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 45 y and 65 y in managers and unskilled workers, respectively; the difference in obesity increased by 4.25% (95% CI: 1.87, 6.52). A similar trend was observed in women.

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 estimates 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 (13).

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 measurements 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 (13).

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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 ≥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.
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...
BMI at 65 y

Increase in inequality in BMI changes

BMI at 45 y

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

A 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

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 (joint 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 < 0.05 (Wald test).
TABLE 3
Trajectories of BMI (in kg/m²) between ages 45 and 65 y as a function of education in men in the French GAZEL (Gaz de France Electricité de France) study

<table>
<thead>
<tr>
<th>Education Level</th>
<th>High</th>
<th>Low</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BMI</td>
<td>95% CI</td>
<td>BMI</td>
</tr>
<tr>
<td>BMI at 45 y²</td>
<td>24.62</td>
<td>24.51, 24.73</td>
<td>25.17</td>
</tr>
<tr>
<td>BMI changes</td>
<td>0.72</td>
<td>0.66, 0.78</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>0.38</td>
<td>0.33, 0.43</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>−0.02</td>
<td>−0.07, 0.04</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>0.07</td>
<td>0.00, 0.14</td>
<td>0.19</td>
</tr>
<tr>
<td>BMI at 65 y²</td>
<td>25.78</td>
<td>25.64, 25.91</td>
<td>26.48</td>
</tr>
<tr>
<td>Increase in ineq.</td>
<td>—</td>
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</tbody>
</table>

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 (not the estimate of social inequality in BMI) for a participant born in 1943.
3 p < 0.001 (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).

TABLE 4
Trajectories of BMI (in kg/m²) between ages 45 and 65 y as a function of education in women in the French GAZEL (Gaz de France Electricité de France) study

<table>
<thead>
<tr>
<th>Education Level</th>
<th>High</th>
<th>Low</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BMI</td>
<td>95% CI</td>
<td>BMI</td>
</tr>
<tr>
<td>BMI at 45 y²</td>
<td>22.29</td>
<td>22.02, 22.57</td>
<td>22.63</td>
</tr>
<tr>
<td>BMI changes</td>
<td>0.93</td>
<td>0.80, 1.05</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>0.55</td>
<td>0.43, 0.67</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>0.32</td>
<td>0.15, 0.49</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>0.27</td>
<td>−0.01, 0.55</td>
<td>0.16</td>
</tr>
<tr>
<td>BMI at 65 y²</td>
<td>24.32</td>
<td>23.92, 24.72</td>
<td>24.82</td>
</tr>
<tr>
<td>Increase in ineq.</td>
<td>—</td>
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<td>—</td>
</tr>
</tbody>
</table>

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 (not the estimate of social inequality in BMI) for a participant born in 1943.
3 p < 0.001 (Wald test).
4 p < 0.05 (Wald test).
5 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 years, 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 years, 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 years, 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 years 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 years, and the weight gain was more rapid, particularly after 55 years 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
and 1.57. These numbers suggest declining inequalities. How-
average, for occupational status in men, the odds ratios were 2.40
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the low compared with the high socioeconomic group. For ex-
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

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.

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, 1.30, 1.70, 1.53, and 1.57. These numbers suggest declining inequalities. How-
sequence 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 socio-
economic 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 con-
tribute to widening social inequalities in health in aging populations.

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The authors’ responsibilities were as follows—AD: performed all the analy-
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pretation of results. The authors declared no conflicts of interest.

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