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Socio-economic factors associated with an increase in fruit and vegetable consumption: a 12-year study in women from the E3N-EPIC study

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Abstract

Objective: To identify individual and contextual socio-economic factors associated with an increase in fruit and vegetable (F&V) consumption over a 12-year period and evaluate if some socio-economic factors were differentially associated with the change in consumption of some types of F&V.

Design: Associations between increased F&V consumption and socio-economic factors were studied with multivariate logistic regression.

Setting: E3N, a French prospective cohort study of 98 995 women.

Subjects: E3N participants (*n* 58 193) with information on diet in 1993 and 2005, and numerous individual and contextual socio-economic factors available.

Results: Associations between some individual socio-economic factors and changes in F&V consumption were observed. For instance, women who lived in a large household (>3 children *v.* no child) had higher probability of increasing their vegetable consumption (OR = 1·33; 95 % CI 1·24, 1·42). This association was driven by higher consumption of courgette and raw cucumber. Living with a partner was associated with higher odds of increasing consumption of fruits (OR = 1·07; 95 % CI 1·02, 1·13) such as pear, peach and grape.

Conclusions: Certain individual socio-economic factors, but none of the contextual socio-economic factors examined, were associated with an increase in F&V consumption. Factors associated with an increase in total F&V consumption were not necessarily associated with an increase in fruit or vegetable consumption separately, or with an increase in each subtype of fruit or vegetable. Magnitudes of the different associations observed also differed when F&V were considered together, separately or by subtype. Increases in F&V consumption were mostly observed in women with high socio-economic position. To develop effective nutritional interventions and policies that take the socio-economic environment of individuals into account, we recommend future research to further focus on (i) pathways through which population characteristics might influence changes in F&V consumption and (ii) existing interactions between individual and contextual socio-economic factors.

Keywords:
Fruit and vegetable
Evolution of diet
Socio-economic environment
E3N-EPIC cohort
Epidemiology

Consumption of fruits and vegetables is associated with a reduced risk of obesity[1], CVD[2] and some cancers[3], as well as a lower risk of all-cause and cardiovascular mortality[4]. The protective effect of fruits and vegetables is attributed to their fibre content, essential micronutrients and non-nutritive phytochemicals[5]. International agencies[6,7] and several countries[8–11] currently recommend people to consume more than five servings daily, disregarding the types of fruit or vegetable.

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It is well established that dietary habits including fruit and vegetable consumption are strongly patterned by socio-economic status[12–16], with socio-economically disadvantaged groups less likely to consume fruits and vegetables[17–19]. The socio-economic environment of individuals is complex and multifactorial. Nevertheless, its influence has generally been studied by considering single specific and conventional socio-economic factors[20] such as education[21] or income tax[22]. It has been suggested that, in order to capture the multidimensional nature of the socio-economic environment, it is preferable to simultaneously consider several socio-economic factors[20,23]. Socio-economic variables are each operationally distinct, may influence health behaviours by conceptually different processes[23] and are not interchangeable. It is therefore recommended, when possible, to study the influence of the socio-economic environment considering various individual and contextual socio-economic factors.

The socio-economic position of an individual is likely to be the result of all existing interactions between these factors[24], including money and time availabilities (examples of individual socio-economic factors), as well as access to grocery stores, transportation and neighbourhood safety (examples of contextual socio-economic factors)[25].

It is of major importance for chronic disease prevention to understand the socio-economic situations associated with having or moving to a healthier diet, since this may help health policy makers develop nutritional guidelines that consider the socio-economic disparities and specifically address the socio-economic groups that little respond to general health-promoting messages.

Fruit and vegetable consumption is often used as a proxy for a healthy diet. Indeed, diets rich in fruits and vegetables have been associated with better overall health status[26–31]. In addition, positive messages such as enhancing fruit and vegetable consumption are better accepted than messages focused on reducing unhealthy components of the diet[32,33], and should lead to substituting less healthy components for fruits and vegetables.

Only a few large cohort studies have multiple dietary intake measurements repeated over time, rending the study of diet evolution difficult. Even though few studies have several dietary intake measures, to our knowledge, they have not considered the impact of both individual and contextual factors on the evolution of diet.

The present study aimed to evaluate, for the first time, the socio-economic factors (both individual and contextual) associated with an increase in total fruit and vegetable consumption over a 12-year period, in women from the large E3N-EPIC prospective cohort study. Thanks to the detailed information in the data, we also have investigated whether these socio-economic factors were associated with an increase in fruit consumption or vegetable consumption separately, or even with an increase in consumption of specific fruits or vegetables.

Methods

The E3N-EPIC cohort study

The E3N-EPIC study is a prospective cohort study of 98 995 French women recruited from a national health insurance plan covering people working in the national education system[34]. E3N (Etude Epidemiologique aupres de femmes de l'Education Nationale) is the French component of the European Prospective Investigation into Cancer and Nutrition (EPIC)[35] and was initiated in 1990. The procedures followed were in accordance with the Helsinki Declaration of 1975 as revised in 1983 and all procedures involving human subjects were approved by the French National Commission for Computerized Data and Individual Freedom (CNIL). All women signed a letter of informed consent to allow their data to be stored, as required by the CNIL.

Participants were sent questionnaires to update health-related information and newly diagnosed diseases every 2 to 3 years. The average follow-up response rate is 83 % (which decreases to 68 % when considering food questionnaires, which are more time-consuming) and, overall, the total loss to follow-up since 1990 is below 3 %.

Study population

A total of 74 522 women answered the first food questionnaire in 1993 and among them, 60 380 women answered the second one in 2005. We excluded those who under- or over-reported energy intake at these two time points (n 1105 and n 1082, respectively) as previously described[36]. These women were in the top and bottom 1 % of the distribution of energy intake to BMR, computed on the basis of age, height and weight. After their exclusion, 58 193 women with available data in 1993 and 2005 were included in the present study. The study selection process is reported in the online supplementary material, Supplemental Fig. 1.

Dietary data

Dietary data were self-reported in June 1993 and July 2005 using a validated diet history questionnaire[37]. The questionnaire was divided into two parts. The first part quantified consumption by frequency (eleven categories, from 'never or less than once a month' to 'seven times a week') and portion sizes per food group or food item, and was grouped by meal occasions (eight occasions from breakfast to after-dinner snacks, including occasions such as the aperitifs before lunch and dinner). The second part provided more detailed qualitative information on separate items within one food group previously reported in the first part. In total, we were able to compute quantities in grams per day for 238 food items (foods and beverages).

A score of adherence to the national dietary guidelines[38] was derived from the dietary data as previously described[39]. The score ranges from 0 (minimal adherence to the dietary guidelines) to 15 (maximal adherence to the dietary guidelines).

Fruit and vegetable consumption

The national dietary guidelines' definition of the fruit and vegetable group was used in the present study[40]. The fruit group was composed of fresh fruit, fruit in syrup, fruit purée and 100 % pure fruit juice. The vegetable group included cooked and raw vegetables and soup. In total, information was available for sixteen types of fresh fruits, eighteen cooked vegetables and sixteen raw vegetables. To study associations between socio-economic factors and the most consumed fruit and vegetable subtypes, we identified the five most consumed fruits in the E3N-EPIC cohort in 1993: peaches, apples, grapefruit, pears and grapes. The five most consumed cooked vegetables in the E3N-EPIC cohort in 1993 were: green beans, courgette, carrots, tomatoes and endives. The five most consumed raw vegetables in the E3N-EPIC cohort in 1993 were: tomatoes, carrots, endives, cucumbers and radishes.

Standard ratio of fruit and/or vegetable consumption in 1993

National dietary guidelines recommend consuming at least five portions of fruit and vegetables daily, which corresponds to approximately 400 g/d[41]. The mean national energy intake in women is about 1800 kcal/d (7530 kJ/d)[42]. Therefore, to take the participants' energy intake into account, we used the ratio of fruit and/or vegetable intake to energy intake. Rather than looking at the crude consumption of fruits and vegetables in grams per day, which would not be the best reflection of physiological needs, we considered fruit and/or vegetable consumption as a function of energy intake as previous studies have done[43,44]. In addition, this provides a form of standardization and the ratio gives an estimate of how fruit and/or vegetable intake contribute(s) to the overall diet. For overall fruit and vegetable consumption, the reference value was 400 g/1800 kcal (400 g/7530 kJ), i.e. 0·22 g/kcal (0·053 g/kJ). For fruit consumption and vegetable consumption considered separately, the references were 200 g/1800 kcal (200 g/7530 kJ), i.e. 0·11 g/kcal (0·027 g/kJ).

Increase in fruit and vegetable consumption over time

To study the increase in fruit and/or vegetable consumption over time, we considered changes in the ratio of daily fruit and/or vegetable intake to daily energy intake between 1993 and 2005. The variable was categorized into a binary factor, where 0 = 'stability or decrease based on the ratio between 1993 and 2005' and 1 = 'increase in the ratio', with 0 taken as the reference category.

Socio-economic information

We considered both individual and contextual socio-economic data in the E3N-EPIC study. The following individual socio-economic variables were available in 1993: level of education (<high school diploma, up to 2 years of university, >2 years of university), occupation in 1993 (currently working *v.* not working), income (corresponding to the current professional activity reported by the women in 1992 or the last one if not currently working and divided into quartiles), number of children (four categories: 0, 1, 2, ≥3) and marital status (single *v.* in couple). The contextual socio-economic factors available in 1993 included place of residence in 1993 (six categories: Paris and suburbs, North, West, East, Centre and South), size of the city of residence in 1993 (computed from the *commune* of residence – the smallest administrative unit in France – and categorized as rural, i.e. areas with fewer than 2000 inhabitants; quasi-rural, i.e. areas with 2000 to 9999 inhabitants; quasi-urban, i.e. areas with 10 000 to 99 999 inhabitants; and large urban, i.e. areas with 100 000 or more inhabitants) and a deprivation index named FDep99[45] computed for each woman in 1993 from the information reported on her *commune* of residence. The FDep99 had been previously constructed at the *commune* level using four variables obtained from the 1999 population census and the tax authority's 2001 household income data[46]: median household income, percentage of high-school graduates in the population aged 15 years or older, percentage of blue-collar workers in the active population and unemployment rate.

We considered all these factors because they have previously been found to be related to diet[22,47–49]. Additionally, we included two less explored contextual socio-economic variables as we estimated that they could help to better characterize the socio-economic status of individuals: (i) the geographical area of birth (eight categories: Paris and suburbs, North, West, East, Centre, South, Dom-Tom (overseas departments and territories of France) and Abroad); and the size of the work area (≤10 000 inhabitants and >10 000 inhabitants).

Individual characteristics

Age, BMI (in kg/m^2), level of physical activity (in MET-h/week, where MET is metabolic equivalent of task) and smoking status (non-smoker, former smoker, current smoker) were used for adjustment because they have been shown to be associated with diet as well as with socio-economic position[47,50–52]. All these data were available in 1993.

Statistical analysis

For variables with <5 % of values missing, missing values were imputed with the median of the study population (quantitative variables) or the mode (qualitative variables). In the case of ≥5 % of missing values, a 'missing' category was created.

Description of the population according to the standard ratio of fruit and/or vegetable consumption in 1993

Women were described in terms of individual characteristics and socio-economic factors depending on whether their ratio of fruit and vegetable consumption in 1993 (see section 'Standard ratio of fruit and/or vegetable

consumption in 1993') was ≥0·22 or <0·22. When consumption of fruits and consumption of vegetables were studied separately, the ratio of ≥0·11 or <0·11 was considered.

Individual characteristics and socio-economic factors associated with an increase in fruit and vegetable consumption over time

Multivariable logistic regression models were performed to estimate OR of increasing consumption of fruits and/or vegetables over a 12-year period as well as their 95 % CI. Factors included in the fully adjusted models were individual socio-economic factors (level of education, occupation in 1993, income, number of children and marital status), contextual socio-economic factors (place of residence in 1993, size of the city of residence in 1993, FDep99, geographical area of birth and size of the work area) and individual characteristics (age, BMI, smoking status and level of physical activity). Models were also adjusted for energy intake evolution between 1993 and 2005 (kcal/d) as well as baseline consumption of fruits and vegetables (only baseline consumption of fruits or baseline consumption of vegetables, when considered separately; g/d).

All statistical analyses were performed using the statistical software package SAS version 9.3. A P value of <0·05 was considered statistically significant.

Results

Fruit and vegetable consumption and baseline characteristics

The main characteristics of the study population are summarized in Table 1. In comparison with women having fruit and vegetable consumption below the standard ratio, women with consumption greater than or equal to the standard ratio were older (16·0 *v.* 28·1 % with age >57·2 years), more physically active (45·1 *v.* 51·5 % with physical activity >37·9 MET-h/week), less frequently current smokers (16·4 *v.* 11·5 %) and had a comparable BMI (78·7 *v.* 77·7 % with normal BMI). In terms of individual socio-economic factors and compared with women having fruit and vegetable consumption below the standard ratio, women with consumption greater than or equal to standard ratio had similar level of education (90·0 *v.* 89·9 % with more than high school diploma), income (30·2 *v.* 28·5 % in the highest quartile), number of children (28·2 *v.* 29·4 % with three or more children) and marital status (84·7 *v.* 83·9 % living with a partner), but they were less frequently with occupation (79·1 *v.* 67·7 %). In terms of contextual socio-economic factors and compared with women having fruit and vegetable consumption below the standard ratio, women with consumption greater than or equal to the standard ratio were more frequently born and living in the South of France *v.* North of France (23·6 and 28·7 % *v.* 30·2 and 37·1 % for the South, and 18·1 and 16·8 % *v.* 12·0 and 11·1 % for the North). No differences were observed in terms of deprivation index (34·6 *v.* 33·8 % living in the most deprived areas) and size of the agglomeration of residence (17·9 *v.* 18·3 % living in large urban areas). When separately considering the consumptions of fruit and vegetables, similar characteristics were observed for women with consumption greater than or equal to the standard ratio.

The main characteristics of the study population in terms of diet are summarized in the online supplementary material, Supplemental Table 1. The mean intake of fruits and vegetables was 662·5 (SD 269·9) g/d. For women having fruit and vegetable consumption below the standard ratio the mean intake was 400·4 (SD 136·1) g/d, while for those having consumption greater than or equal to the standard ratio the mean intake was 753·3 (SD 244·2) g/d. In comparison with women having fruit and vegetable consumption below the standard ratio, women with consumption greater than or equal to the standard ratio were more likely to consume higher quantities of foods considered as healthy such as fish (24·9 (SD 18·6) *v.* 29·8 (SD 22·5) g/d) and olive oil (3·0 (SD 3·9) *v.* 5·4 (SD 6·0) g/d), and less quantities of foods considered as unhealthy such as French fries (12·1 (SD 13·0) *v.* 6·8 (SD 9·2) g/d), pizzas (25·9 (SD 25·1) *v.* 18·7 (SD 20·1) g/d) and sandwiches (15·1 (SD 26·1) *v.* 7·1 (SD 15·4) g/d). They had lower energy (2417·1 (SD 585·6) kcal/d (10 113 (SD 2450) kJ/d) *v.* 2139·7 (SD 519·4) kcal/d (8953 (SD 2173) kJ/d)) and alcohol intakes (16·0 (SD 17·1) *v.* 9·9 (SD 11·9) g/d), as well as higher adherence to guidelines scores (7·5 (SD 2·0) *v.* 9·6 (SD 1·9)). When separately considering the consumptions of fruits and vegetables, similar characteristics were observed for women with consumption greater than or equal to the standard ratio.

Individual socio-economic factors associated with an increase in fruit and vegetable consumption

In the fully adjusted models, higher level of education was positively associated with an increase in fruit consumption (OR = 1·09; 95 % 1·00, 1·18 for >2 years of university *v.* <high school diploma), especially grapefruit consumption (OR = 1·16; 95 % CI 1·08, 1·25). It was also associated with an increase in vegetable consumption (OR = 1·17; 95 % CI 1·08, 1·27), especially cooked vegetables (e.g. OR = 1·27; 95 % CI 1·17, 1·37 for courgette consumption; Tables 2 and 3). The increase in vegetable consumption was 41·4 and 23·2 g/d on average for women with a level of education >2 years of university and <high school diploma, respectively.

Having an occupation was associated with a higher probability of increasing vegetable consumption (OR = 1·20; 95 % CI 1·12, 1·28 *v.* without occupation), with an exception of endive consumption (OR = 0·99; 95 % CI 0·93, 1·06). The increase in vegetable consumption was 48·6 and 14·6 g/d on average for women with and without an

Table 1 Baseline individual and socio-economic characteristics of the population according to their fruit and vegetable consumption in 1993 (E3N-EPIC cohort study, *n* 58 193)

	Fruit and vegetables		Fruit		Vegetables	
Percentage (%)	Women consuming less than the ratio† (*n* 14 972)	Women consuming the ratio† or more (*n* 43 221)	Women consuming less than the ratio‡ (*n* 19 007)	Women consuming the ratio‡ or more (*n* 39 186)	Women consuming less than the ratio§ (*n* 17 685)	Women consuming the ratio§ or more (*n* 40 508)
Individual characteristics						
Age (years)	***		***		***	
≤47·1	33·4	22·1	31·4	21·9	31·0	22·4
47·1–51·5	28·8	23·7	27·9	23·6	27·5	23·9
51·5–57·2	21·8	26·1	22·5	26·2	22·7	26·0
>57·2	16·0	28·1	18·2	28·3	18·8	27·7
BMI (kg/m^2)	***		**		***	
<18·5	3·8	3·1	3·4	3·2	4·1	2·9
18·5–25	78·7	77·7	77·9	78·0	79·3	77·4
25–30	14·2	16·1	15·2	15·8	13·6	16·5
≥30	3·3	3·1	3·5	3·0	3·0	3·2
Physical activity (MET-h/week)	***		***		***	
≤23·1	29·3	23·6	28·4	23·4	28·0	23·8
23·1–37·9	25·6	24·9	25·5	24·8	25·1	25·0
37·9–60·6	23·7	25·3	23·8	25·5	24·3	25·2
>60·6	21·4	26·2	22·3	26·3	22·6	26·0
Smoking status	***		***		***	
Non-smoker	50·5	55·3	50·9	55·6	52·0	55·0
Former smoker	33·1	33·2	33·7	32·9	32·6	33·4
Smoker	16·4	11·5	15·4	11·5	15·4	11·6
Individual socio-economic factors						
Level of education	***		**		***	
<High school diploma	10·0	10·1	10·2	10·0	10·0	10·2
Up to 2 years of university	51·6	54·4	52·6	54·2	51·9	54·4
>2 years of university	38·4	35·5	37·2	35·8	38·1	35·4
Occupation	***		***		***	
No	20·9	32·3	23·0	32·4	23·5	31·9
Yes	79·1	67·7	77·0	67·6	76·5	68·1
Women's income (*n* 50 771; €/year)	***		***		***	
<16 963	11·5	9·7	11·2	9·8	11·2	9·7
16 963–17 713	27·5	28·4	27·7	28·4	27·8	28·4
17 713–24 156	18·4	20·5	19·4	20·2	18·7	20·5
≥24 156	30·2	28·5	29·2	28·8	30·0	28·4
Number of children	***		***		***	
0	10·6	11·9	10·5	12·0	11·2	11·6
1	15·4	15·2	15·2	15·3	15·9	15·0
2	45·8	43·5	45·6	43·4	44·9	43·8
≥3	28·2	29·4	28·7	29·3	28·0	29·6
Marital status	*		***			
Living without partner	15·3	16·1	15·1	16·2	15·7	16·0
Living with a partner	84·7	83·9	84·9	83·8	84·3	84·0
Contextual socio-economic factors						
Area of birth	***		***		***	
South	23·6	30·2	25·9	29·8	24·0	30·6
West	11·2	10·8	11·2	10·8	11·2	10·8
North	18·1	12·0	16·6	12·1	17·1	12·0
East	16·7	15·5	16·3	15·6	16·8	15··4
Centre	8·3	9·4	8·1	9·6	9·0	9·1
Paris and suburbs	15·5	14·4	14·9	14·6	15·2	14·4
Dom-Tom	0·3	0··3	0·2	0·3	0·3	0·3
Abroad	6·3	7·4	6·8	7·2	6·4	7·4
Area of residence	***		***		***	
South	28·7	37·1	31·6	36··7	29·2	37·5
West	11·4	11·0	11·4	10·9	11·5	10·9
North	16·8	11·1	15·5	11·2	15·6	11·3
East	15·6	13·8	15·1	13·8	15·8	13·6
Centre	7·4	8·6	7·3	8·7	8·2	8·3
Paris and suburbs	20·1	18·4	19·1	18·7	19·7	18·4
Size of the agglomeration of residence					***	
Rural (<2000 inhabitants)	17·1	16·4	17·6	16·0	16·5	16·6
Quasi-rural (2000–9999 inhabitants)	26·3	26·2	26·6	26·1	26·1	26·3

Table 1 *Continued*

Percentage (%)	Fruit and vegetables		Fruit		Vegetables	
	Women consuming less than the ratio† (*n* 14 972)	Women consuming the ratio† or more (*n* 43 221)	Women consuming less than the ratio‡ (*n* 19 007)	Women consuming the ratio‡ or more (*n* 39 186)	Women consuming less than the ratio§ (*n* 17 685)	Women consuming the ratio§ or more (*n* 40 508)
Quasi-urban (10 000–99 999 inhabitants)	38·7	39·1	38·3	39·4	39·3	38·9
Large urban areas (≥100 000 inhabitants)	17·9	18·3	17·5	18·5	18·1	18·2
Deprivation index, FDep99						
<−0·51 (less deprived)	32·7	33·1	32·7	33·1	32·9	33·0
0·51–0·21	32·7	33·1	33·0	33·0	32·8	33·1
≥0·21	34·6	33·8	34·3	33·9	34·3	33·9
Size of the working agglomeration (*n* 33 453)	***		***		***	
≤10 000 inhabitants	20·0	16·4	19·6	16·3	19·0	16·6
>10 000 inhabitants	45·1	38·4	43·5	38·5	43·9	38·5

MET, metabolic equivalent of task.
Percentages were significantly different between both categories: **P*<0·05, ***P*<0·01, ****P*<0·001.
†The standard ratio used was 400 g fruit and vegetables/1800 kcal (400 g/7530 kJ), i.e. 0·22 g/kcal (0·053 g/kJ).
‡The standard ratio used was 200 g fruit/1800 kcal (200 g/7530 kJ), i.e. 0·11 g/kcal (0·027 g/kJ).
§The standard ratio used was 200 g vegetables/1800 kcal (200 g/7530 kJ), i.e. 0·11 g/kcal (0·027 g/kJ).

occupation, respectively. Having an occupation was not associated with an increasing fruit consumption, but was associated with increasing grapefruit (OR = 1·14; 95 % CI 1·07, 1·22), pear (OR = 1·14; 95 % CI 1·07, 1·22) and grape (OR = 1·09; 95 % CI 1·02, 1·17) consumption (Tables 2 and 3). The increase in fruit consumption was 96·2 and 69·0 g/d on average for women with and with no occupation, respectively.

Intermediate incomes were modestly associated with a higher probability of increasing vegetable consumption (OR = 1·12; 95 % CI 1·03, 1·21 for third *v.* first quartile for income; Table 2).

The association observed between having three or more children and the probability of increasing vegetable consumption was positive (OR = 1·33; 95 % CI 1·24, 1·42), including raw cucumber consumption (OR = 1·31; 95 % CI 1·23, 1·40; Tables 2 and 3). The increase in vegetable consumption was 39·5 and 24·8 g/d on average for women with three or more children and women with no child, respectively.

Living with a partner was associated with a modestly higher probability of increasing consumption of fruits (OR = 1·07; 95 % CI 1·02, 1·13) and raw vegetables (e.g. OR = 1·14; 95 % CI 1·08, 1·20 for radish consumption; Tables 2 and 3).

Contextual socio-economic factors associated with an increase in fruit and vegetable consumption

When considering contextual socio-economic factors and the probability of increasing fruit and vegetable consumption, no association was observed except for a negative one concerning the size of the place of work (OR = 0·90; 95 % CI 0·85, 0·96 for cities with >10 000 inhabitants *v.* smaller-sized cities; Tables 4 and 5). The increase in fruit and vegetable consumption was 139·8 and 161·6 g/d on average for women working in bigger and smaller cities, respectively.

Individual characteristics associated with an increase in fruit and vegetable consumption

Being older was associated with a lower probability of increasing fruit and vegetable consumption over a 12-year period (OR = 0·71; 95 % CI 0·67, 0·77 for fourth *v.* first quartile for age). The association was stronger for vegetable (OR = 0·63; 95 % CI 0·59, 0·67) than for fruit consumption (OR = 0·86; 95 % CI 0·80, 0·92) and was observed for each type of raw and cooked vegetables. Regarding fruit consumption, only grapefruit (OR = 0·90; 95 % CI 0·84, 0·96) and pear (OR = 0·88; 95 % CI 0·82, 0·94) consumption showed the association (see online supplementary material, Supplemental Table 2). The increase in fruit and vegetable consumption was 162·2 and 70·8 g/d on average for the youngest and oldest women, respectively.

Having a higher BMI was associated with an increase only in vegetable consumption (OR = 1·28; 95 % CI 1·15, 1·42 for obese *v.* normal BMI). All the vegetable subtypes studied showed the association except for courgette consumption (OR = 1·08; 95 % CI 0·97, 1·19; Supplemental Table 2).

Having a higher level of physical activity was positively associated with an increased fruit and vegetable consumption (OR = 1·21; 95 % CI 1·15, 1·28 for the fourth *v.* first quartile of physical activity). The same was observed for the most consumed subtypes of fruits and vegetables except for green beans (OR = 1·04; 95 % CI 0·98, 1·09) and

Table 2 Individual socio-economic factors associated with an increase in fruit and vegetable consumption between 1993 and 2005 using multivariable logistic regression models (E3N-EPIC cohort study, *n* 58 193†)

	Increase in the ratio of consumption to energy intake between 1993 and 2005											
	Fruit and vegetables (*n* 37 333)				Fruit (*n* 37 304)				Vegetables (*n* 32 993)			
	n	%	OR‡	95 % CI	*n*	%	OR‡	95 % CI	*n*	%	OR‡	95 % CI
Level of education												
<High school diploma	3537	60·1	Ref.		3647	62·0	Ref.		3012	51·2	Ref.	
Up to 2 years of university	20 025	64·1	**1·14**	**1·05, 1·23**	20 014	64·1	1·07	0·99, 1·15	17 702	56·7	**1·18**	**1·09, 1·27**
>2 years of university	13 771	65·3	**1·16**	**1·07, 1·26**	13 643	64·7	**1·09**	**1·00, 1·18**	12 279	58·2	**1·17**	**1·08, 1·27**
Occupation												
No	9750	57·1	Ref.		10 161	59·5	Ref.		8431	49·4	Ref.	
Yes	27 583	67·1	**1·21**	**1·12, 1·30**	27 143	65·6	1·03	0·96, 1·11	24 562	59·7	**1·20**	**1·12, 1·28**
Women's income (€/year)												
<16 963	3828	64·5	Ref.		3855	65·0	Ref.		3260	55·0	Ref.	
16 963–17 713	10 641	64·9	1·04	0·96, 1·13	10 532	64·2	1·00	0·93, 1·08	9401	57·3	**1·11**	**1·02, 1·20**
17 713–24 156	7385	63·6	1·02	0·94, 1·11	7459	64·2	1·02	0·94, 1·11	6527	56·2	**1·12**	**1·03, 1·21**
≥ 24 156	10 920	64·9	0·97	0·89, 1·05	10 841	64·5	0·97	0·89, 1·05	9746	57·9	1·08	0·99, 1·17
Number of children												
0	4043	60·4	Ref.		4144	61·9	Ref.		3544	52·9	Ref.	
1	5677	63·9	**1·11**	**1·03, 1·20**	5654	63·7	1·02	0·95, 1·10	5044	56·8	**1·13**	**1·05, 1·22**
2	16 770	65·3	**1·19**	**1·11, 1·27**	16 769	65·3	**1·08**	**1·01, 1·15**	14 739	57·4	**1·19**	**1·11, 1·27**
≥ 3	10 843	64·0	**1·24**	**1·16, 1·33**	10 737	63·4	1·05	0·98, 1·12	9666	57·0	**1·33**	**1·24, 1·42**
Marital status												
Living without partner	5690	61·5	Ref.		5703	61·7	Ref.		5063	54·8	Ref.	
Living with a partner	31 643	64·6	**1·05**	**1·00, 1·11**	31 601	64·6	**1·07**	**1·02, 1·13**	27 930	57·1	1·03	0·98, 1·09

Ref., reference category.
Models are multi-adjusted and further adjusted for individual characteristics, contextual socio-economic factors, energy intake evolution between 1993 and 2005 and baseline consumption of the food group considered.
Significant results are indicated in bold font.
†Information on income was available for 50 771 women.
‡An OR above 1 corresponds to a higher probability for women to increase their ratio of consumption to energy intake between 1993 and 2005.

Table 3 Individual socio-economic factors associated with an increase in fruit and vegetable consumption between 1993 and 2005 using multivariable logistic regression models, with a focus on the most consumed types of fruits and vegetables (E3N-EPIC cohort study, *n* 58 193†)

	Increase in the ratio of consumption to energy intake between 1993 and 2005																			
	Most consumed fruits (mean (SD) intake in 1993 in g)										Most consumed cooked vegetables (mean (SD) intake in 1993 in g)									
	Grapefruit (19·8 (18·0)) (*n* 28 024)		Apple (26·8 (20·5)) (*n* 34 383)		Pear (18·2 (14·8)) (*n* 32 766)		Peach, nectarine (28·0 (20·0)) (*n* 33 088)		Grapes (18·1 (14·5)) (*n* 31 391)		Green beans (19·7 (13·1)) (*n* 26 795)		Courgette (15·2 (11·4)) (*n* 30 564)		Carrot (14·7 (10·7)) (*n* 28 294)		Tomato (13·3 (9·8)) (*n* 26 388)		Endive (13·0 (10·4)) (*n* 28 702)	
	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI
Level of education (Ref. = <high school diploma)																				
Up to 2 years of university	**1·10**	**1·02, 1·18**	1·06	0·99, 1·14	**1·09**	**1·01, 1·17**	**1·11**	**1·03, 1·20**	1·03	0·96, 1·11	**1·10**	**1·02, 1·19**	**1·20**	**1·11, 1·29**	**1·15**	**1·06, 1·24**	**1·12**	**1·04, 1·21**	**1·13**	**1·05, 1·22**
>2 years of university	**1·16**	**1·08, 1·25**	**1·08**	**1·00, 1·17**	**1·09**	**1·01, 1·18**	**1·09**	**1·01, 1·18**	1·02	0·95, 1·11	**1·09**	**1·01, 1·19**	**1·27**	**1·17, 1·37**	**1·15**	**1·06, 1·25**	**1·14**	**1·05, 1·23**	**1·10**	**1·02, 1·19**
Occupation (Ref. = no)																				
Yes	**1·14**	**1·07, 1·22**	1·05	0·98, 1·12	**1·14**	**1·07, 1·22**	1·05	0·98, 1·12	**1·09**	**1·02, 1·17**	**1·13**	**1·05, 1·21**	**1·13**	**1·05, 1·21**	**1·07**	**1·00, 1·15**	**1·13**	**1·05, 1·20**	0·99	0·93, 1·06
Women income (€/year) (Ref. = <16 963)																				
16 963–17 713	1·05	0·98, 1·13	1·07	0·99, 1·15	1·01	0·94, 1·09	0·98	0·91, 1·05	1·01	0·94, 1·09	1·06	0·98, 1·15	1·06	0·98, 1·14	1·06	0·98, 1·14	**1·10**	**1·02, 1·18**	0·96	0·89, 1·03
17 713–24 156	**1·09**	**1·01, 1·17**	1·06	0·98, 1·15	1·03	0·96, 1·11	1·01	0·93, 1·09	1·03	0·96, 1·11	1·07	0·99, 1·16	**1·10**	**1·01, 1·19**	1·07	0·99, 1·16	**1·13**	**1·05, 1·22**	0·99	0·92, 1·07
≥24 156	1·05	0·98, 1·13	0·99	0·92, 1·07	0·96	0·89, 1·03	0·95	0·88, 1·03	0·99	0·92, 1·07	1·04	0·96, 1·12	1·04	0·96, 1·13	1·03	0·95, 1·12	1·07	0·99, 1·15	0·99	0·91, 1·06
Number of children (Ref. = 0)																				
1	1·06	0·99, 1·14	1·03	0·96, 1·11	1·05	0·98, 1·13	**1·12**	**1·05, 1·21**	**1·08**	**1·00, 1·15**	1·01	0·94, 1·08	**1·13**	**1·05, 1·21**	1·00	0·93, 1·08	**1·08**	**1·01, 1·16**	0·99	0·93, 1·07
2	**1·12**	**1·05, 1·19**	1·05	0·98, 1·12	**1·07**	**1·01, 1·14**	**1·08**	**1·02, 1·15**	**1·10**	**1·04, 1·17**	1·02	0·96, 1·09	**1·18**	**1·10, 1·25**	1·02	0·96, 1·09	**1·10**	**1·04, 1·18**	0·98	0·92, 1·05
≥3	**1·12**	**1·05, 1·19**	0·96	0·90, 1·02	1·03	0·96, 1·09	1·03	0·96, 1·10	**1·07**	**1·01, 1·14**	**1·12**	**1·04, 1·20**	**1·26**	**1·18, 1·35**	**1·12**	**1·05, 1·20**	**1·19**	**1·11, 1·27**	0·99	0·93, 1·06
Marital status (Ref. = living without partner)																				
Living with a partner	**1·05**	**1·00, 1·11**	1·04	0·98, 1·09	**1·12**	**1·06, 1·17**	**1·09**	**1·03, 1·15**	**1·09**	**1·03, 1·14**	0·97	0·92, 1·03	**0·92**	**0·87, 0·97**	1·02	0·97, 1·08	1·03	0·98, 1·09	1·02	0·97, 1·08

	Increase in the ratio of consumption to energy intake between 1993 and 2005									
	Most consumed raw vegetables (mean (SD) intake in 1993 in g)									
	Tomato (9·9 (7·5)) (*n* 23 518)		Carrot (6·7 (5·7)) (*n* 24 427)		Endive (6·5 (5·5)) (*n* 23 882)		Cucumber (5·9 (5·8)) (*n* 21 305)		Radish (5·5 (4·8)) (*n* 23 951)	
	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI
Level of education (Ref. = <high school diploma)										
Up to 2 years of university	1·06	0·98, 1·14	1·05	0·98, 1·14	1·03	0·96, 1·11	0·96	0·89, 1·03	**1·12**	**1·04, 1·20**
>2 years of university	**1·08**	**1·00, 1·17**	1·06	0·98, 1·15	1·00	0·92, 1·08	0·95	0·88, 1·03	**1·09**	**1·01, 1·18**
Occupation (Ref. = no)										
Yes	**1·14**	**1·06**, **1·22**	**1·10**	**1·03**, **1·18**	**1·13**	**1·06**, **1·21**	**1·18**	**1·10**, **1·26**	**1·14**	**1·07**, **1·22**
Women income (€/year) (Ref. = <16 963)										
16 963–17 713	1·02	0·94, 1·10	1·01	0·94, 1·09	1·04	0·97, 1·12	**1·09**	**1·02**, **1·18**	1·00	0·93, 1·08
17 713–24 156	0·99	0·91, 1·07	1·00	0·93, 1·08	1·05	0·97, 1·14	**1·08**	**1·00, 1·17**	0·98	0·91, 1·06
≥24 156	0·99	0·92, 1·07	0·97	0·90, 1·05	1·04	0·96, 1·12	**1·08**	**1·00**, **1·16**	0·96	0·89, 1·03
Number of children (Ref. = 0)										
1	**1·12**	**1·04, 1·21**	**1·17**	**1·09, 1·26**	**1·13**	**1·05, 1·22**	**1·12**	**1·05, 1·21**	1·06	0·98, 1·13
2	**1·11**	**1·04, 1·18**	**1·13**	**1·06, 1·21**	**1·12**	**1·05, 1·19**	**1·19**	**1·12, 1·27**	**1·11**	**1·04, 1·18**
≥3	**1·13**	**1·05, 1·21**	**1·17**	**1·10, 1·25**	**1·14**	**1·07, 1·22**	**1·31**	**1·23, 1·40**	**1·15**	**1·08, 1·23**
Marital status (Ref. = living without partner)										
Living with a partner	**1·08**	**1·02, 1·14**	**1·10**	**1·04, 1·16**	**1·08**	**1·03, 1·14**	**1·06**	**1·01, 1·12**	**1·14**	**1·08, 1·20**

Ref., reference category.
Models are multi-adjusted and further adjusted for individual characteristics, contextual socio-economic factors, energy intake evolution between 1993 and 2005 and baseline consumption of the food group considered. Significant results are indicated in bold font.
†Information on the income was available for 50 771 women.
‡An OR above 1 corresponds to a higher probability for women to increase their ratio of consumption to energy intake between 1993 and 2005.

endive (OR = 1·04; 95 % CI 0·99, 1·10; Supplemental Table 2).

Current smoking was associated with a lower probability of increasing fruit (OR = 0·81; 95 % CI 0·76, 0·85) and carrot and tomato consumptions (OR = 0·85; 95 % CI 0·81, 0·90 and OR = 0·93; 95 % CI 0·88, 0·99, respectively). It was also associated with a higher probability of increasing raw endive and cucumber consumptions (OR = 1·06; 95 % CI 1·00, 1·12 and OR = 1·12; 95 % CI 1·06, 1·19, respectively). Former smokers tended to decrease or maintain their apple and pear consumptions (OR = 0·95; 95 % CI 0·91, 0·98 and OR = 0·94; 95 % CI 0·90, 0·97, respectively) and to increase their raw endive, cucumber and radish consumptions (OR = 1·05; 95 % CI 1·01, 1·09, OR = 1·11; 95 % CI 1·07, 1·15 and OR = 1·05; 95 % CI 1·01, 1·09, respectively; Supplemental Table 2).

Discussion

In the large E3N-EPIC cohort, our study investigated the socio-economic factors associated with an increase in fruit and vegetable consumption over a 12-year period. To our knowledge, this is the first prospective study to simultaneously consider the impact of individual and contextual socio-economic factors on changes in fruit and vegetable consumption. In agreement with previously published cross-sectional studies[25,53], our results show that long-term changes in fruit and vegetable consumption are socio-economically patterned. However, the socio-economic factors associated with an increase in fruit consumption were not the same as those associated with an increase in vegetable consumption. The associations also differed according to fruit and vegetable subtypes.

It has previously been suggested that environmental determinants of fruit consumption and vegetable consumption could be different[18]. For example, the presence of fruits in the fruit bowl on the table at home may elicit fruit consumption and culture-specific eating patterns may determine the amount and the type of vegetables eaten during meals.

In our study, associations between socio-economic status and changes in fruit and vegetable consumption over a 12-year period were observed for individual socio-economic factors but not for contextual factors. Some studies have shown that contextual factors such as neighbourhood socio-economic status are associated with fruit and vegetable consumption[54–57], wherein individuals living in neighbourhoods with higher socio-economic status had higher intakes of fruits and vegetables; however, other studies were less conclusive in that respect[58,59]. Defining the contextual aspect of the socio-economic environment and selecting relevant variables to study have been reported to be complex[48,60,61]. Therefore, there is still room to understand the complex interactions between individual and contextual factors to act upon. In our study, all the considered contextual socio-economic factors were found to be unrelated to fruit and vegetable consumption changes over time. It would be interesting to replicate our study design with other contextual socio-economic factors than the ones available in the E3N study.

Higher education and physical activity levels were associated with an increase in fruit and vegetable consumption. Level of education and physical activity have previously been shown to be positively associated with fruit and vegetable consumption in cross-sectional studies[41,49,62]. Educational level may be associated with an increase in fruit and vegetable consumption through several pathways such as dietary knowledge and ability to interpret health education messages[23,63]. Regarding physical activity, our results suggest a global awareness about health and a combination of positive healthy behaviours. Having an occupation and an increased number of children were associated with a higher probability of increasing vegetable consumption. Positive associations between occupation level and consumption of both fruits and vegetables have been previously demonstrated in cross-sectional studies as well[17,41], whereas having children provided mixed results[18]. Our finding that living with a partner was associated with a higher probability of increasing fruit consumption is in line with previous data[18]. Living with a partner may affect a person's fruit and vegetable intake via the partner's eating patterns, social support, sociocultural norms and home availability of fruits and vegetables[18]. In France fruits and vegetables are sold by the kilogram, while other countries such as the UK tend to sell fruits and vegetables in smaller prepacked portions. Therefore, French individuals who live on their own may be less prone to buy fruits and vegetables as well as to do home cooking of vegetables, especially while they are ageing. Also, social networks and supportive social norms have been suggested to be strongly associated with changes in fruit and vegetable consumption[64]. This may partly explain the positive associations we observed between having an occupation, being in a couple, having several children and the increase in fruit and vegetable consumption over time.

When considering the descriptive characteristics of the population in 1993, in comparison with women having fruit and vegetable consumption below the standard ratio, women with consumption greater than or equal to the standard ratio had similar level of education, number of children and marital status, and were less frequently with a professional activity. These results could suggest that the National Nutrition and Health Program[9,18], which started to promote the consumption of five servings of fruits and vegetables daily in 2001 with the help of radio and television announcements, was likely to have a greater impact on women living with a partner, with high education level, with an increased number of children and without professional activity. Women with high physical activity levels were already more likely to follow

Table 4 Contextual socio-economic factors associated with an increase in fruit and vegetable consumption between 1993 and 2005 using multivariable logistic regression models (E3N-EPIC cohort study, *n* 58 193†)

	Fruit and vegetables (*n* 37 333)				Fruit (*n* 37 304)				Vegetables (*n* 32 993)			
	n	%	OR‡	95 % CI	*n*	%	OR‡	95 % CI	*n*	%	OR‡	95 % CI
Area of birth												
South	10 491	63·2		Ref.	10 454	62·9		Ref.	9409	56·6		Ref.
West	4081	64·2	0·93	0·86, 1·01	4059	63·9	0·96	0·89, 1·04	3596	56·6	0·87	0·81, 0·95
North	5294	67·0	0·96	0·89, 1·04	5230	66·2	0·96	0·89, 1·04	4589	58·1	0·88	0·82, 0·95
East	5930	64·4	0·98	0·91, 1·06	5961	64·7	1·04	0·96, 1·12	5213	56·6	0·89	0·83, 0·96
Centre	3448	65·2	1·04	0·95, 1·13	3456	65·3	1·07	0·99, 1·16	3015	57·0	0·96	0·88, 1·04
Paris and suburbs	5406	63·3	0·93	0·86, 0·99	5464	64·0	1·00	0·93, 1·07	4772	55·9	**0·88**	**0·82, 0·94**
Dom-Tom	99	61·9	0·89	0·63, 1·28	99	61·9	0·98	0·69, 1·39	84	52·5	0·76	0·53, 1·07
Abroad	2584	62·5	0·96	0·89, 1·04	2581	62·4	0·95	0·88, 1·03	2315	56·0	0·99	0·92, 1·07
Area of residence												
South	12 786	62·7		Ref.	12 783	62·7		Ref.	11 393	55·9		Ref.
West	4209	65·2	1·05	0·97, 1·14	4150	64·3	1·03	0·96, 1·12	3753	58·1	1·07	0·99, 1·16
North	4925	67·3	0·99	0·91, 1·08	4899	66·9	1·05	0·97, 1·13	4245	58·0	0·93	0·86, 1·01
East	5367	64·7	**0·91**	**0·84, 0·98**	5372	64·8	0·96	0·89, 1·03	4759	57·4	**0·92**	**0·85**, **0·99**
Centre	3098	64·5	1·03	0·94, 1·12	3132	65·2	**1·11**	**1·02, 1·20**	2685	55·9	0·93	0·86, 1·01
Paris and suburbs	6948	63·5	0·95	0·89, 1·01	6968	63·6	0·96	0·89, 1·02	6158	56·2	0·95	0·89, 1·01
Size of the agglomeration of residence												
Rural (<2000 inhabitants)	6287	65·3		Ref.	6260	65·0		Ref.	5526	57·4		Ref.
Quasi-rural (2000–9999 inhabitants)	9902	64·8	0·98	0·92, 1·04	9880	64·6	1·01	0·95, 1·07	8785	57·5	1·00	0·95, 1·06
Quasi-urban (10 000–99 999 inhabitants)	14 522	64·0	1·00	0·94, 1·06	14 528	64·0	1·03	0·97, 1·09	12 755	56·2	0·99	0·94, 1·05
Large urban areas (≥100 000 inhabitants)	6622	62·6	0·97	0·91, 1·04	6636	62·8	1·01	0·94, 1·08	5927	56·0	1·00	0·94, 1·07
Deprivation index, FDep99												
<−0·51 (less deprived)	12 251	63·8		Ref.	12 324	64·2		Ref.	10 869	56·6		Ref.
0·51–0·21	12340	64·3	1·01	0·96, 1·06	12 279	63·9	0·97	0·92, 1·02	10 979	57·2	1·01	0·96, 1·06
≥0·21	12 742	64·4	0·99	0·94, 1·05	12 701	64·2	0·96	0·91, 1·01	11 145	56·3	0·96	0·92, 1·01
Size of the working agglomeration												
≤10 000 inhabitants	7016	69·5		Ref.	6862	68·0		Ref.	6291	62·3		Ref.
>10 000 inhabitants	15 497	66·3	**0·90**	**0·85, 0·96**	15 326	65·6	**0·92**	**0·87, 0·98**	13 776	59·0	**0·89**	**0·84, 0·95**

Ref., reference category.
Models are multi-adjusted and further adjusted for individual characteristics, contextual socio-economic factors, energy intake evolution between 1993 and 2005 and baseline consumption of the food group considered. Significant results are indicated in bold font.
†Information on income was available for 50 771 women.
‡An OR above 1 corresponds to a higher probability for women to increase their ratio of consumption to energy intake between 1993 and 2005.

Table 5 Contextual socio-economic factors associated with an increase in fruit and vegetable consumption between 1993 and 2005 using multivariable logistic regression models, with a focus on the most consumed types of fruits and vegetables (E3N-EPIC cohort study, *n* 58 193†)

	Increase in the ratio of consumption to energy intake between 1993 and 2005																			
	Most consumed fruits (mean (SD) intake in 1993 in g)										Most consumed cooked vegetables (mean (SD) intake in 1993 in g)									
	Grapefruit (19·8 (18·0)) (*n* 28 024)		Apple (26·8 (20·5)) (*n* 34 383)		Pear (18·2 (14·8)) (*n* 32 766)		Peach, nectarine (28·0 (20·0)) (*n* 33 088)		Grapes (18·1 (14·5)) (*n* 31 391)		Green beans (19·7 (13·1)) (*n* 26 795)		Courgette (15·2 (11·4)) (*n* 30 564)		Carrot (14·7 (10·7)) (*n* 28 294)		Tomato (13·3 (9·8)) (*n* 26 388)		Endive (13·0 (10·4)) (*n* 28 702)	
	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI
Area of birth (Ref. = South)																				
West	1·02	0·94, 1·10	1·03	0·95, 1·11	1·01	0·93, 1·09	0·97	0·90, 1·05	0·92	0·86, 1·00	0·96	0·88, 1·04	**0·81**	**0·75, 0·88**	0·93	0·86, 1·01	**0·87**	**0·81, 0·94**	**0·79**	**0·73, 0·85**
North	1·05	0·98, 1·13	0·95	0·88, 1·02	1·05	0·97, 1·13	**0·91**	**0·85, 0·99**	0·94	0·87, 1·01	**0·92**	**0·85, 0·99**	**0·85**	**0·78, 0·91**	0·96	0·89, 1·03	**0·87**	**0·81, 0·94**	0·95	0·88, 1·02
East	1·06	0·99, 1·14	1·02	0·95, 1·10	0·98	0·91, 1·05	0·98	0·91, 1·05	0·98	0·92, 1·05	0·97	0·90, 1·04	**0·91**	**0·84, 0·97**	1·00	0·93, 1·07	**0·85**	**0·79, 0·92**	**0·87**	**0·81, 0·93**
Centre	1·05	0·97, 1·13	1·02	0·94, 1·11	1·05	0·97, 1·13	1·05	0·97, 1·14	0·96	0·89, 1·04	0·96	0·88, 1·04	0·94	0·87, 1·02	0·98	0·90, 1·06	0·95	0·88, 1·03	0·94	0·87, 1·02
Paris and suburbs	1·00	0·94, 1·06	**0·91**	**0·85, 0·97**	1·00	0·94, 1·06	0·97	0·91, 1·04	0·95	0·89, 1·01	0·94	0·88, 1·00	**0·88**	**0·83, 0·94**	**0·92**	**0·86, 0·98**	**0·87**	**0·82, 0·93**	**0·87**	**0·82, 0·93**
Dom-Tom	1·12	0·81, 1·54	0·73	0·52, 1·02	0·73	0·53, 1·02	**0·67**	**0·48, 0·93**	0·90	0·65, 1·25	0·86	0·61, 1·22	0·90	0·64, 1·27	0·80	0·57, 1·12	0·88	0·63, 1·24	0·78	0·56, 1·09
Abroad	0·99	0·92, 1·07	**0·86**	**0·80, 0·93**	0·94	0·87, 1·01	**0·89**	**0·83, 0·96**	0·98	0·91, 1·06	**0·90**	**0·84, 0·98**	1·04	0·96, 1·12	0·94	0·87, 1·01	0·90	**0·83, 0·97**	**0·83**	**0·77, 0·90**
Area of residence (Ref. = South)																				
West	**1·20**	**1·11, 1·29**	1·07	0·99, 1·15	1·02	0·95, 1·10	1·00	0·93, 1·08	1·00	0·93, 1·08	0·96	0·89, 1·04	0·95	0·88, 1·03	1·00	0·93, 1·08	1·02	0·94, 1·10	0·99	0·92, 1·07
North	**1·10**	**1·02, 1·18**	1·06	0·98, 1·14	**1·07**	**1·00, 1·16**	1·01	0·94, 1·09	1·00	0·93, 1·08	0·95	0·88, 1·03	**0·89**	**0·82, 0·96**	1·03	0·95, 1·11	**0·90**	**0·83, 0·97**	1·05	0·98, 1·14
East	**1·07**	**1·00, 1·15**	1·03	0·96, 1·11	0·94	0·88, 1·01	0·95	0·88, 1·02	0·99	0·93, 1·07	**0·91**	**0·85, 0·98**	**0·89**	**0·83, 0·96**	1·01	0·94, 1·08	**0·87**	**0·81, 0·93**	**0·92**	**0·85, 0·99**
Centre	**1·14**	**1·05, 1·23**	**1·15**	**1·06, 1·25**	**1·08**	**1·00, 1·17**	1·00	0·93, 1·09	0·99	0·91, 1·07	**0·86**	**0·80, 0·94**	**0·79**	**0·73, 0·86**	0·98	0·91, 1·07	**0·91**	**0·84, 0·99**	0·96	0·89, 1·04
Paris and suburbs	1·04	0·98, 1·10	0·99	0·93, 1·06	0·98	0·92, 1·04	0·97	0·91, 1·03	0·94	0·89, 1·00	0·99	0·93, 1·06	**0·93**	**0·87, 0·99**	0·99	0·93, 1·06	**0·90**	**0·84, 0·96**	0·99	0·93, 1·05
Size of the agglomeration of residence (Ref. = rural (<2000 inhabitants))																				
Quasi-rural (2000–9999 inhabitants)	1·04	0·98, 1·09	0·96	0·91, 1·02	1·04	0·98, 1·09	1·05	0·99, 1·11	1·01	0·96, 1·07	1·00	0·94, 1·06	1·01	0·95, 1·07	**1·06**	**1·00, 1·12**	0·99	0·94, 1·05	**1·08**	**1·02, 1·14**
Quasi-urban (10 000–99 999 inhabitants)	**1·06**	**1·00, 1·11**	0·99	0·93, 1·04	**1·06**	**1·00, 1·12**	**1·08**	**1·03, 1·15**	1·04	0·98, 1·09	1·01	0·95, 1·07	1·02	0·96, 1·08	1·04	0·99, 1·10	0·98	0·92, 1·03	**1·06**	**1·00, 1·12**
Large urban areas (≥100 000 inhabitants)	**1·06**	**1·00, 1·13**	0·98	0·92, 1·05	**1·13**	**1·06, 1·21**	1·05	0·98, 1·12	1·02	0·96, 1·09	1·02	0·95, 1·09	1·01	0·95, 1·08	1·04	0·98, 1·11	0·96	0·90, 1·03	**1·07**	**1·00, 1·14**
Deprivation index, FDep99 (Ref. = <– 0·51 (less deprived))																				
0·51–0·21	0·96	0·92, 1·00	0·96	0·91, 1·01	0·96	0·91, 1·00	0·96	0·92, 1·01	0·98	0·93, 1·02	1·01	0·96, 1·06	1·01	0·96, 1·06	1·01	0·96, 1·06	0·99	0·94, 1·04	0·98	0·94, 1·03
≥ 0·21	**0·91**	**0·87, 0·96**	0·97	0·92, 1·02	0·99	0·94, 1·04	0·97	0·92, 1·02	0·98	0·93, 1·03	0·98	0·93, 1·03	0·98	0·93, 1·03	0·99	0·94, 1·04	1·00	0·95, 1·05	0·97	0·92, 1·02
Size of the working agglomeration (Ref. = ≤10 000 inhabitants)																				
>10 000 inhabitants	0·97	0·92, 1·03	0·97	0·91, 1·03	**0·93**	**0·88, 0·99**	0·94	0·89, 1·00	0·95	0·90, 1·00	0·97	0·92, 1·03	0·96	0·90, 1·01	0·95	0·90, 1·01	0·99	0·94, 1·05	0·97	0·92, 1·03

Table 5 *Continued*

	Increase in the ratio of consumption to energy intake between 1993 and 2005									
	Most consumed raw vegetables (mean (SD) intake in 1993 in g)									
	Tomato (9·9 (7·5)) (*n* 23 518)		Carrot (6·7 (5·7)) (*n* 24 427)		Endive (6·5 (5·5)) (*n* 23 882)		Cucumber (5·9 (5·8)) (*n* 21 305)		Radish (5·5 (4·8)) (*n* 23 951)	
	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI	OR‡	95 % CI
Area of birth (Ref. = South)										
West	**1·12**	**1·03, 1·21**	**1·21**	**1·12, 1·31**	0·99	0·92, 1·08	**1·24**	**1·15, 1·34**	1·04	0·96, 1·12
North	1·06	0·98, 1·14	**1·12**	**1·04, 1·21**	1·00	0·92, 1·08	**1·18**	**1·10, 1·27**	0·99	0·92, 1·07
East	1·04	0·96, 1·12	**1·09**	**1·01, 1·17**	0·96	0·89, 1·03	**1·30**	**1·21, 1·40**	1·05	0·98, 1·12
Centre	1·07	0·98, 1·16	**1·17**	**1·08, 1·26**	1·03	0·95, 1·11	**1·11**	**1·02, 1·20**	1·05	0·97, 1·13
Paris and suburbs	**1·13**	**1·06, 1·21**	**1·20**	**1·13, 1·28**	1·06	0·99, 1·13	**1·34**	**1·26, 1·43**	**1·09**	**1·03, 1·17**
Dom-Tom	1·11	0·79, 1·57	1·36	0·97, 1·90	0·84	0·59, 1·18	1·28	0·92, 1·78	0·89	0·64, 1·25
Abroad	**1·17**	**1·08, 1·26**	**1·19**	**1·10, 1·28**	1·06	0·98, 1·14	**1·37**	**1·27, 1·48**	**1·08**	**1·00, 1·17**
Area of residence (Ref. = South)										
West	1·04	0·96, 1·12	**1·17**	**1·08, 1·26**	1·01	0·94, 1·10	**1·15**	**1·06, 1·24**	**1·13**	**1·05, 1·22**
North	0·93	0·86, 1·00	1·03	0·95, 1·11	0·94	0·87, 1·01	**1·10**	**1·02, 1·19**	0·98	0·90, 1·05
East	0·93	0·86, 1·00	**1·10**	**1·03, 1·19**	0·96	0·90, 1·04	1·07	0·99, 1·15	1·01	0·94, 1·08
Centre	1·01	0·93, 1·09	1·03	0·95, 1·12	1·02	0·94, 1·10	1·07	0·98, 1·16	1·06	0·97, 1·14
Paris and suburbs	0·96	0·90, 1·03	1·03	0·97, 1·10	0·99	0·93, 1·05	**1·14**	**1·07, 1·21**	0·96	0·90, 1·02
Size of the agglomeration of residence (Ref. = rural (<2000 inhabitants))										
Quasi-rural (2000–9999 inhabitants)	0·98	0·93, 1·04	0·99	0·94, 1·05	0·98	0·93, 1·04	0·96	0·91, 1·01	1·00	0·94, 1·05
Quasi-urban (10 000–99 999 inhabitants)	1·01	0·96, 1·07	0·98	0·93, 1·04	1·00	0·95, 1·06	**0·93**	**0·88, 0·99**	1·03	0·98, 1·09
Large urban areas (≥100 000 inhabitants)	1·01	0·95, 1·08	0·97	0·91, 1·04	1·00	0·93, 1·06	0·95	0·89, 1·02	0·98	0·92, 1·05
Deprivation index, FDep99 (Ref. = < − 0·51 (less deprived))										
0·51–0·21	1·01	0·96, 1·06	1·04	0·99, 1·09	1·00	0·96, 1·05	1·00	0·95, 1·05	1·03	0·98, 1·08
≥ 0·21	0·98	0·93, 1·03	1·01	0·96, 1·06	0·99	0·94, 1·04	0·95	0·90, 1·00	1·00	0·95, 1·05
Size of the working agglomeration (Ref. = ≤ 10 000 inhabitants)										
>10 000 inhabitants	0·95	0·90, 1·01	0·96	0·90, 1·01	1·00	0·95, 1·06	1·00	0·95, 1·06	0·99	0·94, 1·05

Ref., reference category.
Models are multi-adjusted and further adjusted for individual characteristics, individual socioeconomic factors, energy intake evolution between 1993 and 2005 and baseline consumption of the food group considered. Significant results are indicated in bold font.
†Information on the size of the working agglomeration was available for 33 453 women.
‡An odds ratio above 1 corresponds to a higher probability for women to increase their ratio 'consumption/energy intake' between 1993 and 2005.

the recommendations and tended to increase their consumption over the 12-year period, also suggesting a differential impact of the Program in people who were already health-conscious. Those results would be in line with previous results suggesting that national dietary guidelines, when not targeting specific subgroups, reinforce socio-economic inequities[64,65]. Alternatively, we can observe that the adoption of healthy dietary patterns became of worldwide concern[66]. Awareness about healthy diets and their positive impact emerged among several populations. In a recent publication[67], 'healthy diet' was found to be the first dish-choice motive in a large sample of adults living in France. This may partly explain the overall increase in fruit and vegetable intakes observed in our population. However, it has been shown that this increase was socio-economically patterned. Reduction in health inequities became one of the worldwide priorities only a few years ago[68,69].

We have observed various and complex associations between socio-economic factors and fruit and vegetable subtypes, suggesting that efficient nutritional guidelines cannot be obtained solely by encouraging the consumption of fruits and vegetables as a whole but rather by refining the recommendations according to socio-economic strata. To develop effective nutritional interventions and policies that take the socio-economic environment of individuals into account, future research should focus on understanding (i) the pathways through which population characteristics might influence change in fruit and vegetable consumption as well as (ii) existing interactions between individual and contextual factors. However, we believe that receiving more personalized nutritional guidelines (adapted to the socio-economic profile of the individual) will help contribute to a better understanding and adoption of a healthy diet. Furthermore, beyond quantity, it may be important to promote the variety of fruits and vegetables to ensure nutritional adequacy[70].

Strengths and limitations

We are aware of some limitations in our study. Some contextual socio-economic data such as access to grocery stores, transportation and neighbourhood safety are not available at the moment in the E3N-EPIC cohort but have been shown to be associated with fruit and vegetable consumption[71,72]. Our population study was composed of women only. However, dietary patterns have been shown to be gender-patterned[64]. It would therefore be interesting to repeat the analyses among men. Also, women in the E3N-EPIC study tend to have a healthier diet, consume more fruits and vegetables (mean intake of fruits and vegetables being over the recommended 5 servings/d[41]) and are socio-economically more homogeneous than the general population. However, we were still able to observe associations between socio-economic factors and the evolution of fruit and vegetable consumption in our selected population and we assume that these associations would have been even stronger in the general population where a greater variability in diet and socio-economic environment exists. Also, we were not able to quantify the increase in fruit and vegetable consumption due to the National Nutrition and Health Program[9].

Our study has several strengths. We provided a comprehensive picture of the socio-economic factors associated with an increase in fruit and vegetable consumption over time using dietary data with detailed information on subtypes of fruit and vegetable consumption. Dietary data were collected twice over a 12-year period, in a large sample of women. We studied fruit consumption and vegetable consumption separately, which has been investigated only a few times[18,41,73]. Beyond that, to our knowledge, we are the first to study the factors associated with consumption of specific fruits and vegetables. As previously recommended, we were also able to simultaneously consider various socio-economic data including contextual and individual factors[20,23,63,74].

Conclusion

Our results suggest that some individual, but not contextual socio-economic factors are differentially associated with an increase in fruit or vegetable consumption, or with some fruit and vegetable subtypes. Level of education, number of children, marital and occupational status and level of physical activity were all associated with changes in fruit and vegetable consumption, suggesting that, independently from the environment in which people live, nutritional prevention strategies should focus on actions that have an impact at an individual level (nutrition knowledge, attitudes to healthy eating, food motivation, resources, stressors and psychological resources). Individuals with higher socio-economic position were more likely to increase their fruit and vegetable consumption. It would therefore be important to provide better health interventions in socio-economically disadvantaged groups. Our study also highlights that socio-economic determinants of fruit and vegetable consumption evolution differ when studying fruit consumption and vegetable consumption separately, as well as according to fruit and vegetable subtypes, underlining the complexity of the relationship between diet and socio-economic environment. This information should be taken into account when developing nutritional prevention strategies to increase fruit and vegetable consumption in the general population. Such diet modifications could have a significant public health impact by decreasing the overall risk of some cancers or other chronic diseases in the general population.

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Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S1368980017003196

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