Twenty-year trends in dietary patterns in French-speaking Switzerland: toward healthier eating

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ABSTRACT

Background: Dietary patterns provide a summary of dietary intake, but to our knowledge, few studies have assessed trends in dietary patterns in the population.

Objective: The aim was to assess 20-y trends in dietary patterns in a representative sample of the Geneva, Switzerland, population with the consideration of age, sex, education, and generation.

Design: Repeated, independent cross-sectional studies were conducted between 1993 and 2014. Dietary intake was assessed by using a validated food-frequency questionnaire. Dietary patterns were assessed by using principal components analyses.

Results: Among 18,763 adults, 1 healthy ("fish and vegetables") and 2 unhealthy ("meat and chips" and "chocolate and sweets") patterns were identified. Scores for the "fish and vegetables" pattern increased, whereas the "meat and chips" and "chocolate and sweets" pattern scores decreased in both sexes and across all age groups. The stronger increase in the "fish and vegetables" pattern score among the less well-educated participants led to a narrowing of educational differences (mean ± SD scores in 1993: −0.56 ± 1.39 compared with −0.05 ± 1.58 in low- compared with highly educated groups, respectively; $P < 0.001$; scores in 2014: 0.28 ± 1.64 compared with 0.24 ± 1.83, respectively; $P = 0.772$). Generational analysis showed that older age groups tended to show smaller changes than younger age groups: the yearly score change in "chocolate and sweets" was −0.021 (95% CI: −0.027, −0.014; $P < 0.001$) for the 35- to 44-y cohort compared with −0.002 (95% CI: −0.009, 0.005; $P = 0.546$) for the 45- to 54-y cohort.

Conclusions: Three dietary patterns were identified; scores for the "fish and vegetables" pattern increased, whereas the "meat and chips" and the "chocolate and sweets" pattern scores decreased. The stronger increases in the "fish and vegetables" pattern score among the less well-educated participants led to a smaller difference in dietary intake across the different educational levels. *Am J Clin Nutr* 2017;106:217–24.

Keywords: dietary patterns, principal components analysis, trends, population-based sample, epidemiology

INTRODUCTION

Adequate dietary intake is paramount for health promotion and maintenance, and several studies have shown that dietary changes in a population lead to considerable health benefits (1, 2). Dietary intake can be assessed by different metrics, such as macro- and micronutrient intakes, compliance to dietary guidelines, or dietary patterns. Dietary patterns are of interest because they summarize the large variety of foods consumed into a restricted set of markers, enabling the characterization of the diet (3). Several recurring dietary patterns have been described in different populations: the "healthy" pattern is usually composed of fruit, vegetables, fish, and other items such as low-fat or fiber-rich foods, whereas the "unhealthy" pattern is usually composed of meat and sugary, high-fat, or fried foods (4, 5). Interestingly, although dietary patterns have been frequently assessed in cross-sectional studies, studies that assessed how the patterns change with time are considerably less frequent (6–8). Such studies are important to monitor changes in dietary intake in the population and to adapt food policies accordingly to promote and maintain a population's health.

Switzerland is a small European country characterized by a favorable trend in dietary intake (9). Still, the previous study was based on food balance sheets rather than on individual data. Thus, we used the data from the "Bus Santé" study to *1*) characterize dietary patterns in the population of Geneva, Switzerland, and *2*) assess their 20-y trends (1993–2014) overall and according to sex, age group, and educational level.

METHODS

Participants

The Bus Santé study is a cross-sectional, ongoing population-based study designed to collect information on chronic disease risk factors in the canton of Geneva, Switzerland. The sampling methodology of the Bus Santé Geneva study has been reported

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Supplemental Tables 1–18 and Supplemental Figure 1 are available from the "Online Supporting Material" link in the online posting of the article and from the same link in the online table of contents at http://ajcn.nutrition.org.

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Abbreviations used: FFQ, food-frequency questionnaire; KMO, Kaiser-Meyer-Olkin; PCA, principal components analysis.

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previously (10). Every year since 1993, a representative sample of noninstitutionalized men and women aged 35–74 y are recruited. Eligible participants were identified with a standardized procedure by using a residential list established annually by the local government. Random sampling in age- and sex-specific strata was proportional to the corresponding frequencies in the population. A person who could not be reached after 3 mailings and 7 phone calls was replaced by using the same selection protocol as above, but those who were contacted and who refused to participate were not replaced. Included participants were not eligible for future recruitments and surveys. Participation rates ranged from 50% to 66% throughout the study period.

Data collected

Health examinations were conducted throughout the year, from January to December, in 2 clinics and 1 mobile medical unit. Body weight and height were measured by using standard procedures, and BMI (kg/m^2) was calculated. Data for sociodemographic characteristics and smoking and educational history were collected by using self-administered, standardized questionnaires. Trained collaborators performed the examinations, interviewed the participants, and checked the self-administered questionnaires for completion. Procedures were regularly reviewed and standardized across collaborators.

Smoking status (never smokers, ex-smokers, or current smokers) was self-reported. Marital status was categorized as living alone (i.e., being single, divorced, or widowed) or with a partner (i.e., married or cohabiting). Nationality was defined as Swiss and non-Swiss. Due to changes in coding during the study period, educational level attained was grouped into "university" and "lower than university."

Dietary intake

Dietary intake was assessed every year by using a self-administered, semiquantitative food-frequency questionnaire (FFQ), which also included portion sizes (11, 12). This FFQ has been validated against 24-h recalls among 626 volunteers from the Geneva population (10, 12, 13), and data derived from this FFQ have recently contributed to worldwide analyses (14, 15). Briefly, this FFQ assesses the dietary intake of the previous 4 wk and consists of 97 different food items, which account for >90% of the intake of calories, protein, fat, carbohydrates, alcohol, cholesterol, vitamin D, and retinol and 85% of fiber, carotene, and iron. To the best of our knowledge, there is no validated FFQ assessing annual dietary intake in Switzerland, and it has been shown that FFQs assessing dietary intake for shorter periods than 1 y have the same validity as FFQs that assess annual dietary intake (16). Thus, the FFQ used in this study is the best-possible option to assess dietary intake in the Swiss French-speaking population. For each item, consumption frequencies ranging from "less than once during the last 4 weeks" to "2 or more times per day" were provided, and the participants also indicated the average serving size (smaller, equal, or larger) compared with a reference size. Each participant brought along her or his filled-in FFQ, which was checked for completion by trained interviewers the day of the visit.

Dietary patterns were assessed by using daily consumption frequencies, which were defined as follows: never during the past

TABLE 1
Characteristics of the 18,763 participants of the Bus-Santé study (Geneva, Switzerland) for the period 1993–2014[1]

	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013	*P*-trend
Sample size, *n*	757	866	1175	1213	1293	1173	197	250	972	841	637	
Women, *n* (%)	375 (49.5)	436 (50.4)	645 (54.9)	643 (53.0)	694 (53.7)	591 (50.4)	106 (53.8)	124 (49.6)	505 (52.0)	434 (51.6)	346 (54.3)	0.301
Age, y	51.7 ± 10.4	51.0 ± 10.4	51.5 ± 10.3	51.5 ± 10.3	53.1 ± 11.1	51.4 ± 10.8	52.0 ± 11.1	52.1 ± 11.1	51.7 ± 10.7	51.7 ± 10.7	52.7 ± 10.9	0.003
Smoking status, *n* (%)												
Never	330 (43.6)	374 (43.2)	517 (44.0)	540 (44.5)	554 (42.9)	484 (41.3)	87 (44.2)	123 (49.2)	437 (45.0)	381 (45.3)	296 (46.5)	
Former	238 (31.4)	283 (32.7)	398 (33.9)	356 (29.4)	434 (33.6)	409 (34.9)	63 (32.0)	75 (30.0)	318 (32.7)	285 (33.9)	230 (36.1)	0.055[2]
Current	189 (25.0)	209 (24.1)	260 (22.1)	317 (26.1)	305 (23.6)	280 (23.9)	47 (23.9)	52 (20.8)	217 (22.3)	175 (20.8)	111 (17.4)	<0.001[2]
BMI, kg/m^2	24.4 ± 3.8	24.5 ± 3.7	24.4 ± 4.0	24.6 ± 3.8	24.7 ± 3.9	24.9 ± 3.9	24.8 ± 4.2	25.0 ± 4.3	25.0 ± 4.0	25.1 ± 4.1	25.3 ± 4.0	<0.001
BMI categories, *n* (%)												
Normal	478 (63.1)	521 (60.2)	721 (61.4)	721 (59.4)	760 (58.8)	662 (56.4)	111 (56.4)	140 (56.0)	521 (53.6)	463 (55.1)	314 (49.3)	
Overweight	221 (29.2)	281 (32.5)	353 (30.0)	390 (32.2)	417 (32.3)	391 (33.3)	67 (34.0)	85 (34.0)	348 (35.8)	274 (32.6)	238 (37.4)	<0.001[2]
Obese	58 (7.7)	64 (7.4)	101 (8.6)	102 (8.4)	116 (9.0)	120 (10.2)	19 (9.6)	25 (10.0)	103 (10.6)	104 (12.4)	85 (13.3)	<0.001[2]
Living alone, *n* (%)	199 (26.3)	211 (24.4)	311 (26.5)	318 (26.2)	358 (27.7)	331 (28.2)	70 (35.5)	66 (26.4)	253 (26.0)	221 (26.3)	166 (26.1)	0.003
Swiss nationality, *n* (%)	546 (72.1)	585 (67.6)	880 (74.9)	890 (73.4)	941 (72.8)	820 (69.9)	140 (71.1)	176 (70.4)	675 (69.4)	587 (69.8)	447 (70.2)	<0.001
University degree, *n* (%)	254 (33.6)	230 (26.6)	334 (28.4)	395 (32.6)	435 (33.6)	439 (37.4)	81 (41.1)	115 (46)	395 (40.6)	383 (45.5)	290 (45.5)	<0.001

[1] Values are means ± SDs unless otherwise indicated. Data from all years were used in the analysis, but for the purposes of space and formatting, only data from the odd-numbered years are shown. Statistical analysis was performed by using linear regression for continuous data and by using logistic regression (simple or multinomial, where indicated) for categorical data. Due to the number of statistical association tests performed, significance was considered for 2-sided tests with $P < 0.001$.

[2] Multinomial regression was used. For multinomial regression, never smokers and those with a normal BMI were considered as the reference group.

4 wk = 0, 1 time/mo = 1/28; 2–3 times/mo = 2.5/28; 1–2 times/wk = 1.5/7; 3–4 times/wk = 3.5/7; 1/d = 1, and ≥2/d = 2.5. The 97 items were then grouped into 40 food and nutrient groups, including vitamin and food supplements (**Supplemental Table 1**). Conversion into nutrients was performed on the basis of the French Centre d'Information sur la Qualité des Aliments food-composition table. Reference portions were defined by the use of common household measures such as "1 slice" (of bread), "3" biscuits, "1 cup" of yogurt (also used for some fruit and vegetables such as peas or berries), "1 tablespoon," "1 portion" (also used for some fruit and vegetables such as tomatoes or bananas), or "1 glass" (of water or of wine, because size depends on the type of beverage). The reference portion was defined as the median of the portion size distribution in the validation paper (i.e., the validation survey), and the "smaller" and "larger" portions were defined as the first and the third quartiles of the distribution (17). Total energy intake was computed including alcohol consumption.

Exclusion criteria

Participants with missing data for education, age, weight, height, marital status, smoking habits, or nationality were excluded. Those aged <35 or >75 y were also excluded. Participants who reported <30 items consumed during the past 4 wk were also excluded, because this was considered as a marker of either incomplete reporting or of dietary monotony.

Ethics statement

The Bus Santé Geneva study was approved by the University of Geneva Ethics Committee, and all of the study participants provided informed written consent to participate in the study. The study has been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Statistical analysis

Statistical analyses were performed by using Stata version 14.1 for windows (StataCorp). Descriptive results are expressed as number of participants (percentage) or as means ± SDs. Bivariate analyses were performed by using chi-square test for categorical variables and Student's *t* test or ANOVA for continuous variables. Trends in the characteristics of the sample were assessed by linear regression for continuous data and by logistic regression (simple or multinomial) for categorical data.

Dietary patterns were assessed by principal components analysis (PCA) with varimax rotation, as performed by others (3, 18–20), by using all of the data. The Kaiser-Meyer-Olkin (KMO) test and the Bartlett test of sphericity were applied to assess the appropriateness of applying PCA to the data set. The KMO was 0.739, which was above the suggested minimum of 0.5 (21). The Bartlett test of sphericity showed a P value <0.0001. Hence, both the KMO and the Bartlett test indicated that the data were suitable for PCA.

The number of dietary patterns to be retained was based on the same criteria as described by others (18, 22), namely the following: *1*) an eigenvalue >1, *2*) the analysis of the scree plot, and *3*) the interpretability of the dietary pattern. Food items with absolute factor loadings ≥0.300 were considered to characterize the dietary pattern. The robustness of the dietary patterns was

TABLE 2
Twenty-year trends (1993–2014) for the "fish and vegetables" pattern score, overall and by participant characteristics, for the 18,763 participants of the Bus-Santé study: Geneva, Switzerland[1]

	Year											Trend			
												Unadjusted		Adjusted	
	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013	Slope (95% CI)	*P*	Slope (95% CI)	*P*
Sample size, *n*	757	866	1175	1213	1293	1173	197	250	972	841	637				
Overall	−0.39 ± 1.47	−0.29 ± 1.56	−0.17 ± 1.44	−0.07 ± 1.71	0.04 ± 1.54	0.13 ± 1.61	0.09 ± 1.63	0.24 ± 1.56	0.14 ± 1.83	0.19 ± 1.80	0.29 ± 1.77	0.029 (0.026, 0.033)	<0.001	0.025 (0.021, 0.029)	<0.001
Men	−0.65 ± 1.43	−0.56 ± 1.42	−0.41 ± 1.38	−0.43 ± 1.55	−0.21 ± 1.49	−0.23 ± 1.48	−0.27 ± 1.45	0.07 ± 1.44	−0.04 ± 1.96	0.01 ± 1.92	0.00 ± 1.72	0.034 (0.029, 0.039)	<0.001	0.029 (0.024, 0.034)	<0.001
Women	−0.13 ± 1.47	−0.01 ± 1.65	0.03 ± 1.46	0.25 ± 1.78	0.25 ± 1.55	0.48 ± 1.66	0.39 ± 1.71	0.42 ± 1.67	0.31 ± 1.69	0.37 ± 1.67	0.52 ± 1.78	0.026 (0.020, 0.031)	<0.001	0.022 (0.016, 0.027)	<0.001
P-interaction													0.033		0.039
Age group															
35–44 y	−0.36 ± 1.49	−0.33 ± 1.42	−0.09 ± 1.46	−0.17 ± 1.69	0.17 ± 1.55	0.10 ± 1.66	0.39 ± 2.04	−0.01 ± 1.28	0.08 ± 1.55	0.21 ± 1.70	0.30 ± 1.94	0.025 (0.018, 0.032)	<0.001	0.019 (0.012, 0.025)	<0.001
45–54 y	−0.37 ± 1.44	−0.17 ± 1.78	−0.23 ± 1.38	−0.03 ± 1.86	0.04 ± 1.59	0.10 ± 1.65	−0.07 ± 1.37	0.20 ± 1.79	0.16 ± 1.88	0.16 ± 1.73	0.15 ± 1.57	0.028 (0.021, 0.035)	<0.001	0.025 (0.018, 0.032)	<0.001
55–64 y	−0.38 ± 1.44	−0.36 ± 1.46	−0.27 ± 1.47	−0.08 ± 1.57	−0.05 ± 1.50	0.03 ± 1.44	0.17 ± 1.45	0.40 ± 1.25	0.26 ± 2.27	0.25 ± 2.01	0.55 ± 1.99	0.036 (0.028, 0.044)	<0.001	0.035 (0.027, 0.043)	<0.001
65–74 y	−0.54 ± 1.60	−0.34 ± 1.47	0.01 ± 1.52	0.08 ± 1.57	−0.06 ± 1.49	0.39 ± 1.66	−0.37 ± 1.19	0.60 ± 2.00	0.08 ± 1.56	0.13 ± 1.87	0.22 ± 1.56	0.031 (0.021, 0.040)	<0.001	0.027 (0.018, 0.037)	<0.001
P-interaction													0.127		0.034
Education															
University	−0.05 ± 1.58	−0.09 ± 1.38	0.19 ± 1.48	0.24 ± 1.91	0.36 ± 1.51	0.29 ± 1.73	0.25 ± 1.77	0.35 ± 1.38	0.34 ± 1.58	0.22 ± 1.83	0.28 ± 1.45	0.015 (0.008, 0.021)	<0.001	0.015 (0.009, 0.021)	<0.001
Other	−0.56 ± 1.39	−0.35 ± 1.62	−0.31 ± 1.41	−0.22 ± 1.57	−0.13 ± 1.53	0.03 ± 1.53	−0.03 ± 1.51	0.15 ± 1.7	0.01 ± 1.97	0.17 ± 1.78	0.29 ± 2.01	0.033 (0.028, 0.038)	<0.001	0.031 (0.026, 0.036)	<0.001
P-interaction													<0.001		<0.001

[1] Values are mean ± SD scores unless otherwise indicated. Data from all years were used in the analysis, but for the purposes of space and formatting, only data from the odd-numbered years are shown. Statistical analysis by ANOVA or linear regression was performed, with adjustment for sex, age group, education, BMI (continuous), marital status (living with partner or living alone), nationality (Swiss or non-Swiss), and smoking status (current, former, or never). P values for interaction refer to the interaction between the variable of interest and year. Due to the number of statistical association tests performed, significance was considered for 2-sided tests with $P < 0.001$.

assessed by sampling 90% or 80% of the participants for each study year. For each sample drawn, PCA was performed; results from 100 samples (at 90% and 80% sampling rates) were then pooled and the averages and corresponding 95% CIs were calculated.

For each participant, the scores related to the dietary patterns were computed by using all of the data available. As suggested by others (23), the associations between the different dietary pattern scores and dietary intakes (macro- and micronutrients) were assessed, except that we used Spearman correlation and the 95% CIs were estimated by using the ci2 command of Stata. This command calculates CIs for the correlation coefficients on the basis of Fisher's transformation (24). Correlations were assessed after adjustment for total energy intake (i.e., on the residuals of the regression between nutrients and total energy intake) (25).

Trends in dietary pattern scores were assessed by using linear regression, with dietary pattern score as the dependent variable and year as the independent variable. Both simple and multivariate regressions were performed; in the latter case, adjustments were performed for sex, age (continuous), smoking status (never, former, or current), BMI categories (continuous), marital status (single or couple), nationality (Swiss or non-Swiss), and educational level (university or lower than university). Interactions between the main determinants (i.e., sex, age group, and education) with study year were also assessed by including the corresponding components in the model. Interaction terms were modeled as the product of the 2 variables of interest (i.e., sex × year for the interaction between year and sex).

Generational analysis was conducted by using age groups of 35–44 y and 45–54 y in 1993. The 35- to 44-y age group in 1993 corresponded to the 40- to 49-y age group 5 y later (1998) and to the 45- to 54-y age group in 2003. To assess 20-y trends, only the age groups of 35–44 y and 45–54 y in 1993, corresponding to age groups 55–64 y and 65–74 y in 2013, were considered.

Two sensitivity analyses were performed: *1*) by summing the intakes from each food group weighted by the factor loadings obtained for period 1993–1999 and *2*) as previously performed but by using a simplified calculation (26) in which only the foods with the highest loadings at the pattern of interest were summed with a weight of ±1, a method also applied by others (6, 27). For example, consider 2 foods, A and B, and their respective loadings of 0.84 and 0.05 for a given pattern; the weights of 0.84 and 0.05 will be applied in calculation 1, whereas only food A (highest loading) will be given a weight of 1 in calculation 2. A third sensitivity analysis was performed after excluding participants who reported a total energy intake <850 kcal/d (28), because underreporting could bias trends for some (but not all) dietary patterns (29). Due to the number of statistical association tests performed, significance was considered for 2-sided tests with $P < 0.001$.

RESULTS

Selection of participants and characteristics of the final sample

Of the initial 20,125 participants, 1362 (6.8%) were excluded. The reasons for exclusion are summarized in the **Supplemental Figure 1**. The characteristics of the included and excluded participants are summarized in **Supplemental Table 2**; excluded

TABLE 3
Twenty-year trends (1993–2014) for the "meat and chips" pattern score, overall and by participant characteristics, for the 18,763 participants of the Bus-Santé study: Geneva, Switzerland[1]

	Year											Trend			
												Unadjusted		Adjusted	
	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013	Slope (95% CI)	*P*	Slope (95% CI)	*P*
Sample size, *n*	757	866	1175	1213	1293	1173	197	250	972	841	637				
Overall	0.09 ± 1.65	0.16 ± 1.56	0.10 ± 1.52	0.02 ± 1.59	−0.01 ± 1.56	0.03 ± 1.64	−0.23 ± 1.50	−0.22 ± 1.74	−0.05 ± 1.50	−0.15 ± 1.48	−0.17 ± 1.54	−0.013 (−0.017, −0.010)	<0.001	−0.011 (−0.014, −0.008)	<0.001
Men	0.70 ± 1.69	0.65 ± 1.60	0.68 ± 1.50	0.57 ± 1.58	0.56 ± 1.58	0.56 ± 1.69	0.47 ± 1.38	0.27 ± 1.50	0.44 ± 1.56	0.35 ± 1.54	0.31 ± 1.52	−0.019 (−0.024, −0.014)	<0.001	−0.014 (−0.019, −0.008)	<0.001
Women	−0.53 ± 1.34	−0.33 ± 1.36	−0.37 ± 1.38	−0.47 ± 1.43	−0.51 ± 1.36	−0.49 ± 1.41	−0.84 ± 1.34	−0.73 ± 1.82	−0.50 ± 1.28	−0.62 ± 1.26	−0.57 ± 1.45	−0.009 (−0.014, −0.005)	<0.001	−0.007 (−0.012, −0.003)	0.001
P-interaction													0.007		0.026
Age group															
35–44 y	0.29 ± 1.76	0.44 ± 1.61	0.31 ± 1.51	0.30 ± 1.54	0.30 ± 1.67	0.36 ± 1.73	0.13 ± 1.65	−0.03 ± 1.56	0.08 ± 1.43	0.20 ± 1.51	0.14 ± 1.59	−0.012 (−0.019, −0.005)	0.001	−0.011 (−0.017, −0.004)	0.001
45–54 y	0.15 ± 1.70	0.16 ± 1.63	0.2 ± 1.53	0.11 ± 1.68	0.05 ± 1.48	−0.06 ± 1.57	−0.38 ± 1.52	−0.02 ± 1.42	0.06 ± 1.66	−0.10 ± 1.48	−0.15 ± 1.45	−0.011 (−0.017, −0.004)	0.001	−0.011 (−0.017, −0.005)	<0.001
55–64 y	−0.10 ± 1.54	−0.24 ± 1.39	−0.13 ± 1.42	−0.22 ± 1.49	−0.25 ± 1.50	−0.23 ± 1.45	−0.5 ± 1.36	−0.65 ± 1.36	−0.31 ± 1.46	−0.49 ± 1.35	−0.33 ± 1.61	−0.015 (−0.022, −0.008)	<0.001	−0.011 (−0.018, −0.004)	0.001
65–74 y	−0.18 ± 1.32	0.06 ± 1.36	−0.28 ± 1.61	−0.45 ± 1.47	−0.31 ± 1.44	−0.16 ± 1.72	−0.34 ± 1.25	−0.34 ± 2.74	−0.14 ± 1.32	−0.53 ± 1.42	−0.49 ± 1.48	−0.015 (−0.024, −0.007)	0.001	−0.015 (−0.023, −0.007)	<0.001
P-interaction													0.403		0.446
Education															
University	0.07 ± 1.63	0.08 ± 1.47	−0.08 ± 1.43	−0.15 ± 1.66	−0.05 ± 1.46	−0.09 ± 1.59	−0.42 ± 1.5	−0.36 ± 1.50	−0.25 ± 1.46	−0.25 ± 1.38	−0.27 ± 1.47	−0.014 (−0.019, −0.008)	<0.001	−0.014 (−0.020, −0.009)	<0.001
Other	0.10 ± 1.66	0.19 ± 1.59	0.18 ± 1.55	0.10 ± 1.55	0.01 ± 1.61	0.10 ± 1.67	−0.10 ± 1.50	−0.10 ± 1.92	0.09 ± 1.51	−0.07 ± 1.56	−0.08 ± 1.6	−0.010 (−0.015, −0.005)	<0.001	−0.009 (−0.013, −0.005)	<0.001
P-interaction													0.348		0.235

[1] Values are mean ± SD scores unless otherwise indicated. Negative scores indicate low adherence to the dietary pattern, whereas positive scores indicate high adherence. Data from all years were used in the analysis, but for the purposes of space and formatting, only data from the odd-numbered years are shown. Statistical analysis by ANOVA or linear regression was performed, with adjustment for sex, age group, education, BMI (continuous), marital status (living with partner or living alone), nationality (Swiss or non-Swiss), and smoking status (current, former, or never). *P* values for interaction refer to the interaction between the variable of interest and year. Due to the number of statistical association tests performed, significance was considered for 2-sided tests with $P < 0.001$.

participants were older and more frequently never smokers, obese, single, non-Swiss, and less educated than included participants.

The characteristics of the participants included in the analysis according to survey year are summarized in **Table 1**. Over the study period, the following items increased: percentage of participants with a university-level education, mean BMI, percentage of divorced participants, and percentage of participants born outside of Switzerland.

Dietary patterns

The results of the PCA are summarized in **Supplemental Table 3**. Three dietary patterns were identified that explained 19.8% of the overall variance. The first dietary pattern, "fish and vegetables" (healthy), had high loadings for lean fish and seafood and vegetables. The second dietary pattern, "meat and chips" (unhealthy), had high loadings for red meat, processed meat, and French fries. The third dietary pattern, "chocolate and sweets" (unhealthy), had high loadings for chocolate and canned fruit (Supplemental Table 3). The results did not change when 90% or 80% of the participants were sampled (**Supplemental Tables 4** and **5**, respectively).

The correlations between the 3 dietary pattern scores and selected macro- and micronutrients are provided in Supplemental Table 5. Almost all of the correlations were significant. The "fish and vegetables" pattern was positively correlated with intakes of protein, MUFAs and PUFAs, dietary fiber, iron, carotene, and vitamin D and negatively associated with SFAs, alcohol, and retinol. The "meat and chips" pattern was positively associated with animal protein, SFAs, dietary fiber, cholesterol, and alcohol and negatively associated with vegetable protein, carbohydrates, calcium, carotene, and vitamin D. The "chocolate and sweets" pattern was positively associated with total carbohydrates and monodisaccharides, SFAs, and dietary fiber and negatively associated with total and animal protein, cholesterol, alcohol, and iron (**Supplemental Table 6**).

Twenty-year trends in dietary patterns

The 20-y trends in the 3 dietary patterns, overall and according to different clinical and sociodemographic characteristics, are summarized in **Tables 2–4**. Negative scores indicate low adherence, whereas positive scores indicate high adherence to the dietary pattern.

The "fish and vegetables" pattern score increased overall and in all subgroups considered (by sex, age categories, and educational levels). The trends were similar across sexes and age categories, whereas less-educated participants showed a stronger increase than more well-educated participants (Table 2). Similar findings were obtained in sensitivity analyses (**Supplemental Tables 7–9**), with the exception that, in one case, the trend among more well-educated participants was no longer significant.

The "meat and chips" pattern score decreased overall and in all subgroups considered, and trends were similar across all subgroups (Table 3). Comparable findings were obtained in sensitivity analyses (**Supplemental Tables 10–12**), with the exception that the decrease was stronger in men than in women.

The "chocolate and sweets" pattern score decreased overall and in all subgroups considered. Trends were similar across all

TABLE 4
Twenty-year trends (1993–2014) for the "chocolate and sweets" pattern score, overall and by participant characteristics, for the 18,763 participants of the Bus-Santé study: Geneva, Switzerland[1]

	Year											Trend			
												Unadjusted		Adjusted	
	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013	Slope (95% CI)	*P*	Slope (95% CI)	*P*
Sample size, *n*	757	866	1175	1213	1293	1173	197	250	972	841	637				
Overall	0.33 ± 1.44	0.21 ± 1.45	0.11 ± 1.39	0.08 ± 1.43	0.10 ± 1.36	−0.08 ± 1.33	−0.16 ± 1.38	−0.07 ± 1.29	−0.19 ± 1.35	−0.26 ± 1.42	−0.32 ± 1.31	−0.029 (−0.032, −0.026)	<0.001	−0.028 (−0.031, −0.025)	<0.001
Men	0.21 ± 1.37	0.14 ± 1.36	0.04 ± 1.46	−0.05 ± 1.38	0.01 ± 1.35	−0.15 ± 1.25	−0.27 ± 1.37	−0.13 ± 1.32	−0.27 ± 1.36	−0.37 ± 1.39	−0.39 ± 1.27	−0.028 (−0.032, −0.023)	<0.001	−0.027 (−0.032, −0.022)	<0.001
Women	0.46 ± 1.50	0.28 ± 1.53	0.17 ± 1.33	0.19 ± 1.46	0.17 ± 1.37	−0.01 ± 1.40	−0.05 ± 1.39	0.00 ± 1.27	−0.12 ± 1.34	−0.16 ± 1.44	−0.27 ± 1.34	−0.030 (−0.034, −0.025)	<0.001	−0.029 (−0.033, −0.024)	<0.001
P-interaction													0.498		0.774
Age group															
35–44 y	0.17 ± 1.42	0.14 ± 1.33	0.06 ± 1.46	−0.07 ± 1.37	−0.05 ± 1.29	−0.20 ± 1.26	−0.28 ± 1.27	−0.13 ± 1.23	−0.26 ± 1.32	−0.46 ± 1.35	−0.49 ± 1.36	−0.034 (−0.040, −0.028)	<0.001	−0.031 (−0.037, −0.025)	<0.001
45–54 y	0.34 ± 1.49	0.05 ± 1.51	0.07 ± 1.35	0.07 ± 1.40	0.08 ± 1.46	−0.31 ± 1.14	−0.23 ± 1.28	−0.24 ± 1.41	−0.30 ± 1.25	−0.20 ± 1.46	−0.33 ± 1.20	−0.027 (−0.033, −0.021)	<0.001	−0.026 (−0.032, −0.020)	<0.001
55–64 y	0.34 ± 1.42	0.42 ± 1.56	−0.01 ± 1.33	0.10 ± 1.53	0.02 ± 1.26	0.02 ± 1.35	0.13 ± 1.79	0.10 ± 1.35	−0.22 ± 1.38	−0.23 ± 1.34	−0.33 ± 1.36	−0.028 (−0.035, −0.021)	<0.001	−0.025 (−0.032, −0.018)	<0.001
65–74 y	0.71 ± 1.37	0.50 ± 1.34	0.60 ± 1.37	0.37 ± 1.44	0.45 ± 1.40	0.49 ± 1.61	−0.15 ± 1.13	0.11 ± 1.10	0.22 ± 1.48	0.03 ± 1.55	−0.06 ± 1.34	−0.030 (−0.039, −0.021)	<0.001	−0.029 (−0.037, −0.020)	<0.001
P-interaction													0.369		0.467
Education															
University	0.28 ± 1.53	0.27 ± 1.45	0.07 ± 1.49	0.07 ± 1.54	0.10 ± 1.46	−0.07 ± 1.36	−0.15 ± 1.37	−0.05 ± 1.36	−0.11 ± 1.34	−0.26 ± 1.36	−0.37 ± 1.27	−0.027 (−0.032, −0.022)	<0.001	−0.027 (−0.032, −0.022)	<0.001
Other	0.36 ± 1.40	0.19 ± 1.45	0.13 ± 1.35	0.08 ± 1.38	0.09 ± 1.31	−0.08 ± 1.31	−0.16 ± 1.39	−0.08 ± 1.24	−0.25 ± 1.35	−0.26 ± 1.47	−0.29 ± 1.35	−0.030 (−0.034, −0.026)	<0.001	−0.028 (−0.032, −0.024)	<0.001
P-interaction													0.352		0.546

[1] Values are mean ± SD scores unless otherwise indicated. Negative scores indicate low adherence to the dietary pattern, whereas positive scores indicate high adherence. Data from all years were used in the analysis, but for the purposes of space and formatting, only data from the odd-numbered years are shown. Statistical analysis by ANOVA or linear regression was performed, with adjustment for sex, age group, education, BMI (continuous), marital status (living with partner or living alone), nationality (Swiss or non-Swiss), and smoking status (current, former, or never). *P* values for interaction refer to the interaction between the variable of interest and year. Due to the number of statistical association tests performed, significance was considered for 2-sided tests with $P < 0.001$.

subgroups (Table 4), and similar findings were obtained in sensitivity analyses (**Supplemental Tables 13–15**).

Twenty-year generational trends

The trends for the 3 dietary pattern scores within the generational groups (ages 35–44 y and 45–54 y) are summarized in **Table 5**. The "fish and vegetables" pattern score increased, whereas the "meat and chips" pattern score decreased similarly in both cohorts (Table 5). Similar findings were obtained when patterns were computed by using the factor loadings for the period 1993–1999 or by using the simplified method (**Supplemental Tables 16** and **17**).

The "chocolate and sweets" pattern score decreased only in the 35- to 44-y cohort, whereas it remained unchanged in the 45- to 54-y cohort (Table 5). Similar findings were obtained when patterns were computed by using the factor loadings for the period 1993–1999 (Supplemental Table 16, except that the interaction was no longer significant) or by using the simplified method (Supplemental Table 17).

DISCUSSION

To our knowledge, this is the first study to assess trends in dietary patterns in Switzerland, and one of the few that assessed trends in dietary patterns worldwide.

Dietary patterns

Three patterns were identified, 1 considered as healthy ("fish and vegetables") and 2 considered as unhealthy ("meat and chips" and "chocolate and sweets"). The "fish and vegetables" pattern closely resembled the "prudent" or "healthy" patterns identified in Canadian (30), Swedish (5), and US (31) studies. The "meat and chips" pattern was similar to the "meat, processed meat, and French fries" in a Puerto Rican study (32) or the "Western" pattern in a Canadian study (30). Similarly, the "chocolate and sweets" pattern identified in this study was similar to the "sweets" pattern described in Puerto Rico (32).

Women had higher scores for the "fish and vegetables" pattern and lower scores for the "meat and chips" and the "chocolate and sweets" patterns than did men, a finding that was also reported previously (33). Similarly, participants with a university degree scored higher in the "fish and vegetables" pattern, a finding also in agreement with the literature (34). Finally, increasing age tended to be associated with lower scores for the "meat and chips" pattern, again in agreement with the literature (33), whereas the higher scores for the "chocolate and sweets" pattern were somewhat unexpected and await further investigation.

Twenty-year trends in dietary patterns

The increase in the "fish and vegetables" scores is in agreement with the national statistics with regard to fish consumption (increase from 7.8 kg/inhabitant in 2000 to 8.8 kg/inhabitant in 2010) (35) and with a study that showed an increase in the availability of vegetables (9). Importantly, participants with a lower educational level improved their scores more quickly than participants with a university degree, so that the educational gap observed in 1993 was no longer present in 2014.

TABLE 5
Twenty-year trends (1993–2014) for the "fish and vegetables," "meat and chips," and "chocolate and sweets" pattern scores, by generational cohort in 1993: Bus-Santé study (Geneva, Switzerland)[1]

	Year											Trend			
												Unadjusted		Adjusted	
	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013	Slope (95% CI)	*P*	Slope (95% CI)	*P*
Fish and vegetables															
35- to 44-y cohort	−0.36 ± 1.49	−0.27 ± 1.40	−0.11 ± 1.49	−0.19 ± 1.80	0.11 ± 1.58	0.10 ± 1.65	−0.06 ± 1.41	0.41 ± 1.69	0.43 ± 2.43	0.27 ± 2.04	0.55 ± 1.99	0.039 (0.031, 0.047)	<0.001	0.036 (0.028, 0.044)	<0.001
45- to 54-y cohort	−0.37 ± 1.44	−0.22 ± 1.80	−0.27 ± 1.40	−0.04 ± 1.60	−0.08 ± 1.57	0.03 ± 1.44	0.06 ± 1.39	0.43 ± 1.42	0.01 ± 1.47	0.08 ± 1.78	0.22 ± 1.56	0.026 (0.018, 0.033)	<0.001	0.026 (0.018, 0.033)	<0.001
P-interaction													0.019		0.038
Meat and chips															
35- to 44-y cohort	0.29 ± 1.76	0.50 ± 1.63	0.28 ± 1.57	0.20 ± 1.65	0.13 ± 1.48	−0.06 ± 1.57	−0.50 ± 1.49	−0.22 ± 1.44	−0.09 ± 1.75	−0.38 ± 1.37	−0.33 ± 1.61	−0.042 (−0.049, −0.035)	<0.001	−0.036 (−0.043, −0.029)	<0.001
45- to 54-y cohort	0.15 ± 1.70	0.06 ± 1.60	0.06 ± 1.50	−0.06 ± 1.57	−0.3 ± 1.51	−0.23 ± 1.45	−0.35 ± 1.40	−0.68 ± 1.34	−0.29 ± 1.28	−0.47 ± 1.44	−0.49 ± 1.48	−0.033 (−0.040, −0.025)	<0.001	−0.028 (−0.035, −0.021)	<0.001
P-interaction													0.072		0.084
Chocolate and sweets															
35- to 44-y cohort	0.17 ± 1.42	0.15 ± 1.34	0.13 ± 1.40	0.04 ± 1.34	0.00 ± 1.35	−0.31 ± 1.14	−0.29 ± 1.34	−0.12 ± 1.37	−0.26 ± 1.35	−0.17 ± 1.41	−0.33 ± 1.36	−0.024 (−0.03, −0.018)	<0.001	−0.021 (−0.027, −0.014)	<0.001
45- to 54-y cohort	0.34 ± 1.49	0.02 ± 1.51	−0.03 ± 1.34	0.00 ± 1.41	0.05 ± 1.41	0.02 ± 1.35	0.05 ± 1.73	0.02 ± 1.16	0.09 ± 1.51	−0.04 ± 1.54	−0.06 ± 1.34	−0.005 (−0.012, 0.002)	0.148	−0.002 (−0.009, 0.005)	0.546
P-interaction													<0.001		<0.001

[1] Values are mean ± SD scores unless otherwise indicated. Negative scores indicate low adherence to the dietary pattern, whereas positive scores indicate high adherence. Data from all years were used in the analysis, but for the purposes of space and formatting, only data from the odd-numbered years are shown. Statistical analysis by ANOVA or linear regression was performed, with adjustment for sex, age group, education, BMI (continuous), marital status (living with partner or living alone), nationality (Swiss or non-Swiss), and smoking status (current, former, or never). *P* values for interaction refer to the interaction between the variable of interest and year. Due to the number of statistical association tests performed, significance was considered for 2-sided tests with $P < 0.001$.

The decrease in the "meat and chips" pattern score is opposed to the increase in meat availability in Switzerland (9). In addition, men tended to show a stronger decrease in the "meat and chips" pattern score than women, a finding in contradiction with a previous US study in which the decrease in meat consumption was found only in women (36). Possible explanations are that the "meat and chips" pattern does not solely account for meat consumption and that in our study women already scored very low in this pattern, so that further decreases would not be easy to achieve.

The "chocolate and sweets" pattern scores decreased overall and in all subgroups studied, which suggests that participants are reducing their consumption of sugary and high-calorie foods. Indeed, a decrease in sugar consumption from 43.2 kg/inhabitant in 2007 to 40.2 kg/inhabitant in 2013 was reported for the Swiss population (35), as well as a decrease in chocolate sales in Switzerland, from 69,829 tons in 2010 to 64,383 tons in 2015 (37). Still, this beneficial trend is not in agreement with previous studies conducted in the same population (38, 39). Again, a likely explanation is that the "chocolate and sweets" pattern does not solely account for total mono- and disaccharide intake; namely, the loadings for sugar and sodas were rather low (Table 1).

Twenty-year generational trends

Trends in dietary patterns by generational group tended to replicate the trends observed in the general population. Still, for the "chocolate and sweets" pattern, no significant decrease was found in the 45- to 54-y age group cohort. Possible explanations are that aging is associated with a fondness for savory foods (40) or to an unwillingness to change dietary habits (41).

Importance for public health nutrition

Dietary patterns have been shown to be associated with metabolic diseases such as obesity (30), hypertension (22), dyslipidemia (22), and diabetes (32). Hence, interventions aimed at improving dietary patterns should be considered.

Study limitations

This study has several limitations. First, excluded participants differed significantly from those from whom the dietary patterns were computed; hence, dietary patterns were derived from a healthier sample and might not fully represent the true dietary patterns in the general population. Still, the percentage of excluded participants was small (6%), so we believe this might not have a major impact on the results. Participation rates were modest but in line with other studies (42), and the sex and age distributions from the Bus Santé study were close to those in the Geneva canton as obtained from the Geneva Office of Statistics (www.ge.ch/statistique/domaines/01/01_02_1/tableaux.asp#5; **Supplemental Table 18**). Hence, we believe that the sample can be considered as being representative of the Geneva population aged 35–74 y. The FFQ only captured dietary intake from the previous 4 wk, so we cannot exclude that some variations due to seasonality could intervene. Although a 4-wk period might not adequately capture the individual dietary consumption throughout the year, the Bus Santé study recruits participants all year long. Hence, the average dietary consumption of the Geneva population can reasonably be obtained for each year. In addition, possible reporting biases, such as underreporting of certain foods due to social desirability or inadequate evaluation of portions, cannot be ruled out. Still, it has been shown that FFQ data provide useful information on dietary patterns (43), and 2 of the patterns identified were similar to those reported in other studies (4, 5). Switzerland is a multilingual country, and the study was limited to a French-speaking canton; thus, it is possible that dietary behaviors in German- or Italian-speaking regions might be different, but to our knowledge, no data are currently available to verify this hypothesis. The 3 patterns explained only 20% of the total variance, but this is likely due to the large number of food groups included in the PCA (44). Indeed, results of PCA are sensitive to the number (and grouping method) of food items, the number of factors to extract, and the method of rotation. However, we applied the same methods as used in other studies (3, 18–20), the varimax rotation allows obtaining factors that are not correlated, and PCA has been shown to produce results similar to other methods such as reduced rank regression (45). Importantly, the results from the PCA were rather robust, as suggested by the sensitivity analyses (Supplemental Tables 4 and 5). Finally, although the FFQ was validated against 24-h recalls, the original publications (12, 17) did not provide any correlation coefficient.

Conclusions

Three dietary patterns were identified in the Geneva population: the "fish and vegetables" pattern score increased, whereas the "meat and chips" and the "chocolate and sweets" pattern scores decreased. The stronger improvement in the scores for "fish and vegetables" among the less-well-educated participants led to a narrowing of educational differences. Conversely, older age groups showed smaller changes in dietary patterns than younger age groups.

The authors' responsibilities were as follows—PM-V: analyzed the data, wrote most of the manuscript, and had primary responsibility for the final content; IG: conducted the research and wrote part of the manuscript; J-MG and J-MT: designed the research; and all authors: read and approved the final manuscript. None of the authors reported a conflict of interest.

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