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Comparison of Dietary Intakes Between a Large Online Cohort Study (Etude NutriNet-Santé) and a Nationally Representative Cross-Sectional Study (Etude Nationale Nutrition Santé) in France: Addressing the Issue of Generalizability in E-Epidemiology

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Despite some advantages over traditional methods, Web-based studies elicit concerns about generalizability. To address this issue, we compared dietary intakes between an electronic (e-) cohort study and a nationally representative survey. We studied 49,443 French volunteers aged 18–74 years recruited during 2009–2010 in the NutriNet-Santé Study, a general population-based e-cohort study. The Etude Nationale Nutrition Santé (ENNS; 2006–2007), a cross-sectional study with a nationally representative sample of 2,754 French adults aged 18–74 years, served as the reference data set. Reported dietary intakes from three 24-hour dietary records were weighted and compared between the two studies via Student *t* tests for mean location, using a >5% cutoff for establishing practically meaningful differences. We observed similar intakes as regards carbohydrates, total lipids, protein, and total energy. However, intakes of fruit and vegetables, fiber, vitamins B_6, B_9, C, D, and E, iron, and magnesium were higher in the e-cohort than in the ENNS, while intakes of alcohol and nonalcoholic beverages were lower in the e-cohort. Significant sex-specific differences were observed regarding vitamins A and B_{12}, zinc, and potassium. True intake differences, mode effects, and volunteer bias might each contribute to explaining the findings. In the future, repeated use of the same tool in large e-cohorts with heterogeneous dietary exposures could serve research purposes and supplement group-level monitoring of dietary trends.

diet; dietary intake; e-epidemiology; food and beverages; generalizability; nutrients; questionnaires; surveys

Abbreviations: ASA24, Automated Self-Administered 24-Hour; e-, electronic; ENNS, Etude Nationale Nutrition Santé.

The World Health Organization has stressed that continued, global-scale monitoring of dietary practices is critical for the development of well-targeted public health efforts and for the evaluation of existing programs aimed at reducing the incidence and prevalence of noncommunicable diseases, including obesity (1). A challenge regarding dietary surveillance, however, is obtaining accurate, comprehensive, and representative data (2). To this end, the US National Cancer Institute recently launched the Automated Self-Administered 24-Hour (ASA24) Dietary Assesment Tool (Westat, Inc., Rockville, Maryland), which is a freely available Web-based tool for researchers, clinicians, and educators modeled on the US Department of Agriculture's Automated Multiple-Pass Method and featuring a comprehensive list of food and beverage terms derived from the 2007–2008 National Health and Nutrition Examination Survey (3, 4). It can be used for large-scale diet monitoring, providing good-quality dietary intake data (3–5). Some large epidemiologic cohort studies have also incorporated Web-based assessment tools for the repeated evaluation of diet and physical activity (6).

In turn, researchers in several validation studies comparing dietary data obtained via online instruments with those gathered via traditional methods (interview with a dietitian, paper-and-pencil questionnaires), using the doubly labeled water technique or urinary biomarkers as a reference measure, have reported promising results in terms of agreement/concordance

and overall data quality in electronic (e-) epidemiologic research (7–13). However, to the best of our knowledge, and given the recurring concerns about and potential consequences of volunteer bias (14), no studies have yet compared the self-reported dietary intake of volunteers against an established reference—that is, data provided via dietitian interviews by a randomly selected, representative population sample. We undertook the present study in order to address this issue and to gain a better understanding of the generalizability of food and nutrient intakes reported by participants in a prospective e-cohort study in France. Specifically, we compared the dietary intakes of adult volunteers enrolled in the NutriNet-Santé Study, an e-cohort study, with those reported by a nationally representative sample of adults from the Etude Nationale Nutrition Santé (ENNS; 2006–2007), a cross-sectional study. Such a comparison was appropriate and feasible because the NutriNet-Santé and ENNS studies employed the same 24-hour dietary assessment instrument, which was self-administered in the former sample and completed in the context of telephone-based dietitian interviews in the latter sample. This study also extends previous work addressing the issue of generalizability in e-epidemiology by comparing volunteers' self-reported sociodemographic information with national French census data (15, 16).

METHODS

NutriNet-Santé e-cohort

The NutriNet-Santé Study, an ongoing e-cohort study, was launched in France in May 2009, with enrollment and participation taking place exclusively online via a dedicated and secure Web site (www.etude-nutrinet-sante.fr) (17). Volunteers with Internet access aged ≥18 years are recruited via a combination of traditional (e.g., flyers available in physicians' offices) and online (e.g., Website advertising) strategies, including vast, recurrent multimedia campaigns (television, radio, national/regional newspapers, billboards) (18). The provision of informed consent and an electronic signature are mandatory for enrollment. The NutriNet-Santé study protocol was approved by the ethics committee of the French National Institute for Health and Medical Research and by the National Commission on Informatics and Liberty. To our knowledge, this study is the first large (>150,000 enrollees to date), exclusively Web-based general-population prospective cohort study aimed at elucidating the multifaceted relationship between nutrition and health.

Upon enrollment in the NutriNet-Santé Study, participants are asked to complete a set of 5 questionnaires on 1) sociodemographic factors and lifestyle, 2) health status, 3) physical activity, 4) anthropometric factors, and 5) diet (17). For the present study, we used data from volunteers aged 18–74 years who resided in continental France, enrolled in 2009–2010, and had at least 3 available 24-hour dietary records (described below; see Figure 1).

Etude Nationale Nutrition Santé

In the present study, data from the ENNS were used as the reference data set. The ENNS was a cross-sectional study carried out in 2006–2007 and employing a multistage, stratified random sample of the 18- to 74-year-old noninstitutionalized population living in continental France (n = 3,115). It represented a major component of the system for national surveillance of the nutritional status, dietary intake, and physical activity of the French population, established by the National Nutrition and Health Program (2). The ENNS contained data on dietary intake, physical activity, and clinical and biomarker measurements, gathered during home visits (e.g., physical activity questionnaire), by telephone (i.e., 24-hour diet recalls), and/or during clinic visits (i.e., blood pressure, anthropometric factors).

Assessment of food and nutrient intake

As noted above, the present comparison analysis was feasible given that NutriNet-Santé and ENNS employed the same 24-hour dietary assessment instrument. In addition, both studies featured dietary assessments carried out over 3 nonconsecutive days (spread over a 2-week period), including 2 weekdays and 1 weekend. For each food and beverage item consumed over a period of 24 hours (midnight to midnight), participants in both studies were asked to provide detailed information on the quantity, preparation/recipes/seasoning, and corresponding settings (time and place). For foods with potentially high nutrient variability, participants were also asked to provide the brand name. Respondents could estimate portion sizes using validated photographs (19, 20). Likewise, both studies relied on the same food composition table, which included more than 2,500 different food items, for estimation of macro- and micronutrient intake.

Dietary assessment in NutriNet-Santé was carried out via a user-friendly Web-based 24-hour dietary record tool designed for self-administration. Participants reported their dietary intakes with the help of a food/beverage browser and/or a search engine. The tool features a comprehensive user's guide and a built-in control system (with visual cues and prompts), both of which help minimize the chance of forgetting consumed items. In turn, dietary assessment in ENNS was carried out over the telephone by trained dietitians who also probed for potential omissions of consumed items. Apart from the administration mode, a principal difference between ENNS and NutriNet-Santé as regards dietary intake assessment was the advance knowledge of the assessment days only in the latter study, thus triggering the potential for reactivity (i.e., reporting of intake that is healthier than usual) (21, 22).

Covariates

For sample description and comparison purposes, we used sociodemographic data provided in NutriNet-Santé and ENNS, as follows: age (as a continuous variable (years) and also categorized into 18–29 years, 30–54 years, and 55–74 years), region of birth (France, including Corsica and overseas territories; the rest of Europe; Africa; other), marital status (living alone, married/cohabiting), educational level (up to elementary school; middle school or equivalent; high school diploma or associate's degree;

undergraduate or graduate degree), occupational category (unemployed/disabled/homemaker/student, blue-collar/manual labor, self-employed/artisan/farmer, executive/professional staff, retired), presence of children aged <18 years in the household (yes/no), and smoking habits (never, former, or current smoker).

Statistical analysis

Daily mean dietary consumption in both NutriNet-Santé and ENNS was calculated from three 24-hour records weighted for the type of day on which the record was completed (weekday or weekend). In both studies, underreporting was identified using Black's method (23), which is based on an estimate of the person's basal metabolic rate calculated via Schofield's equations (24) and taking into account sex, age, height, weight, and physical activity level. For the definition of extreme and likely underreporting, the same cutoffs for energy intake/basal metabolic rate were used in both studies. Thus, a total of 12% and 15% of the participants in ENNS and NutriNet-Santé, respectively, were excluded due to underreporting. Individuals with fewer than three 24-hour records were also excluded from the respective samples. Thus, comparisons were made using 74% (n = 49,443; Figure 1) of the eligible NutriNet-Santé volunteers and 88% (n = 2,754) of the ENNS sample.

Next, the same statistical calibration was applied to both data sets. In particular, sex-specific weights were calculated according to 2007 national census figures for age

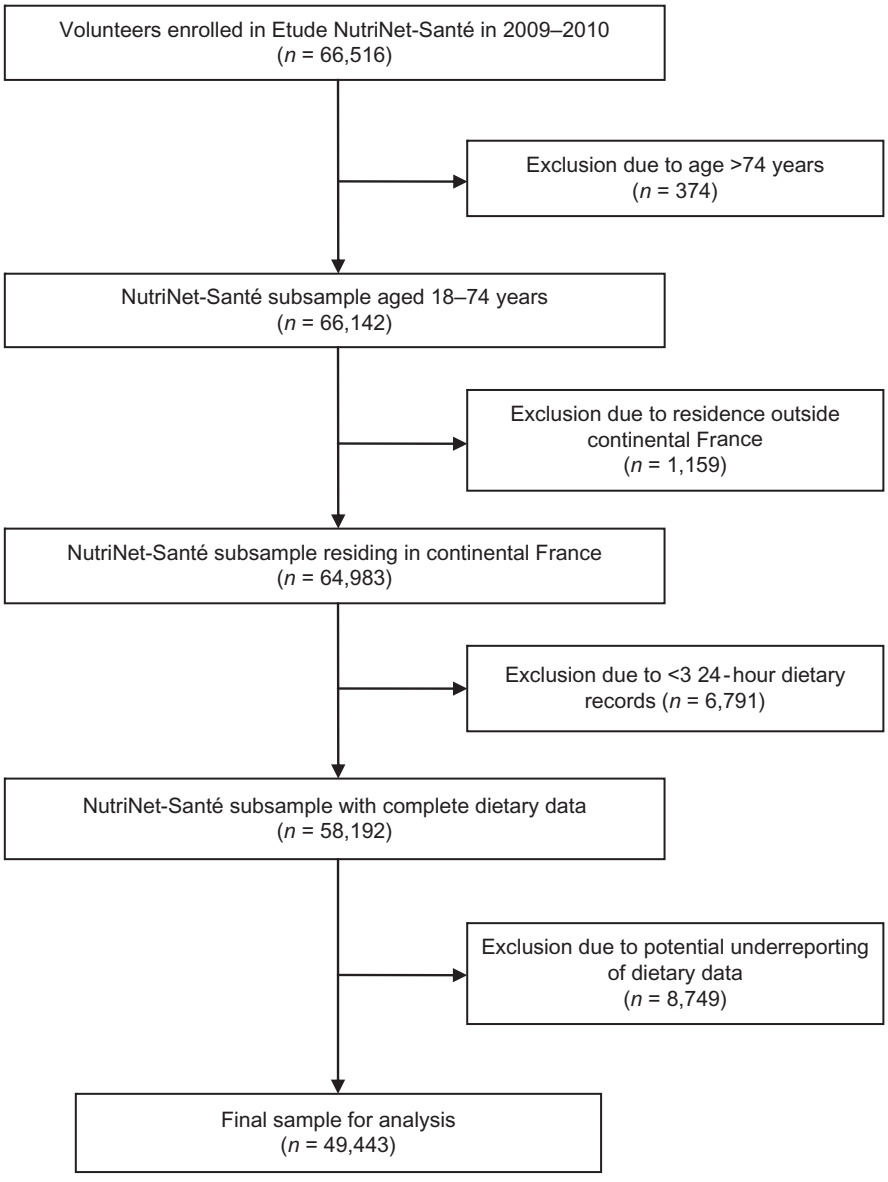

Figure 1. Selection of study participants from the NutriNet-Santé e-cohort, France, 2009–2010.

(18–29 years, 30–54 years, and 55–74 years), educational level (up to elementary school; middle school; high school or associate's degree; undergraduate or graduate degree), presence of children aged <18 years in the household (yes/no), and season of data collection (February–May, June–September, October–January) and were modeled via the SAS CALMAR macro (SAS Institute, Inc., Cary, North Carolina) developed by the French Census Bureau (2, 25). The weighted data regarding nutrient and food group intake from the two samples were then compared using Student *t* tests for mean location and the standard error of the mean. All analyses were conducted with SAS (version 9.3), tests of statistical significance were 2-sided, and the significance level was set at $P \leq 0.01$ owing to the large sample size and the multiple testing performed. Furthermore, as in prior analyses of NutriNet-Santé data (26), a difference between 2 mean values was interpreted as significant only when it exceeded a 5% threshold.

RESULTS

Characteristics of the NutriNet-Santé sample

The NutriNet-Santé sample included 49,443 adults (Figure 1). The sex-specific characteristics (raw and weighted data) of the sample and the respective data from ENNS are presented in Table 1. In total, women comprised 77% of the NutriNet-Santé sample, and 95% of the participants were born in France (including its overseas territories). Women were somewhat younger than were men (mean age = 41.2 (standard deviation, 13.7) years vs. 47.1 (standard deviation, 14.8) years) in NutriNet-Santé, whereas they were comparable in age in ENNS. Nearly three-quarters of the e-cohort had postsecondary education (raw data). Prior to weighting, the biggest discrepancies in the sociodemographic characteristics between the e-cohort and ENNS were seen for educational level, occupational category, and smoking status. Following the statistical weighting and as expected, the percentage distribution in the e-cohort of the characteristics taken into account by the calibration (age, education, children in household) became identical to that in ENNS, whereas the remaining characteristics continued to diverge, to some (occupational category) or a large (smoking status) extent.

Energy, food, and nutrient intake

Daily mean energy, food, and nutrient intake among participants in the e-cohort, as compared with the ENNS, is summarized by sex and presented in Table 2 (food groups) and Table 3 (total energy and nutrients). For both sexes, intake of fruit/vegetables and fish/seafood was significantly higher in the e-cohort than in ENNS, while intake of potatoes/pulses (legumes), meat/eggs, and nonalcoholic beverages was significantly lower in the e-cohort. Mean differences in intake of milk/yogurt, fast food, and alcoholic beverages also reached statistical significance, yet with important variation by sex. Unlike men, women in the e-cohort had lower intake of milk/yogurt yet somewhat higher intake of fast food and alcoholic beverages than women in ENNS. Next, none of the following mean differences in intake reached significance according to the preestablished criteria: added fat among women; bread/cereal, cheese, and salty food among men; and desserts/pastries in both sexes. Overall, the largest relative mean differences in food/beverage consumption (relative to ENNS) among men and women, respectively, were seen for sweetened nonalcoholic beverages (−47.5% and −43.9%), fish/seafood consumption (27.7% and 28.8%), water and nonalcoholic light beverages (−29.9% and −23.4%), and fruit and vegetable consumption (21.8% and 16.1%) (Table 2).

As regards the macronutrients (Table 3), only intake of monounsaturated fatty acids among women exhibited a statistically significant mean difference when the e-cohort was compared with the ENNS (28.5 g/day vs. 25.9 g/day). Among men, intake of saturated fatty acids reached a borderline-significant difference between the two studies. Next, notable similarities across the two samples were observed as regards intake of protein (men: 96.1 g/day vs. 98.3 g/day; women: 75.7 g/day vs. 74.1 g/day), total lipids (men: 97.1 g/day vs. 98.4 g/day; women: 75.9 g/day vs. 73.3 g/day), and carbohydrates (men: 238.6 g/day vs. 246.1 g/day; women: 184.0 g/day vs. 180.4 g/day). In terms of micronutrient intake, however, a number of significant and sex-specific findings emerged (Table 3). Mean differences in intake of vitamin A reached significance only among men (i.e., higher β-carotene and lower retinol intake in NutriNet-Santé than in ENNS), whereas mean differences in intake of vitamin B_{12}, zinc, and potassium were significant only among women (all 3 with higher intakes in NutriNet-Santé than in ENNS). As compared with ENNS, the e-cohort exhibited higher intake of dietary fiber, vitamins B_6, B_9, C, D, and E, iron, and magnesium. Overall, the largest relative mean differences in nutrient intake (relative to ENNS) were seen for vitamin C (22.6%) and vitamin D (18.6%) among men and for vitamin D (25.0%) and magnesium (16.5%) among women. Regarding total energy intake, mean values were very similar between the e-cohort and ENNS (men: 2,326.3 kcal/day vs. 2,388.7 kcal/day; women: 1,767.9 kcal/day vs. 1,713.7 kcal/day).

DISCUSSION

The question about generalizability concerns practically all epidemiologic research endeavors featuring volunteer-based sampling. This study addressed the issue of generalizability in the context of e-epidemiology by comparing dietary intakes between adult volunteers aged 18–74 years in a large prospective e-cohort study (2009–2010) and a nationally representative cross-sectional sample (2006–2007) of the French population in the same age range. Prior research had in fact shown evidence of the feasibility and attractiveness of Web-based tools as regards dietary data collection in large-scale research, highlighting the potential to collect high-quality dietary intake information at a relatively lower cost and with less attrition compared with traditional methods (5). Overall, our findings suggested comparable intakes as regards total energy, simple and complex carbohydrates, total lipids, and protein in both

Table 1. Baseline Sociodemographic Characteristics of Volunteers in an Electronic Cohort Study, the NutriNet-Santé Study (2009–2010; $n = 49{,}443$), and Comparison With Participants in a Nationally Representative Study, the Etude Nationale Nutrition Santé (2006–2007; $n = 2{,}754$)[a]

	NutriNet-Santé Study[b]						ENNS[c] (Weighted[d] Data), %	
	Raw Data				Weighted[d] Data, %			
	Men ($n = 11{,}385$)		Women ($n = 38{,}058$)		Men	Women	Men ($n = 1{,}014$)	Women ($n = 1{,}740$)
	No.	%	No.	%				
Age, years								
18–29	1,713	15.0	9,672	25.4	22.6	21.5	22.6	21.5
30–54	5,316	46.7	20,409	53.6	49.9	49.4	49.9	49.4
55–74	4,356	38.3	7,977	21.0	27.5	29.1	27.5	29.1
Region of birth								
France (including Corsica and overseas territories)	10,779	94.7	36,176	95.1	94.8	95.3	92.8	92.0
Europe (excluding France)	205	1.8	818	2.1	1.5	2.4	1.7	2.6
Africa	347	3.0	798	2.1	3.4	1.8	5.0	4.2
Other	54	0.5	266	0.7	0.3	0.5	0.5	1.2
Marital status								
Living alone (single, divorced, etc.)	2,639	23.2	11,032	29.0	24.7	28.4	28.3	28.6
Married or cohabiting	8,746	76.8	27,026	71.0	75.3	71.6	71.7	71.4
Educational level								
Up to elementary school	402	3.5	1,042	2.7	28.8	32.7	28.8	32.7
Middle school or equivalent	2,414	21.2	5,971	15.7	38.5	32.4	38.5	32.4
High school or equivalent, associate's degree	4,373	38.4	19,453	51.1	22.0	25.9	22.0	25.9
Undergraduate or graduate degree	4,196	36.9	11,592	30.5	10.7	9.0	10.7	9.0
Occupational category								
Unemployed, disabled, homemaker, student	1,210	10.6	8,453	22.2	15.3	27.8	11.0	21.9
Blue-collar, manual labor	1,422	12.5	8,987	23.6	26.5	30.8	42.3	41.3
Self-employed, artisan, farmer	354	3.1	689	1.8	4.0	2.8	4.9	2.4
Executive, professional staff	5,018	44.1	15,021	39.5	31.3	20.2	20.3	16.5
Retired	3,381	29.7	4,908	12.9	22.9	18.4	21.5	17.9
Presence of children aged <18 years in household								
No	7,930	69.6	23,817	62.6	64.1	64.5	64.1	64.5
Yes	3,455	30.4	14,241	37.4	35.9	35.5	35.9	35.5
Smoking habits								
Never smoker	4,804	42.2	19,530	51.3	39.4	48.7	32.6	56.7
Former smoker	4,735	41.6	11,869	31.2	41.8	32.4	33.2	18.1
Current smoker	1,846	16.2	6,655	17.5	18.8	18.9	34.2	25.2

Abbreviation: ENNS, Etude Nationale Nutrition Santé.

[a] The analysis included NutriNet-Santé and ENNS participants with complete dietary data from three 24-hour dietary records.

[b] The current analysis included persons aged 18–74 years residing in continental France with complete dietary data at baseline.

[c] The ENNS was a cross-sectional, population-based survey using multistage sampling with random selection of French households.

[d] Sex-specific data weighted for age, education, presence of children in the household, and season of data collection, using French 2007 Census figures.

sexes. Regarding the different food and beverage groups, we found a number of statistically significant differences in mean intake values; however, the magnitude of these differences was relatively small (i.e., <5%), except for fruit/vegetables, alcohol, and nonalcoholic beverages. In particular, we found that in both men and women, intake of fruit and vegetables was higher in the e-cohort than in ENNS, while intake of alcohol and nonalcoholic beverages (both light and sweetened) was lower in the e-cohort. Ergo, compared with the national figures, the volunteers in the e-cohort exhibited higher intakes of dietary fiber, vitamins B_6, B_9 (folate), C, D, and E, iron, and magnesium.

Table 2. Daily Mean Food (g/day) and Beverage (mL/day) Intakes Among Volunteers in an Electronic Cohort Study, the NutriNet-Santé Study (2009–2010; $n = 49{,}443$), and Comparison With Participants in a Nationally Representative Study, the Etude Nationale Nutrition Santé (2006–2007; $n = 2{,}754$)[a,b]

	Men			Women		
	NutriNet-Santé Study[c]	ENNS	Difference, %[d]	NutriNet-Santé Study[c]	ENNS	Difference, %[d]
Fruit, vegetables, 100% fruit/vegetable juice	467.01 (2.88)[e]	383.36 (11.44)	21.8	459.02 (1.31)	395.22 (7.25)	16.1
Bread, cereals, pasta	200.47 (0.99)	197.79 (2.12)	1.4	139.38 (0.38)	128.67 (4.60)	8.3
Potatoes, rice, pulses (legumes)	91.51 (0.69)	104.69 (3.03)	−12.6	70.10 (0.32)	78.95 (2.07)	−11.2
Meat, poultry, organ meats, eggs	118.68 (0.72)	137.70 (3.11)	−13.8	92.43 (0.29)	103.61 (2.03)	−10.8
Fish, seafood	42.04 (0.45)	32.93 (1.73)	27.7	38.22 (0.22)	29.67 (1.20)	28.8
Milk, yogurt	153.72 (1.54)	144.48 (7.21)	6.4	142.62 (0.74)	154.27 (4.51)	−7.6
Cheese	56.05 (0.49)	55.61 (2.00)	0.8	51.39 (0.27)	44.83 (1.28)	14.6
Sweets, desserts, pastries, honey	167.38 (1.08)	171.33 (5.07)	−2.3	139.85 (0.48)	135.53 (2.84)	3.2
Fast food	43.09 (0.58)	46.40 (3.12)	−7.1	31.07 (0.24)	26.94 (1.51)	15.3
Salty food (cold cuts, pretzels, potato chips, olives)	45.61 (0.50)	43.96 (1.93)	3.8	31.40 (0.22)	28.07 (1.05)	11.9
Added fat (butter, oil, margarine, sauces)	46.11 (0.30)	49.29 (1.34)	−6.5	38.02 (0.13)	39.47 (0.74)	−3.7
Water, nonalcoholic light beverages (excluding sodas and juice)	1,036.70 (5.43)	1,476.91 (34.99)	−29.9	1,041.35 (2.82)	1,359.38 (22.75)	−23.4
Sweetened nonalcoholic beverages (sodas, juice)	71.42 (1.43)	135.92 (11.29)	−47.5	53.73 (0.62)	95.73 (7.13)	−43.9
Alcoholic beverages	181.76 (2.32)	202.00 (14.50)	−10.0	66.79 (0.58)	55.63 (3.03)	20.1

Abbreviation: ENNS, Etude Nationale Nutrition Santé.

[a] The analysis included NutriNet-Santé and ENNS participants with complete dietary data from three 24-hour dietary records.

[b] Sex-specific data weighted for age, education, presence of children in the household, and season of data collection, using French 2007 Census figures.

[c] All comparisons were significant at $P \leq 0.01$, except for cheese consumption among men.

[d] Mean difference relative to ENNS values.

[e] Values are presented as mean (standard error).

The observed differences in dietary intake might be partly due to reporting bias and/or selection bias, given that enrollment in the e-cohort took place on a voluntary basis whereas the ENNS sample was the product of a multistage, stratified random selection scheme. It should be noted that both NutriNet-Santé and ENNS ultimately focused on nutrition, with the possibility that the former study likely attracted nutrition-conscious volunteers motivated for long-term follow-up, whereas the latter, a cross-sectional study, represented a major component of the national system for monitoring the nutritional status, dietary intake, and physical activity of the French population. The NutriNet-Santé recruitment strategies also preclude knowledge of participation and refusal rates. Whereas the statistical weights efficiently corrected the bias entailed in the frequency distributions of age, educational level, and presence of children in the household, the distributions of the remaining sociodemographic characteristics in the e-cohort (occupational status, smoking) remained divergent.

Investigation of the sociodemographic profiles in NutriNet-Santé revealed a substantially lower portion of current smokers in both sexes, compared with the nationally representative ENNS data. This is in line with the purported health-conscious profile of the e-cohort compared with the general population. In addition, research has provided evidence of increased social differentiation in tobacco use in France, seen in a decreasing trend in tobacco use/smoking, particularly among individuals of higher socioeconomic status (27). In particular, nationally representative data for adults aged 18–75 years revealed that during the period 2000–2007, smoking prevalence decreased by 22% among executive managers while no decrease was observed among persons who were unemployed (27). Consistent with evidence from traditional and e-epidemiologic research (14, 28), a large portion of the NutriNet-Santé sample had a relatively high socioeconomic status. In addition, comprehensive smoke-free policies were implemented in the country in 2007–2008 (i.e., the period between the two studies), which resulted in substantial reductions in smoking in public places, coupled with marked support for these smoke-free measures (29). Such developments might help explain the reduced proportion of smokers in the e-cohort.

In NutriNet-Santé, we observed evidence of healthy dietary regimens, given that mean intake of fruit/vegetables was 467.0 g/day (vs. 383.4 g/day in ENNS) among men and 459.0 g/day (vs. 395.2 g/day in ENNS) among women, while the minimum recommended by the World Health Organization is 400 g/day for the prevention of chronic

Table 3. Daily Mean Intakes of Energy, Macronutrients, and Micronutrients Among Volunteers in an Electronic Cohort Study, the NutriNet-Santé Study (2009–2010; $n = 49{,}443$), and Comparison With Participants in a Nationally Representative Study, the Etude Nationale Nutrition Santé (2006–2007; $n = 2{,}754$)[a,b]

	Men			Women		
	NutriNet-Santé Study[c]	ENNS	Difference, %[d]	NutriNet-Santé Study[c]	ENNS	Difference, %[d]
Total energy, kcal/day	2,326.31 (5.79)[e]	2,388.67 (27.70)	−2.6	1,767.94 (2.21)	1,713.69 (14.02)	3.2
Macronutrients, g/day						
Total carbohydrates	238.61 (0.69)	246.11 (3.33)	−3.0	184.04 (0.27)	180.35 (1.69)	2.0
Complex carbohydrates	134.11 (0.46)	139.39 (2.03)	−3.8	95.95 (0.18)	95.00 (1.10)	1.0
Simple sugars	103.90 (0.40)	105.91 (2.11)	−1.9	87.49 (0.16)	84.62 (1.02)	3.4
Total lipids	97.11 (0.32)	98.44 (1.27)	−1.4	75.95 (0.13)	73.30 (0.74)	3.6
Saturated fatty acids	39.55 (0.15)	41.71 (0.63)	−5.2	30.98 (0.06)	30.84 (0.36)	0.5
Monounsaturated fatty acids	36.48 (0.13)	34.77 (0.48)	4.9	28.48 (0.06)	25.91 (0.27)	9.9
Polyunsaturated fatty acids	13.96 (0.06)	14.65 (0.23)	−4.7	10.92 (0.03)	11.15 (0.16)	−2.1
Protein	96.13 (0.26)	98.31 (1.13)	−2.2	75.72 (0.10)	74.10 (0.70)	2.2
Dietary fiber	21.30 (0.08)	19.12 (0.30)	11.4	18.17 (0.03)	16.10 (0.19)	12.9
Micronutrients						
Calcium, mg/day	1,028.98 (3.48)	1,022.16 (13.91)	0.7	879.87 (1.50)	869.80 (9.94)	1.2
Retinol, μg/day	608.97 (8.01)	668.23 (37.71)	−8.9	480.38 (3.72)	496.11 (27.02)	−3.2
β-Carotene, μg/day	3,418.12 (27.22)	3,196.52 (113.87)	6.9	3,270.61 (13.40)	3,211.01 (67.38)	1.9
Vitamin B_6, mg/day	2.04 (0.01)	1.89 (0.02)	7.9	1.63 (0.00)	1.52 (0.02)	7.2
Vitamin B_9, μg/day	352.74 (1.27)	332.61 (4.78)	6.1	312.18 (0.59)	292.16 (3.15)	6.9
Vitamin B_{12}, μg/day	6.36 (0.06)	6.17 (0.21)	3.1	5.02 (0.03)	4.66 (0.14)	7.7
Vitamin C, mg/day	117.53 (0.78)	95.87 (3.49)	22.6	109.87 (0.44)	96.68 (1.70)	13.6
Vitamin D, μg/day	2.93 (0.02)	2.47 (0.10)	18.6	2.50 (0.01)	2.00 (0.06)	25.0
Vitamin E, mg/day	13.16 (0.05)	11.72 (0.22)	12.3	11.10 (0.03)	9.62 (0.12)	15.4
Zinc, mg/day	13.06 (0.04)	13.09 (0.18)	−0.2	10.29 (0.02)	9.67 (0.11)	6.4
Iron, mg/day	15.63 (0.06)	14.00 (0.20)	11.6	12.45 (0.02)	10.80 (0.12)	15.3
Potassium, mg/day	3,344.58 (9.15)	3,194.87 (38.86)	4.7	2,840.51 (3.99)	2,668.44 (24.74)	6.4
Magnesium, mg/day	372.75 (1.19)	329.68 (3.68)	13.1	310.03 (0.52)	266.18 (2.54)	16.5

Abbreviation: ENNS, Etude Nationale Nutrition Santé.

[a] Complete dietary data from three 24-hour dietary records.

[b] Sex-specific data weighted for age, education, presence of children in the household, and season of data collection, using French 2007 Census figures.

[c] All comparisons were significant at $P \leq 0.01$, except for calcium and zinc intakes among men and saturated fatty acid intake among women.

[d] Mean difference relative to ENNS values.

[e] Values are presented as mean (standard error).

diseases such as cancer, heart disease, diabetes, and obesity (30). In turn, current daily salt consumption—a major predictor of cardiovascular morbidity—in most European countries (including France) is estimated to be in the range of 7–18 g/day, with no European Union member states meeting recommended levels (1). Surprisingly, intake of salty food and fast food among women (but not men) in NutriNet-Santé was somewhat higher as compared with the national figures. Next, as regards fish/seafood and alcoholic beverages, the respective habitual intake might not be well captured by three 24-hour dietary records, given that such items are episodically consumed. In turn, the analyses showed that intake of dairy products varied by sex and type of product, with milk/yogurt intake being higher among men and lower among women in the e-cohort compared with ENNS, whereas intake of cheese was higher in the e-cohort only among women, and cheese intakes were practically identical among men in NutriNet-Santé and ENNS.

Given that both studies employed the same food composition table and the same validated photographs of portion sizes, relied on 3 non-consecutive-day dietary assessments,

including 2 weekdays and 1 weekend (which potentially limited both intraindividual variability and reactivity (31)), and used the same statistical calibration, the same 24-hour dietary assessment instrument, and the same criteria for exclusion of underreporting individuals, the observed differences in intake could be explained by the mode of administration (self-report vs. dietitian interview), the period of data collection (2009–2010 for NutriNet-Santé and 2006–2007 for ENNS), and the sample composition (volunteers vs. a stratified random sample). Whereas the reliance on motivated volunteers is indeed seen as a limitation of the e-cohort, bearing on its generalizability, it has been reported that the study's being Internet-based, willingness to help advance public health research, and the study's receiving exclusively public funding were key motives for choosing to enroll in this e-cohort (32). In turn, prior reports based on representative data from French adults have indicated that dietary habits in France evolve very slowly (33, 34); thus, the elapsed time between the two studies is not seen as being of sufficient length for any appreciable modifications in dietary behaviors. The findings also do not seem to suggest the presence of strong social desirability bias (for example, participants in ENNS, who were interviewed by a dietitian over the telephone, reported lower rather than higher intake of fruits and vegetables in both sexes compared with participants in NutriNet-Santé). Overall, researchers advocate the continued collection of self-report dietary intake data owing to the comprehensive and useful information about food and beverage consumption on the population level, which is valuable for research on diet-disease associations and also can help inform nutrition policies (35).

As we noted above, a number of validation studies have been carried out as regards Web-based dietary assessment tools. For example, a feeding study recently demonstrated the criterion validity of the ASA24 dietary recall, which was shown to perform well as regards the relationships with true energy, nutrient, and food-group intakes and portion sizes (36). In addition, a feasibility study with a large and diverse US sample showed that intake estimates for total energy and for most of the studied nutrients and food groups were equivalent between the ASA24 and the Automated Multiple-Pass Method at a 20% bound (5). In the context of NutriNet-Santé, one validation study compared the Web-based 24-hour dietary record tool with the reference method (dietitian's interview) and showed strong agreement between the two methods, while also suggesting that the Web-based tool might reduce potential judgment bias (7). In another study, Lassale et al. (12) explored the validity of the Web-based tool by comparing protein, potassium, and sodium intakes (reported on three 24-hour dietary records) with 24-hour urinary biomarkers and showed that the Web-based tool performed well in estimating protein and potassium intakes and fairly well in estimating sodium intake.

In conclusion, concerted and comprehensive action in the areas of food and nutrition has been stressed as a priority for the European Region of the World Health Organization, as part of efforts to curb the prevalence of obesity and noncommunicable chronic diseases (1). The present study supports the practice of Web-based collection of comprehensive dietary data from a large and diverse volunteer sample. Moreover, the findings fill knowledge gaps regarding the accuracy and generalizability of dietary data by providing a quantitative description of the parallels between self-reported dietary intake by e-cohort volunteers and dietary intake data provided via dietitian interviews in a randomly selected, representative population sample. The findings—based on a comparison of mean daily intakes—revealed notable similarities in intake as regards total energy, simple and complex carbohydrates, total lipids, and protein, while differences largely pertained to intake of fruit, vegetables, and related micronutrients. A different comparison methodology—taking into account the specifics and details of the value distributions, for example—might have revealed a more nuanced picture of the discrepancies and similarities between the two studies. Overall, true differences in intake, administration mode effects, reactivity, and volunteer bias might each contribute to explaining the findings. In the future, repeated use of the same Web-based tool in large e-cohorts with heterogeneous dietary exposure, such as NutriNet-Santé, could serve not only research purposes but also as a supplement to group-level monitoring of dietary trends.

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