/Files/Maps/Global_BloodPressurePrevalence_BothSexes_2008.png

29. Neufeld LM, García-Guerra A, Leroy J *et al.* (2006) Impacto del Programa Oportunidades en nutrición y alimentación en zonas urbanas de México. In *Evaluación externa del impacto del Programa Oportunidades*, pp. 29–124 [B Hernández-Prado and M Hernández-Ávila, editors]. Cuernavaca, Morelos: Instituto Nacional de Salud Pública.