Do socioeconomic factors shape weight and obesity trajectories over the transition from midlife to old age? Results from the French GAZEL cohort study

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ABSTRACT
Background: Obesity is a contemporary epidemic that does not affect all age groups and sections of society equally.
Objective: The objective was to examine socioeconomic differences in trajectories of body mass index (BMI; in kg/m²) and obesity between the ages of 45 and 65 y.
Design: A total of 13,297 men and 4532 women from the French GAZEL (Gaz de France Electricité de France) cohort study reported their height in 1990 and their weight annually over the subsequent 18 y. Changes in BMI and obesity between ages 45 and 49 y, 50 and 54 y, 55 and 59 y, and 60 and 65 y as a function of education and occupational position (at age 35 y) were modeled by using linear mixed models and generalized estimating equations.
Results: BMI and obesity rates increased between the ages of 45 and 65 y. In men, BMI was higher in unskilled workers than in managers at age 45 y; this difference in BMI increased from 0.82 (95% CI: 0.66, 0.99) at 45 y to 1.06 (95% CI: 0.85, 1.27) at 65 y. Men with a primary school education compared with those with a high school degree at age 45 y had a 0.75 (95% CI: 0.51, 1.00) higher BMI, and this difference increased to 1.32 (95% CI: 1.03, 1.62) at age 65 y. Obesity rates were 3.35% and 7.68% at age 45 y and 9.52% and 18.10% at age 65 y in managers and unskilled workers, respectively; the difference in obesity increased from 0.82 (95% CI: 0.66, 0.99) at 45 y to 1.06 (95% CI: 0.85, 1.27) at 65 y.
Conclusions: Weight continues to increase in the transition between midlife and old age; this increase is greater in lower socioeconomic groups.

INTRODUCTION
The World Health Organization (WHO) global reports estimate that 1.6 billion adults were overweight and ≥400 million were obese in 2005. The epidemic of overweight and obesity is on the rise, and the corresponding figures are projected to be 2.3 billion and ≥700 million by 2015 (1). Obesity is linked to both chronic diseases (2, 3) and mortality (4), making it a public health priority. An inverse association between markers of socioeconomic position and obesity has been shown in the developed world (5–8), and the emergence of similar phenomena is seen in developing countries (9).

A review of 144 studies published in 1989 clearly established that obesity rates across the human life span were higher in the lower compared with the higher socioeconomic groups (7). There is now consistent evidence showing that socioeconomic factors influence weight trajectories until early adulthood (10–12). However, whether this applies to the period from midlife to old age remains unclear. Obesity carries substantial health risks even in the elderly, and a recent review suggests that some of this risk is likely to have been underestimated in early studies (13). Relative risks for disease associated with obesity decrease with age, but the absolute risk increases due to the increase in the prevalence of obesity with age (14).

In longitudinal analyses of age-related weight trajectories, age rather than period should be used as a time scale. This is an important methodologic point because the use of period (time of measurement) to assess change in weight does not allow age effects to be separated from cohort effects. At least 3 previous studies have used appropriate methods, but 2 of them were based on younger individuals (11, 12), and the third showed education to influence weight but not weight change in all age groups (15).

Thus, it remains unclear if socioeconomic factors, education, and measures of adult socioeconomic position shape weight trajectories in the transition from midlife to old age.

We examined whether socioeconomic position influences weight trajectories over mid- to late adulthood in an occupational cohort of workers of the French National Utilities. We used repeat measurement) to assess change in weight does not allow age effects to be separated from cohort effects. At least 3 previous studies have used appropriate methods, but 2 of them were based on younger individuals (11, 12), and the third showed education to influence weight but not weight change in all age groups (15).

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annual measures of weight over an 18 y period, a follow-up that is substantially longer than in most previous studies in this field. Because education may capture mainly early-life socioeconomic circumstances (16), we used both occupation and education to examine socioeconomic differences in the trajectories of body mass index (BMI) and obesity.

SUBJECTS AND METHODS

Data were drawn from the GAZEL (Gaz de France Electricité de France) study (17). This cohort was established in 1989 from employees of France’s national electricity and gas company, Electricité de France–Gaz de France (EDF-GDF). EDF-GDF employees hold civil servant–like status, which offers job security and opportunities for occupational mobility. Typically, employees are hired when they are in their 20s and stay with the company until retirement. In 1989, the study baseline, 15,011 men aged 40–50 y and 5614 women aged 35–50 y, provided consent to take part in a longitudinal follow-up. Because women comprise only 20% of EDF-GDF employees, the age range for inclusion in the GAZEL study was wider for women to allow for a larger proportion of women in the study. The study design consisted of an annual questionnaire used to collect data on health, lifestyle, individual, familial, social, and occupational factors and life events. The collection of data via questionnaire was independent of the employer, EDF-GDF, and continues past retirement age. The GAZEL study received approval from the national commission overseeing ethics of data collection in France (Commission Nationale Informatique et Liberté, Paris, France).

Measures

Demographic factors

Demographic factors considered were age, sex, and year of birth. Men were between 41.1 and 51.6 y old at the start of the study (in 1990), and women were between 36.1 and 51.4 y old. The birth years ranged from 1939 to 1948 for men and from 1939 to 1953 for women.

Socioeconomic factors

Two measures were used in the analysis: occupational position and education. The measure of occupational position was determined from the employer’s records of grade of employment, which are available for the entire career of the participants. The majority of the GAZEL participants have seen great upward social mobility; consequently, use of the baseline (1990) measure of occupational position would have resulted in a proxy measure of age. We chose to use occupational position at age 35 y, before the measure of BMI, to represent midcareer status. This measure has 3 levels: managers (high occupational position), skilled workers (intermediate occupational position), and unskilled workers (low occupational position). Education was also measured by using a 3-level variable: low (primary school or less, leaving school at ≈11 y), intermediate (for professional qualifications), and higher educational level (secondary school degree, the baccalaureate taken at ≈18 y of age, or higher).

BMI

BMI (in kg/m²) was calculated from self-reported height and weight. Data on height and weight were collected by using annual questionnaires from 1990 to 2007, a follow-up of 18 y. Given that height is unlikely to change much over the study period, we preferred to use the 1990 measure of height in calculations of BMI and obesity for all years. Obesity was defined as BMI $\leq$ 30 according to WHO criteria (18).

Statistical analysis

Analysis consisted of modeling age-related trajectories of continuous measures of BMI by using a linear mixed effects model because this method is well adapted to longitudinal data (19). We used age rather than the year of data collection as the time scale in the analysis because the objective of the analysis was to estimate age-related changes in social inequalities in BMI. The 18-y follow-up of the cohort resulted in observed data covering an age range from 41.1 to 68.9 y in men and 36.1–68.3 y in women. Given the 10-y span in birth years in men and the 15-y span in women, not everyone contributes to the analysis at all ages. Only participants from the later birth years contribute to the analysis before the age of 50 y, and only those from the earliest birth years contribute to the estimation of the effect of age after 60 y. To maximize the longitudinal dimension of the analysis, we restricted the age range examined between 45 and 65 y, and we did not stratify the analysis by birth cohort but adjusted for the birth year in the analysis. The underlying assumption in this approach is that the weight trajectories (rate of change) over the observation window are similar for all birth cohorts. Extensive

FIGURE 1. BMI between 45 and 65 y of age, grouped by 2-y birth cohorts, in men (A) and women (B) in the French GAZEL (Gaz de France Electricité de France) study.
descriptive analyses (Figure 1) support this assumption. Furthermore, we repeated the analysis described below in a subgroup of participants from birth years 1940–1943 for whom the 18 y of follow-up from 1990 to 2007 covers the age range from 50 to 65 y.

The effect of age on BMI was examined by using a piecewise linear function for age with knots (join points that mark the transition from one age-band to the next) at ages of 50, 55, and 60 y. Random effects were fitted for the intercept and the slopes. We adjusted for year of birth as a continuous variable, centered on 1943 because individuals born in this year contribute to all 4 age segments as follows: <50 y, 50–54, 55–59 y, and ≥60 y. We examined potential differences in change in BMI with aging (between 45 and 49 y, 50 and 54 y, 55 and 59 y, and 60 and 65 y of age) in the different socioeconomic groups by entering the measure of socioeconomic position under consideration and an interaction term between this measure and age into the model. The high socioeconomic group was the reference category in all analyses.

We also examined age-related obesity trajectories in the 3 education and occupation groups using longitudinal logistic regression analysis based on generalized estimating equations (GEEs) (19). The correlation structure used in this analysis was the Toeplitz matrix, which assumes that a pair of responses that are equally separated in time have the same correlation (19). The probabilities predicted by the GEE logistic regression model in the low and high occupational groups at ages 45, 50, 55, 60, and 65 y were used to calculate absolute social inequalities in obesity by using the difference in the high and low socioeconomic groups. We then examined whether inequalities at age 50 y were higher than those at age 45 y by fitting a 95% CI around the increase in absolute social inequalities with use of the bootstrap method (20). Similarly, we compared the inequality in BMI at age 55 y with that at age 50 y, inequality at age 60 y with that at age 55 y, and inequality at age 65 y with that at age 60 y. Finally, we also compared the inequality over the 20- y observation window by comparing differences in BMI/obesity in the socioeconomic groups at ages 45 and 65 y. All analyses were stratified by sex and carried out by using SAS version 9.1 (SAS Institute Inc, Cary, NC).

RESULTS

Sample characteristics

All participants with complete sociodemographic data and with at least one measure of BMI between the ages 45 and 65 y were included in the analyses—a total of 13,297 men (89% of those included at baseline) and 4532 women (81% of those included at baseline). Because “complete case” analysis, particularly over a long follow-up, is based on an increasingly healthy group, which leads to biased estimates, we chose to include in the analysis all individuals with at least one BMI measure. However, most individuals provided multiple measures; the mean number of BMI measures was 13.1 for men and 11.1 for women (range: 1–18), 75% had ≥10 measures, and 14% had <5 measures. The observed BMI (Figure 1), with 2 successive birth years grouped together, showed clear cohort effects because, at the same age, BMI of participants born earlier was lower than that of participants born more recently. However, there was no evidence that BMI trajectories (ie, increase in BMI with age) differed by birth cohort.

Age-related trajectories in BMI

BMI increased between the ages of 45 and 65 y, and the increase was greater in women than in men (P < 0.001 for interaction between sex and age). The rate of increase slowed with increasing age; BMI in men increased by 0.74 (95% CI: 0.71, 0.77) between ages 45 and 49 y, by 0.32 (95% CI: 0.30, 0.35) between ages 50 and 54 y, by 0.08 (95% CI: 0.05, 0.10) between ages 55 and 59 y, and by 0.16 (95% CI: 0.12, 0.20) between ages 60 and 65 y. In women, the corresponding figures were 0.99 (95% CI: 0.93, 1.06), 0.67 (95% CI: 0.61, 0.72), 0.36 (95% CI: 0.29, 0.42), and 0.18 (95% CI: 0.07, 0.29).

Results for BMI trajectories in the 3 occupational groups in men are shown in Table 1. Because the data are centered on individuals born in 1943, the BMI values apply to these individuals, but the slope (change in BMI) applies to all. BMI at age 45 y was 25.37 in the low occupational group and 24.55 in the high occupational group, which is a difference of 0.82 (95% CI: 0.66, 0.99). Mean BMI increased by 0.73 (95% CI: 0.66, 0.81) between ages 45 and 49 y and by 0.40 (95% CI: 0.34, 0.46) between ages 50 and 54 y in the high occupational group. In the low group, the corresponding figures were 0.71 (95% CI: 0.64, 0.78) and 0.37 (95% CI: 0.32, 0.43). Thus, the increase in BMI between ages 45 and 54 y was almost similar in the low compared with the high occupational group in men; the difference in increase was −0.03 (95% CI: −0.13, 0.08) between ages 45 and 49 y and −0.02 (95% CI: −0.10, 0.06) between ages 50 and 54 y.

BMI in men from the high occupational group did not increase (−0.04; 95% CI: −0.10, 0.03) between ages 55 and 59 and increased somewhat (+0.08; 95% CI: −0.01, 0.16) between ages 60 and 65 y. However, it increased more rapidly in the low occupational group over the same period (+0.16; 95% CI: 0.10, 0.22, between ages 55 and 59 y; +0.16; 95% CI: 0.08, 0.24, between ages 60 and 65 y). Compared with the high occupational group, BMI between 45 and 65 y of age increased by an excess of 0.13 (95% CI: −0.01, 0.27) in the intermediate group and increased by an excess of 0.24 (95% CI: 0.07, 0.40) in the low occupational group. Sensitivity analysis, carried out in 4466 men born between 1940 and 1943, with BMI data for the entire period between 50 and 65 y, showed very similar findings, with BMI increasing by 0.24 (95% CI: 0.04, 0.44) in the low compared with the high occupational group.

Results for BMI trajectories between ages 45 and 65 y in women are shown in Table 2. At age 45 y, the low occupational group had an average BMI that was 0.71 (95% CI: 0.25, 1.17) higher than in managers. BMI increased in all groups over the subsequent period, but there was no robust evidence of greater increase in BMI in the low compared with the high occupational group (0.34; 95% CI: −0.22, 0.90).

Results for BMI trajectories in the 3 education groups for men and women, respectively, are shown in Tables 3 and 4. The pattern of results for education is very similar to that reported for occupational position. However, the increase in BMI between the ages of 45 and 65 y in men and women was greater in the low socioeconomic group assessed by using education. This meant that social inequalities over the follow-up showed a greater increase with the measure of education when compared
TABLE 1
Trajectories of BMI (in kg/m²) between ages 45 and 65 y as a function of occupational position in men in the French GAZEL (Gaz de France Electricité de France) study

<table>
<thead>
<tr>
<th>Age at 45 y</th>
<th>High occupational position, managers (n = 2270)</th>
<th>Intermediate occupational position, skilled workers (n = 8044)</th>
<th>Low occupational position, unskilled workers (n = 2983)</th>
<th>Difference between high and intermediate occupational group</th>
<th>Difference between high and low occupational group</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI changes</td>
<td>BMI 95% CI</td>
<td>BMI 95% CI</td>
<td>BMI 95% CI</td>
<td>ΔBMI 95% CI</td>
<td>ΔBMI 95% CI</td>
</tr>
<tr>
<td>Between ages 45 and 49 y</td>
<td>24.55 ± 0.73</td>
<td>24.42 ± 0.66</td>
<td>25.08 ± 0.75</td>
<td>25.37 ± 0.71</td>
<td>0.53 ± 0.64</td>
</tr>
<tr>
<td>Between ages 50 and 54 y</td>
<td>25.26 ± 0.40</td>
<td>25.01 ± 0.34</td>
<td>25.30 ± 0.39</td>
<td>25.26 ± 0.37</td>
<td>0.01 ± 0.32</td>
</tr>
<tr>
<td>Between ages 55 and 59 y</td>
<td>26.49 ± 0.08</td>
<td>26.01 ± 0.08</td>
<td>26.22 ± 0.10</td>
<td>26.78 ± 0.16</td>
<td>0.12 ± 0.12</td>
</tr>
<tr>
<td>Between ages 60 and 65 y</td>
<td>26.92 ± 0.08</td>
<td>26.56 ± 0.08</td>
<td>26.89 ± 0.10</td>
<td>26.82 ± 0.16</td>
<td>0.13 ± 0.13</td>
</tr>
</tbody>
</table>

Increase in inequality in BMI between 45 and 65 y | — | — | — | 0.13 ± 0.01 |

ΔBMI = BMI at 65 y – BMI at 45 y

1 Estimates are from a linear mixed-effects model, with random effects for the intercept and the slopes. Age was entered in the model as a piecwise linear function with knots (join points that mark the transition from one age-band to the next) at ages 50, 55, and 60 y.

2 Mean BMI (but not the estimate of social inequality in BMI) for a participant born in 1943.

3 P < 0.001 (Wald test).

4 P < 0.01 (Wald test).

5 P < 0.05 (Wald test).

with occupation. Thus, over the follow-up period, BMI in the low compared with the high education group increased by an excess of 0.57 (95% CI: 0.34, 0.80) in men [comparable estimate for occupation is 0.24 (95% CI: 0.07, 0.40)] and 0.80 (95% CI: 0.26, 1.35) in women [comparable estimate for occupation is 0.34 (95% CI: −0.22, 0.90)].

Age-related trajectories in obesity

Obesity trajectories in the 3 occupational groups are shown in Figure 2A for men and in Figure 2B for women. Obesity in men aged 45 y was estimated at 3.35% in the high occupational group and at 7.68% in the low occupational group. At 65 y, this had increased to 9.52% and 18.10%, respectively. Here again, the obesity rates apply to individuals born in 1943, but the change in obesity applies to all individuals. The absolute inequality (arithmetic difference in obesity between the high and low socioeconomic groups) in men was 4.33% at age 45 y, 4.65% at age 50 y, 6.33% at age 55 y, 7.38% at age 60 y, and 8.57% at age 65 y. CIs determined by the bootstrap method showed an increase of 4.24% (95% CI: 1.87, 6.52) in difference

TABLE 2
Trajectories of BMI (in kg/m²) between ages 45 and 65 y as a function of occupational position in women in the French GAZEL (Gaz de France Electricité de France) study

<table>
<thead>
<tr>
<th>Age at 45 y</th>
<th>High occupational position, managers (n = 284)</th>
<th>Intermediate occupational position, skilled workers (n = 2549)</th>
<th>Low occupational position, unskilled workers (n = 1699)</th>
<th>Difference between high and intermediate occupational group</th>
<th>Difference between high and low occupational group</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI changes</td>
<td>BMI 95% CI</td>
<td>BMI 95% CI</td>
<td>BMI 95% CI</td>
<td>ΔBMI 95% CI</td>
<td>ΔBMI 95% CI</td>
</tr>
<tr>
<td>Between ages 45 and 49 y</td>
<td>22.18 ± 0.72</td>
<td>22.54 ± 0.48</td>
<td>22.63 ± 0.96</td>
<td>22.89 ± 0.96</td>
<td>0.37 ± 0.06</td>
</tr>
<tr>
<td>Between ages 50 and 54 y</td>
<td>22.72 ± 0.60</td>
<td>22.36 ± 0.37</td>
<td>22.72 ± 0.96</td>
<td>22.68 ± 0.70</td>
<td>0.06 ± 0.10</td>
</tr>
<tr>
<td>Between ages 55 and 59 y</td>
<td>23.22 ± 0.27</td>
<td>22.30 ± 0.65</td>
<td>23.05 ± 0.32</td>
<td>22.89 ± 0.17</td>
<td>0.14 ± 0.14</td>
</tr>
<tr>
<td>Between ages 60 and 65 y</td>
<td>24.58 ± 0.15</td>
<td>24.34 ± 0.65</td>
<td>24.68 ± 0.32</td>
<td>24.68 ± 0.17</td>
<td>0.07 ± 0.14</td>
</tr>
<tr>
<td>BMI at 65 y</td>
<td>25.10 ± 0.15</td>
<td>24.63 ± 0.32</td>
<td>25.24 ± 0.32</td>
<td>24.68 ± 0.17</td>
<td>0.05 ± 0.14</td>
</tr>
</tbody>
</table>

Increase in inequality in BMI between 45 and 65 y | — | — | — | 0.59 ± 0.04 |

ΔBMI = BMI at 65 y – BMI at 45 y

1 Estimates are from a linear mixed-effects model, with random effects for the intercept and the slopes. Age was entered in the model as a piececwise linear function with knots (join points that mark the transition from one age-band to the next) at ages 50, 55, and 60 y.

2 Mean BMI (but not the estimate of social inequality in BMI) for a participant born in 1943.

3 P < 0.001 (Wald test).

4 P < 0.01 (Wald test).

5 P < 0.05 (Wald test).
in obesity rates between high and low occupational groups over the ages of 45 and 65 y. Obesity in women at 45 y of age was estimated at 2.47% and 5.08% in the high and low occupational groups, respectively. At 65 y, the corresponding figures were 7.27% and 10.98%. There was no increase in inequality in obesity between the ages of 45 and 65 y; absolute difference in obesity rates increased by 1.11% (95% CI: −3.58, 5.74).

Obesity trajectories as a function of education are shown in Figure 3A for men and in Figure 3B for women. For men, education-related increase in inequalities in obesity was 5.29% (95% CI: 1.65, 9.12), similar to that observed for occupation. Obesity in women at 45 y of age was estimated at 4.10% and 7.60% in the high and low educational groups, respectively. At 65 y, the corresponding figures were 10.63% and 17.46%. Absolute inequality in obesity between the ages of 45 and 65 increased by 3.33% (95% CI: −1.57, 6.28).

### Table 3

<table>
<thead>
<tr>
<th>Education Level</th>
<th>BMI</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>High degree</td>
<td>24.66</td>
<td>24.51, 24.73</td>
</tr>
<tr>
<td>Low degree</td>
<td>26.17</td>
<td>25.10, 25.24</td>
</tr>
<tr>
<td>Difference</td>
<td>0.55</td>
<td>0.43, 0.67</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Education Level</th>
<th>BMI</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>High degree</td>
<td>25.37</td>
<td>25.15, 25.59</td>
</tr>
<tr>
<td>Low degree</td>
<td>25.15</td>
<td>25.45, 25.59</td>
</tr>
<tr>
<td>Difference</td>
<td>0.75</td>
<td>0.51, 1.00</td>
</tr>
</tbody>
</table>

### Table 4

<table>
<thead>
<tr>
<th>Education Level</th>
<th>BMI</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>High degree</td>
<td>24.62</td>
<td>24.51, 24.73</td>
</tr>
<tr>
<td>Low degree</td>
<td>26.17</td>
<td>25.10, 25.24</td>
</tr>
<tr>
<td>Difference</td>
<td>0.55</td>
<td>0.43, 0.67</td>
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<tr>
<td>Difference</td>
<td>0.75</td>
<td>0.51, 1.00</td>
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1 Estimates are from a linear mixed-effects model, with random effects for the intercept and the slopes. Age was entered in the model as a piecewise linear function with knots (join points that mark the transition from one age-band to the next) at ages 50, 55, and 60 y.

2 Mean BMI (but not the estimate of social inequality in BMI) for a participant born in 1943.

3 P < 0.001 (Wald test).

4 P < 0.01 (Wald test).
DISCUSSION

We used 18 repeated measurements of body weight to examine the effect of socioeconomic circumstances on BMI trajectories over the transition period from midlife to old age. Results show BMI to continue to increase between the ages of 45 and 65 y, albeit at a slower rate at older ages, and increases to be greater in women than in men. Social inequalities in BMI were evident at the age of 45 y, and the age-related increase in BMI was more pronounced in the low socioeconomic group. This led to an increase in social inequalities in BMI over time. There was evidence of a similar pattern for obesity. Inequalities with education for both BMI and obesity appeared to be larger, particularly among women.

The obesity epidemic is gradually becoming a worldwide phenomenon, and evident throughout the human life span (21–23). Old age is generally thought to be accompanied by declining weight (14), and it remains unclear whether the years leading up to old age are accompanied by increasing body weight. Our analyses show that BMI increases continually between ages 45 and 65 y, with a greater increase in women as has been reported previously (24). Even though the rate of increase slowed with age, there was a significant increase in weight even between the ages of 60 and 65 y in both men and women in our data. These results are important because of the higher absolute risk of disease and mortality associated with weight gain in this age group (13, 14). Our results show that individuals in the low socioeconomic groups, measured either by occupation or education, had higher BMIs than those in the high socioeconomic groups at all ages between 45 and 65 y, and the weight gain was more rapid, particularly after 55 y of age among individuals in the low socioeconomic groups.

There is consistent evidence to show that weight trajectories in early adulthood are socially patterned (10–12). However, in late adulthood, the evidence is mixed, with some (5, 10, 25–27) but not all (15, 24, 28) studies showing greater weight gain in lower socioeconomic groups. A major drawback in most of these analyses is the method of analysis in which several measures of BMI, ranging from 2 to 9 (11, 28), are used to estimate weight gain per year in the different socioeconomic groups over the follow-up period. This method conflates age and cohort effects. We found 3 previous studies that used age rather than year of measurement as the time scale to examine age-related weight trajectories (11, 12, 15). In both of these studies—one that used 4 and the other that used 9 measures of BMI in individuals aged...
18–45 y—the results are similar to ours (11, 12). The third study, in 4070 men and women aged 20–59 at baseline, used 3 measures of BMI over 11 y (15). Their results showed mean BMI in the low education group to be higher at baseline and throughout the follow-up, but education inequalities did not increase over the follow-up. Our results, which showed an increase in inequalities, are based on a longer follow-up and on the use of both occupation and education to assess socioeconomic position.

A literature review showed occupational position to be a more relevant marker of socioeconomic circumstances when assessing weight trajectories (5). However, there is also evidence to show that weight gain in women is more strongly related to childhood socioeconomic circumstances (27). This is supported by our results because the effects of education are stronger in women. However, the pattern of results for both measures is similar. This is not surprising because occupation, education, and income are likely to be highly correlated in this occupational cohort of participants that work for the same organization. It is possible that results will vary more in the general population where education, occupation, and income may not be as tightly associated with each other.

Weight trajectories are often examined by using obesity as the outcome because it is a recognized risk factor for multiple health outcomes (13, 14). Our results show higher rates of obesity in the low socioeconomic group at all ages. These rates are lower than those in the United States or the United Kingdom but are comparable to those observed in the nationally representative decennial health surveys in France (29). In our data, obesity levels increased between the ages of 45 and 65 y in both men and women; in men, absolute social inequalities in obesity more than doubled over this period.

Methodologic considerations

We explicitly set out to model age-related BMI and obesity trajectories as a function of socioeconomic position. Analyses on rate of change of BMI and obesity were adjusted for the effect of birth year because BMI in more recent birth cohorts is higher than that in older birth cohorts at all ages. We did not adjust for wave of data collection (period effects) because it would lead to estimations of “between-person” or cross-sectional effects of age (15). A recent study compared the adjustments for period and for birth cohort and showed that the results obtained by using the first strategy are misleading because what is interpreted as an effect of age is actually an artifact due to cohort effects (15). Our method of modeling weight trajectories by using a piecewise approach also allows simple comparison of inequalities for 4 intervals of 5 y each (45–49 y, 50–54 y, 55–59 y, and 60–65 y) between the ages of 45 and 65 y.

Obesity risk in the elderly is best assessed by using absolute rather than relative risk (14). We focused on absolute inequality, which is simply the arithmetic difference in BMI or the obesity rates between socioeconomic groups. The model used to estimate obesity trajectories also provides odds ratios for risk of obesity in the low compared with the high socioeconomic group. For example, for occupational status in men, the odds ratios were 2.40 at 45 y, 1.85 at 50 y, 1.96 at 55 y, 2.08 at 60 y, and 2.10 at 65 y; in women, the corresponding figures were 2.11, 1.50, 1.70, 1.53, and 1.57. These numbers suggest declining inequalities. However, the decline evident in relative measures is simply a consequence of increase in obesity over time in all groups, including the denominator (high socioeconomic group) used to calculate relative risk (29).

Limitations and conclusions

There are some caveats to the results reported in this article. Body weight and height were self-reported, and it is well known that these data are subject to some bias (30, 31). A study in a subsample of the GAZEL cohort examined the validity of self-reported against measured weight and height and showed the former to underestimate BMI by 0.29 and 0.44 in men and women, respectively (32). However, this is unlikely to affect our results on rate of change in weight because social inequalities in weight gain would be overestimated only if the reporting bias changed with aging differently in the socioeconomic groups.

Our analysis makes the assumption that weight trajectories (the rate of change) are similar for all birth cohorts. This assumption appeared to hold in our data but could not be fully verified for the entire period from 45 to 65 y of age because no one was followed over the whole period. However, sensitivity analysis in a subgroup between the ages of 50 and 65 y showed results similar to the overall results. A further concern, as in most longitudinal studies, is the greater proportion of missing data in the low socioeconomic group and in older participants. A final limitation is that there were few women in the high occupational category; the width of the CI suggests that this limited the power in the analyses. It should also be noted that only 20% of the workforce from which the GAZEL cohort is drawn consisted of women, leading to the possibility that these women are not fully representative of the general female population.

In conclusion, this study highlights the importance of socioeconomic factors in shaping BMI and obesity trajectories in the transition period from midlife to old age. The findings reported here are important because obesity is a risk factor for several chronic diseases, such as diabetes, cardiovascular disease, and some cancers (2, 3) and for mortality (33, 34). Consequently, widening social inequalities in weight gain are likely to contribute to widening social inequalities in health in aging populations.

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