Probability of an Obese Person Attaining Normal Body Weight: Cohort Study Using Electronic Health Records

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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 United Kingdom, a national strategy report recommends that the management of obesity 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 individuals 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] To understand the frequency with which reductions in body mass index (BMI, defined as weight in kilograms divided by the square of height in meters) may occur in a large population, we estimated the probability of an obese individual attaining normal body weight or a reduction of 5% in body weight.

METHODS

We conducted a population-based cohort study using primary care electronic health records from family practices in the United Kingdom. We selected a cohort of adults aged 20 years and older from the UK Clinical Practice Research Datalink (CPRD), an anonymized database of longitudinal patient electronic medical records from primary care. The CPRD is the world's largest primary care database and contains more than 7% of the UK population, with nearly 700 general practices contributing data that meets quality standards for research.[7] The CPRD data are considered to be broadly representative of the UK population in terms of patient demographic characteristics and the size and distribution of practices.[7] Our research was part of a larger study to evaluate the use of bariatric surgery. We aimed to estimate body weight transitions in the absence of bariatric surgery; therefore, we excluded participants who received bariatric surgery.

Objectives. We examined the probability of an obese person attaining normal body weight.

Methods. We drew a sample of individuals aged 20 years and older from the United Kingdom's Clinical Practice Research Datalink from 2004 to 2014. We analyzed data for 76 704 obese men and 99 791 obese women. We excluded participants who received bariatric surgery. We estimated the probability of attaining normal weight or 5% reduction in body weight.

Results. During a maximum of 9 years' follow-up, 1283 men and 2245 women attained normal body weight. In simple obesity (body mass index = 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 1290 for men and 1 in 677 for women with morbid obesity (body mass index = 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.

Conclusions. The probability of attaining normal weight or maintaining weight loss is low. Obesity treatment frameworks grounded in community-based weight management programs may be ineffective. (*Am J Public Health*. Published online ahead of print July 16, 2015: e1–e6. doi:10.2105/AJPH.2015.302773)

Sample Selection

There were 2 006 296 patients registered in the CPRD between November 1, 2004, and October 31, 2014, who were aged 20 years or older and had 3 or more BMI records. A minimum of 3 BMI records per patient was required to estimate weight changes, including weight regain following weight loss. The annual count of the CPRD registered population aged 20 years and older peaked at 3.7 million during this period, with a total of 7.1 million participants aged 20 years or older registered at any time during the period.

We classified participants according to the BMI value of their first record into 6 categories: 18.5 to 24.9 (normal weight), 25.0 to 29.9 (overweight), 30.0 to 34.9 (simple obesity), 35.0 to 35.9 (severe obesity), 40.0 to 44.9 (morbid obesity), and 45.0 or greater (superobesity) kilograms per meters squared. We selected a random sample of up to 30 000 participants, using the sample command in Stata version 13 (StataCorp LP, College Station, TX), from each category of BMI and gender, resulting in 314 477 participants. There were fewer than 30 000 women with a BMI of 45 or greater

kilograms per meters squared and fewer than 30 000 men with a BMI of either 40 to 45 or 45 or greater kilograms per meters squared.

We then extracted full CPRD records for this sample. We analyzed data for research quality records for each participant. The start was the latest of November 1, 2004, the participant registration date, or the general practice CPRD start date. The end date was the earliest of October 31, 2014, the date death or end of registration, or the last data collection date for the general practice. We excluded the 2738 (1%) participants who had bariatric surgery and the 32 757 (10%) participants who had fewer than 3 BMI values recorded between November 1, 2004 and October 31, 2014; this left 278 982 participants for further analysis.

Analysis

We conducted a longitudinal analysis of BMI records. The start date for each participant was the later of November 1, 2004 or the beginning of the patient's CPRD record. The end date was the earlier of October 31, 2014 or the end of the patient's CPRD record. We used the first BMI record after the participant start date

as the index BMI, and we used the date of this record as the index date. We evaluated the number of BMI records for each BMI category, and we calculated the number of records showing either an increase or a decrease in BMI category. For patients who showed a decrease in BMI category, we evaluated whether subsequent changes in BMI category were increases or further decreases.

We analyzed data in a time-to-event framework to evaluate the proportion of patients from each starting BMI category who attained either, first, a normal body weight or, second, a 5% reduction in body weight during the 9-year follow-up. We did not envisage a 5% reduction in body weight in the original study protocol, but we added it as a minor amendment because this is a widely recommended target for body weight reduction. In the first analysis, we estimated the annual probability of attaining normal body weight. We used the number of events (BMI category recorded as $<25 \text{ kg/m}^2$) and the person-years of follow-up to estimate the annual rates and their confidence intervals (CIs), which we converted to annual probabilities using the formula $1 - \exp^{-\text{rate}}$.

Among participants who reduced their BMI category, we evaluated the direction of the next change in BMI category. In the second analysis, to examine the proportion of participants who lost 5% of their body weight, we also evaluated the development of a body weight that was more than 95% of the initial body weight in a time-to-event framework. We conducted analyses in Stata version 13 using the stset, sts list, and stcox commands.

RESULTS

Our analysis included 278 982 participants—129 194 men and 149 788 women—who were registered between November 1, 2004, and October 31, 2014, and had 3 or more BMI measurements recorded during this period. The initial distribution of the sample by gender and BMI is shown in Table 1. The 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 was a minimum of 25 000 male and 23 000 female participants each for the BMI categories 18.5 to 24.9 (normal weight), 25.0 to 29.9 (overweight), 30.0 to 34.9 (simple obesity), and 35.0 to 39.9

(severe obesity) kilograms per meters squared. There were similarly high numbers of female participants with an index BMI of 40.0 to 44.9 kilograms per meters squared (morbid obesity) but fewer male participants in this category at baseline (14 767). There were 6481 men and 18 451 women with a baseline BMI of 45.0 or greater kilograms per meters squared (superobese).

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 9 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 of those initially categorized as superobese. Only 14% of men and 15% of women showed decreases in BMI category without increases over the same period.

The proportion of participants with records indicating only decreases in BMI increased with baseline BMI category, which were the highest proportions observed for those initially categorized as morbidly obese (men: 19%; women: 19%) and superobese (men: 21%; women: 19%). A small proportion of participants (men: 12%; women: 12%) 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 more than a third of participants (men: 35%; women: 38%) and was most common among severely obese (men: 46%; women: 47%) and morbidly obese (men: 51%; women: 52%) participants.

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, 1283 men and 2245 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 BMI category. In morbidly obese patients, the annual probability of achieving normal weight was 1 in 1290 for men and 1 in 677 for

women. In women, the probability of achieving normal weight among superobese participants was 1 in 608, which is similar to that observed among morbidly obesite participants. In the smaller number of superobese men, the probability was higher at 1 in 362.

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 morbidly obese patients, 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 superobese patients (1 in 5 for men and 1 in 6 for women). However, among participants who lost 5% body weight, 52.7% (95% CI=52.4%, 53.0%) at 2 years and 78.0% (95% CI=77.7%, 78.3%) at 5 years had BMI records that indicated weight gain to values above the 5% weight loss threshold.

Figure 1 shows the percentage of men and women whose later BMI records revealed an increase, a further decrease, or no change in BMI category among patients with a recorded decrease in BMI category over the study period. 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 the morbidly obese (men: 16%; women: 19%) and superobese (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

Analysis of primary care electronic health records for a large population-based sample of men and women over a 9-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 124 for women and 1 in 210 for men. The

TABLE 1—Number of BMI Records per Participant and Proportions Showing No Change, Increase, Decrease, or Weight Cycling Over 9 Years Following First BMI Record: United Kingdom, 2004–2014

Initial BMI Category	No.	Age, Years, Mean ±SD	Number of BMI Records, Median (IQR)	All Records Show No Change in BMI Category, Frequency (%)	≥ 1 Decrease in BMI Category and No Increases, Frequency (%)	≥ 1 Increase in BMI Category and No Decreases, Frequency (%)	Records Show Both Increases and Decreases in BMI Category, Frequency (%)
Men, kg/m²							
18.5–24.9	25 082	58 ±18	5 (3–7)	14 217 (57)	799 (3)	5 032 (20)	5 034 (20)
25.0–29.9	27 408	58 ±15	5 (3–8)	13 281 (48)	3 243 (12)	3 428 (13)	7 456 (27)
30.0–34.9	27 966	56 ±14	6 (4–10)	10 320 (37)	4 620 (17)	2 901 (10)	10 125 (36)
35.0–39.9	27 490	53 ±13	7 (4–12)	7 200 (26)	5 070 (18)	2 525 (9)	12 695 (46)
40.0–44.9	14 767	50 ±13	8 (4–14)	2 761 (19)	2 810 (19)	1 596 (11)	7 600 (51)
≥ 45.0	6 481	47 ±13	8 (4–14)	2 828 (44)	1 353 (21)	NA	2 300 (35)
All	129 194	55 ±15	6 (4–10)	50 607 (39)	17 895 (14)	15 482 (12)	45 210 (35)
Women, kg/m²							
18.5–24.9	23 640	46 ±20	4 (3–7)	14 047 (59)	844 (4)	4 346 (18)	4 403 (19)
25.0–29.9	26 357	52 ±19	5 (3–8)	10 140 (38)	3 696 (14)	4 197 (16)	8 324 (32)
30.0–34.9	27 251	52 ±17	6 (4–10)	8 275 (30)	4 621 (17)	3 626 (13)	10 729 (39)
35.0–39.9	27 373	49 ±16	7 (4–11)	6 322 (23)	4 910 (18)	3 304 (12)	12 837 (47)
40.0–44.9	26 716	48 ±15	7 (4–13)	4 680 (18)	5 009 (19)	3 108 (12)	13 919 (52)
≥ 45.0	18 451	46 ±14	8 (5–14)	8 945 (48)	3 472 (19)	NA	6 034 (33)
All	149 788	49 ±17	6 (4–10)	52 409 (35)	22 552 (15)	18 581 (12)	56 246 (38)

Note. BMI = body mass index; IQR = interquartile range; NA = not applicable to highest BMI category.

likelihood of attaining normal weight declined with increasing BMI category, with the lowest probability observed for morbidly obese patients. The smaller group of superobese patients was 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 greater than 95% of the initial value, within 2 to 5 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 by low intervention uptake rates or their lack of effectiveness.

TABLE 2—Annual Probability of Achieving Normal Weight by Initial BMI Category and Gender: United Kingdom, 2004–2014

Initial BMI Category	No. Participants	No. Person-Years During Follow-Up	No. Attaining Normal BMI	Annual Probability of Attaining Normal BMI, Estimate (95% CI)
Men, kg/m²				
30.0–34.9	27 966	179 746	857	1 in 210 (197, 225)
35.0–39.9	27 490	174 386	249	1 in 701 (619, 797)
40.0–44.9	14 767	91 528	71	1 in 1 290 (1023, 1651)
≥ 45.0	6481	38 367	106	1 in 362 (300, 442)
Women, kg/m²				
30.0–34.9	27 251	173 066	1 398	1 in 124 (118, 131)
35.0–39.9	27 373	175 356	408	1 in 430 (390, 475)
40.0–44.9	26 716	170 483	252	1 in 677 (599, 769)
≥ 45.0	18 451	113 540	187	1 in 608 (527, 704)

Note. BMI = body mass index; CI = confidence interval. Normal weight is having a BMI < 25 kg/m².

TABLE 3—Annual Probability of Achieving a 5% Reduction in Body Weight by Initial BMI Category and Gender: United Kingdom, 2004–2014

Initial BMI Category	No. Participants	No. Person-Years During Follow-Up	No. Attaining 5% Reduction in Body Weight	Annual Probability of Attaining 5% Reduction in Body Weight
Men, kg/m²				
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, kg/m²				
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

Note. BMI = body mass index.

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 under way 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.[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 et al. 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, our study highlights the current failures in combatting existing obesity cases at a population level.

We observed reductions in BMI category more frequently among patients with a higher baseline BMI, but these decreases were more likely to be followed by subsequent increases than further decreases or stability in BMI category. Weight cycling, evidenced by both increases and decreases in BMI category, was 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 than has 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 our 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
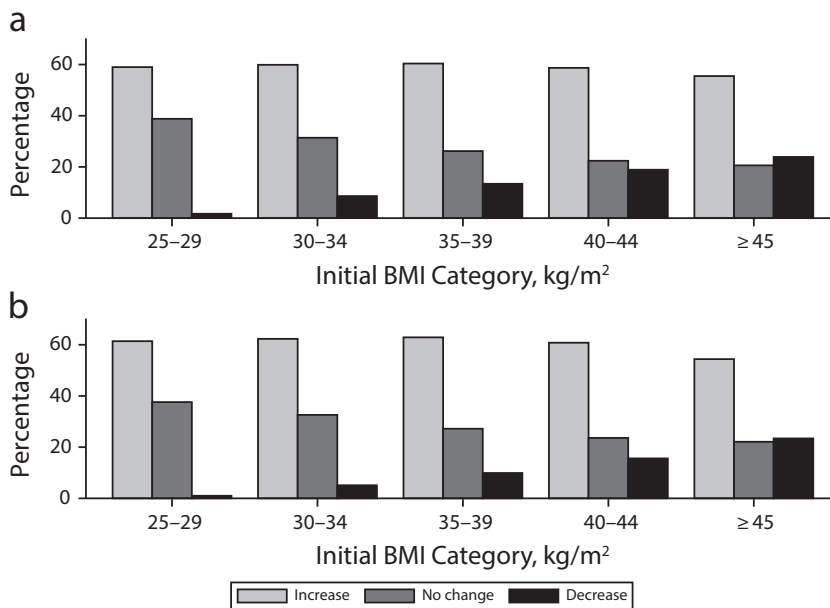
Note. BMI = body mass index. Data are presented by gender and initial BMI category.

FIGURE 1—Data for subsequent changes in BMI category in participants who showed an initial decrease in BMI category for (a) women and (b) men: United Kingdom, 2004–2014.

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 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 2 years. It has previously been reported that approximately 80% of people who intentionally achieve weight loss of 10% or more 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. We have presented data for adults aged 20 years and older. 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 that the majority of obese individuals would like to lose weight and that a large proportion is actively attempting to reduce their weight,[25,26] so a relatively high level of intentionality among obese participants may be assumed.

Additionally, monitoring BMI among obese patients in primary care has been shown to predict treatment positively.[27] Patients in this study were required to have a minimum of 3 BMI measurements recorded, suggesting that 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 body weight in primary care is generally related to the opportunity to do so and depends 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] A 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 of 30 or greater kilograms per meters squared measured in the past 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 3 BMI records. We acknowledge that participants with fewer than 3 BMI records may show different patterns of weight change, and our 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 comorbidity seen in obese compared with 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 3 or more BMI measurements recorded over the 9-year study period represent a biased, less healthy sample compared with 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 our sample.

Conclusions

Our findings indicate that current nonsurgical obesity treatment strategies are failing to achieve sustained weight loss for the majority of obese patients. For patients with a BMI of 30 or greater kilograms per meters squared, 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

individual level, the greatest opportunity for tackling the current obesity epidemic may be found outside primary care. Research to develop wider reaching public health policies is needed to prevent obesity at the population level. ■

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Human Participant Protection

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