

# The cost of obesity in Canada

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## Abstract

**Background:** Almost one-third of adult Canadians are at increased risk of disability, disease and premature death because of being obese. In order to allocate limited health care resources rationally, it is necessary to elucidate the economic burden of obesity.

**Objective:** To estimate the direct costs related to the treatment of and research into obesity in Canada in 1997.

**Methods:** The prevalence of obesity (body mass index of 27 or greater) in Canada was determined using data from the National Population Health Survey, 1994–1995. Ten comorbidities of obesity were identified from the medical literature. A population attributable fraction (PAF) was calculated for each comorbidity with data from large cohort studies to determine the extent to which each comorbidity and its management costs were attributable to obesity. The direct cost of each comorbidity was determined using data from the Canadian Institute of Health Information (for direct expenditure categories) and from Health Canada (for the proportion of expenditure category attributable to the comorbidity). This prevalence-based approach identified the direct costs of hospital care, physician services, services of other health professionals, drugs, other health care and health research. For each comorbidity, the cost attributable to obesity was determined by multiplying the PAF by the total direct cost of the comorbidity. The overall impact of obesity was estimated as the sum of the PAF-weighted costs of treating the comorbidities. A sensitivity analysis was completed on both the estimated costs and the PAFs.

**Results:** The total direct cost of obesity in Canada in 1997 was estimated to be over \$1.8 billion. This corresponded to 2.4% of the total health care expenditures for all diseases in Canada in 1997. The sensitivity analysis revealed that the total cost could be as high as \$3.5 billion or as low as \$829.4 million; this corresponded to 4.6% and 1.1% respectively of the total health care expenditures in 1997. When the contributions of the comorbidities to the total cost were considered, the 3 largest contributors were hypertension (\$656.6 million), type 2 diabetes mellitus (\$423.2 million) and coronary artery disease (\$346.0 million).

**Interpretation:** A considerable proportion of health care dollars is devoted to the treatment and management of obesity-related comorbidities in Canada. Further research into the therapeutic benefits and cost-effectiveness of management strategies for obesity is required. It is anticipated that the prevention and treatment of obesity will have major positive effects on the overall cost of health care.

## Résumé

**Contexte :** L'obésité représente un risque accru d'incapacité, de maladie et de mort prématurée pour presque le tiers des adultes du Canada. Afin de répartir de façon rationnelle les ressources limitées consacrées aux soins de santé, il faut préciser le fardeau économique que représente l'obésité.

**Objectif :** Estimer les coûts directs liés au traitement de l'obésité et à la recherche en la matière au Canada en 1997.

**Méthodes :** On a déterminé la prévalence de l'obésité (indice de masse corporelle de 27 ou plus) au Canada à partir des données tirées de l'Enquête nationale sur la santé de la population de 1994–1995. Dix comorbidités de l'obésité ont été tirées des écrits médicaux. On a calculé une fraction étiologique du risque (FER) pour chaque comorbidité à partir de données tirées d'études de cohortes importantes pour déterminer dans quelle mesure chaque comorbidité et ses coûts de



## Evidence

## Études

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*This article has been peer reviewed.*

CMAJ 1999;160:483-8

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prise en charge étaient attribuables à l'obésité. Le coût direct de chaque comorbidité a été établi à partir de données de l'Institut canadien d'information sur la santé (dans le cas des catégories de dépenses directes) et de Santé Canada (pour la proportion de la catégorie de dépenses attribuable à la comorbidité). Cette démarche fondée sur la prévalence a permis de dégager les coûts directs des soins hospitaliers, des services médicaux, des services d'autres professionnels de la santé, des médicaments, d'autres soins de santé et de la recherche sur la santé. Pour chaque comorbidité, on a calculé le coût attribuable à l'obésité en multipliant le FER par le coût total direct de la comorbidité. On a estimé l'impact global de l'obésité en faisant le total des coûts des traitements des comorbidités, pondérés en fonction du FER. On a effectué une analyse de sensibilité à la fois des coûts estimatifs et des FER.

**Résultats :** Le coût direct total de l'obésité au Canada en 1997 a été estimé à plus de 1,8 milliard de dollars, ce qui correspond à 2,4 % du total des dépenses des soins de santé consacrées à toutes les maladies au Canada en 1997. L'analyse de sensibilité a révélé que le coût total pourrait atteindre 3,5 milliards de dollars ou 829,4 millions à peine, soit 4,6 % ou 1,1 % respectivement du total des dépenses consacrées aux soins de santé en 1997. Compte tenu des contributions des comorbidités au coût total, les trois facteurs de contribution les plus importants ont été l'hypertension (656,6 millions de dollars), le diabète de type 2 (423,2 millions) et la coronaropathie (346,0 millions).

**Interprétation :** Le traitement et la prise en charge de comorbidités liées à l'obésité au Canada englobent une proportion considérable des budgets des soins de santé. Des recherches plus poussées sur les avantages thérapeutiques et la rentabilité des stratégies de prise en charge de l'obésité s'imposent. On prévoit que la prévention et le traitement de l'obésité auront des effets positifs importants sur le coût global des soins de santé.

Obesity is the most common metabolic condition in industrialized nations. The National Population Health Survey 1994–1995 revealed that 30.5% of Canadians between the ages of 20 and 64 are obese (body mass index [BMI] of 27 or greater).<sup>1</sup> International estimates of the prevalence of obesity vary widely and may depend on cultural and socioeconomic factors in addition to the age group and timeframe studied and the definition of obesity used. For comparison, with a cutoff BMI of over 30 the reported prevalence of obesity among men and women respectively is 15% and 22% in Europe,<sup>2</sup> 19.9% and 24.9% in the United States<sup>3</sup> and 13.5% for men and women in Canada.<sup>1</sup>

Given the high prevalence of obesity and the existence of large cohort studies establishing its health risks, we considered it timely to estimate the cost of obesity to the Canadian health care system. Because there are limited health care resources, disease-specific cost estimates are essential to facilitate priority setting and the allocation of future health care dollars to areas where the economic burden of illness is greatest.

Obesity is known to reduce quality of life,<sup>4</sup> increase morbidity<sup>5</sup> and lead to premature death.<sup>6–8</sup> Recent economic studies in the United States,<sup>9,10</sup> France,<sup>11</sup> Australia,<sup>12</sup> New Zealand<sup>13</sup> and The Netherlands<sup>14,15</sup> have measured the monetary implications of obesity on health care ex-

penses. These estimates were based on the premise that obesity is a known risk factor for a number of serious diseases such as cardiovascular diseases,<sup>16–18</sup> hypertension,<sup>19,20</sup> type 2 diabetes,<sup>21,22</sup> dyslipidemia,<sup>23</sup> gallbladder disease<sup>24,25</sup> and cancer.<sup>26–28</sup> The cost of obesity in these countries accounted for 2% to 6.8% of the total health care expenditures. In this study we used similar methodology to estimate the economic burden of obesity in Canada.

## Methods

### Obesity and comorbidities

Obesity is defined as a BMI of 27 or greater.<sup>11,29,30</sup> Comorbidities used in our analysis were those with well-established epidemiological associations with obesity<sup>16–28</sup> and whose monetary costs could be determined from the National Health Expenditures Database (NHED) of the Canadian Institute of Health Information (CIHI). To allocate the proportion of the total costs of these diseases attributed to obesity, we used the population attributable fraction (PAF), which provides an estimate of the extent to which a disease and its management costs are attributable to an individual factor. The PAF is calculated using the formula  $P(RR - 1) / [P(RR - 1) + 1]$ , where P is the probability of a person being obese in a given population and RR is the relative risk for the disease in an obese subject.<sup>31</sup>

Primary data on the prevalence of obesity in Canada was obtained from the National Population Health Survey, which



provided BMI distribution by age and sex.<sup>1</sup> We used reviews<sup>5,32,33</sup> to identify the comorbidities of obesity initially. An extensive MEDLINE search was then conducted to identify prospective studies investigating the risks of morbidity associated with obesity. Articles on each comorbidity were found with the use of the corresponding MeSH term for the comorbidity and the following methodological search terms: “follow-up studies,” “longitudinal studies,” “prospective studies,” “cohort studies,” “risk factors,” “relative risk,” “prevalence” and “incidence.” A clinical epidemiologist reviewed each article using the published criteria for evaluating studies about prognosis to ensure that only valid estimates were used.<sup>34</sup> For each comorbidity, the most valid study was selected from those meeting the criteria. Whenever possible, a valid study for men and another for women was identified for each comorbidity. When more than one valid study was found for a comorbidity, the study with the largest sample and the longest follow-up was used to calculate our relative risks and PAF estimates.

## Statistical analysis

We estimated the relative risk for each comorbidity as follows. First, disease- and sex-specific estimates of relative risk stratified by BMI level were obtained from the valid studies identified in our literature search. Second, we calculated the disease- and sex-specific logarithm of the relative risk,  $\ln(\text{RR})$ , and then estimated the standard error of the  $\ln(\text{RR})$  from the given confidence limits for each BMI grouping. Third, weighted averages of the sex-specific  $\ln(\text{RR})$  were computed to obtain overall  $\ln(\text{RR})$  estimates for BMIs below 27 and BMIs of 27 or greater. The weights used were the proportion of men, or women, with a particular BMI taken from the National Population Health Survey.<sup>1</sup> Finally, the population relative risk for each comorbidity was calculated as the ratio of the relative risk computed for individuals with a BMI of 27 or greater to those with a BMI of less than 27. Equal weighting was given for men and women for all diseases except postmenopausal breast cancer and endometrial cancer, for which only data for women were used. For postmenopausal breast cancer, the weights used were the proportion of women over 50 years with a particular BMI.

Confidence intervals (CIs) for the relative risks were computed as follows. The variance of the  $\ln(\text{RR})$  for obese and nonobese individuals was calculated as a weighted sum of variances for each BMI group. The variance of the  $\ln(\text{RR})$  for obesity was then computed as the sum of the variances for individuals with a BMI of less than 27 and for those with a BMI of 27 or greater. The 95% CIs for the  $\ln(\text{RR})$  for obesity were approximated as the  $\ln(\text{RR}) \pm 2$  standard errors. The 95% CIs for the relative risk were computed by taking the anti-logarithm of the CIs for the  $\ln(\text{RR})$ .

The PAF for obesity was computed for each comorbidity. The relative risks for the disease given obesity and the proportion of obese individuals from the National Population Health Survey<sup>1</sup> (male or female except for those with breast cancer and endometrial cancer) were used to calculate the PAF. The 95% CIs for the PAF were computed according to the methods described in Leung and Kupper.<sup>35</sup>

## Cost of illness

We estimated the economic burden of obesity in Canada using cost-of-illness methodology.<sup>36</sup> The societal perspective was chosen for the measurement of all costs. We followed a prevalence-based approach in identifying the population-attributable risks for the various comorbidities of obesity. The prevalence data were combined with published data on the direct costs incurred to manage these comorbidities during 1997. The source of the total direct costs were expenditures on hospital care, physician services, services by other health professionals, drugs, other health care and health research. The PAF for each of the 10 comorbidities studied was multiplied by the cost of the comorbidity and summed to obtain the total cost estimate.

The total direct cost for the various cost categories was extracted from the NHED forecast for 1997. All of these expenditure categories except for hospital care were allocated to individual comorbidities using economic burden-of-illness (EBI) data from Health Canada for 1993.<sup>37</sup> When the EBI diagnostic category coincided with a particular comorbidity identified in our analysis, the EBI proportion of the expenditure category was used. When the cost for a particular comorbidity was not directly calculable because its expenditure share was lumped into a larger disease category, Canadian incidence rates or pertinent data from the United States were used to allocate a portion of the broader category to the comorbidity. The NHED hospital costs were allocated using hospital morbidity data from Statistics Canada.<sup>38</sup> (A comprehensive explanation of these costing methods and their limitations is detailed in a technical manual available upon request from the authors.)

## Sensitivity analysis

Two-way sensitivity analysis was performed to assess the influence of variations in the comorbidity cost estimates and PAFs. Baseline costs were varied  $\pm 20\%$  to account for possible imprecision in cost estimates; 95% CIs were used to vary PAFs.

## Results

A total of 361 articles were retrieved through the MEDLINE search and screened for estimates of risk. Of the 126 relevant articles, 45 were of acceptable quality. Given our definition of obesity, the literature search yielded the following comorbidities for inclusion in our cost analysis: postmenopausal breast cancer,<sup>26</sup> colorectal cancer,<sup>27</sup> coronary artery disease,<sup>16,17</sup> endometrial cancer,<sup>28</sup> gallbladder disease,<sup>24,25</sup> hyperlipidemia,<sup>23</sup> hypertension,<sup>19,20</sup> pulmonary embolism,<sup>39</sup> stroke<sup>18</sup> and type 2 diabetes.<sup>21,22</sup>

Valid sex-specific estimates of relative risk were found for all comorbidities except colorectal cancer, pulmonary embolism and stroke. Because we could not find a valid estimate of relative risk for colorectal cancer in women, we conservatively assumed that a BMI of 27 or greater conferred no excess risk to women for that disease. Analo-

gously, we assumed that obesity did not increase the risk of stroke among men. (Sex-specific relative risk and PAF estimates are provided in the technical report, which is available from the authors upon request.)

The overall relative risk estimates and PAFs for men and women combined for each of the 10 comorbidities are presented in Table 1. The relative risks ranged from 1.14 for stroke to 4.37 for type 2 diabetes. The PAF estimates indicate that more than 20% of all cases of endometrial cancer, gallbladder disease, hypertension, pulmonary embolism and type 2 diabetes in Canada were attributable to obesity.

Fig. 1 displays the estimated prevalence of obesity in Canada, stratified by age and sex. The costs of the individual comorbidities and their PAF-weighted sum as the total direct cost of obesity in 1997 are shown in Table 2. The total direct cost of obesity was estimated to be over \$1.8 billion. With the total direct health care expenditures in Canada forecasted to be \$76.6 billion for 1997 (NHED database), the proportion attributable to obesity is therefore 2.4% of the total cost of illness.

In the sensitivity analysis, simultaneously varying the PAF (lower and upper limits of the 95% CI) and costs ( $\pm 20\%$ ) revealed that the total cost could be as low as \$829.4 million or as high as \$3.5 billion. This corresponds to 1.1% and 4.6% respectively of the total costs of illness in Canada in 1997.

## Interpretation

Our estimated cost of obesity in Canada in 1997 (over \$1.8 billion), when considered as a proportion of health

**Table 1: Relative risks for selected comorbidities in obese subjects and the population attributable fractions (PAFs) for obesity**

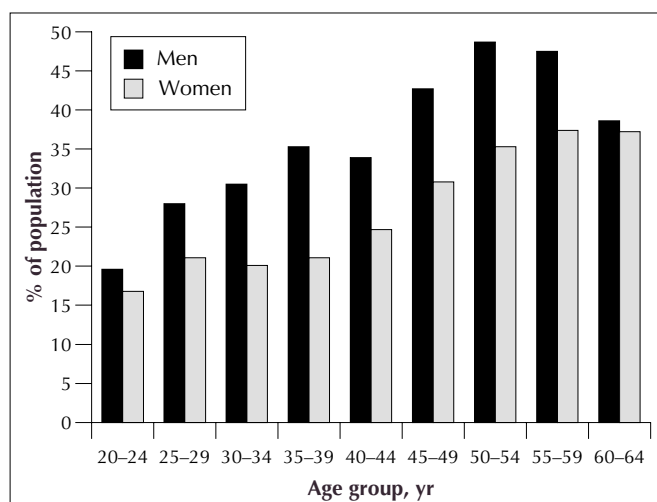
Comorbidity	Relative risk (and 95% CI)	PAF* (and 95% CI), %
Breast cancer, postmenopausal <sup>26</sup>	1.31 (0.9–1.96)	9.1 (0–15.7)
Coronary artery disease <sup>16,17</sup>	1.72 (1.19–2.48)	17.9 (8.3–34.5)
Colorectal cancer <sup>27</sup>	1.16 (0.82–1.64)	4.7 (0–15.7)
Endometrial cancer <sup>28</sup>	2.19 (1.05–4.56)	26.6 (8.6–58.3)
Gallbladder disease <sup>24,25</sup>	1.85 (1.41–2.43)	20.6 (12.6–31.8)
Hyperlipidemia <sup>23</sup>	1.41 (0.84–2.38)	11.2 (0–28.9)
Hypertension <sup>19,20</sup>	2.51 (1.98–3.18)	31.6 (23.1–40.0)
Pulmonary embolism <sup>39</sup>	2.39 (1.28–4.48)	29.8 (7.3–52.3)
Stroke <sup>18</sup>	1.14 (0.91–1.42)	4.0 (0–11.1)
Type 2 diabetes <sup>21,22</sup>	4.37 (2.76–6.93)	50.7 (35.8–65.6)

Note: CI = confidence interval.

\*The PAF indicates the extent to which each comorbidity and its management costs are attributed to obesity. It is calculated using the formula  $P/(RR - 1)/[P/(RR - 1) + 1]$ , where P is the probability of a person being obese in a given population and RR is the relative risk for the disease in an obese subject.

care expenditures (2.4%), is similar to the proportion of health care expenditures in New Zealand (2.5%; obesity defined as a BMI of 30 or more),<sup>13</sup> Australia (2%; BMI 30 or more for obesity)<sup>12</sup> and France (2%; BMI 27 or more).<sup>11</sup> Our estimate is somewhat lower than the proportion in The Netherlands (4%; BMI 25 or more)<sup>15</sup> and the United States (5.5%–6.8%; BMI 27.8 or more for men and 27.3 or more for women).<sup>9,10</sup> Clearly, the definition of obesity varies from study to study and from population to population. Although we recognize that any cutoff for the BMI would be open to discussion, we believe that our definition of obesity (BMI 27 or greater) is most appropriate for Canada.

In adopting a cost-of-illness approach, we primarily set out to identify “the scope of the problem” so that the potential benefits to society of disease elimination may be estimated. A prevalence-based approach is appropriate for aiding financial forecasting of expected expenditures because it allows one to determine the annual economic burden of a disease. This is just a first step, though, because it stops short of providing insight into the value of specific medical interventions that could lessen the burden of the disease. An incidence-based approach can aid decision-making on what treatment or research strategy to implement because the cost per new case reflects potential savings from programs that may reduce the incidence of the disease or improve outcomes. For the incidence approach, we would have had to know the likely course of the diseases attributable to obesity. We would also have had to consider the duration of illness, survival rates since onset, medical resources that will be used and their cost during the course of the diseases, data that are not readily available. Thus, for practical considerations of data availability, we followed the prevalence-based approach. Even though the incidence-based approach is theoretically preferable for chronic diseases or conditions, prevalence-based cost-of-illness studies



**Fig. 1: Estimated prevalence of obesity in Canada, by age and sex. (Obesity = body mass index of 27 or greater.)**



dominate the literature.<sup>40</sup> Our choice, therefore, facilitates comparison with findings from other countries.

The next step is to assess the cost-effectiveness of specific interventions, including prevention, diet, exercise, behaviour therapy, pharmacotherapy and surgery. It is anticipated that the prevention and treatment of obesity will have important positive effects on other disease areas and on the overall cost of health care because the associated comorbidities such as coronary artery disease, hypertension and type 2 diabetes are among the most costly in Canada. In addition, the indirect costs of these comorbidities, although not estimated as part of our analysis, will be greatly reduced. The effects of obesity and associated comorbidities on health-related quality of life also needs to be assessed. The primary indirect economic consequence of obesity for society may be considered by estimating the loss in productivity resulting from disability and premature death due to obesity-related illnesses. It has been conservatively estimated that indirect costs totalled \$23 billion in the United States in 1990.<sup>10</sup> Other issues to consider are the psychological and social restrictions placed on obese individuals. They have limited social, educational and professional opportunities and often experience negative peer attitudes, negative self-image, job discrimination, absenteeism from jobs and underachievement in education.<sup>4</sup> Until studies that incorporate all of these dimensions are undertaken, we will have to rely on partial estimates of the burden of obesity.

Apart from our not including indirect costs in our analysis, there are other aspects of our study that lead us to believe that our estimates are conservative and biased

downward. First, we did not include all obesity-related diseases. Gout and osteoarthritis were excluded because their cost share could not be separated from the overall costs of endocrine diseases and musculoskeletal disorders respectively. The cost of treating obesity itself was not included in our analysis because provincial health care systems do not fund the treatment of obesity alone. Inclusion of these diseases would potentially increase our estimates substantially. For instance, if we were to assume, as per Colditz,<sup>9</sup> that the PAF (15%) for osteoarthritis<sup>41,42</sup> applies to all musculoskeletal disorders, then our point estimate of the cost of obesity would increase by an additional \$488 million.

Second, not all cost categories of the NHED (e.g., "capital" and "other institutions") were allocable to comorbidities. The difference between total expenditures and allocable expenditures in the NHED for 1997 was approximately 20%, and the effect of this additional cost on our point estimate is difficult to assess. Another limitation with respect to the expenditure data is that we could not break down costs by age and sex. The assignment of total hospital costs to individual comorbidities was also problematic. With no data available to adjust for case mix or severity, we were able to adjust only for length of stay per separation by disease category and not for the intensity of care. When using the proportion of disease due to a specific cause to allocate health care costs, it is important to note that, although PAFs can be independent, they are not mutually exclusive. Biological interactions between causes can be additive or multiplicative. Therefore, the proportion of disease attributable to various causes does not sum to 100% but is unbounded.<sup>43</sup>

Third, our estimated relative risks were generally lower

**Table 2: Estimated direct costs of obesity and the selected comorbidities\***

Comorbidity	Expenditure category; cost, \$ thousands						Total cost, \$ thousands	Cost attributable to obesity, \$ thousands§
	Hospital care†	Physician services	Services of other health professionals	Drugs‡	Other health care	Health research		
Breast cancer, postmenopausal	92 821	31 926	3 963	44 350	37 513	6 817	217 390	19 782
Coronary artery disease	1 080 329	275 225	34 160	318 160	222 116	2 727	1 932 717	345 956
Colorectal cancer	239 787	57 247	7 105	38 565	66 141	15 724	424 569	19 955
Endometrial cancer	23 205	6 605	820	8 677	7 897	1 363	48 567	12 919
Gallbladder disease	262 992	128 805	15 987	147 510	105 628	5 544	666 466	137 292
Hyperlipidemia	126 339	NA	NA	372 308	48 372	NA	547 019	61 266
Hypertension	97 977	265 317	75 655	1 071 137	567 629	NA	2 077 715	656 558
Pulmonary embolism	92 821	NA	NA	NA	35 538	NA	128 359	38 251
Stroke	2 036 897	77 063	9 565	318 160	394 872	909	2 837 466	106 943
Type 2 diabetes	304 245	128 805	36 729	190 896	155 974	17 996	834 645	423 165
<b>Total</b>							<b>9 714 913</b>	<b>1 822 087</b>

Note: NA = not available.

\*Amounts are given in 1997 Canadian dollars.

†Includes cost of hospital drugs.

‡Excludes cost of hospital drugs.

§This cost was derived by multiplying the total cost for a given comorbidity by the comorbidity's PAF (Table 1).



than those reported for other countries.<sup>9,11-13</sup> One explanation may be that our relative risks refer to the excess risk for a comorbidity in an obese subject relative to a nonobese subject, whereas 3 of the 4 other studies<sup>9,12,13</sup> compared the risk in an obese person with that in a lean person. This discrepancy, along with the varying BMI cutoffs used to define obesity and the number of comorbidities included, make international comparisons problematic.

Given these considerations, our higher cost estimate from the sensitivity analysis is probably closer to the true cost of obesity. The sensitivity analysis allowed us to incorporate the imprecision surrounding our PAFs and cost estimates.

Finally, stepping back from all the cost estimates presented here, we need to remind ourselves continually that obesity is associated with substantial morbidity and mortality. According to a recent publication, about 300 000 people die each year in the United States because of being obese.<sup>44</sup> In-depth assessments of the therapeutic benefits and cost-effectiveness of management strategies for obesity and other chronic conditions are imperative for the rational allocation of future health expenditures in Canada.

We thank Daphne Guh, Hector Leon, Narmin Nepomuceno, Tuhin Rahman, Dianne Skippen, Fatma Telli and Sophia Wang for their research and administrative assistance.

Funding to support this research was provided by a grant to Dr. Birmingham from Hoffmann-La Roche Limited. The authors retained complete independence from the sponsor in selecting methodology, data sources and manuscript preparation. Dr. Anis's research program is supported by a grant from the British Columbia Ministry of Health and the Ministry responsible for Seniors. Dr. Palepu's research is supported by a scholarship from the St. Paul's Hospital Foundation.

Competing interests: Dr. Birmingham receives funds from Hoffmann-La Roche Limited and other companies to attend meetings and conferences related to obesity.

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