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Probability of an obese person attaining normal body weight: cohort study using electronic health records

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WHAT IS THE PROBABILITY OF AN OBESE PERSON ATTAINING NORMAL BODY WEIGHT? COHORT STUDY USING ELECTRONIC HEALTH RECORDS

Abstract

Objectives: Obesity is an increasing clinical and public health concern. This study aimed to answer the question: 'What is the probability of an obese person attaining normal body weight?'

Methods: A sample of men and women aged 20 years and over was drawn from the Clinical Practice Research Datalink (CPRD). Participants who received bariatric surgery were excluded. The probability of attaining either normal weight, or 5% reduction in body weight, were estimated.

Findings: Data were analysed for 278,982 participants including 76,704 obese men and 99,791 obese women. During a maximum of 9 years' follow-up, 1,283 men and 2,245 women attained normal body weight. In simple obesity (BMI 30·0-34·9 Kg/m^2), the annual probability of attaining normal weight was 1 in 210 for men and 1 in 124 for women, increasing to 1 in 1,290 for men and 1 in 677 for women with morbid obesity (BMI 40·0-44·9 Kg/m^2). The annual probability of achieving a 5% weight reduction was 1 in 8 for men, and 1 in 7 for women with morbid obesity. Among participants who lost 5% body weight, 52·7% (95% confidence interval 52·4 to 53·0%) showed weight regain at two years and 78·0% (77·7 to 78·3%) at five years.

Conclusions: The low probability of attaining normal weight, or maintaining weight loss, raises questions concerning whether current obesity treatment frameworks, grounded in community-based weight management programmes, may be expected to achieve public health impact.

Introduction

Overweight and obesity are growing global health concerns.[1] Strategies to control obesity emphasize obesity management and weight reduction as well as obesity prevention. In the UK, a national strategy report recommended that the management of obesity should be an integral part of clinical practice.[2] This envisages that patients may transition from obesity to a more healthy body weight. A target of 5% body weight loss is often recommended for obese subjects who intend to lose weight.[3] However, access to weight management interventions may be limited [4] and weight management interventions have only small and poorly maintained effects on body weight.[5, 6] In order to understand the frequency with which reductions in body mass index may occur in a large population, this study aimed to estimate the probability of an obese individual attaining normal body weight, or a reduction of 5% in body weight.

Methods

Data source

A population-based cohort study was conducted using primary care electronic health records from family practices in the United Kingdom. A cohort of adults aged 20 years and over was selected from the UK Clinical Practice Research Datalink (CPRD), an anonymized database of longitudinal patient electronic medical records from primary care. At present, the CPRD is the world's largest primary care database, representing over 7% of the UK population with nearly 700 general practices currently contributing data meeting quality standards for research.[7] The CPRD data is considered to be broadly representative of the UK population in terms of patient demographic characteristics and the size and distribution of practices.[7] The research was part of a larger study to evaluate the use of bariatric surgery. This analysis

aimed to estimate body weight transitions in the absence of bariatric surgery. Participants who received bariatric surgery were therefore excluded.

Sample selection

There were 2,006,296 patients registered in CPRD between 1 November 2004 and 31 October 2014, who were aged 20 years or older and had three or more body mass index records. A minimum of three body mass index records per patient was required to estimate weight changes, including weight regain following weight loss. The annual count of the CPRD registered population aged more than 20 years peaked at 3·7 million during this period, with a total of 7·1 million individual participants aged 20 or older registered at any time during the period. Participants were classified according to the body mass index (BMI) value of their first record into the categories: 18·5 to 24·9 Kg/m^2 (normal weight); 25·0 to 29·9 (over-weight); 30·0-34·9 (simple obesity); 35·0 to 35·9 (severe obesity); 40·0-44·9 (morbid obesity); and 45·0 or greater (super obesity). A random sample of up to 30,000 participants was selected, using the 'sample' command in Stata version 13, from each category of body mass index and gender, resulting in a total of 314,477 participants. There were fewer than 30,000 women with BMI ≥45 kg/m^2 and fewer than 30,000 men with either BMI 40-45 or ≥45 Kg/m^2. Full CPRD data records were then extracted for this sample. Data were analyzed for research quality records for each participant. The start was the later of 1st November 2004, the participant registration date, or the general practice CPRD start date. The end date was the earliest of 31st October 2014, the date death or end of registration, or the last data collection date for the general practice. There were 2,738 (1%) participants with bariatric surgery who were excluded, as were 32,757 (10%) who had fewer than three body

mass index values recorded between 1 November 2004 and 31 October 2014, leaving 278,982 participants for further analysis.

Analysis

A longitudinal analysis of BMI records was conducted. The start date for each participant was the later of 1st November 2004 or the beginning of the patient's CPRD record. The end date was the earlier of 31st October 2014 or the end of the patient's CPRD record. The first BMI record after the participant start date was used as the index BMI and the date of this record was used as the index date. The number of BMI records was evaluated for each BMI category and the number of records showing either an increase or decrease in BMI category was calculated. For patients who showed a decrease in BMI category, we evaluated whether subsequent changes in BMI category represented increases or further decreases. Data were analyzed in a time-to-event framework to evaluate first, the proportion of patients from each starting BMI category who attained either normal body weight or second, a 5% reduction in body weight during nine years' follow-up. A 5% reduction in body weight was not envisaged in the original study protocol but was added as a minor amendment because this is a widely recommended target for body weight reduction. In the first analysis, the annual probability of attaining normal body weight was estimated. The number of events (BMI category recorded as less than 25 Kg/m^2) and the person years of follow-up was used to estimate the annual rates, and their confidence intervals, which were converted to annual probabilities using the formula, $1-\exp^{-rate}$. Among participants who reduced BMI category, the direction of the next change in BMI category was evaluated. In the second analysis, to examine the proportion of participants who lost 5% of body weight, the development of a body weight that was more than 95% of the initial body weight was also evaluated in a time-to-event framework.

Analyses were conducted in Stata version 13 (College Station, TX) using the *stset, sts list* and *stcox* commands.

Results

The analysis included 278,982 participants, 129,194 men and 149,788 women who were registered between 1st November 2004 and 31st October 2014, and had three or more BMI records recorded during this period. The initial distribution of the sample by gender and BMI is shown in Table 1. Mean age was 55 years for men and 49 years for women. At the index date (date of the first BMI record in the study period) there were a minimum of 25,000 male and 23,000 female participants each for the BMI categories; 18·5-24·9 (normal weight), 25·0-29·9 (overweight), 30·0-34·9 (obese) and 35·0-39·9 (severe obese). There were similarly high numbers of female participants with an index BMI of 40·0-44·9 (morbid obese) but fewer male participants in this category at baseline (14,767). There were 6,481 men and 18,451 women with a baseline BMI ≥45·0 (super obese).

[Table 1 here]

Table 1 also shows the frequency and proportion of participants recorded as having no change in BMI category, increases in BMI category, decreases in BMI category or weight cycling (both increases and decreases) over nine years following first BMI record. The number of BMI records per participant increased with baseline BMI category. The proportion of participants showing no change was greatest among participants in the normal weight category (men; 57%, women; 59%) and decreased with higher baseline BMI, with the exception those initially categorized as super obese. Only 14% of all men and 15% of women showed decreases in BMI category without increases over the same period. The proportion of

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participants with records indicating only decreases in BMI increased with baseline BMI category, the highest proportions observed for those initially categorized as morbidly obese (men; 19%, women; 19%) and super obese (men; 21%, women; 19%). A small proportion of participants (12% each of men and women) had only BMI category increases recorded, with the highest proportion found among those initially categorized as normal weight (men; 20%, women; 18%). Weight cycling was observed in over a third of participants (35% of men and 38% of women) and was most common among severely obese (men; 46%, women; 47%) and morbidly obese (men; 51%, women; 52%) participants.

[Table 2 here]

Table 2 shows the frequency of transitioning to normal body weight during up to 9·9 years follow-up after the first BMI record. During a maximum of 9 years' follow-up, 1,283 men and 2,245 women attained normal body weight records. The annual probability of achieving normal body weight was 1 in 210 for men and 1 in 124 for women with simple obesity. The probability declined with increasing body mass index category. In patients with morbid obesity, the annual probability of achieving normal weight was 1 in 1,290 for men and 1 in 677 for women. In women, the probability of achieving normal weight among super-obese participants was 1 in 608, similar to that observed in morbid obesity. In the smaller number of super-obese men, the probability was higher at 1 in 362.

[Table 3 here]

Annual probabilities of achieving a clinically relevant 5% reduction in body weight are shown in Table 3. The annual probability of experiencing a 5% weight reduction was 1 in 12

for men and 1 in 10 for women with simple obesity. Probability increased with increasing BMI category. For patients with morbid obesity, the annual probability of achieving 5% reduction in body weight was 1 in 8 for men and 1 in 7 for women. The highest annual probability was observed among patients with super obesity (1 in 5 for men and 1 in 6 for women). However, among participants who lost 5% body weight, 52·7% (95% confidence interval 52·4 to 53·0%) at 2 years, and 78.0% (77·7 to 78·3%) at five years, had BMI records that indicated weight gain to values above the 5% weight loss threshold.

[Figure 1 here]

Among patients with a recorded decrease in BMI category over the study period, Figure 1 shows the percentage of men and women whose later BMI records revealed either an increase, a further decrease or no change in BMI category. The majority of patients (men 61%; women 59%) whose records showed a decrease in BMI category went on to record a subsequent increase in BMI category. These proportions were similar for men and women and across BMI categories. The proportion of patients who showed a second decrease in BMI category was highest among patients with morbid (men 16 %, women 19%) and super obesity (men 23%, women 24%) and was considerably less frequent in lower BMI categories. Overweight patients and those with simple obesity were the most likely to display no further BMI category change following a recorded decrease.

Discussion

Summary of findings

Analysis of primary care electronic health records for a large population based sample of men and women over a nine year period revealed that the probability of obese patients attaining normal weight was very low. The annual probability of patients with simple obesity attaining a normal body weight was only 1 in 131 for women and 1 in 225 for men. The likelihood of attaining normal weight declined with increasing BMI category with the lowest probability observed for patients with morbid obesity. The smaller group of patients with super obesity represented a departure from this trend, but nevertheless showed a low probability of attaining normal body weight. Although the probability of patients achieving a 5% reduction in body weight was considerably higher, the majority of these patients went on to regain lost weight, as evidenced by BMI records of >95% of the initial value, within two to five years of the first record that was lower than 95% of the initial value.

These findings raise questions concerning whether current obesity treatment frameworks, grounded in weight management programs accessed through primary care, may be expected to achieve clinically relevant and sustained reductions in BMI for the vast majority of obese patients and whether they could be expected to do so in the future. The lack of sustained BMI reductions could be driven both by low intervention uptake rates or their lack of effectiveness. In a previous study, we reported that weight loss interventions are currently offered only to a minority of patients in primary care.[4] Efforts are underway to improve this situation, with the proportion of patients with obesity offered multicomponent weight loss interventions included among potential new indicators in the 2016/2017 consultation for the Clinical Commissioning Group Indicator Set (CCG OIS).[8] However, even when treatment is accessed, evidence suggests behavioral weight loss interventions focusing on caloric

restriction and increased physical activity are unlikely to yield clinically significant reductions in body weight.[5, 9] A recent series of reviews documented the limited progress in reversing the global obesity epidemic and called for regulatory actions from governments as well as coordinated efforts across industry and society to reduce obesity.[10-13] Dietz and colleagues warn that preventive strategies are unlikely to reduce weight in people living with severe obesity and stress the need for changes in the delivery of care for these patients.[14] In combination with previous research, this study highlights the current failures in combatting existing obesity cases at a population level.

Comparison with other results

Reductions in BMI category were observed more frequently among patients with a higher baseline BMI but these decreases were more likely to be followed by subsequent increases rather than further decreases or stability in BMI category. Weight cycling, evidenced by both increases and decreases in BMI category, were most common among men and women with baseline BMIs in the morbid obese category. Greater instability in weight trajectories among patients with higher BMIs has been reported previously.[15] Weight cycling has been linked to a higher risk of morbidity and mortality compared to stable obesity[16-18] although evidence of causality remains inconclusive.[19]

The higher likelihood of decreases in BMI category and of 5% weight loss among the more severely obese participants in this study is consistent with results from clinical trials[20] and previous cohort studies[21] in which higher BMI predicted greater weight loss. The increased probability of weight reduction among patients with more severe obesity may reflect more accurate perceptions of personal weight status[22, 23] and higher treatment rates among these patients. It is also possible that BMI decreases in severely obese patients reflect unintentional

weight loss resulting from greater comorbidity. The finding that a high proportion of patients in this study experienced a period of weight regain following weight loss is also consistent with previous research. At least 50% of patients who achieved 5% weight loss were shown to have regained this weight within two years. It has previously been reported that approximately 80% of people who intentionally achieve weight loss greater or equal to 10% of their body weight will regain that weight within a year.[24]

Strengths and Limitations

This study had the strengths of a large population-based cohort with prolonged follow-up. Data are presented for adults aged over 20 years. Inspection of age-specific values revealed, as expected, greater weight gain at younger ages and a somewhat greater tendency to weight loss at older ages. It was not possible to evaluate intentionality of weight loss. Previous studies have reported the majority of obese individuals would like to lose weight and a large proportion are actively attempting to reduce their weight,[25, 26] so a relatively high level of intentionality among obese participants may be assumed. Additionally, monitoring of BMI among obese patients in primary care has been shown to positively predict treatment.[27] Patients in the present study were required to have a minimum of three BMI measurements recorded, suggesting an inflated proportion of patients in this sample may have been involved in and interested in weight management interventions. Nevertheless, we acknowledge that unintentional weight loss was also included and might result from physical disorders such as cancer, or psychological concerns, such as bereavement.[28-30] Additional in-depth analyses might evaluate patterns of weight change in relation to comorbidity.

Recording of body weight in primary care is generally opportunistic and dependent on patients attending the practice. We acknowledge that weight measurements in electronic

health records may be associated with error and bias including measurement error; confounding by indication, if weight changes prompt weight measurements; variation between professionals and family practices in measurement recording[31] and weight management strategies.[4] Higher patient baseline BMI was associated with a higher frequency of BMI measurements recorded over the study period. UK general practices have contractual financial incentives to provide a register of adult patients who have a BMI greater or equal to 30 kg/m^2 measured in the last 15 months[32] which may lead to more frequent recording of BMI for obese patients. We reported on the recording of BMI in primary care in a previous study.[31] For this study, we selected participants with a minimum of three BMI records. We acknowledge that participants with fewer than three BMI records may show different patterns of weight change and the present results might be biased through their omission. However, we believe that this is one of the largest studies yet reported on body weight changes in the general population. The relatively high levels of co-morbidity seen in obese compared to normal weight patients would also likely result in more regular consultations and more frequent recording of BMI. However it is possible that patients from all BMI categories with three or more BMI measurements recorded over the nine year study period represent a biased, less healthy sample compared to the general population. If this is the case then unintentional weight loss, along with comorbidities contributing to weight gain such as mobility impairment, may have influenced BMI changes disproportionately in the current sample.

Conclusions

Findings from this study indicate that current non-surgical obesity treatment strategies are failing to achieve sustained weight loss for the majority of obese patients. For patients with a BMI of 30 Kg/m^2 or greater, maintaining weight loss was rare and the probability of achieving normal weight was extremely low. Research to develop new and more effective

approaches to obesity management is urgently required. Obesity treatment programs should prioritize prevention of further weight gain, along with the maintenance of weight loss in those who achieve it. However in the absence of effective interventions targeted at the level of the individual, the greatest opportunity for tackling the current obesity epidemic may be found outside of primary care. Research to develop wider-reaching public health policies is needed to prevent obesity at the population level.

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Table 1. Number of BMI records per participant and proportions showing no change, increase, decrease or weight cycling over nine years following first BMI record.

Initial BMI category	N	Mean (SD) age (years)	Number of BMI records, median (IQR)	All records show no change in BMI category	One or more decreases in BMI category & no increases	One or more increases in BMI category & no decreases	Records show both increases and decreases in BMI category
MEN							
18·5-24·9	25,082	58 (18)	5 (3 to 7)	14,217 (57)	799 (3)	5,032 (20)	5,034 (20)
25·0-29·9	27,408	58 (15)	5 (3 to 8)	13,281 (48)	3,243 (12)	3,428 (13)	7,456 (27)
30·0-34·9	27,966	56 (14)	6 (4 to 10)	10,320 (37)	4,620 (17)	2,901 (10)	10,125 (36)
35·0-39·9	27,490	53 (13)	7 (4 to 12)	7,200 (26)	5,070 (18)	2,525 (9)	12,695 (46)
40·0-44·9	14,767	50 (13)	8 (4 to 14)	2,761 (19)	2,810 (19)	1,596 (11)	7,600 (51)
≥45·0	6,481	47 (13)	8 (4 to 14)	2,828 (44)	1,353 (21)	NA	2,300 (35)
All	129,194	55 (15)	6 (4 to 10)	50,607 (39)	17,895 (14)	15,482 (12)	45,210 (35)
WOMEN							
18·5-24·9	23,640	46 (20)	4 (3 to 7)	14,047 (59)	844 (4)	4,346 (18)	4,403 (19)
25·0-29·9	26,357	52 (19)	5 (3 to 8)	10,140 (38)	3,696 (14)	4,197 (16)	8,324 (32)
30·0-34·9	27,251	52 (17)	6 (4 to 10)	8,275 (30)	4,621 (17)	3,626 (13)	10,729 (39)
35·0-39·9	27,373	49 (16)	7 (4 to 11)	6,322 (23)	4,910 (18)	3,304 (12)	12,837 (47)
40·0-44·9	26,716	48 (15)	7 (4 to 13)	4,680 (18)	5,009 (19)	3,108 (12)	13,919 (52)
≥45·0	18,451	46 (14)	8 (5 to 14)	8,945 (48)	3,472 (19)	NA	6,034 (33)
All	149,788	49 (17)	6 (4 to 10)	52,409 (35)	22,552 (15)	18,581 (12)	56,246 (38)

BMI, body mass index; NA, not applicable to highest BMI category

Table 2: Annual probability of achieving normal weight (BMI<25 Kg/m^2) by initial BMI category and gender.

Initial BMI category	Number of participants	Number of person years during follow-up	Number attaining normal BMI	Annual probability of attaining normal BMI		
				Estimate	Lower 95% confidence limit	Upper 95% confidence limit
MEN						
30·0-34·9	27,966	179,746	857	1 in 210	1 in 197	1 in 225
35·0-39·9	27,490	174,386	249	1 in 701	1 in 619	1 in 797
40·0-44·9	14,767	91,528	71	1 in 1,290	1 in 1,023	1 in 1,651
≥45·0	6,481	38,367	106	1 in 362	1 in 300	1 in 442
WOMEN						
30·0-34·9	27,251	173,066	1,398	1 in 124	1 in 118	1 in 131
35·0-39·9	27,373	175,356	408	1 in 430	1 in 390	1 in 475
40·0-44·9	26,716	170,483	252	1 in 677	1 in 599	1 in 769
≥45·0	18,451	113,540	187	1 in 608	1 in 527	1 in 704

Table 3: Annual probability of achieving a 5% reduction in body weight by initial BMI category and gender.

Initial BMI category	Number of participants	Number of person years during follow-up	Number attaining 5% reduction in body weight (%)	Annual probability of attaining 5% reduction in body weight
MEN				
30·0-34·9	27,966	135,394	11,869	1 in 12
35·0-39·9	27,490	118,266	13,805	1 in 9
40·0-44·9	14,767	57,099	8,100	1 in 8
≥45·0	6,481	20,900	4,177	1 in 5
WOMEN				
30·0-34·9	27,251	123,567	12,792	1 in 10
35·0-39·9	27,373	116,042	13,972	1 in 9
40·0-44·9	26,716	103,849	15,208	1 in 7
≥45·0	18,451	63,397	11,340	1 in 6

Figure 1: Changes in BMI category following an initial decrease in BMI category. Data are presented by gender and initial BMI category.