Healthcare costs associated with overweight and obesity at an individual versus a population level – a HUNT study

ORIGINAL ARTICLE

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BACKGROUND

The interpretation of research results is affected by how results are presented. We show the importance of presenting the association between body mass index (BMI) and healthcare costs from both the individual perspective and the population perspective.

MATERIAL AND METHOD

Using measurements of height and weight from the Nord-Trøndelag Health Study (HUNT Study) linked to register data on specialist healthcare costs and demographics, we estimated the association between BMI and specialist healthcare costs by means of regression analyses.

RESULTS

From an individual perspective, the association between BMI and specialist healthcare costs was strongest in people in obesity classes 2 and 3 (BMI ≥ 35 kg/m²). In contrast, from a population perspective, the association was strongest in the case of overweight (BMI ≥ 25 kg/m²) or obesity class 1 (BMI ≥ 30 kg/m²), as there are more people in this BMI range.

INTERPRETATION

The study emphasises the importance of including the population perspective in research studies and policy decision-making processes. People with severe obesity have a high individual risk, but their use of health services has less significance for the overall costs of health care since they are fewer people in this group.

MAIN FINDINGS

By estimating the association between body mass index (BMI) and specialist healthcare costs, we illustrate the differences between the individual perspective and the population perspective: a low disease risk in a large proportion of the population can lead to at least as many cases as a high disease risk in a small proportion of the population.

From an individual perspective, the cost of obesity was highest for people with severe obesity (BMI > 35 kg/m²).

From a population perspective, taking into consideration the proportion of the population with normal weight, overweight or obesity, the cost was highest in those with overweight or mild obesity, (BMI 25–35 kg/m²), as this group is larger.
Geoffrey Rose's seminal article from 1985, which is still relevant today, illustrates the importance of distinguishing between the individual perspective and the population perspective (1). The main message is that a low disease risk in a large proportion of the population can lead to at least as many cases as a high disease risk in a small proportion of the population.

Even though Rose's description of the strengths and weaknesses of the two perspectives have long been known, the individual perspective is still given most focus today, often through measures to counteract high risk and provide personalised medicine. A population perspective entails looking at the distribution of disease in the whole population, thereby including the population-wide burden of less severe cases. In this article, we demonstrate why it is not beneficial merely to emphasise an individual perspective. We use the example of body mass index (BMI) and healthcare costs as a suitable measurement of the total disease burden.

High BMI is a well-established cause of morbidity and early death (2). National treatment guidelines recommend treating people with class 2 obesity (BMI ≥ 35 kg/m²) or a waist circumference of more than 102 cm for men and 88 cm for women. Factors such as weight-related risk and comorbidity also impact on the recommendation. The guidelines thus target the reduction of morbidity in individuals with the highest disease risk (3).

In the period 1984–2008, the proportion of people with obesity (BMI ≥ 30 kg/m²) in Norway grew from 8 % to 23 % in men, and from 13 % to 23 % in women (4). But it was not only the proportion with obesity that increased. Average BMI increased by approximately one BMI point each decade between 1980 and 2000 (5). This was a result of a shift in the entire BMI distribution towards a higher BMI. Consequently, BMI increased among those with a low BMI as well as those with a high BMI.

In this study, we estimated the change in specialist healthcare costs for a one point difference in BMI at various BMI levels. As there are more people with overweight than people with obesity in the population, we assumed that the individual perspective and the population perspective would produce different results.

Material and method

We used data from the third round of the Nord-Trøndelag Health Study (HUNT3), the Norwegian Patient Registry (NPR) and Statistics Norway.

All inhabitants of the former county of Nord-Trøndelag aged ≥ 20 years were invited to participate in HUNT3, and 54 % took part (6). The data collection included surveys, interviews and clinical measurements, including measurement of height (to the nearest centimetre) and weight (to the nearest half kilo) (6). Sociodemographic variables such as smoking status, marital status, urban/rural living status, and country of birth were self-reported. The HUNT3 study (2006–2008) overlapped with the introduction of the Norwegian Patient Registry in 2008.

HUNT3 data were linked to data on the use of specialist health care and diagnosis-related groups (DRGs) based on reporting to the NPR in the period 2009–2016. We also used data from Statistics Norway on income and education in the same year as the individual responded to the HUNT survey, in addition to data on death or migration in the period 2009–2016.

Annual specialist healthcare costs from 2009 to 2016 was calculated by multiplying the DRG cost weight by the average cost per DRG-point for the respective year (7). Those who were not registered as using health services in a given year but who lived in Norway were assumed to have had zero use of health services. Persons who were not resident in Norway in a given year were excluded for that year. In the case of those who had died, health service
use was incorporated up to and including the year of their death. We then estimated the average annual healthcare costs adjusted to Norwegian kroner in 2016 using the consumer price index (8).

The association between BMI and specialist healthcare costs was estimated using a two-part model. First, we used logistic regression to estimate the association between BMI and the likelihood of using health services (healthcare cost > 0). Then we used a general linear model with a log-link and gamma distribution to estimate the association between BMI and total healthcare use (healthcare costs given that these were greater than zero). The two parts of the model were combined using the methods described by Deb et al. (9).

We adjusted for confounding variables in the association between BMI and healthcare costs based on knowledge obtained from a 2017 systematic literature review by Kent et al. (10): age (continuous), education (primary and lower secondary school, upper secondary school, short higher education (≤ 3 years), and long higher education (> 3 years)), smoking status (never smoked, former smoker, daily smoker, and occasional smoker), marital status (married/cohabitant, never married, widow/widower, and divorced/separated), urban/rural living status, income (continuous) and country of birth (born in Norway of Norwegian parents, and all others) (10). BMI was included as a continuous variable in all analyses.

Earlier research has shown that the association between BMI and healthcare costs is non-linear (11–14). In order to estimate the non-linear association between BMI and healthcare costs, we added a quadratic BMI term in the regression equation. In the individual perspective, we reported the marginal change in healthcare costs per unit change in BMI. Earlier studies have shown that the association between BMI and healthcare costs is U-shaped or J-shaped (11–14). This means that the costs for an individual with a very low or very high BMI are higher than the costs for an individual of normal weight. Therefore we expect that the marginal difference from an increase in BMI 15 kg/m² to 16 kg/m² is negative (decreasing use of healthcare and declining costs) while the marginal difference from an increase in BMI 30 kg/m² to 31 kg/m² is positive (increasing use of healthcare and increasing costs).

To estimate the effects from the population perspective, we multiplied the marginal change in healthcare costs for each BMI value by the proportion of HUNT3 participants with that specific BMI value. For example, the marginal change between BMI 20 kg/m² and 21 kg/m² was multiplied by the proportion of individuals with BMI 20.00–20.99 kg/m² etc. Then we multiplied the BMI-adjusted marginal change by the number of individuals who were 20 years and older in Norway in 2022 (2,103,744 men and 2,086,792 women (15)). As the association between BMI and healthcare costs have previously proved to be sex specific, we performed analyses for both men and women.

**ETHICAL ASPECTS**

The study was approved by the Regional Committee for Medical and Health Research Ethics and by all relevant register owners (Application ID 30029, application number 2016/537).

**Results**

The sample consisted of 22,648 men and 27,391 women with an average age of 53 years (standard deviation 19.0) (Table 1). In total, 75 % of the men and 61 % of the women had overweight (BMI > 25 kg/m²) or obesity (BMI > 30 kg/m²). Of these, 3.7 % of the men and 6.6 % of the women had class 2 obesity (BMI ≥ 35 kg/m²), indicating that the threshold for treatment in the specialist health service has been reached. A total of 22.4 % of the men had a waist circumference of > 102 cm, and 23.4 % of the women had a waist circumference of > 88 cm (3).
Table 1

Descriptive information on the sample (everyone who participated in HUNT3), distributed between men and women. The figures represent the number (n) and the percentage (%) in the different categories.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>Men Number (%)</th>
<th>Women Number (%)</th>
</tr>
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<tr>
<td>Total</td>
<td>All</td>
<td>22,648 (100.0)</td>
<td>27,391 (100.0)</td>
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<td>BMI category (kg/m²)</td>
<td>Underweight (BMI &lt; 18.5)</td>
<td>69 (0.3)</td>
<td>234 (0.9)</td>
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<td>Normal weight (BMI 18.5–25)</td>
<td>5,631 (24.9)</td>
<td>10,418 (38.0)</td>
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<td>Overweight (BMI 25–30)</td>
<td>11,863 (52.4)</td>
<td>10,334 (37.7)</td>
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<td>Obesity class 1 (BMI 30–35)</td>
<td>4,241 (18.7)</td>
<td>4,599 (16.8)</td>
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<td>Obesity class 2+ (BMI ≥ 35)</td>
<td>844 (3.7)</td>
<td>1,806 (6.6)</td>
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<td>Level of education</td>
<td>Primary and lower secondary school</td>
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<td>6,390 (23.3)</td>
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<td>Upper secondary school</td>
<td>13,091 (57.8)</td>
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<td>University college/university &lt; 4 years</td>
<td>3,626 (16.0)</td>
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<td>University college/university ≥ 4 years</td>
<td>1,347 (5.9)</td>
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<td>Never smoked</td>
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<td>Former smoker</td>
<td>7,976 (35.2)</td>
<td>7,863 (28.7)</td>
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<td>Daily smoker</td>
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<td>Occasional smoker</td>
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<td>13,994 (61.8)</td>
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<td>Widow/widower</td>
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<td>Urban environment</td>
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<td>17,420 (63.6)</td>
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<td>Rural environment</td>
<td>8,049 (35.5)</td>
<td>9,573 (34.9)</td>
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<td></td>
<td>Missing information</td>
<td>262 (1.2)</td>
<td>398 (1.5)</td>
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</table>

BMI AND HEALTH SERVICE COSTS

Healthcare costs associated with overweight and obesity at an individual versus a population level – a HUNT study | Tidsskrift for Den norskelegeforening
From an individual perspective, the change in specialist healthcare costs with a one BMI point increase was greatest at the extremes of the BMI distribution (Figure 1, Figure 2). This means that if we compare a man with BMI 37 kg/m$^2$ with a man with BMI 38 kg/m$^2$, the expected specialist healthcare costs increased by NOK 2,110, while a corresponding comparison of men with BMI 27 kg/m$^2$ and 28 kg/m$^2$ showed an increase in expected costs of NOK 293. Similarly, a woman with BMI 37 kg/m$^2$ compared with a woman with BMI 38 kg/m$^2$ produced an increase in specialist healthcare costs of NOK 1,306, while a corresponding comparison of women with BMI 27 kg/m$^2$ and 28 kg/m$^2$ gave an increase of NOK 277.

**Figure 1** Marginal specialist healthcare expenditure following a one BMI unit increase in men in Norway, estimated from an individual perspective. The red lines (for BMI 30 kg/m$^2$ and 35 kg/m$^2$) indicate treatment thresholds for BMI. BMI has the greatest impact on the marginal costs at the extremes of the scale. Confidence intervals of 95% are shown in order to illustrate the degree of uncertainty associated with the estimates.
Figure 2 Marginal specialist healthcare costs following a one BMI unit increase in women in Norway, estimated from an individual perspective. The red lines (for BMI 30 kg/m² and 35 kg/m²) indicate treatment thresholds for BMI. BMI has the greatest impact on the marginal costs at the extremes of the scale. Confidence intervals of 95% are shown in order to illustrate the degree of uncertainty associated with the estimates.

From a population perspective (Figure 3, Figure 4), the greatest change in specialist healthcare costs was found following a one BMI point increase in the part of the population with overweight (BMI 25–30 kg/m²) or mild obesity (BMI 30–35 kg/m²). This applied to both men and women. The findings imply that from a population perspective, the greatest potential for reducing specialist healthcare costs is seen around BMI 29/30 kg/m².

Figure 3 Marginal specialist healthcare costs following a one BMI unit increase in men in Norway, estimated from a population perspective. The red lines (for BMI 30 kg/m² and 35 kg/m²) indicate treatment thresholds for BMI. BMI has the greatest impact on the marginal costs at the extremes of the scale. Confidence intervals of 95% are shown in order to illustrate the degree of uncertainty associated with the estimates.
35 kg/m²) indicate treatment thresholds for BMI. When taking into account the size of the population at different places on the BMI scale, the marginal costs are highest in the overweight part of the population.

Figure 4 Marginal specialist healthcare costs following a one BMI unit increase in women in Norway, estimated from a population perspective. The red lines (for BMI 30 kg/m² and 35 kg/m²) indicate treatment thresholds for BMI. When taking into account the size of the population at different places on the BMI scale, the marginal costs are highest in the overweight part of the population.

We will use the same example as above: if all men with BMI 37 kg/m² increased their BMI to 38 kg/m², we could expect a rise in healthcare costs of NOK 24,473,152, compared with NOK 69,604,936 if all men with BMI 27 kg/m² increased their BMI to 28 kg/m². Similarly, if all women with BMI 37 kg/m² increased their BMI to 38 kg/m², the expected healthcare costs would be NOK 26,405,928 compared with NOK 43,325,082 if all women with BMI 27 kg/m² increased their BMI to 28 kg/m².

Discussion

We have shown the value of using both an individual and a population perspective when studying the association between BMI and specialist healthcare costs. In an individual perspective, healthcare costs increased most for people with severe obesity. In contrast, in a population perspective, costs increased most in the overweight part of the population. This difference is primarily driven by the fact that a larger proportion of the population is overweight compared to the proportion with severe obesity.

These two perspectives reflect different strategies for reducing morbidity and healthcare use as a result of elevated BMI. The first strategy entails treating people who cross a given treatment threshold. This represents the use of the individual perspective, which is widespread in today’s health service (3). The second strategy entails preventing the causes of obesity in the population, as small changes in BMI at the population level can have major consequences for society. Such an approach would help reduce the consequences of a mild and moderate elevation in BMI in large parts of the population, and could also reduce the proportion of people who cross the treatment threshold in the upper ranges of the distribution (1).
The article has some weaknesses. First, we wanted to estimate the impact BMI has on specialist healthcare costs because of a growth in morbidity. Meanwhile, we know that the association between BMI and specialist healthcare costs is prone to measurable and unmeasurable confounders, reverse causality and measurement errors. The aim of this study was not to give a better estimate of the causal effects of BMI on healthcare costs – many earlier studies have already done so. We use a method on which present-day recommendations on weight and weight classes are largely based, adjusting for any confounding variables. In spite of the limitations of the method, our analysis provides a good illustration of how interpretations can vary depending on whether an individual perspective or a population perspective is employed. Second, the estimated specialist healthcare costs are based on the period 2009–2016. New treatments for obesity have become available since 2016, and this could affect the specialist healthcare costs linked to obesity. Third, we cannot be certain that the associations between BMI and specialist healthcare use derived from HUNT participants are representative for Norway. We do not have national data on BMI in Norway, and it is therefore not possible to test this assumption. There may perhaps be geographic variations in the range of health services provided for overweight and obese individuals. The specific marginal estimates may therefore vary somewhat, but it is likely that the distribution of marginal costs is approximately the same as shown in this study. Fourth, the disease risk (and specialist healthcare costs) may be influenced by the selection of the sample in relation to age and mortality. The healthiest people with a high BMI survive, and this will erroneously diminish the estimated disease risk (and healthcare costs). However, this will not change the trends we see in our study. Finally, BMI has limitations as a measurement of obesity, partly because it does not distinguish between muscle mass and body fat mass.

The article also has a number of strengths. Geoffrey Rose’s perspective has not been applied previously using economic outcomes. Healthcare costs are a good way to summarise the total burden of a disease, and this article provides an important backdrop for discussing the sustainability of the health services. Although it has long been known that elevated BMI is a public health problem, the population perspective has received less attention than the individual perspective.

The fact that the population perspective is often forgotten is reflected in the public discourse, which is often more focused on individuals with obesity and less on BMI developments in the population. One example of this is the Norwegian Broadcasting Corporation’s programme Eit feitt liv [A fat life]. Here the presenter, Ronny Brede Aase, is informed that he is contributing to the increase in society’s healthcare costs, and he refers to himself as an ‘expense item’. In contrast, our study has shown that from a population perspective, the cost to society is mostly driven by people with overweight, not by those with obesity. Clarification of the perspective used in discussions of BMI would help moderate the portrayal of obesity as a major item of expenditure. This would help focus attention on the distribution of BMI in the population as well as on the collective problem represented by its development.

Our study shows that by identifying interventions that have a good effect at population level, we can achieve health benefits and economic gains by implementing cost-effective measures both within and outside the health service. If we succeed in identifying cost-effective population interventions to reduce factors that affect people’s BMI and consequently their health, these interventions will probably impact on the disease burden in relation to a number of other diseases in addition to the disease burden associated with overweight and obesity.

CONCLUSION
We have described the importance of studying the consequences of BMI from both an individual and a population perspective. Even though obesity is associated with higher healthcare costs per individual, healthcare costs associated with overweight are greater due to the number of people affected. For the individual, it is obesity that has the greatest consequences, but for society, it is overweight. We encourage researchers and clinicians to evaluate interventions from both perspectives, and urge decision-makers to include both perspectives in decision-making processes.

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