A patient-centred approach to estimate total annual Healthcare Costs by Body Mass Index in the UK Counterweight Programme

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Abstract

Background

Previous studies, based on relative risks for certain secondary diseases, have shown greater healthcare costs in higher body mass index (BMI) categories. The present study quantifies the relationship between BMI and total healthcare expenditure, with the patient as the unit of analysis.

Methods

Analyses of cross-sectional data, collected over 18-months in 2002-2003, from 3,324 randomly-selected patients, in 65 general practices across UK. Healthcare costs estimated from primary care, outpatient, accident/emergency and hospitalisation attendances, weighted by unit costs taken from standard sources.

Results

In univariate analyses, significant associations ($p<0.05$) were found between total healthcare expenditure and all dependent variables (women>men, drinker<non-drinkers, smokers>non-smokers, and increasing with greater physical activity, age and BMI. In multivariate analysis, age, sex, BMI, smoking and alcohol consumption remained significantly associated with healthcare cost, and together explained just 9% of the variance in healthcare expenditure. Adjusted total healthcare cost was £16 (95% CI £11-£21) higher per unit BMI. All cost categories were significantly ($p<0.003$) higher for those with BMI >40 compared to BMI<20 kg/m^2: prescription drugs (men: £390 versus £16; women: £211 versus £73), hospitalisation (men: £72 versus £0; women: £243 versus £107), primary care (men: £191 versus £69; women: £268 versus £153) and outpatient care (£234 versus £107 women only).

Conclusions

Annual healthcare expenditure rose a mean of £16 per unit greater BMI, doubling between BMI 20-40kg/m^2. This gradient may be an underestimate if the lower-BMI patients with heights and weights recorded had other costly diseases.

Word count - 240

Introduction

The obesity epidemic is a major drain on world economies, as obesity becomes the leading cause of ill-health in the developed world.[1] In Scotland, 66% of adults are overweight (BMI>25), including 26% obese with BMI >30kg/m^2.[2] Obesity is a known risk factor for a variety of diseases, including cardiovascular disease, diabetes, colon cancer, arthritis, gallbladder disease and depression.[3] It also increases "minor illnesses" and drug prescriptions in almost all prescribing categories.[4]

In addition to direct healthcare cost, obesity also causes lost productivity, from absence from work and premature death. Partial costing based on limited health outcomes, for which age/sex/BMI-stratified data exist, put the direct healthcare cost of obesity in the UK in 2002 at between £991 million to £1.124 billion, plus indirect costs of between £2.4 billion-2.7 billion.[5]

There are, methodologically, two approaches to calculating the healthcare cost of obesity. Most have linked the relative risk of selected diseases associated with obesity, to the population prevalence of obesity and applied standard unit costs.[6-8] This population-attributable-risk method provides an estimate of only part of the economic burden of obesity because few secondary diseases have sound epidemiological data broken down by age, sex and BMI. A second approach is direct linkage of obesity or BMI data to healthcare expenditure at the individual level.[9-12]

A recent systemic review by Mueller-Riemenschneider et al.[13] reported obesity-related healthcare burdens, based only on diabetes, CHD, colon cancer costs, of up to 10.4 billion Euros across Western European countries. The figure varies widely from 0.09 % to 0.61 % of the gross domestic product of each country. Obese individuals are more likely to be hospitalised.[14] In Sweden, excess annual healthcare cost for the overweight (BMI = 25 to ≤30kg/m^2) and the obese (BMI≥30kg/m^2) was estimated at 2.3 % (US$ 269 million) of the country's total hospital care.[15] In Brazil, the estimated total cost of overweight and obesity is put at 3.0 % of total inpatient cost for men and 5.8 % for women, aged 20-60 years.[16] Among the claims made on 61 US employers' health plans, obesity-

related medical expenses (not including drugs) accounted for 2.8% of all medical costs between 2000-2004.[17]

Above BMI 30 kg/m^2, healthcare costs increase further.[8,9,11,12,18-25] In 15,355 US adults, the adjusted average number of all-cause hospitalisations over 13 years was 1,316, 1,543 and 2,025 per 1,000 for adults with BMI <25, 25-30 and >30kg/m^2.[14].

In a cross-sectional study involving 34,932 US participants, Wang et al.[25] reported greater healthcare cost with each BMI unit between 25-45kg/m^2, of US$ 119.7 (4%) per unit BMI for medical cost, and US$82.6 (7%) per unit BMI for pharmaceutical cost. A Canadian study of adults in 1994 reported $8.90 per capita greater cost of physicians' services per unit BMI above 20kg/m^2.[10] Using a hypothetical cohort Markov-type model of obese individuals, Rappange et al.[26] proposed higher lifetime drug expenditures for obese people, and savings from obesity prevention.

Similarly, a patient-centred approach to increased actual drug prescription costs associated with greater BMI has been published.[4] The total healthcare cost associated with a unit increase in BMI in the UK population is not known. The present study aimed to quantify the relationship between BMI and total healthcare cost, calculated from recorded resource use, with the individual patient as the unit of analysis.

Methods

Secondary analyses were conducted on cross-sectional data collected as part of the Counterweight audit.[27] Ethical approval was received from the West Midlands Multi-Centre Research Ethics Committee (MREC) and subsequently from various local ethics committees. The sample was 3,450 (1,385 men and 2,065 women) randomly selected adult patient records collected over an 18-month period in 2002-2003, from 65 UK Primary Care practices selected to represent urban and rural regions across the UK, with a wide range of socio-economic catchments. They were three random samples of those patients who for some reason (undefined) had their height and weight recorded,

1150 from each BMI stratum <25, 25-30 and >30. The data also included geographic area, smoking, alcohol consumption and physical activity participation. Healthcare data included appointments with the general practitioner, practice nurse, health visitor, dietitian and outpatient specialist appointments. They also included accident and emergency (A&E) attendance and hospital admissions, healthcare consumption at the primary care, outpatient and inpatient costs were calculated based on these indices, adding drug prescription costs, which have already been published[4].

BMI was computed from recorded mean weight and height during audit period (for those with multiple weight records) (n=418), single records during audit (n=1,578), or last recorded data before the audit (n = 1,453). There were 896 current smokers, 649 ex-smokers and 1,552 non-smokers, (status not recorded for 353 (10%)), and 2,009 participants drank alcohol while 801 did not, (data unavailable for 640 participants (19%)). Physical activity categories included 262 inactive, 515 light, 471 moderate and 65 heavy physical activity, (data unavailable for 2011 participants (60%)).

Five categories of cost – primary care, A&E department, outpatient department, and in-patient stay - were identified. The previously calculated total cost of drugs prescribed for each patient over the 18-month period was added,[27] to provide the total healthcare cost of each patient for the 18-month period. Assuming that costs were spread evenly the annual (12-month) healthcare cost was calculated for each patient [as 12/18 x 18-month cost]. Healthcare unit costs were taken from standard figures.[28]

Prescription costs were not available for one general practice (50 participants). The number of GP appointments for one participant was not known and 75 participants had no record of either weight or height and hence no BMI. These 126 participants were excluded from all further analyses. Therefore, 3324 participants (1971 women and 1353 men) with data complete for healthcare cost and BMI were included for analysis.

Statistical Analyses

Analyses were undertaken using SPSS version 19.0. Summary statistics of personal, lifestyle variables (smoking, alcohol intake and physical activity level) and healthcare costs were produced. Dummy variables were created for missing data and these were considered as a group (unknown) under each variable. ANOVA was used to explore differences in healthcare costs across each lifestyle factor. The mean unadjusted healthcare cost associated with each unit BMI was calculated. The small numbers with BMI below 20kg/m^{-2} (2.3%) and above 40kg/m^{-2} (3.2%), were collapsed.

In multivariate analyses, the best-fit model was constructed checking for assumptions of linearity, constancy of variance and normality. Annual healthcare costs at quintiles of BMI (<25, 25-30, 30-35, 35-40, >40kg/m^2) were compared to assess associations with BMI. Furthermore, BMI^2 was incorporated to test if a quadratic association was more appropriate. Multiple linear regression modelled change in annual healthcare cost per unit change in BMI. Annual healthcare cost (±95% confidence interval) associated each unit of BMI, adjusting for age, sex and lifestyle (the marginal effect) was obtained. A two-part model, to calculate the association on condition that cost has been incurred, was also tested.

Results

Data are presented on UK adults (aged 17-76y) randomly selected from a list of patients who, for some reason (undefined) had had their height and weight recorded in primary care records. During the 18-month audit period, there were 18,301 GP appointments for 2,827 patients, 6,384 Practice Nurse appointments for 1,754 patients, and 57 dietitian appointments for 41 patients, and 62% (n= 2230) of the study participants received at least one prescription drug. There were 5,673 visits to various outpatient departments by 2,983 of the participants, and 384 admissions for a total of 1,545 bed days. Hospitalisation duration ranged from 1-54 days, median two days. There were 336 visits to the A&E department by 254 patients.

Mean (SD) age was 47(15)y and 48(14)y for women and men respectively. BMI ranged from 16.2-64.3kg/m^2 for women and 18.4-53.9kg/m^2 for men; mean (SD) of 28.1(6.0)kg/m^2 and 27.9(5.2)kg/m^2 respectively. Mean healthcare costs for each category of care are displayed in Table 1. Most of the patients included had some health resource use: 3.6% of the women and 12.5% of the men had zero healthcare cost during the study period.

Annual healthcare cost was significantly ($p<0.001$) associated with BMI and with age, in men (Pearson's $r=0.10$, $r=0.29$ respectively) and also in women ($r=0.13$, $r=0.22$ respectively). This significant association of cost with age and BMI was also observed at the different levels of healthcare (supplementary table 1). Mean healthcare cost was therefore, generally higher at higher BMI though the relationship is not totally clear with unadjusted figures (supplementary table 2).

There were 744 current smokers with reported mean (SD) number of cigarettes smoked per day of 17(11). Alcohol consumption was more common (n=1796) and reported mean (SD) consumption was 13(11) units per week. The number of cigarettes smoked currently per day (Pearson $r=0.03$, $p=0.10$) and the number of units of alcohol drank per week ($r=-0.04$, $p=0.06$) showed poor correlation with annual healthcare cost. In grouped (categorical) analyses, ex-smoker, non-drinkers and the inactive had significantly higher healthcare cost than other categories (Figure 1).

Annual healthcare cost at quintiles of BMI suggested a linear relationship, and linear association explained 9% of the variance in healthcare cost. Using a quadratic function (BMI^2) in the model was not significant ($p=0.07$). Higher annual healthcare cost was significantly associated with increasing age, increasing BMI, being female and smoking (Table 2). No demonstrable effect was observed with physical activity, while alcohol consumption was associated with a lower cost. After adjusting for sex, age, smoking, alcohol consumption and physical activity, each higher unit BMI was associated with £16 (95% CI £11 to £21) higher annual healthcare cost. BMI accounted for 1.3% of the variance in healthcare cost. The two-part model produced similar results. As demonstrated in Figure 2, annual healthcare cost more than doubles at BMI 40kg/m^2 compared to 20kg/m^2.

All categories of cost were higher for those with BMI above 40kg/m^2 compared to BMI below 20kg/m^2, significantly so for prescription drugs (£390 versus £16 for men, £211 versus £73 for women, p<0.001), hospitalisation (£72 versus £0 for men, £243 versus £107 for women, p=0.002), primary care (£191 versus £69 for men, £268 versus £153 for women, p<0.001) and outpatient care (£234 versus £107 women only, p<0.003) [Figure 2 and much clearer in the coloured supplementary figure].

Discussion

The present study used individual-level healthcare cost data to quantify the change in healthcare cost associated with greater body mass index. The data indicated that a unit difference in BMI of a UK adult relates to a £16 difference in annual healthcare cost, across the BMI range 20-40kg/m^2, with very similar figures for men and women. The data were collected from a large number (65) of randomly selected general practices across the UK, reflecting both rural and urban populations, and across a wide range of socio-economic catchments, as indicated by post codes. The sample size was large (n=3324) and the ability to control for lifestyle factors was important, to confirm the significant association between BMI, lifestyle factors and healthcare cost.

At the univariate level of analyses, healthcare cost was significantly associated with age, sex, BMI and lifestyle factors. Women had greater healthcare cost than men, and cost increased with increasing age. Physical activity appeared to be protective while smoking increases healthcare cost. After adjustments, inactivity was no longer significantly associated with healthcare cost, perhaps because the effects of physical activity on healthcare cost are mediated through changes in BMI and after controlling for BMI, and smoking and drinking (which also influence BMI), the independent effect of physical activity was no longer significant.

Paradoxically, alcohol consumers had lower healthcare cost compared to non-drinkers. The relationship between health and alcohol consumption is a “J-shaped” curve[29], such that low-to-

moderate drinking is protective against ill-health, so might reduce healthcare cost. However, it could be that drinkers did not take up healthcare appointments or stopped seeking healthcare, thus reducing their healthcare cost. Alternatively, sick individuals might have stopped drinking or simply misreported no consumption, thus leading to misclassification. Social desirability response bias is a major limitation to all self-report data[30]. Many confounders and mediators affect the relationship between healthcare cost and BMI. Biologically, men and women have different health needs. BMI increases with age, and health commonly deteriorates. Physical activity is useful in weight control, and has other health benefits. Smokers tend to have lower weights but poorer health, while alcohol consumption may be associated with excess weight and also poor health, and non-drinkers include sick former drinkers.

After adjusting for age, sex and lifestyle, increasing BMI remained significantly associated with higher healthcare cost. If this association were causal, BMI might not simply be in the causal pathway between biology/lifestyle and healthcare cost, but may have its own marginal effect on healthcare cost. Across the BMI range 20-40kg/m^2, adjusted annual healthcare cost was £16 greater for each higher unit BMI. This figure might be of value in planning obesity prevention and weight management services. However, the gradient of healthcare costs, between BMI 20 and 40kg/m^2 seen in this study is likely to underestimate the true gradients, because the study relied on data from patients whose height and weight had been recorded. The reasons for recording height and weight in primary care vary. Firstly, only patients attending for a consultation of some kind are included. Secondly, while those with BMI >30kg/m^2 may have had height and weight recorded purely because of their evident obesity, these measurements are rarely made for normal-weight patients (BMI <25kg/m^2) – and usually only if there is a disease which threatens weight-loss. Thus the normal-weight patients in the present study are likely to be those with relatively high disease burdens.

In figure 2, it appears healthcare costs plateaus at BMI 35 kg/m^2. This may be a statistical uncertainty due to the relatively small numbers in the highest BMI categories. Above BMI 35 kg/m^2, the number of subjects at each BMI point dropped to <60 compared to >200 subjects for BMI 22-28

219 kg/m^2, and >100 subject for BMI 29-34 kg/m^2. The study was not stratified to achieve equal numbers
220 for each BMI point. However, these numbers may reflect current population distribution of BMI.
221 There is in fact a small increase in adjusted healthcare cost at each higher BMI point above 35 kg/m^2.
222 Viewed as a whole, there is a steady increase in healthcare costs with higher BMI.

223 A limitation of the project was variation in how and when weight and height were measured. In more
224 recent times, due to the rising awareness of obesity, patients usually have weight and height recorded
225 at registration with a GP. In this study, height was generally by self-report. There were multiple
226 entries for weights of some people, for whom the average weight recorded during the data collection
227 period was used. For some participants, there were no recorded weights during the study period and
228 the last recorded weight, which could have changed, was used. However, if weight is not being
229 recorded, it is less likely that there is weight change in the particular individual.

230 Alcohol, smoking and physical activity were self-reported, so the reliability of these measurements is
231 weak. However, using categorical data for these variables improved their validity. There were
232 missing data for these measurements, requiring creation of dummy variables. Also, the data in
233 medical records did not include information on education, occupation or socioeconomic status,
234 which are important determinants of health and healthcare use.

235 These cross-sectional data may be used for planning healthcare and weight management
236 programmes, though with caution; they are based on patients who had height and weight recorded in
237 primary care and not a representative sample of the general population.

238 Conclusion

239 Each unit increase in BMI is associated with £16 higher annual healthcare cost, after adjusting for
240 sex, age, smoking, alcohol consumption and physical activity level. BMI accounts for more than one
241 per cent of the variance in healthcare cost among individuals, but the healthcare cost more than

doubles for an individual with BMI 40kg/m^2 compared to BMI 20kg/m^2. This gradient may be an underestimate if the lower-BMI patients with heights and weights recorded had other costly diseases.

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Conflicts of interest

None declared by any co-author

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References

1. World Health Organization (WHO). *Obesity and Overweight*, Geneva 2006. Available online: http://www.who.int/dietphysicalactivity/publications/facts/obesity/en/ (accessed May 2012).

2. Scottish Health Survey 2008. The Scottish Government. ISBN 9780755981076, UK, Sept 29, 2009. Available online at: *http://www.scotland.gov.uk/Publications/2009/09/28102003/76* (Accessed may 2012).

3. Bray GA. Pathophysiology of obesity. *AJCN* 1992; **55:** 488S-494S.

4. Counterweight Project Team. Influence of body mass index on prescribing costs and potential cost savings of a weight management programme in primary care. *J Health Ser Res & Policy* 2008; **13(3):** 158–166.

5. HMSO Summary of the House of Commons Health Committee report on Obesity 2004. Available online at: http://www.parliament.the-stationery-office.co.uk/cmhealth.htm (Accessed May 2012).

6. Birmingham CL, Muller JL, Palepu A, Spinelli JJ, Anis AH. The cost of obesity in Canada. *Can Med Assoc Journal* 1999; **160:** 483–488.

7. Katzmarzyk PT, Janssen I. The economic costs associated with physical inactivity and obesity in Canada: an update. *Can J Applied Physio* 2004; **29:** 90–115.

8. Wolf AM, Finer N, Allshouse AA, Pendergast KB, Sherrill BH, Caterson I, et al. PROCEED: Prospective Obesity Cohort of Economic Evaluation and Determinants: baseline health and healthcare utilization of the US sample. *Diab Obesity Metabol* 2008; **10(12):** 1248-1260.

9. Quesenberry Jr CP, Caan B, Jacobson A. Obesity, health services use, and healthcare costs among members of a health maintenance organization. *Archive Internal Med* 1998; **158(5):** 466-472.

10. Finkelstein MM. Obesity, cigarette smoking and the cost of physicians' services in Ontario. *Can J Public Health* 2001; **92:** 437–440.

11. Sturm R. The effects of obesity, smoking, and drinking on medical problems and costs. *Health Affilates* (Millwood) 2002; **21(2):** 245-253.

12. Raebel MA, Malone DC, Conner DA, Xu S, Porter JA, Lanty FA. Health services use and healthcare costs of obese and nonobese individuals. *Archives Internal Med* 2004; **164(19):** 2135-2140.

13. Mueller-Riemenschneider F, Reinhold T, Berghofer A, Willich SN. Health-economic burden of obesity in Europe. *Eur J Epidem* 2008; **23(8):** 499-509.

14. Han E, Truesdale KP, Taber DR, Cai J, Juhaeri J, Stevens J. Impact of overweight and obesity on hospitalization: race and gender differences. *Int J Obes* 2009; **33(2):** 249-256.

15. Borg S, Persson U, Odegaard K, Berglund G, Nilsson JA, Nilsson PM. Obesity, survival, and hospital costs - Findings from a screening project in Sweden. *Value Health* 2005; **8(5):** 562-571.

16. Sichieri R, do Nascimento S, Coutinho W. The burden of hospitalization due to overweight and obesity in Brazil. *Cadernos De Saude Publica* 2007; **23(7):** 1721-1727.

17. Long DA, Reed R, Lehman, G. The cost of lifestyle health risks: Obesity. *J Occup Environ Med* 2006; **48(3):** 244-251.

18. Heithoff KA, Cuffel BJ, Kennedy S, Peters J. The association between body mass and healthcare expenditures. *Clinl Therapy* 1997; **19(4):** 811-820.

19. Thompson D, Brown JB, Nichols GA. Body mass index and future healthcare costs: A retrospective cohort study. *Obes Res* 2001; **9(3):** 210-218.

20. Bungum T, Satterwhite M, Jackson AW, Morrow JR. The Relationship of Body Mass Index, Medical Costs, and Job Absenteeism. *Amer J Health Behav* 2003; **27(4):** 456-462.

21. Andreyeva T, Sturm R, Ringel JS. Moderate and severe obesity have large differences in healthcare costs. *Obesity Research* 2004; 12(12): 1936-1943.

22. Wee CC, Phillips RS, Legedza ATR, Davis SB, Soukup JR, Colditz GA, et al. Healthcare expenditures associated with overweight and obesity among US adults: importance of age and race. *Amer J Public Health* 2005; **95:** 1159-1165.

23. von Lengerke T, Reitmeir P, John J. Direct medical costs of (severe) obesity: a bottom-up assessment of over- vs. normal-weight adults in the KORA-study region (Augsburg, Germany)]. *Gesundheitswesen.* 2006; **68(2):** 110-115.

24. Valderrama A, Lawrence L. Association between BMI and healthcare expenditures using the 2002 Medical Expenditure Panel Survey. *Value in Health* 2006; **9(3):** A89-A90.

25. Wang F, McDonald T, Bender J, Reffitt B, Miller A, Edington D. Association of healthcare costs with per unit body mass index increase. *J Occup Environ Med* 2006; **48(7):** 668-674.

26. Rappange DR, Brouwer WBF, Hoogenveen RT, van Baal PHM. Healthcare costs and obesity prevention: drug costs and other sector-specific consequences. *Pharmacoeconomics* 2009; **27(12):** 1031-44.

27. Counterweight Project Team. A new evidence-based model for weight management in primary care: the Counterweight Programme. *J HumNutr Diet* 2004; **17:** 191–208.

28. Curtis L. Unit costs of health and social care. Personal social services research unit report. Canterbury: University of Kent, 2009.

29. Rehm J, Greenfield TK, Rogers JD. Average Volume of Alcohol Consumption, Patterns of Drinking, and All-Cause Mortality: Results from the US National Alcohol Survey. *Amer J Epidem* 2001; **153(1):** 64-71.

30. Worsley A, Baghurst KI, Leich DR. Social desirability response bias and dietary inventory responses. *Hum Nutr App Nutr* 1984; **38:** 29-35.

Table 1: Mean and 95% CI of annual cost at each category of healthcare in UK Counterweight Project 2002-2003. The means are for the number (N) of individuals who benefitted from the care category.

Cost category	Women			Men		
	N	Mean (£)	95% CI (£)	N	Mean (£)	95% CI (£)
Primary Care	1774	176	168 - 184	1112	131	123 - 139
Out Patient	946	291	273 - 310	527	293	269 - 316
Accident & Emergency	151	81	73 - 88	100	84	73 - 96
Hospitalisation	172	1162	949 - 1376	100	1307	1056 - 1557
GP Prescription	1645	144	131 - 156	975	180	160 - 201
Any Healthcare	1860	557	519 - 595	1184	519	471 - 568

Table 2: Multiple linear regression model for annual healthcare cost in the UK Counterweight Project 2002-2003, showing significant associations and their individual contribution to variance in healthcare (R^2 change). Adjusted annual healthcare cost increased with age, BMI and smoking, and appear to decrease with drinking.

	Unstandardized Coefficients β	95% CI	Sig.	R^2 Change
Sex (male)	-78	-133 to -23	0.006	0.003
Age (y)	13	11 to 15	<0.001	0.06
BMI (kg/m^2)	**16**	**11 to 21**	**<0.001**	**0.013**
Alcohol				
no	reference category			
Yes	-121	-187 to -54	<0.001	0.001
Unknown	-107	-200 to -14	0.024	0.003
Smoking				
Never smoked	reference category			
Ex-smoker	100	26 to 174	0.008	0.001
Current smoker	72	5 to 138	0.034	0.002
Unknown	-67	-174 to 40	0.222	-
Physical activity				
Heavy	reference category			
Inactive	178	-37 to 392	0.105	-
Light	134	-70 to 337	0.199	-
Moderate	40	-164 to 244	0.702	-
Unknown	147	-48 to 342	0.14	-

Figure Legends

Figure 1: Associations of annual healthcare cost, with smoking, alcohol consumption and physical activity in the UK Counterweight Project 2002-2003. On the vertical axes are mean and 95% confidence interval of the annual healthcare cost associated with each category.

Figure 2: Mean annual healthcare cost by care category at each BMI unit, adjusted for sex, age, smoking, alcohol consumption and physical activity.