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Socio-economic indicators are independently associated with intake of animal foods in French adults

Caroline Méjean[1,*], Wendy Si Hassen[1], Christelle Lecossais[1], Benjamin Allès[1], Sandrine Péneau[1], Serge Hercberg[1,2,3] and Katia Castetbon[2,4]

[1]Université Paris 13, Sorbonne Paris Cité, Equipe de Recherche en Epidémiologie Nutritionnelle (EREN), Centre d'Épidémiologie et Statistiques Paris Nord, Inserm (U1153), Inra (U1125), Cnam, Université Paris 5, Université Paris 7, F-93017 Bobigny, France: [2]Université Paris 13, Sorbonne Paris Cité, Unité de Surveillance et d'Épidémiologie Nutritionnelle (USEN), SMBH Paris, Bobigny, France: [3]Department of Public Health, Hôpital Avicenne, Bobigny, France: [4]Université Libre de Bruxelles, Ecole de Santé Publique, Centre de Recherche en Épidémiologie, Biostatistiques et Recherche Clinique, Bruxelles, Belgium

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Abstract

Objective: The specific role of major socio-economic indicators (education, occupation, income) in influencing consumer choice of animal foods (AF) intake could reveal distinct socio-economic facets, thus enabling elucidation of mechanisms leading to social inequalities in health. We investigated the independent association of each indicator with intake of different AF and their effect modification.

Design: Cross-sectional study. AF intake was estimated using three 24 h dietary records. Associations between socio-economic factors and AF intake and interactions between socio-economic indicators were assessed using ANCOVA adjusted for age and energy intake. Analyses were performed separately for men and women, since gender interactions were found.

Setting: France.

Subjects: Adults (*n* 92 036) participating in the NutriNet-Santé Study.

Results: Low educated persons had higher intake of red meat (+9–12 g/d), processed meat (+6–9 g/d) and poultry (for men, +7 g/d) than those with a higher education level. Percentage of fish consumers was lower in individuals of the lowest income class compared with those in higher classes. Manual workers had a higher intake of cream desserts (for men, +14 g/d) than managerial staff. Few significant interactions were found. In stratified analyses, persons with the highest income consumed more yoghurt than those who had lower income, only in low educated individuals.

Conclusions: Socio-economic disparities in AF intake varied according to the socio-economic indicator, suggesting the specific influence of each indicator on AF intake. In particular, lower education was associated with higher intake of red and processed meats and cream desserts, and had an effect modification on the relationship between income and AF intake.

Keywords
Socio-economic position
Animal foods
Education
Income
Occupation

Evidence concerning the nutritional value of animal foods (AF) is sometimes contradictory, leading to opposing effects on chronic diseases such as cancer and CVD[1,2]. AF are rich sources of high-quality proteins, vitamins and minerals, including bioavailable Fe, vitamin D, Zn, Ca and vitamin B_{12}[3]; intake of healthy AF such as low-fat fish and milk decreases the risk of colorectal cancers, high blood pressure and CVD[1,4–7]. In contrast, high intake of unhealthy AF rich in fat and Na, such as processed and red meat and cheese, has been shown to increase the risk of CVD and colorectal cancer[1,2,5].

Dietary factors may contribute substantially to explaining the impact of socio-economic position (SEP) on mortality and morbidity related to chronic diseases (up to 66 %)[8–10], underlining the importance of socio-economic disparities in diet. Evidence is mounting that a high SEP, as defined by high education level, high income and high occupational category, is consistently associated with healthy dietary patterns, including greater consumption of fruits, vegetables and whole-grain foods[11–13]. SEP is the product of a number of social and economic factors; the relationship between each of the three major

*Corresponding author: Email c.mejean@eren.smbh.univ-paris13.fr

socio-economic indicators (education, occupation and income) with dietary intake may be independent of the two other socio-economic factors[13,14]. As underlined by Galorbardes *et al.*[13], the three socio-economic indicators are weakly correlated, since they represent different concepts[15,16]. They should therefore be taken into account simultaneously[17] and interactions between them should be examined to better understand their importance in terms of diet. For AF, each SEP indicator may be independently associated with intake. Income probably influences intake of expensive AF through a direct effect on financial resources, while knowledge and skills attained through education may make individuals more receptive to health education messages concerning AF intake[16]. Occupation reflects social standing and could be related to intake of some AF because of social networks[13].

Although numerous studies on the association between SEP and the intake of different groups of AF have been conducted, few of them have examined the independent effect of socio-economic indicators[13,18–22]. They showed that findings were not systematically concordant with those of studies using a single SEP. For instance, when adjusted for occupation or income, education was not associated, or was inversely associated, with cheese intake[20,22], while a large majority of studies using only one SEP indicator showed higher cheese intake among individuals with higher socio-economic status. In contrast, significant associations remained after adjustment for other SEP indicators, such as positive associations between income, education or occupation and intake of fish and poultry[11,20,21]. Only one study simultaneously used the three socio-economic indicators, but low-fat milk was the sole AF assessed[18]. Study of the relationship between intake of AF and socio-economic indicators is useful for elucidating mechanisms leading to social inequality in health, since intake of diverse AF may differentially influence the onset of major chronic pathologies.

The aim of our study was to assess the independent cross-sectional associations of each major socio-economic factor (education, occupation and income) with the intake of multiple AF groups. In addition, the effect modification of each socio-economic indicator upon associations between the other two SEP indicators and AF intake was investigated.

Methods

Population

Our sample was composed of 92 036 individuals who were participants in the NutriNet-Santé Study, a large web-based prospective cohort launched in France in May 2009, with a scheduled follow-up of 10 years. It was implemented in a general population targeting Internet-using adult volunteers aged 18 years or older. The study was designed to investigate the relationship between nutrition and health, as well as determinants of dietary behaviour and nutritional status. The design, methods and rationale have been described previously[23]. Briefly, in order to be included in the cohort, participants had to fill in an initial set of questionnaires assessing dietary intake, physical activity, anthropometry, lifestyle and socio-economic conditions, along with health status at baseline.

Data collection

All data used in the present study were collected at baseline.

Socio-economic position and demographic characteristics

SEP of participants was assessed at baseline by three indicators: education, income and occupation, using categories consistent with the French National Institute of Statistics' definitions[24]. If participants were unemployed or retired, we noted the occupational category of their last job. Participants were asked their monthly household income, including salary, social benefits, family allowance and rental income. To assess educational level, participants gave their highest attained diploma. Demographic factors included gender, age, marital status, place of residence, and presence of children in the household.

Educational level was recoded into four categories according to the distribution throughout the entire sample: primary education, secondary education, undergraduate (corresponding to up to 3 years after the high-school diploma) and postgraduate (more than 3 years after the high-school diploma). Occupation was recoded into six classes: manual worker, employee, intermediate profession (technician, skilled employee, teacher, nurse, etc.), managerial staff, self-employed (craftsman, shopkeeper, company manager, farmer) and never employed (homemaker, student, disabled). Household income per month was calculated by household units. One household unit was attributed for the first adult in the household, 0·5 for other persons aged 14 years or older and 0·3 for children under 14 years[25]. Categories used for monthly income were the following: <1200 €, 1200–1800 €, 1800–2700 € and >2700 € per household unit, plus a category for individuals who were unwilling to answer.

Dietary intake assessment

At baseline, participants were invited to provide three random validated 24 h dietary records during a 2-week period (one weekend day and two weekdays)[23]. The dietary record is completed via an interactive interface and is designed for self-administration on the Internet[26]. The web-based dietary assessment method relies on a meal-based approach, recording all foods and beverages (type and quantity) consumed at breakfast, lunch, dinner and all other eating occasions. First, the participant fills in the names of all food items eaten. Next, he/she estimates portion sizes for each reported food and beverage according to standard measurements (e.g. home containers, grams indicated on the package) or using

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images available via the interactive interface. These photographs, taken from a validated illustrated booklet[27], represent more than 250 foods (corresponding to 1000 generic foods) served in seven different portion sizes. A study investigating the validity of our web-based self-reported dietary record tool with respect to 24 h urinary and plasma biomarkers showed that the web-based dietary record tool used in the NutriNet-Santé Study performs well at estimating protein (0·61 in men, 0·64 in women) and K (0·78 in men, 0·42 in women) intakes (intra-cluster correlation coefficients), and fairly well at estimating fruits and vegetables (correlation with plasma β-carotene: 0·35 in men and 0·41 in women), fish (correlation with plasma DHA + EPA: 0·51 in men and 0·54 in women), β-carotene (0·37 in men, 0·38 in women), vitamin C (0·58 in men, 0·32 in women), Na (0·47 in men, 0·37 in women) and *n*-3 fatty acid intakes (0·36 in men, 0·38 in women; Spearman correlation coefficients)[28,29]. In addition, a pilot study comparing our web-based 24 h recording tool with a dietitian's interview showed strong agreement between the two methods, particularly for AF intake[26].

Values for energy were estimated using published nutrient databases[30] and were completed for recent market foods and recipes. Foods were classified according to the information provided in the French Nutrition and Health Program (Programme National Nutrition Santé) guidelines[31], leading to nine AF groups (fish, red meat, processed meat, poultry, eggs, milk, cheese, yoghurt, cream desserts). A single composite dish could be classified into several different groups. A ratio of animal added fats to total added fats was also used to assess the proportion of animal added fats in dietary intake. We added intake of butter and other added animal fats, such as thick and single cream, lard and duck fats, and we divided by the intake of total added fats, that also includes oil, margarine and salad dressing.

Statistical analysis

The present cross-sectional analysis focused on 92 036 participants included in the NutriNet-Santé Study, included between May 2009 and October 2013, living in the French metropolitan area, who had completed at least three 24 h dietary records at baseline, were not energy under-reporters and who had no missing data for socio-economic indicators, age or BMI (Fig. 1). Complete case analysis was therefore conducted.

For each participant, the daily average quantity of each AF group (in grams) was calculated from 24 h records, including weighting according to the day (weekdays or weekend) to take into account the effect of whether the dietary record was done on a weekend or a weekday. Energy under-reporting participants were identified by the method of Black[32]. Briefly, BMR was estimated by the Schofield equations[33] according to sex, age, weight and height collected at enrolment in the study. The ratio of energy intake to BMR was compared with a physical activity level of 1·55 or below, the WHO value for 'light' activity, so as to identify energy under-reporting participants[32]. The latter were consequently excluded from analysis. In addition, participants had the option of indicating whether the reported consumption was representative of his/her usual diet or differed considerably (due to illness, dieting, a social event, etc.); this information was taken into account to identify specific conditions that might objectively explain low energy intake. Energy under-reporting during a 24 h record might not be due solely to conscious or unconscious omission of food items, but also to under-eating that day because of specific conditions that might objectively explain low energy intake[32]. When participants declared that reported consumption was not representative of his/her usual diet (mainly due to illness in our sample), they were not considered as under-reporters[34]. The 24 h record was

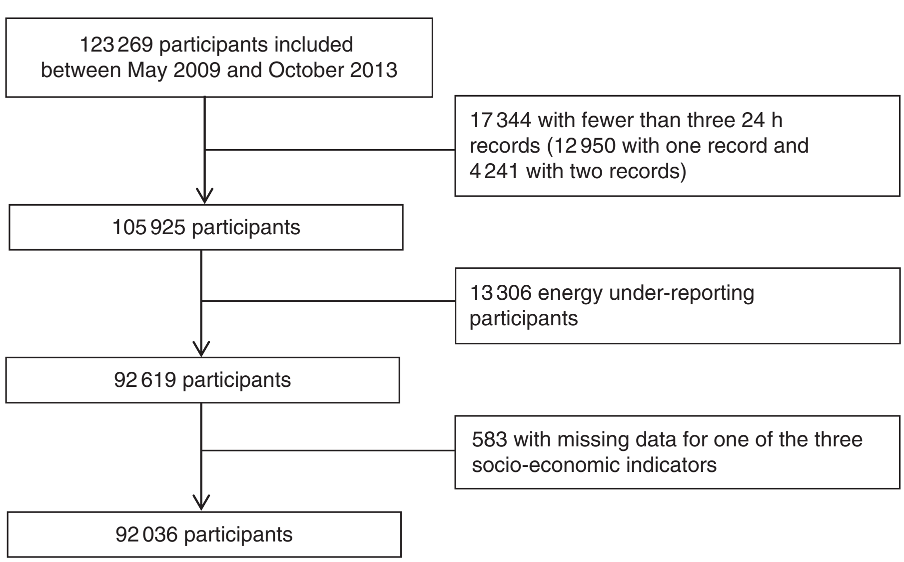

Fig. 1 Flowchart showing selection of participants for the present study

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consequently kept and the daily average energy intake was calculated from the three 24 h records.

Independent associations between socio-economic factors and intake of multiple AF were examined using ANCOVA, with the most highly educated group, the highest income group and the managerial group as references. In addition, associations between socio-economic indicators and the fact that the person was a consumer, i.e. that he/she reported eating the food at one of these three recordings at least one time (compared with those who did not report consuming the food at any of the three recordings), were assessed using logistic regression. First, models adjusted for total energy intake, age, BMI and total AF intake were constructed. Then, the three socio-economic indicators (education, income and occupation) were included together in the models. Collinearity between the three SEP indicators was investigated by examining the variance inflation factor, with a value of 4 as the maximum level to identify collinearity[35]. All analyses were performed separately for men and women, since gender interactions were found.

Linear and non-linear effects were tested. A *P* value of <0·05 was initially considered statistically significant. Then, to take into account multiple comparisons, we calculated the Bonferroni correction, leading to a *P* value of <0·002 (twenty tests for each type of model). Because the large sample size increased the likelihood of significant findings, a result concerning mean intake was interpreted as significant if it had a *P* value of <0·002 and if the difference in mean intake between individuals in the highest SEP category and those in the lowest category was clinically relevant. Based on results of meta-analyses on the effects of AF intake on cancers and CVD[1,4,36–38], the difference in intake of red meat, processed meat, poultry, fish, eggs and cheese was considered significant if it was >5 g/d. The difference in milk intake was interpreted as significant if it was >20 g/d, while the threshold was 12 g/d for yoghurt and cream dessert intake. We felt that these differences in intake of AF between groups could have a long-term impact on the incidence of CVD and cancer. For associations between the fact that the person was a consumer and socio-economic indicators, a result was interpreted as significant with a *P* value of <0·002. Interactions between income and education or occupation, and between education and occupation, were also tested. When the interaction between income and the other two SEP indicators was significant (*P* value of <0·05), we performed stratified analyses of associations between AF intake and income by educational or occupational strata. Results for interactions between education and occupation are not shown.

Individuals unwilling to declare their income had highly diversified sociodemographic profiles, so we did not interpret comparisons between their intakes and those of the other income classes. To optimize the robustness of statistical tests, we performed sensitivity analyses by reanalysing data after exclusion of participants unwilling to declare income. For occupational categories, comparisons between intakes of self-employed and never-employed participants and those of the other occupational categories were not interpreted, since these two groups are strongly heterogeneous in terms of social status and networks. However, we hypothesized that they were part of a socio-economic gradient in terms of AF intake, along with the other occupational classes. They were therefore included in multivariate analysis. Since the category ‘never-employed participants’ was heterogeneous in terms of social status and networks, and was composed of students (*n* 4372), homemakers and disabled persons (*n* 656), sensitivity analyses were performed by excluding homemakers and disabled persons, using an approach identical to that described above. Data management and statistical analyses were performed using the statistical software package SAS version 9.3.

Results

Comparisons between participants in the analysis sample and those who provided one or two 24 h records showed that the percentage of young persons (18–30 years), employees/manual workers (for men) and persons unwilling to divulge their income was lower in the final sample used for analyses than for those with one or two records (data not shown). Percentages of young persons, those with an undergraduate educational level, employees, never employed and those in the lowest income class were higher for women than for men (Table 1).

Table 1 Characteristics of the sample of adults (*n* 92 036) participating in the NutriNet-Santé Study, France, May 2009–October 2013

	Women (*n* 72 252)		Men (*n* 19 784)		
	n	%	*n*	%	*P* value
Age					<0·0001
18–30 years	18 460	25·5	2930	14·8	
30–50 years	30 369	42·0	7200	36·4	
50–65 years	20 034	27·7	6922	34·9	
>65 years	3389	4·7	2732	13·8	
Educational level					<0·0001
Primary	1905	2·6	689	3·5	
Secondary	24 199	33·5	6686	33·8	
Undergraduate	23 418	32·4	4830	24·4	
Postgraduate	22 730	31·4	7579	38·3	
Occupational category					<0·0001
Self-employed	2041	2·8	953	4·8	
Never employed	4400	6·1	628	3·2	
Manual worker	1448	2·0	1027	5·2	
Employee	24 600	34·0	2722	13·8	
Intermediate profession	19 481	26·9	4642	23·5	
Managerial staff	20 282	28·1	9812	49·6	
Monthly household income group					<0·0001
Unwilling to declare	9334	12·9	1364	6·9	
<1200 €	13 317	18·4	2477	12·5	
1200–1800 €	18 142	25·1	4556	23·0	
1800–2700 €	16 299	22·6	5072	25·6	
>2700 €	15 160	20·9	6315	31·9	

Percentages of the elderly (>65 years), those with a postgraduate education, managerial staff, manual workers, self-employed and those in the highest income class were lower for women than for men. Overall, the variance inflation factor of each SEP indicator was between 1·22 and 1·49, indicating that SEP indicators were not collinear. Only results on associations between binary variables and socio-economic indicators with a *P* value of <0·002, and between quantitative variables and socio-economic indicators considered to be clinically relevant, are described. No difference from the main results was found in sensitivity analysis when individuals unwilling to declare their income or homemakers and disabled persons were excluded (data not shown).

Associations between education and animal foods intake

For both genders, intake of red meat (difference: +9 to 12 g/d), processed meat (difference: +6 to 9 g/d) and poultry (difference: +7 g/d in men) was significantly higher in persons from the lowest education level compared with those from the highest (Tables 2 and 3). Individuals from the two intermediate education levels (secondary education and undergraduate) had intermediate AF intake for all food groups between the highest and the lowest levels, highlighting an educational gradient in AF intake (data not tabulated). Although no difference was found in mean intake of yoghurts and cream desserts (only in women), the percentage of yoghurt consumers was lower in persons with the lowest education level compared with those with the highest, while the percentage of consumers of cream desserts was higher (see online supplementary material, Supplemental Table 1). Differences between high and low educational categories for AF intake in models not adjusted for occupation and income were higher than in models adjusted for the two indicators, particularly for intake of poultry and milk (Supplemental Table 2 and Supplemental Table 3).

Associations between income and animal foods intake

Although no difference was observed in mean fish intake, the percentage of consumers of this food group was lower

Table 2 Differences in animal food group intakes between the highest and lowest SEP categories of occupation, household income and education in women (*n* 72 252) participating in the NutriNet-Santé Study, France, May 2009–October 2013; results from fully adjusted models*

	Intake (g/d) in total sample		Occupation		Monthly household income		Education	
Animal food group	Mean	SD	Difference between managerial staff and manual workers (g/d or %)†	*P* value‡	Difference between >2700 € and <1200 € (g/d or %)†	*P* value‡	Difference between postgraduate and primary level (g/d or %)†	*P* value‡
Fish								
Mean intake in consumers	47·1	37·7	4·2	<0·0001	3·0	0·002	−2·2	0·12
Red meat								
Mean intake in consumers	56·3	38·4	−0·3	<0·0001	−0·8	0·49	−8·6	<0·0001
Processed meat								
Mean intake in consumers	37·1	29·4	−1·3	0·001	−0·1	0·67	−6·0	<0·0001
Poultry								
Mean intake in consumers	40·7	32·3	−3·7	0·007	0·6	0·79	−4·7	0·0008
Eggs								
Mean intake in consumers	23·0	22·7	−0·4	<0·0001	2·9	0·04	−1·8	0·002
Milk								
Mean intake in consumers	143·3	136·4	−19·1	<0·0001	−17·4	<0·0001	−9·9	<0·0001
Cheese								
Mean intake in the whole sample	35·2	28·3	1·3	0·11	−0·6	0·89	2·3	<0·0001
Yoghurt								
Mean intake in consumers	120·8	106·4	7·1	0·19	10·3	0·005	−4·7	0·05
Cream desserts								
Mean intake in consumers	75·7	53·7	−2·4	0·004	−5·2	0·52	−8·4	<0·0001
Added animal fats								
Ratio of added animal fats to total added fats§	0·33	0·26	−0·02	0·0007	0·0	0·28	0·0	0·77

SEP, socio-economic position.
*All models were adjusted for age, total energy intake, BMI, total animal foods intake, occupation, household income and education. In bold, result interpreted as significant; i.e. with a *P* value of <0·002, and when the difference in mean intake between individuals belonging to the highest SEP category and those of the lowest category was clinically significant, i.e. >5 g/d for intake of fish, red meat, processed meat, poultry, eggs and cheese, >20 g/d for milk intake and >12 g/d for yoghurt intake.
†Subtraction of mean intake (g/d) or percentage of consumers between individuals belonging to the highest socio-economic category and those in the lowest category.
‡*P* value for non-linear association.
§Ratio of intake of animal added fats to intake of total added fats, in the whole sample.

in the lowest income category than in the highest category (see online supplementary material, Supplemental Table 1). Differences between high and low income classes in intake of red meat (in men), poultry (in men) and cream desserts (in men) in models not adjusted for occupation and education were significant compared with fully adjusted models (Supplemental Table 2 and Supplemental Table 3).

Associations between occupation and animal foods intake

In men, higher intake of cream desserts was reported for manual workers compared with managerial staff (difference: +14 g/d; Table 3). Employees had higher intake of cream desserts than manual workers and lower intake than managerial staff; there was no difference between intermediate professions and managerial staff (data not tabulated). Although no difference was found for mean intake of yoghurts and cream desserts (only in women), the percentage of yoghurt consumers was lower in manual workers than in managerial staff, while the percentage of cream dessert consumers was higher (see online supplementary material, Supplemental Table 1). In fully adjusted models, differences according to occupational categories were non-significant or lower for many AF groups, such as red meat, poultry, milk and cream desserts (in women), compared with models not adjusted for the other two indicators (Supplemental Table 2 and Supplemental Table 3).

Stratified analyses

Significant interactions were found for yoghurt intake between education and income (women, $P=0{\cdot}004$; men, $P=0{\cdot}02$) and between occupation and income, but only in women ($P=0{\cdot}009$). For both genders, stratified results by education level showed, in individuals with primary education only, that those belonging to the highest income class consumed higher quantities of yoghurt than persons in the lower categories (Tables 4 and 5). For stratified results in women by occupational group, no difference in yoghurt intake according to income class was interpreted as significant whatever the occupational category (Table 6). In men, there was a significant interaction between education and income for red meat ($P=0{\cdot}02$). In stratified analysis by educational level, no significant

Table 3 Differences in animal food group intakes between the highest and lowest SEP categories of occupation, household income and education in men (*n* 19 784) participating in the NutriNet-Santé Study, France, May 2009–October 2013; results from fully adjusted models*

	Intake (g/d) in total sample		Occupation		Monthly household income		Education	
Food groups	Mean	SD	Difference between managerial staff and manual workers (g/d or %)†	*P* value‡	Difference between >2700 € and <1200 € (g/d or %)†	*P* value‡	Difference between postgraduate and primary level (g/d %)†	*P* value‡
Fish								
Mean intake in consumers	55·0	44·6	–1·8	0·57	3·7	0·02	–3·2	0·06
Red meat								
Mean intake in consumers	74·2	50·2	–2·3	0·87	–1·5	0·02	–9·7	<0·0001
Processed meat								
Mean intake in consumers	48·8	39·7	– 2·8	0·41	–3·4	0·005	–8·0	0·0008
Poultry								
Mean intake in consumers	48·7	39·4	–3·7	0·01	–1·1	0·43	–6·4	0·001
Eggs								
Mean intake in consumers	26·0	27·1	–3·6	0·02	–3·2	0·29	–2·2	0·18
Milk								
Mean intake in consumers	160·3	149·5	–18·0	0·0007	–3·7	0·38	–2·9	0·06
Cheeses								
Mean intake in the whole sample	46·1	35·9	4·3	0·02	–0·1	0·59	2·5	0·31
Yoghurt								
Mean intake in consumers	115·8	85·9	–11·4	0·004	5·4	0·14	–3·1	0·14
Cream desserts								
Mean intake in consumers	85·3	64·9	–12·2	< 0·0001	–5·1	0·75	–0·7	0·56
Added animal fats								
Ratio of added animal fats to total added fats§	0·30	0·26	0·01	0·35	0	0·54	0	0·25

SEP, socio-economic position.
*All models were adjusted for age, total energy intake, BMI, total animal foods intake, occupation, household income and education. In bold, result interpreted as significant; i.e. with a *P* value of <0·002, and when the difference in mean intake between individuals belonging to the highest SEP category and those in the lowest category was clinically significant, i.e. >5 g/d for intake of fish, red meat, processed meat, poultry, eggs and cheese, >20 g/d for milk intake and >12 g/d for yoghurt intake.
†Subtraction of the mean intake (g/d) or the percentage of consumers between individuals belonging to the highest socio-economic category and those in the lowest category.
‡*P* value for non-linear association.
§Ratio of intake of animal added fats to intake of total added fats, in the whole sample.

Table 4 Intake of red meat and yoghurt according to income class, stratified by education level, in men (*n* 19 784) participating in the NutriNet-Santé Study, France, May 2009–October 2013*,†

	Red meat				Yoghurt			
Education	Mean (g/d)	SE	Difference between >2700 € and <1200 € (g/d)‡	*P* value	Mean (g/d)	SE	Difference between >2700 € and <1200 € (g/d)‡	*P* value
Participants with primary education level								
Income category								
<1200 €/month	91·8	8·8	4·6	0·06	**107·2**	**13·9**	**21·5**	**0·0001**
1200–1800 €/month	87·4	8·9	4·8		**99·3**	**12·1**	**29·3**	
1800–2700 €/month	82·8	7·5	9·2		110·9	12·8	18·8	
>2700 €/month	87·6	8·3			129·4	13·8		
Participants with secondary education level								
Income classes								
<1200 €/month	75·7	1·7	0·9	0·40	115·3	3·5	4·2	0·07
1200–1800 €/month	79·2	1·4	−2·6		119·4	2·8	9·4	
1800–2700 €/month	75·4	1·5	1·2		116·6	3·0	12·7	
>2700 €/month	76·5	1·9			119·6	3·6		
Participants with undergraduate education level								
Income classes								
<1200 €/month	73·6	2·4	−0·5	0·34	116·2	4·9	−5·1	0·49
1200–1800 €/month	70·2	2·0	2·8		109·1	4·0	1·7	
1800–2700 €/month	73·9	2·1	−0·8		116·4	4·1	−5·3	
>2700 €/month	73·1	2·2			111·2	4·3		
Participants with postgraduate education level								
Income classes								
<1200 €/month	76·5	3·0	−5·3	0·26	106·3	5·8	4·0	0·28
1200–1800 €/month	72·9	2·5	−1·7		106·5	4·9	3·3	
1800–2700 €/month	71·1	2·4	0·1		107·8	4·6	3·2	
>2700 €/month	71·2	2·3			110·2	4·4		

SEP, socio-economic position.
*All models for food group intake were adjusted for age, total energy intake, BMI, total animal foods intake and occupation. In bold, result interpreted as significant, i.e. with a *P* value of <0·002, and when the difference in mean intake between individuals belonging to the highest SEP category and those in the lowest category was clinically significant, i.e. >5 g/d for intake of red meat and >12 g/d for yoghurt intake.
†Mean intake in consumers only.
‡Subtraction of the mean intake (g/d) between individuals belonging to the highest socio-economic category and those in the lowest category.

difference in red meat intake was found according to income class whatever the educational level (Table 4). In women, a significant interaction between education and income was observed for milk consumers ($P=0·0001$). In stratified analysis by educational level, no significant difference in milk intake was found according to income class whatever the education level (Table 5). In women, interactions between education and income for intake and percentage of cream dessert consumers were significant (respectively $P=0·02$ and $P=0·06$). Stratified results showed a very slight difference in cream dessert intake (difference: −2 to 6 g/d) and the percentage of consumers (difference: +2 %) according to income group in secondary and undergraduate educational strata, while no significant difference was found in primary or postgraduate levels (data not tabulated).

Discussion

Compared with persons of high socio-economic status, consumers of red and processed meats and cream desserts were more numerous at lower socio-economic levels, and the latter also had higher mean intakes of these foods. In contrast, the percentage of consumers of fish and yoghurt among persons with low socio-economic status was lower than in those of high socio-economic status. The relationship between AF intake and SEP varied according to the socio-economic indicator used and these indicators rarely interacted.

Our study confirms that each SEP indicator was independently associated with at least one dietary outcome. In agreement with the literature[11,39–40], a lower education level was associated with higher intake of unhealthy AF, particularly meat products, and education level modulated relationships between income and intake of dairy products. Occupation and income were associated with percentage of consumers of dairy products. Differences between high and low educational categories in AF intake in models not adjusted for occupation or income were slightly higher than in models adjusted for the other two indicators. In contrast, in fully adjusted models, these differences according to occupational category and, to a lesser extent, according to income class were substantially attenuated for many AF groups compared with unadjusted models. Education therefore appears to be the strongest and most robust independent predictor of AF intake. It determines the occupation and income[16,17], and may influence the understanding and

Table 5 Intake of yoghurt and percentage of milk consumers according to income category, stratified by education level, in women (*n* 72 252) participating in the NutriNet-Santé Study, France, May 2009–October 2013*

	Yoghurt				Milk		
Education	Mean (g/d)†	SE	Difference between >2700 € and <1200 € (g/d)‡	*P* value	Milk consumers (%)	Difference between >2700 € and <1200 € (%)‡	*P* value
Participants with primary education level							
Income category							
<1200 €/month	13·0	6·0	32·1	0·0001	56·4	−9·7	0·0001
1200–1800 €/month	113·7	5·7	31·3		61·7	−15·1	
1800–2700 €/month	114·8	7·0	30·2		55·9	−9·2	
>2700 €/month	145·1	9·6			46·7		
Participants with secondary education level							
Income classes							
<1200 €/month	117·2	1·7	3·7	0·02	58·1	−3·2	<0·0001
1200–1800 €/month	120·5	1·6	0·4		61·2	−6·4	
1800–2700 €/month	124·7	1·8	−3·8		55·0	−0·1	
>2700 €/month	120·9	2·2			54·8		
Participants with undergraduate education level							
Income classes							
<1200 €/month	114·9	2·4	1·9	0·002	56·1	−1·8	0·009
1200–1800 €/month	121·1	2·2	−4·4		58·0	−3·8	
1800–2700 €/month	121·9	2·3	−5·2		57·3	−3·0	
>2700 €/month	116·7	2·4			54·3		
Participants with postgraduate education level							
Income classes							
<1200 €/month	116·3	3·3	6·4	0·02§	57·7	−0·6	0·38
1200–1800 €/month	118·3	3·1	4·3		55·0	2·1	
1800–2700 €/month	118·9	3·0	3·7		56·5	0·6	
>2700 €/month	122·6	2·9			57·1		

SEP, socio-economic position.
*All models for food group intake and percentage of consumers were adjusted for age, total energy intake, BMI, total animal foods intake and occupation. In bold, result interpreted as significant; i.e. with a *P* value of <0·002, and when the difference in mean intake between individuals belonging to the highest SEP category and those in the lowest category was clinically significant, i.e. >12 g/d for yoghurt intake.
†Mean intake in consumers only.
‡Subtraction of the mean intake (g/d) or the percentage of consumers between individuals belonging to the highest socio-economic category and those in the lowest category.
§*P* value for linear association.

importance accorded to preventive health measures and the capacity to generate behaviour that is beneficial on a long-term basis, such as low intake of meat[13,16]. Occupation may influence intake partly via workplace behaviour and the social environment, while income has a direct impact on diet through financial resources[13]. Differences between unadjusted and fully adjusted models also suggest that use of a single SEP measure might lead to misinterpreting relationships between the SEP indicator and dietary intake, and confirm that they should be studied simultaneously[13,14]. Under- or overestimation of socio-economic disparities in AF intake may have implications for public health strategies. Our findings provide information useful for identifying subgroups of the population at high nutritional risk in terms of AF intake. This is a key element when implementing nutritional public health measures targeting disadvantaged groups, particularly in the current context of health inequalities, which remain important.

Red meat, processed meat, poultry and fish

Results concerning red and processed meat were in agreement with the literature[11,40–42]. In particular, our study highlighted the importance of education compared with other socio-economic factors. Less-well-educated persons may not clearly perceive the negative health implications of consuming red and processed meat. In addition, the symbolic role of meat (i.e. its supposed contribution to physical strength and energy), along with existing social norms in this population, may affect the decision to continue eating meat despite its cost[43]. Understanding why persons with less education prefer eating meat is critical, since they are more strongly affected by chronic diseases for which meat intake is a risk factor[1,9,10].

Our results regarding poultry agreed with a French study showing an inverse association between education and intake of white meat[21], but was not consistent with most previous studies[11]. More highly educated individuals were possibly more concerned by food safety crises in the meat industry over the last decade; consequently, they may have reduced their overall intake of meat-based foods, including poultry. Moreover, a vegetarian lifestyle is more frequently found in this group[44].

Our finding regarding the relationship between income and fish consumption was in agreement with the few available studies that used income as a socio-economic indicator[42,45,46]. The lower percentage of fish consumers

Table 6 Intake of yoghurt according to income group, stratified by occupational category, in women (*n* 72 252) participating in the NutriNet-Santé Study, France, May 2009–October 2013*

	Yoghurt			
Occupation	Mean (g/d)†	SE	Difference between >2700 € and <1200 € (g/d)‡	*P* value
Manual workers				
Income classes				
<1200 €/month	113·6	7·1	−4·9	0·15
1200–1800 €/month	126·9	7·4	−18·3	
1800–2700 €/month	107·3	10·5	1·4	
>2700 €/month	108·7	18·8		
Employees				
Income classes				
<1200 €/month	118·2	1·8	1·4	0·02
1200–1800 €/month	120·7	1·5	−1·1	
1800–2700 €/month	126·0	1·8	−6·4	
>2700 €/month	119·6	2·6		
Intermediate professions				
Income classes				
<1200 €/month	116·5	2·9	2·5	0·16
1200–1800 €/month	121·4	2·3	−2·5	
1800–2700 €/month	122·2	2·2	−3·2	
>2700 €/month	119·0	2·4		
Managerial staff				
Income classes				
<1200 €/month	110·5	4·3	10·1	0·006§
1200–1800 €/month	117·7	3·2	2·9	
1800–2700 €/month	118·0	2·9	2·6	
>2700 €/month	120·6	2·9		

SEP, socio-economic position.
*All models for food group intake and percentage of consumers were adjusted for age, total energy intake, BMI, total animal foods intake and occupation. In bold, result interpreted as significant; i.e. with a *P* value of <0·002, and when the difference in mean intake between individuals belonging to the highest SEP category and those in the lowest category was clinically significant, i.e. >12 g/d for yoghurt intake.
†Mean intake in consumers only.
‡Subtraction of the mean intake (g/d) or the percentage of consumers between individuals belonging to the highest socio-economic category and those of the lowest category.
§*P* value for linear association.

in persons with a lower income compared with those with a higher income may be related to the high cost of fish. Cost constraint induced a decrease in fish intake as it ranks as one of the most expensive food groups[47,48]. Unlike previous studies[11,13,21,42,45,49], in our work, fish intake was not associated with education or occupation. However, most previous works did not simultaneously take into account several different socio-economic indicators.

Dairy products

Our findings on the absence of a relationship between SEP indicators and cheese intake contrasted with a systematic review and meta-analysis showing a positive association between education or occupation and consumption of cheese; it also highlighted substantial heterogeneity in results across European countries (not including French data), emphasizing the importance of conducting country-specific research[50]. In addition, previous works that took several socio-economic indicators into account showed ambiguous results[13,19,22,39,51,52]. A culture-oriented hypothesis might explain our results: cheese is commonly consumed in France during lunch or as a snack by the entire population; thus, no socio-economic differences were found. Our results regarding milk intake are concordant with a systematic review and meta-analysis showing no significant association of milk consumption with education or occupation[50].

Regarding yoghurt and cream desserts, education, occupation and household income each contributed to differences in consumption. Consistent with previous studies[11,23,39,40,49,53], the percentage of yoghurt consumers among manual workers and, to a lesser extent, less-well-educated persons was lower, whereas individuals with low SEP ate more cream desserts than those in higher categories. Our findings suggest that socio-economic disparities exist in choices of healthy (yoghurt) *v.* less healthy (cream dessert) dairy products, rather than socio-economic differences in overall intake of dairy products. Taken together, our results showed no differences in total intake of dairy products whatever the SEP indicator used (results not shown). Our stratified results showed no difference in yoghurt intake between income categories whatever the education level, except for the least-well-educated group. This highlights the fact that the individual capacity to understand and make use of public health information, as expressed by the education

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level[14,16], could override the cost barrier to intake of healthy dairy products. In addition, education may involve exposure to family eating habits acquired during childhood, thereby influencing healthier dietary behaviour in adulthood[16]. Poor dietary habits in childhood among the less educated may persist throughout adulthood; they include the choice of high-fat dairy desserts instead of yoghurt, combined with poor current dietary choices related to restrained access to better-quality but more expensive dairy foods[13].

Added animal fats

No socio-economic differences in the ratio of intake of added animal fats to total added fats were found. Consistent with results from other European Mediterranean countries[54], intake of added animal fats such as butter, cream, lard and duck fats in France may be influenced by cultural or regional variations rather than socio-economic factors[55].

Study limitations

Interpretation of the present results should take into account several limitations. Since the sample was not random, individuals belonging to high SEP groups were more numerous and had healthier lifestyles than the general population, with higher intake of fruits and vegetables[56]. Differences in dietary intake between SEP categories are probably greater in the general population. However, findings regarding intake of dairy products, meat, seafood and eggs in a nationally representative random sample of the French population[56] showed estimates equivalent to those in our study. In addition, over-representation of women in our sample could be explained by the fact that women are more likely to participate in voluntary-based health and epidemiological studies, whatever the field[57]. Women may also be over-represented in our sample because they have greater interest in nutrition. Although only 21·5 % of our sample was male, the distribution of men in the different SEP categories was sufficient to interpret differences in intake between these categories. Moreover, the large size and demographic heterogeneity of our sample provided high statistical power for investigating stratified associations of income with AF intake by education and occupation category. Causal inferences regarding associations between AF consumption and socio-economic characteristics must be viewed with caution due to the cross-sectional design of the present study. Unhealthy dietary habits may lead to chronic disease and obesity, thereby influencing socio-economic status. The problem of accuracy in web-based self-reported data also arises for repeated 24 h dietary records, compared with interviews by trained dietitians. However, the strength of our study lies in its reliance on at least three validated dietary records randomly assigned over a 2-week period, which appears to be reliable for estimating usual dietary intake[28,29] and is the recommended method in wide-scale epidemiological studies[58], as it enables a valid estimate of usual diet[59]. Another limitation was that the 'occupation' criterion cannot be reliably used for social groups outside the paid workforce[16], including homemakers, disabled persons and students. Also, self-employed persons are difficult to classify, since this category is extremely heterogeneous and includes company managers, freelancers, shopkeepers, craftspeople and workers in informal sectors of the economy. As a result, comparison between their intakes and those of the other categories may be biased. For this reason, results for these occupational categories were not interpreted, since such groups are extremely heterogeneous in terms of social status and relationships. Also, personal income is a sensitive question and participants may be reluctant to provide such information, although this point may have been overstated[16]. Since this SEP indicator is subject to more non-responses than other SEP questions, socio-economic differences may be incorrectly estimated.

Conclusion

In conclusion, our findings reveal that low socio-economic populations, particularly in terms of education, made unhealthier AF intake choices than persons in higher categories; these included meat products and high-fat dairy desserts instead of fish and low-fat desserts. In addition, simultaneous use of three socio-economic indicators and the study of their interactions highlighted distinct facets of SEP that may influence AF intake, consequently providing a better understanding of mechanisms leading to social inequalities in health. Further works assessing the dynamic nature of socio-economic indicators using repeated measures throughout a lifetime would be useful, since the prospective effects of their variations upon current dietary behaviour are not yet known.

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Supplementary material

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