EPIDEMIOLOGICAL EVALUATION OF DIETARY INTAKE IN THE SWISS POPULATION: DIETARY INTAKE IN SWITZERLAND

Pedro Marques-Vidal

Epidemiological evaluation of dietary intake in the Swiss population

Dietary intake in Switzerland

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Diet in Switzerland: not only chocolate and cheese

Epidemiologische evaluatie van voedingsinname in de Zwiterse populatie

Het zwitserse voedingspatroon: meer dan chocolade en kaas

Proefschrift

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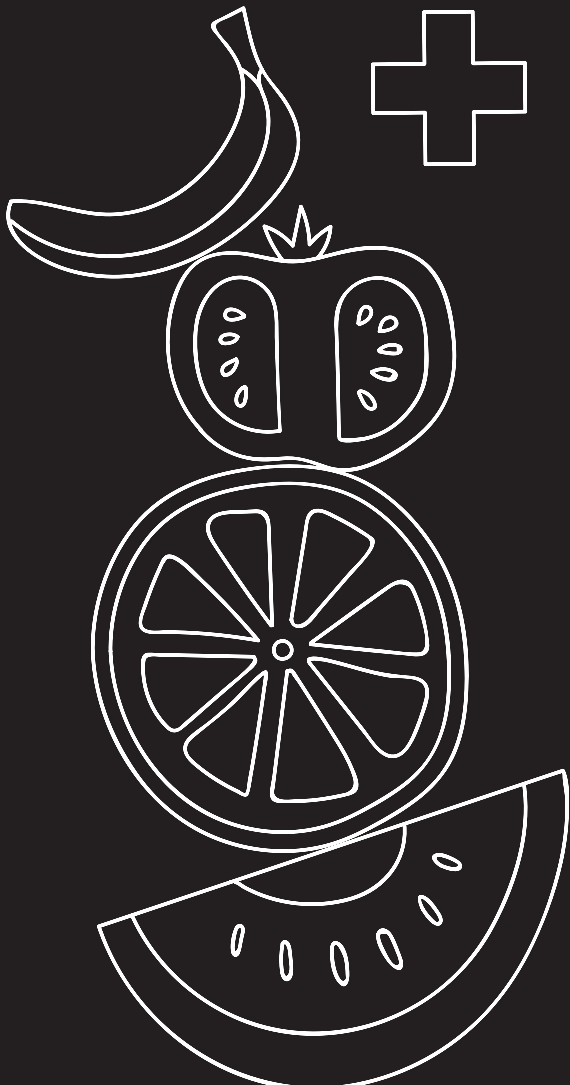
CHAPTER 1



General introduction

1

1.1 *Dietary intake in Switzerland: is there anybody out there?*

Diet is a cornerstone for the prevention of non-communicable diseases (NCDs).[1] Knowledge obtained from major economic crises such as in Cuba in 1989-2000[2 3] or Poland between 1986 and 1994 [4] shows that massive changes in the diet of the population can lead to substantial decreases in the prevalence of NCDs. For Cuba, the decreased in 1000 kcalories intake per capita from 2900 to 1860 led to a decline in 51% of deaths attributed to diabetes, 35% to deaths due do coronary heart disease, and 20% due to stroke.[2] In Poland, the shift from butter to vegetable oils and the increase in fruit intake led to a 25% decrease of in deaths from coronary heart disease.[4] Although such changes might not be feasible or event desirable in modern democracies, they show that modulation of dietary intake at the population level is an effective method to prevent the rising burden of NCDs.

Switzerland is a small European country with the world's second highest and ever-increasing health expenditure per capita.[5] NCDs account for a considerable part of health expenditures in Switzerland. In 2002, obesity-related costs represented between 2153 and 3229 million CHF (between 1915 and 2872 million €) (2.3 to 3.5% of total health care expenditures)[6], and this value has tripled to reach 8,000 million CHF (7115 million €) in 2012.[7] Similarly, *per capital* annual diabetes costs increased from 5036 € in 2006 to 5331 € in 2011.[8] Importantly, most health care costs are supported by people themselves, via the health insurance premiums. Indeed, in Switerland, social security only covers a fraction of health expenditures, the remaining of which is paid via individual health insurance. The escalating costs of healthcare have put a considerable economic pressure in many households, and an increasing number of people fail to pay the premiums, request for financial help or simply do not seek medical treatment. Cantons are increasingly requested for help regarding healthcare, and for the Vaud canton, the number of people receiving health subsidies increased from 47,897 in 1986 to 200,158 in 2006 [9], while the total amount of subsidies increased from 101 to 526 million CHF (89.8 to 467.8 million €) during the same period.[10]

Still, despite indications that lifestyle interventions are cost-effective in the prevention of obesity and associated diseases[11], there are little if no food policies aimed at preventing NCDs in Switzerland. The reason relies on the political structure and separation of powers between the Swiss federal government and the 26 cantons. Although the recent vote of 24th September 2017 added an amendment to the 104th article of the Swiss constitution regarding food safety [12], the "safety" issue mainly relates to food provision from local and sustainable sources and does not focus on health. Indeed, according to the Swiss constitution, the federal government can only act regarding (article 118) "a) the use of foodstuffs as well as therapeutic products, narcotics, organisms, chemicals and items that may be dangerous to health; b) the combating of communicable, widespread or particularly dangerous human and animal diseases; and c) protection against ionising radiation".[13] Interestingly, the terms "Prevention" (from a health perspective) and "Public health" are absent from the text. Indeed, it is the competence of the cantons to organize the health system for the citizens *via* their cantonal constitutions. For instance, the constitution of the canton Vaud contains a specific article (#65) related to public health and prevention[14], but no topics regarding food safety of production. Finally, a non-governmental institution (Promotion santé Suisse, www.promotionsante.ch) is mandated by the health insurances and the cantons to "initiate, coordinate and evaluate measures aimed at promoting health and preventing disease". Among the various topics covered by this institution, two are specifically related to diet: sugar-sweetened beverages at school and diet in elderly. Still, Promotion santé suisse cannot implement by itself any preventive measure, its role being to support local measures or to recommend specific measures to the canton authorities. Hence, most interventions are conducted at the canton or even at the community level.

The lack of a central authority responsible for public health policies in Switzerland considerably impairs the implementation measures to prevent NCDs. This is further complicated regarding dietary prevention by the separation of competencies: the federal government can legislate regarding food but not health, while cantons can legislate regarding health but not food. Finally, as Switzerland is a multilingual country (German, French, Italian and Rumantsch), national surveys specifically aimed at assessing dietary intake were inexistent till 2014 [15 16] due to the lack of standardized questionnaires. Indeed, only the Geneva canton used a validated food frequency questionnaire [17] to assess dietary intake in the population.

Overall, in a country known for its cheese and chocolate traditions and for being the homeland of one of the biggest food conglomerates in the world, there was a striking lack of information regarding a) the dietary intake of the population; b) the associations between diet and non-communicable diseases, and c) the dietary management of non-communicable diseases.

1.2 Dietary intake: so simple and so complicated

Everybody eats. This is a natural, essential and routine behaviour for all living creatures. Still, dietary intake is as complicated to quantify as it is simple to perform. Dietary intake can be assessed at the population level using aggregated data such as food production, import and export metrics[18 19], or at the individual level using advanced blood markers.[20] Dietary intake can be assessed either by questionnaire[21], by 24-h interviews, by food records with or without food weighting, by blood or urine markers or by newer technologies such as mobile phone devices[22]. Individual dietary intake can be estimated by converting foods into nutrients using food composition tables[23] or by advanced biochemical and genetic analyses. Markers of dietary intake can consist of several foods grouped together such as dietary patterns or dietary scores;

individual foods, macro- or micronutrients such as minerals and vitamins and other components of the "omics" family such as amino-acids, fatty acids, sugar components, or microRNAs.[20] The analyses are further challenged by large between- and within-individual variation[24], associated to other "variance-inflating" factors such as differences in food composition tables[23], geography[16] and season.[25 26] Other markers will not focus on foods themselves but on feeding behaviours such as food consumption occasions[27], time of meals[28], or with whom the subject eats.[29]

Overall, there is no definite, gold standard method for assessing dietary intake, and all studies must rely on somewhat imprecise instruments and estimations. Still, despite all these limitations, the information collected has consistently shown that specific dietary behaviours, namely a diet rich in fruits, vegetables, nuts, fish and vegetable oils could contribute to prevent the occurrence of NCDs.[30-33]

1.2 Objectives

The main objective of this thesis was to assess the trends in dietary intake of the adult Swiss population (**Figure 1.1**). The main objective was divided in three subobjectives

1. Assess the trends in dietary intake of the adult Swiss population
2. Assess the effect of diet on cardiovascular risk factors
3. Assess the dietary management of cardiovascular risk factors among adult patients

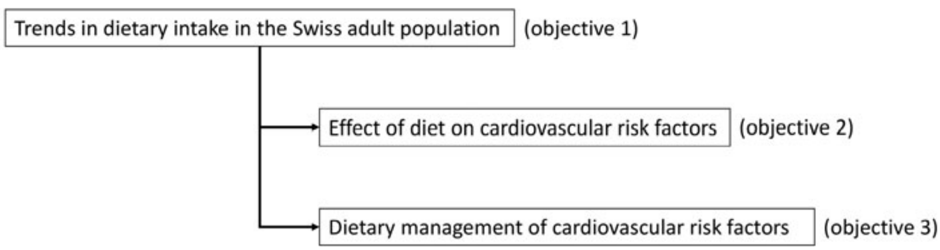


Figure 1.1. Overview of the objectives of this thesis.

1.3 Study populations

THE COLAUS STUDY

The CoLaus Study is a prospective study aiming to assess the prevalence of cardiovascular risk factors and to identify new molecular determinants of these risk factors in the population of the city of Lausanne, Switzerland.[34] In Switzerland, all people living for over 90 days in a given location are to be included in the corresponding population register. This register includes information on gender, age and address. Hence, for the CoLaus study, the sampling frame was composed of all subjects aged 35 to 75 included in the population register of Lausanne (n=56,694 in 2003). A simple, non-stratified random sample was drawn, and invitation letters were sent. If no answer was provided, a second invitation letter was sent, and if no answer was obtained, three phone calls were performed. The following inclusion criteria were applied: (a) written informed consent and (b) willingness to take part in the examination and to provide blood samples. Recruitment began in June 2003 and ended in May 2006 and included 6733 participants, corresponding to a response rate of 41%. The evaluation included an interview, a physical exam, blood sampling and a set of questionnaires. The first follow-up was performed between April 2009 and September 2012, 5.6 years on average (median: 5.4; range 4.5 to 8.8 years) after the baseline. A second follow-up was performed between May 2014 and April 2017, 10.9 years on average (median: 10.7; range 8.8 to 13.6 years) after the baseline. The procedures of both follow-ups were like the baseline, except that questionnaires focusing on dietary intake were applied.

THE BUS SANTÉ STUDY

The "Bus Santé" study is a cross-sectional, on-going 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 previously.[35] Every year since 1993, a representative sample of non-institutionalized men and women aged 35 to 74 years is recruited. Eligible subjects were identified with a standardized procedure 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 was not reached after three mailings and seven phone calls was replaced using the same selection protocol as above, but people who were reached and 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.

DIETARY INTAKE

In both CoLaus and Bus Santé studies, dietary intake was assessed using a validated, self-administered, semi-quantitative FFQ which also included portion size [17 36]. Briefly, this FFQ assesses the dietary intake of the previous four weeks and consists of 97 different food items that account for over 90% of the intake of calories, proteins, fat, carbohydrates, alcohol, cholesterol, vitamin D and retinol, and 85% of fibre, carotene and iron. 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 participants indicated the average serving size (smaller, equal or bigger) compared to a reference size.

1.4 *Thesis outline*

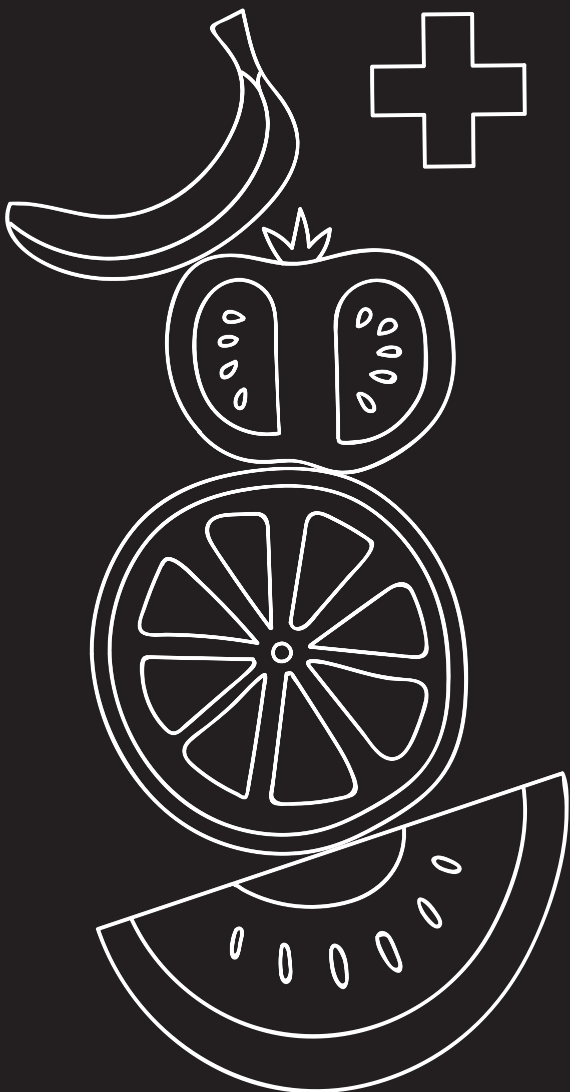
Chapter 2 focuses on the trends in dietary intake in Switzerland. **Chapter 2.1** provides the trends in dietary patterns in the Geneva canton. **Chapter 2.2** enumerates the different barriers to healthy eating reported by the Swiss population, and their trends. **Chapter 2.3** focuses on the trends regarding compliance to the guidelines set up by the Swiss society of nutrition in the Geneva canton, and on the possible impact of the guidelines regarding the trends. **Chapter 2.4** focuses on trends in vitamin, mineral and dietary supplements in a cohort conducted in the city of Lausanne

Chapter 3 assesses the association between dietary intake and several socio-demographic factors and cardiovascular risk factors. **Chapter 3.1** describes several dietary patterns and their socio-demographic factors in the city of Lausanne. **Chapter 3.2** presents the associations between markers of dietary intake and inflammatory levels. **Chapter 3.3** studies the associations between dietary intake and incident hypertension in the city of Lausanne.

Chapter 4 provides information on the dietary management of cardiovascular risk factors in Switzerland. **Chapter 4.1** compares the dietary intake of patients with dyslipidemia to those of the general population. **Chapter 4.2** compares the dietary intake of patients with diabetes to those of the general population. **Chapter 4.3** assesses whether the occurrence of a coronary event leads to changes in dietary intake.

Chapter 5 discusses the results and provides an overall picture of dietary intake in Switzerland. Recommendations regarding food policies and future research are provided.

CHAPTER 2



Trends in dietary intake and behaviours in Switzerland

2

CHAPTER 2.1

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

Marques-Vidal P, Gaspoz JM, Theler JM and Guessous I.
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2.1

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: 20.56 ± 1.39 compared with 20.05 ± 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 20.021 (95% CI: 20.027, 20.014; P< 0.001) for the 35- to 44-y cohort compared with 20.002 (95% CI: 20.009, 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.

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 favourable 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 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 weeks 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 fibre, 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 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 2.1.1**). 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 weeks 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 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 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 modelled 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 61, 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 **supplemental figure 2.1.1**. The characteristics of the included and excluded participants are summarized in **supplemental table 2.1.2**; excluded 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 2.1.1**. 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.

Table 2.1.1. Characteristics of the 18,763 participants of the Bus-Santé study (Geneva, Switzerland) for period 1993-2014.

	1993	**1995**	**1997**	**1999**	**2001**	**2003**	**2005**	**2007**	**2009**	**2011**	**2013**	**P for trend**
Sample size	757	866	1175	1213	1293	1173	197	250	972	841	637	
Women	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 (years)	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												
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 §
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 §
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												
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 §
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 §
Living alone	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	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	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

Results are expressed as mean ± SD or as number of participants (percentage). BMI, body mass index. Data from all years were used in the analysis, but for the sake of space and formatting only data from the odd numbered years are reported in the paper. Statistical analysis by linear regression for continuous data and by logistic regression (simple or § multinomial) for categorical data. For multinomial regression, never smokers and normal BMI were considered as the reference group. Due to the number of statistical association tests performed, statistical significance was considered for two-sided tests with p<0.001.

Dietary patterns

The results of the PCA are summarized in **supplemental table 2.1.3**. 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 2.1.3**). The results did not change when 90% or 80% of the participants were sampled (**Supplemental tables 2.1.4** and **2.1.5**, respectively).

The correlations between the 3 dietary pattern scores and selected macro- and micronutrients are provided in **supplemental table 2.1.5**. Almost all of the correlations were significant. The "fish and vegetables" pattern was positively correlated with intakes of protein, MUFAs and PUFAs, dietary fibre, 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 fibre, 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 fibre and negatively associated with total and animal protein, cholesterol, alcohol, and iron (**Supplemental table 2.1.6**).

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 2.1.2–2.1.4**. 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 2.1.2**). Similar findings were obtained in sensitivity analyses (**Supplemental tables 2.1.7–2.1.9**), 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 2.1.3**). Comparable findings were obtained in sensitivity analyses (**Supplemental tables 2.1.10–2.1.12**), 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 subgroups (**Table 2.1.4**), and similar findings were obtained in sensitivity analyses (**Supplemental tables 2.1.13–2.1.15**).

Table 2.1.2. Twenty-year trends (1993-2014) for the "Fish & vegetables" pattern score, overall and by participants' characteristics, for the 18,763 participants of the Bus-Santé study, Geneva, Switzerland.

	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013
Sample size	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
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
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
Age group											
[35-44]	-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
[45-54]	-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
[55-64]	-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
[65-74]	-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
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
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

Results are expressed as mean ± standard deviation or as slope and (95% confidence interval). Data from all years were used in the analysis, but for the sake of space and formatting only data from the odd numbered years are reported in the paper. Statistical analysis by ANOVA or linear regression adjusting for gender; age group; education; body mass index (continuous); marital status (living in couple, living alone); nationality (Swiss, non-Swiss) and smoking status (current, former, 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, statistical significance was considered for two-sided tests with $p<0.001$.

Table 2.1.2 (continued). Twenty-year trends (1993-2014) for the “Fish & vegetables” pattern score, overall and by participants’ characteristics, for the 18,763 participants of the Bus-Santé study, Geneva, Switzerland.

	Trend, unadjusted	p-value	Trend, adjusted	p-value
Overall	0.029 (0.026 , 0.033)	<0.001	0.025 (0.021 , 0.029)	<0.001
Men	0.034 (0.029 , 0.039)	<0.001	0.029 (0.024 , 0.034)	<0.001
Women	0.026 (0.020 , 0.031)	<0.001	0.022 (0.016 , 0.027)	<0.001
	P-value for interaction	0.033	P-value for interaction	0.039
Age group				
[35-44]	0.025 (0.018 , 0.032)	<0.001	0.019 (0.012 , 0.025)	<0.001
[45-54]	0.028 (0.021 , 0.035)	<0.001	0.025 (0.018 , 0.032)	<0.001
[55-64]	0.036 (0.028 , 0.044)	<0.001	0.035 (0.027 , 0.043)	<0.001
[65-74]	0.031 (0.021 , 0.040)	<0.001	0.027 (0.018 , 0.037)	<0.001
	P-value for interaction	0.127	P-value for interaction	0.034
Education				
University degree	0.015 (0.008 , 0.021)	<0.001	0.015 (0.009 , 0.021)	<0.001
Other	0.033 (0.028 , 0.038)	<0.001	0.031 (0.026 , 0.036)	<0.001
	P-value for interaction	<0.001	P-value for interaction	<0.001

Results are expressed as mean ± standard deviation or as slope and (95% confidence interval). Statistical analysis by ANOVA or linear regression adjusting for gender; age group; education; body mass index (continuous); marital status (living in couple, living alone); nationality (Swiss, non-Swiss) and smoking status (current, former, 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, statistical significance was considered for two-sided tests with p<0.001.

Table 2.1.3. Twenty-year trends (1993-2014) for the "Meat & chips" pattern score, overall and by participants' characteristics, for the 18,763 participants of the Bus-Santé study, Geneva, Switzerland.

	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013
Sample size	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
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
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
Age group											
[35-44]	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
[45-54]	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
[55-64]	-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
[65-74]	-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
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
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

Negative scores indicate low adherence, while positive scores indicate high adherence to the dietary pattern. Data from all years were used in the analysis, but for the sake of space and formatting only data from the odd numbered years are reported in the paper. Results are expressed as mean ± standard deviation or as slope and (95% confidence interval). Statistical analysis by ANOVA or linear regression adjusting for gender; age group; education; body mass index (continuous); marital status (living in couple, living alone); nationality (Swiss, non-Swiss) and smoking status (current, former, 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, statistical significance was considered for two-sided tests with $p<0.001$.

Table 2.1.3 (continued). Twenty-year trends (1993-2014) for the "Meat & chips" pattern score, overall and by participants' characteristics, for the 18,763 participants of the Bus-Santé study, Geneva, Switzerland.

	Trend, unadjusted	**p-value**	**Trend, adjusted**	**p-value**
Overall	-0.013 (-0.017 , -0.010)	<0.001	-0.011 (-0.014 , -0.008)	<0.001
Men	-0.019 (-0.024 , -0.014)	<0.001	-0.014 (-0.019 , -0.008)	<0.001
Women	-0.009 (-0.014 , -0.005)	<0.001	-0.007 (-0.012 , -0.003)	0.001
	P-value for interaction	0.007	P-value for interaction	0.026
Age group				
[35-44]	-0.012 (-0.019 , -0.005)	0.001	-0.011 (-0.017 , -0.004)	0.001
[45-54]	-0.011 (-0.017 , -0.004)	0.001	-0.011 (-0.017 , -0.005)	<0.001
[55-64]	-0.015 (-0.022 , -0.008)	<0.001	-0.011 (-0.018 , -0.004)	0.001
[65-74]	-0.015 (-0.024 , -0.007)	0.001	-0.015 (-0.023 , -0.007)	<0.001
	P-value for interaction	0.403	P-value for interaction	0.446
Education				
University degree	-0.014 (-0.019 , -0.008)	<0.001	-0.014 (-0.020 , -0.009)	<0.001
Other	-0.010 (-0.015 , -0.005)	<0.001	-0.009 (-0.013 , -0.005)	<0.001
	P-value for interaction	0.348	P-value for interaction	0.235

Negative scores indicate low adherence, while positive scores indicate high adherence to the dietary pattern. Results are expressed as mean ± standard deviation or as slope and (95% confidence interval). Statistical analysis by ANOVA or linear regression adjusting for gender; age group; education; body mass index (continuous); marital status (living in couple, living alone); nationality (Swiss, non-Swiss) and smoking status (current, former, 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, statistical significance was considered for two-sided tests with p<0.001.

2.1

Table 2.1.4. Twenty-year trends (1993-2014) for the "Chocolate & sweet" pattern score, overall and by participants' characteristics, for the 18,763 participants of the Bus-Santé study, Geneva, Switzerland.

	1993	**1995**	**1997**	**1999**	**2001**	**2003**	**2005**	**2007**	**2009**	**2011**	**2013**
Sample size	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
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
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
Age group											
[35-44]	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
[45-54]	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
[55-64]	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
[65-74]	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
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
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

Negative scores indicate low adherence, while positive scores indicate high adherence to the dietary pattern. Results are expressed as mean ± standard deviation or as slope and (95% confidence interval). Data from all years were used in the analysis, but for the sake of space and formatting only data from the odd numbered years are reported in the paper. Statistical analysis by ANOVA or linear regression adjusting for gender; age group; education; body mass index (continuous); marital status (living in couple, living alone); nationality (Swiss, non-Swiss) and smoking status (current, former, 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, statistical significance was considered for two-sided tests with p<0.001.

Table 2.1.4 (continued). Twenty-year trends (1993-2014) for the "Chocolate & sweet" pattern score, overall and by participants' characteristics, for the 18,763 participants of the Bus-Santé study, Geneva, Switzerland.

	Trend, unadjusted	p-value	Trend, adjusted	p-value
Overall	-0.029 (-0.032 , -0.026)	<0.001	-0.028 (-0.031 , -0.025)	<0.001
Men	-0.028 (-0.032 , -0.023)	<0.001	-0.027 (-0.032 , -0.022)	<0.001
Women	-0.030 (-0.034 , -0.025)	<0.001	-0.029 (-0.033 , -0.024)	<0.001
	P-value for interaction	0.498	P-value for interaction	0.774
Age group				
[35-44]	-0.034 (-0.040 , -0.028)	<0.001	-0.031 (-0.037 , -0.025)	<0.001
[45-54]	-0.027 (-0.033 , -0.021)	<0.001	-0.026 (-0.032 , -0.020)	<0.001
[55-64]	-0.028 (-0.035 , -0.021)	<0.001	-0.025 (-0.032 , -0.018)	<0.001
[65-74]	-0.030 (-0.039 , -0.021)	<0.001	-0.029 (-0.037 , -0.020)	<0.001
	P-value for interaction	0.369	P-value for interaction	0.467
Education				
University degree	-0.027 (-0.032 , -0.022)	<0.001	-0.027 (-0.032 , -0.022)	<0.001
Other	-0.030 (-0.034 , -0.026)	<0.001	-0.028 (-0.032 , -0.024)	<0.001
	P-value for interaction	0.352	P-value for interaction	0.546

Negative scores indicate low adherence, while positive scores indicate high adherence to the dietary pattern. Results are expressed as mean ± standard deviation or as slope and (95% confidence interval). Statistical analysis by ANOVA or linear regression adjusting for gender; age group; education; body mass index (continuous); marital status (living in couple, living alone); nationality (Swiss, non-Swiss) and smoking status (current, former, 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, statistical significance was considered for two-sided tests with p<0.001.

2.1

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 2.1.5**. The "fish and vegetables" pattern score increased, whereas the "meat and chips" pattern score decreased similarly in both cohorts (**Table 2.1.5**). 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 2.1.16 and 2.1.17**).

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 2.1.5**). Similar findings were obtained when patterns were computed by using the factor loadings for the period 1993–1999 (**Supplemental table 2.1.16**, except that the interaction was no longer significant) or by using the simplified method (**Supplemental table 2.1.17**).

Table 2.1.5. Twenty-year trends (1993-2014) for the "Fish & vegetables", the "Meat & chips" and the "Chocolate & sweets" pattern scores, by generational cohort in 1993, Bus-Santé study, Geneva, Switzerland.

	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013
"Fish & vegetables"											
[35-44] 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
[45-54] 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
"Meat & chips"											
[35-44] 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
[45-54] 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
"Chocolate&sweets"											
[35-44] 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
[45-54] 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

Negative scores indicate low adherence, while positive scores indicate high adherence to the dietary pattern. Results are expressed as mean ± standard deviation or as slope and (95% confidence interval). Data from all years were used in the analysis, but for the sake of space and formatting only data from the odd numbered years are reported in the paper. Statistical analysis by ANOVA or linear regression adjusting for gender; age group; education; body mass index (continuous); marital status (living in couple, living alone); nationality (Swiss, non-Swiss) and smoking status (current, former, 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, statistical significance was considered for two-sided tests with $p<0.001$.

Table 2.1.5 (continued). Twenty-year trends (1993-2014) for the "Fish & vegetables", the "Meat & chips" and the "Chocolate & sweets" pattern scores, by generational cohort in 1993, Bus-Santé study, Geneva, Switzerland.

	Trend, unadjusted	p-value	Trend, adjusted	p-value
"Fish & vegetables"				
[35-44] cohort	0.039 (0.031 , 0.047)	<0.001	0.036 (0.028 , 0.044)	<0.001
[45-54] cohort	0.026 (0.018 , 0.033)	<0.001	0.026 (0.018 , 0.033)	<0.001
	P-value for interaction	0.019	P-value for interaction	0.038
"Meat & chips"				
[35-44] cohort	-0.042 (-0.049 , -0.035)	<0.001	-0.036 (-0.043 , -0.029)	<0.001
[45-54] cohort	-0.033 (-0.040 , -0.025)	<0.001	-0.028 (-0.035 , -0.021)	<0.001
	P-value for interaction	0.072	P-value for interaction	0.084
"Chocolate & sweets"				
[35-44] cohort	-0.024 (-0.03 , -0.018)	<0.001	-0.021 (-0.027 , -0.014)	<0.001
[45-54] cohort	-0.005 (-0.012 , 0.002)	0.148	-0.002 (-0.009 , 0.005)	0.546
	P-value for interaction	<0.001	P-value for interaction	<0.001

Negative scores indicate low adherence, while positive scores indicate high adherence to the dietary pattern. Results are expressed as mean ± standard deviation or as slope and (95% confidence interval). Statistical analysis by ANOVA or linear regression adjusting for gender; age group; education; body mass index (continuous); marital status (living in couple, living alone); nationality (Swiss, non-Swiss) and smoking status (current, former, 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, statistical significance was considered for two-sided tests with p<0.001.

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.

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 2.1.1**).

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 savoury 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 2.1.18**). 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 behaviours 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 2.1.4 and 2.1.5**). Finally, although the FFQ was validated against 24-h recalls, the original publications[12, 17] did not provide any correlation coefficient.

2.1

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.

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SUPPLEMENTAL MATERIAL

Supplemental material for this chapter can be found online
https://academic.oup.com/ajcn/article/106/1/217/4634027#supplementary-data

CHAPTER 2.2

Twenty-four-year trends and determinants of change in dietary compliance with Swiss dietary guidelines

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2.2

ABSTRACT

Background and aims: a healthy diet is the cornerstone of disease prevention, and dietary guidelines have been issued in most countries. We aimed to assess trends in compliance with dietary guidelines in the population of Geneva, Switzerland.

Methods: multiple cross-sectional, population-based surveys conducted between 1993 and 2016 in the canton of Geneva, Switzerland [20 310 participants (52.3% women, mean age 51.9±10.7 years)]. Trends in compliance with the Swiss dietary guidelines regarding food intake were assessed using logistic regression a) for each guideline and b) for at least three guidelines. Compliance before and after the first and second issuing of the guidelines was assessed.

Results: after multivariable adjustment, compliance with fruits increased overall [odds ratio and (95% confidence interval) for one-year increase: 1.007 (1.003-1.012), p<0.001], in men, participants aged over 45 and with low educational level. Compliance with vegetables increased overall [1.015 (1.008-1.022), p<0.001], in both genders, age groups [45-54] and [55-64] and participants with low educational level. Compliance with meat increased in women [1.007 (1.001-1.013), p=0.021] and participants with a university degree. Compliance with fresh fish increased in age group [55-64] [1.009 (1.000-1.018), p=0.041]. Compliance with dairy products decreased overall [0.979 (0.972-0.986), p<0.001] and in all groups studied, except for age group [65-74]. Compliance with at least three guidelines increased in age group [55-64] only [1.013 (1.002-1.024), p=0.019]. No effect of the issuing of the guidelines was found.

Conclusion: in the Geneva adult population compliance with the Swiss dietary guidelines improved little. Issuing of dietary guidelines did not impact trends.

INTRODUCTION

Dietary intake is the cornerstone for prevention of noncommunicable diseases[1] and food guidelines are instruments to guiding healthy food choices by the population[2]. Many countries have issued national dietary guidelines[3-5]. Compliance with dietary recommendations is an important factor for health maintenance and disease prevention[6], but several studies have shown that compliance with national dietary guidelines is low[7, 8]. Still, of the few studies that assessed trends in compliance with dietary guidelines[9-12], some focused on a single guideline11 or on a specific group of the population12. In Switzerland, the dietary guidelines were first issued by the Swiss society of nutrition in 1998, and again in 2011[5, 13]. Whether the publication of the guidelines led to changes in compliance has never been assessed.

In a previous study[14], we assessed trends in compliance with Swiss guidelines regarding nutrient intake in the Geneva adult population. Still, compliance with nutrient intake is harder to convey than to food intake, and many recent studies have pointed out that the protective role of diet against noncommunicable diseases is not due to nutrients alone, but to food and dietary patterns[15-18].

Thus, we now aimed to assess the 24-year trends (1993-2016) in compliance with the Swiss Society of Nutrition (SSN) guidelines for food intake[5]. We also assessed whether the issuing of the Swiss dietary guidelines led to significant changes in compliance. Our hypothesis was that overall compliance increased in the adult population of Geneva, but that the issuing of the guidelines had little if no effect.

PARTICIPANTS AND METHODS

Participants

The “Bus Santé” study is a cross-sectional, on-going population-based study designed to collect information on chronic disease risk factors in the canton of Geneva, Switzerland. Geneva is the westernmost canton of Switzerland, surrounded on almost all sides by France[19]. The sampling methodology of the “Bus Santé” Geneva study has been reported previously[20]. Every year since 1993, a representative sample of non-institutionalized men and women aged 35 to 74 years is recruited. Participation rates ranged from 50% to 66% throughout the study period.

Dietary intake

Dietary intake was assessed using a validated, self-administered, semi-quantitative FFQ which also included portion size[21, 22]. Information derived from this FFQ has contributed to several reports from large consortium such as the Global Burden of Disease[23, 24]. 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 participants indicated the average serving size (smaller, equal or bigger) compared to a reference size.

Reported frequencies were transformed into daily consumption frequencies as follows: "never these last 4 weeks"=0; "once/month"=1/28; "2–3/month"=2.5/28; "1–2/week"=1.5/7; "3–4 times/week"=3.5/7; "once/day"=1 and "2+/day"=2.5. The consumption frequency of one food category was obtained by summing up all individual consumption frequencies of foods related to that category. For example, daily fruit consumption was obtained by summing up the daily consumptions of fresh fruits (5 items) and fruit juices (fresh and processed without added sugar).

Participants were dichotomized according to whether they followed the dietary guidelines for fruits, vegetables, meat, fish and dairy products from the Swiss Society of Nutrition[13]. The guidelines were a) ≥2 fruit portions/day; b) ≥3 vegetable portions/day; c) ≤5 meat portions/week; d) ≥1 fish portion/week and e) ≥3 dairy products portions/day. As the FFQ queried about fresh and fried fish, two categories were considered: one including and one excluding fried fish, as several studies have shown that fried fish or fried foods are associated with an increased risk of cardiovascular events[25, 26], and also because fried fish represented between 34% (in 2007) and 41% (in 1993) of all fish consumed. Participants were further dichotomized if they complied with at least three guidelines or not; two categories of compliance were created, depending on the type of fish consumed (including or excluding fried fish).

Covariates

Health examinations were conducted throughout the year, from January to December, in two clinics and one mobile medical unit. Body weight and height were measured using standard procedures, and body mass index (BMI, kg/m^2) was calculated. Data for socio-demographic characteristics, smoking and educational history were collected 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, current smokers) was self-reported. Marital status was categorized as living alone (i.e. being single, divorced and widowed) or in couple (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 "other".

Exclusion criteria

We applied the following exclusion criteria: a) participants reporting less than 30 items consumed, as this was considered as a marker of either incomplete reporting or of dietary monotony; b) age <35 or ≥75 years; and c) missing data for any covariate (age, BMI, education, marital status, smoking habits or nationality).

Ethics statement

The "Bus Santé" Geneva study was approved by the University of Geneva ethics committee and all 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 analysis was performed using Stata software version 15.1 (Stata Corp, College Station, TX, USA). Descriptive results were expressed as number of participants (percentage) for categorical variables or as mean ± standard deviation (SD) for continuous variables. Bivariate analysis was performed using chi-square test for categorical variables and analysis of variance for continuous variables. Yearly trends were assessed using unadjusted and multivariable-adjusted logistic regression using compliance to each guideline (dichotomous, yes/no) as dependent variable and year, gender [except when stratifying on gender]; age group [except when stratifying on age group]; education [except when stratifying on education]; body mass index (normal, overweight, obese); marital status (living in couple, living alone); nationality (Swiss, non-Swiss) and smoking status (current, former, never) as independent variables. Results were expressed as multivariable-adjusted odds ratios (OR) and [95% confidence interval (CI)] for a one-year increment. In both unadjusted and adjusted analyses, survey year was used as a continuous variable. Differences in trends between age groups were assessed by including an interaction term (i.e. age groups × year) in the multivariable models.

Generational analysis was conducted using [35-44] and [45-54] age groups in 1993. The [35-44] age group in 1993 corresponded to the [40-49] age group five years later (1998) and to the [45-54] age group in 2003. To assess 20-year trends, only age groups [35-44] and [45-54] in 1993, corresponding to age groups [55-64] and [65-74] in 2016 and further on, were considered. Differences in age groups regarding trends were assessed by including an interaction term (i.e. age groups × year) in the multivariable models.

The impact of the guidelines on compliance was assessed by comparing compliance levels in the 5-year period before and after the issuing of the guidelines. Firstly, we compared period 1993-1997 with period 1998-2002, and period 2006-2010 with period 2011-2015. Secondly, a pooled analysis grouping the two 5-year periods before and the two 5-year period after the issuing of the guidelines was performed. Statistical significance was considered for a two-tailed test with $p<0.05$.

RESULTS

Characteristics of participants

Of the initial 22,730 participants, 2420 (10.6%) were excluded. The reasons for exclusion are indicated in **supplemental figure 2.3.1** and the comparison between included and excluded participants is provided in **supplemental table 2.2.1**. Excluded participants were younger (secondary to the age exclusion criteria), more frequently women, less frequently current smokers, had a slightly lower BMI, lived more frequently alone and were more frequently non-Swiss than included ones.

The characteristics of the participants according to survey year are summarized in **table 2.2.1** and the complete data is available in **supplemental table 2.2.2**. Between 1993 and 2016, mean age and BMI of participants increased; the frequency of current smokers and participants with an educational level below university decreased, and the frequency of participants who were overweight or obese, non-Swiss or lived in couple increased.

Table 2.3.1: Characteristics of the participants of Bus-Santé study (Geneva, Switzerland) for the period 1993-2016.

	1993	2016	Yearly trend	P-value
Age (years)	51.9 ± 10.3	51.9 ± 11.0	0.030 (0.008 - 0.052)	0.007
Woman, n (%)	335 (50.0)	360 (50.9)	0.997 (0.993 - 1.001)	0.106
Smoking status, n (%)				
Never	296 (44.2)	336 (47.5)		
Former	168 (25.1)	232 (32.8)	1.003 (0.998 - 1.008)	0.236
Current	206 (30.8)	139 (19.7)	0.979 (0.975 - 0.984)	<0.001
BMI (kg/m²)	24.4 ± 3.8	25.1 ± 4.3	0.038 (0.030 - 0.046)	<0.001
BMI categories, n (%)				
Normal	414 (61.8)	386 (54.6)		
Overweight	202 (30.2)	235 (33.2)	1.012 (1.008 - 1.017)	<0.001
Obese	54 (8.1)	86 (12.2)	1.030 (1.023 - 1.038)	<0.001
Living in couple, n (%)	488 (72.8)	526 (74.4)	0.995 (0.990 - 0.999)	0.022
Nationality, non-Swiss, n (%)	173 (25.8)	260 (36.8)	1.015 (1.011 - 1.020)	<0.001
Education, non-university, n (%)	447 (66.7)	331 (46.8)	0.958 (0.954 - 0.962)	<0.001

*BMI, body mass index. Results are expressed as mean ± SD or as number of participants (percentage) except for column trend, where the results are expressed as slope (95% confidence interval) for continuous variables and as odds ratio (95% confidence interval) for categorical variables. Data from all years were used in the analysis, but for the sake of space and formatting only data from the first and last years are reported. Statistical analysis by linear regression for continuous data and by logistic regression (simple or § multinomial) for categorical data. For multinomial regression, never smokers and normal BMI were considered as the reference group. For complete data, please consult **supplemental table 2.2.2**.*

Trends in compliance with dietary guidelines

The trends in compliance with at least three dietary guidelines overall and stratified by gender and age group is summarized in **tables 2.2.2** (including fried fish) and **2.2.3** (excluding fried fish), and the overall results are presented in **supplemental tables 2.2.3** (including fried fish) and **2.2.4** (excluding fried fish). In non-adjusted analysis, compliance (including fried fish) increased in women and decreased in participants with educational level below university; after multivariate adjustment, compliance increased in the [55-64] age group and decreased in [35-44] and [45-

54] age groups (**table 2.2.2 and supplemental table 2.2.3**). When fried fish was excluded, compliance increased in the whole sample and in men, the [55-64] age group and in participants with educational level below university; after multivariate adjustment, compliance increased only in the [55-64] age group (**table 2.2.3 and supplemental table 2.2.4**).

Trends regarding individual guidelines are indicated in **supplemental tables 2.2.5** (for fruits), **2.2.6** (for vegetables), **2.2.7** (for meat), **2.2.8** (for fish, including fried fish), **2.2.9** (for fish, excluding fried fish) and **2.2.10** (for dairy products). For compliance with fruits, after multivariate adjustment, an improvement was found in the whole sample, in men, in participants aged over 45 and with educational level below university; the increase in men was significantly different from women (p for interaction: 0.003), while no difference was found between educational levels (p for interaction: 0.298) (**supplemental table 2.2.5**). For compliance with vegetables, improvements were found in the whole sample, for both genders, in the [45-54] and [55-64] age groups and in participants with educational level below university; the increase in participants with educational level below university was significantly different from participants with a university degree (p for interaction: 0.024) (**supplemental table 2.2.6**). For compliance with meat, improvements were found in women and in participants with a university degree (**supplemental table 2.2.7**). For compliance with fish (including fried fish), a decrease was found in the whole sample, in the [45-54] age group and in participants with university degree (**supplemental table 2.2.8**); when fried fish was excluded, an increase in compliance was found in the [55-64] age group (**supplemental table 2.2.9**). Finally, compliance with dairy products decreased in the whole sample and in almost all groups studied, except for the [65-74] age group (**supplemental table 2.2.10**).

Table 2.2.2: Twenty-four year trends (1993-2016) in compliance with at least three dietary guidelines (including fried fish) for the participants of the Bus-Santé study, Geneva, Switzerland.

	1993	2016	OR (95% CI) [a]	P-value [a]	OR (95% CI) [b]	P-value [b]	P-value for interaction[b]
Overall	175 (26.1)	176 (24.9)	1.003 (0.998-1.008)	0.223	1.002 (0.997-1.006)	0.511	
Gender							0.748
Female	59 (17.6)	68 (19.6)	1.008 (1.001-1.016)	0.029	1.005 (0.998-1.013)	0.183	
Male	116 (34.6)	108 (30.0)	1.000 (0.994-1.006)	0.912	0.999 (0.993-1.005)	0.765	
Age group (years)							0.244
35-44	40 (20.7)	38 (16.9)	0.993 (0.984-1.002)	0.152	0.990 (0.980-0.999)	0.029	
45-54	54 (24.3)	48 (23.2)	1.004 (0.995-1.012)	0.413	1.005 (0.997-1.014)	0.235	
55-64	54 (31.0)	51 (34.5)	1.008 (0.998-1.017)	0.118	1.010 (1.000-1.020)	0.058	
65-74	27 (33.3)	39 (30.7)	1.005 (0.994-1.016)	0.401	1.005 (0.993-1.016)	0.426	
Education							0.190
University	64 (28.7)	97 (25.8)	0.995 (0.988-1.002)	0.175	0.994 (0.987-1.002)	0.141	
Other	111 (24.8)	79 (23.9)	1.007 (1.000-1.013)	0.034	1.006 (1.000-1.012)	0.067	

Results are expressed as number of participants and (percentage) and as odds ratio (OR) and 95% confidence interval (CI). Percentages are computed based on the number of participants for each category (i.e. 35-44 years) within each year. Data from all years were used in the analysis, but for the sake of space and formatting only data from the first and last years are reported. Statistical analysis by logistic regression: a, unadjusted; b adjusting for gender [except when stratifying on gender]; age group [except when stratifying on age group]; education [except when stratifying on education]; body mass index (normal, overweight, obese); marital status (living in couple, living alone); nationality (Swiss, non-Swiss) and smoking status (current, former, never). For complete data, please consult ***supplemental table 2.2.3***.

Table 2.2.3: Twenty-four year trends (1993-2016) in compliance with at least three dietary guidelines (excluding fried fish) for the participants of the Bus-Santé study, Geneva, Switzerland.

	1993	2016	OR (95% CI) [a]	P-value [a]	OR (95% CI) [b]	P-value [b]	P-value for interaction [b]
Overall	122 (18.2)	135 (19.1)	1.005 (1.000-1.010)	0.038	1.003 (0.998-1.008)	0.202	
Gender							0.502
Female	85 (25.4)	85 (23.6)	1.004 (0.910-1.010)	0.239	1.002 (0.995-1.009)	0.561	
Male	37 (11.0)	50 (14.4)	1.010 (0.004-1.019)	0.022	1.006 (0.997-1.014)	0.203	
Age group (years)							0.141
35-44	26 (13.5)	28 (12.4)	0.995 (0.985-1.005)	0.334	0.990 (0.980-1.000)	0.074	
45-54	36 (16.2)	34 (16.4)	1.003 (0.993-1.012)	0.554	1.004 (0.994-1.013)	0.464	
55-64	45 (25.9)	44 (29.7)	1.011 (1.000-1.021)	0.032	1.013 (1.002-1.024)	0.019	
65-74	15 (18.5)	29 (22.8)	1.011 (0.999-1.023)	0.061	1.012 (0.999-1.024)	0.059	
Education							0.146
University	48 (21.5)	78 (20.7)	0.994 (0.987-1.002)	0.502	0.997 (0.989-1.005)	0.429	
Other	74 (16.6)	57 (17.2)	1.006 (1.000-1.012)	0.019	1.008 (1.001-1.014)	0.036	

Results are expressed as number of participants and (percentage) and as odds ratio (OR) and 95% confidence interval (CI). Percentages are computed based on the number of participants for each category (i.e. 35-44 years) within each year. Data from all years were used in the analysis, but for the sake of space and formatting only data from the first and last years are reported. Statistical analysis by logistic regression: a unadjusted; b adjusting for gender [except when stratifying on gender]; age group [except when stratifying on age group]; education [except when stratifying on education]; body mass index (normal, overweight, obese); marital status (living in couple, living alone); nationality (Swiss, non-Swiss) and smoking status (current, former, never). For complete data, please consult ***supplemental table 2.2.4***.

Generational trends in compliance with dietary guidelines

The results for the generational trends in compliance with dietary guidelines are indicated in **table 2.2.4** and **supplemental table 2.2.11**. After multivariable adjustment, compliance with at least three guidelines (with or without fried fish) improved in both groups; compliance with fruits, vegetables, meat and fish (excluding fried) improved, while no changes were found regarding compliance with fish (including fried) and dairy products.

2.2

Table 2.2.4: Twenty-four year trends (1993-2016) in compliance with at least three dietary guidelines (excluding fried fish) for the participants of the Bus-Santé study, Geneva, Switzerland. Twenty-three-year generational trends (1993-2016) in compliance with dietary guidelines for the participants of the Bus-Santé study, Geneva, Switzerland.

	1993	2016	OR (95% CI) [a]	P-value [a]	OR (95% CI) [b]	P-value [b]	P-value for interaction [b]
At least 3							0.934
35-44	40 (20.7)	43 (37.1)	1.030 (1.021-1.040)	<0.001	1.033 (1.023-1.043)	<0.001	
45-54	54 (24.3)	29 (30.2)	1.028 (1.018-1.038)	<0.001	1.035 (1.024-1.045)	<0.001	
At least 3, no fried fish							0.499
35-44	26 (13.5)	38 (32.8)	1.040 (1.029-1.051)	<0.001	1.043 (1.032-1.055)	<0.001	
45-54	36 (16.2)	20 (20.8)	1.030 (1.019-1.041)	<0.001	1.036 (1.025-1.047)	<0.001	
Fruits							0.627
35-44	78 (40.4)	66 (56.9)	1.026 (1.018-1.035)	<0.001	1.029 (1.020-1.039)	<0.001	
45-54	95 (42.8)	52 (54.2)	1.033 (1.024-1.042)	<0.001	1.040 (1.031-1.050)	<0.001	
Vegetables							0.744
35-44	10 (5.2)	19 (16.4)	1.032 (1.019-1.046)	<0.001	1.034 (1.020-1.049)	<0.001	
45-54	21 (9.5)	8 (8.3)	1.021 (1.006-1.035)	0.003	1.027 (1.012-1.042)	<0.001	
Meat							0.578
35-44	102 (52.9)	68 (58.6)	1.014 (1.006-1.023)	0.001	1.016 (1.007-1.024)	<0.001	
45-54	117 (52.7)	53 (55.2)	1.013 (1.004-1.022)	0.002	1.016 (1.007-1.055)	<0.001	
Fish (all)							0.436
35-44	136 (70.5)	82 (70.7)	1.005 (0.996-1.015)	0.222	1.006 (0.997-1.010)	0.166	
45-54	158 (71.2)	67 (69.8)	1.003 (0.994-1.013)	0.435	1.005 (0.994-1.015)	0.336	
Fish (excl. fried)							0.187
35-44	70 (36.3)	63 (54.3)	1.026 (1.018-1.035)	<0.001	1.026 (1.017-1.035)	<0.001	
45-54	85 (38.3)	44 (45.8)	1.014 (1.005-1.022)	0.002	1.015 (1.006-1.025)	0.001	
Dairy products							0.270
35-44	13 (6.7)	10 (8.6)	0.998 (0.984-1.011)	0.789	0.997 (0.983-1.011)	0.705	
45-54	14 (6.3)	14 (14.6)	1.005 (0.991-1.019)	0.421	1.003 (0.989-1.018)	0.616	

Results are expressed as number of participants and (percentage) and as odds ratio (OR) and 95% confidence interval (CI). Percentages are computed based on the number of participants for each generational cohort within each year. Statistical analysis by logistic regression: a unadjusted; b adjusting for gender; education; body mass index (normal, overweight, obese); marital status (living in couple, living alone); nationality (Swiss, non-Swiss) and smoking status (current, former, never). For complete data, please consult ***supplemental table 2.3.11****.*

Impact of the issuing of the guidelines on compliance

The results for the impact of the issuing of the Swiss dietary guidelines in 1998 and 2011 on compliance with at least three dietary guidelines are indicted in **table 2.2.5**. Overall, no significant changes were found regarding compliance before and after the issuing of the guidelines for both periods concerned, and similar findings were obtained when the analysis was split by gender, age group or educational level. Similar findings were obtained for the individual guidelines or when pooling the periods before and after each issuing of the guidelines (1998 and 2011; **supplemental tables 2.2.12 to 2.2.19**).

Table 2.2.5: Compliance with at least 3 dietary guidelines five years before and after publication of the Swiss dietary guidelines, overall and stratified by gender, age group and educational categories, Bus Santé study, Geneva, Switzerland.

	1998-2002 vs. 1993-1997	**P-value**	**2011-2015 vs. 2006-2010**	**P-value**
Overall	1.017 (0.929 - 1.113)	0.718	0.992 (0.870 - 1.131)	0.906
Gender				
Female	1.007 (0.869 - 1.166)	0.929	0.998 (0.813 - 1.226)	0.985
Male	1.021 (0.910 - 1.146)	0.718	0.984 (0.830 - 1.167)	0.855
Age group (years)				
35-44	0.983 (0.829 - 1.164)	0.839	0.832 (0.654 - 1.059)	0.135
45-54	1.005 (0.853 - 1.184)	0.954	1.079 (0.836 - 1.392)	0.560
55-64	1.026 (0.856 - 1.230)	0.780	0.950 (0.733 - 1.233)	0.701
65-74	1.106 (0.880 - 1.390)	0.387	1.230 (0.893 - 1.694)	0.205
Education				
University	1.061 (0.905 - 1.243)	0.465	0.970 (0.794 - 1.186)	0.769
Other	0.997 (0.892 - 1.113)	0.954	0.999 (0.840 - 1.187)	0.988

Results are expressed as odds ratio and (95% confidence interval) for periods of five years before relative to after issuing the guidelines (1998 and 2011). Statistical analysis by logistic regression adjusting for gender [except when stratifying on gender]; age group [except when stratifying on age group]; education [except when stratifying on education]; body mass index (normal, overweight, obese); marital status (living in couple, living alone); nationality (Swiss, non-Swiss) and smoking status (current, former, never). Results are expressed as odds ratio and (95% confidence interval) for periods of five years before relative to after issuing the guidelines (1998 and 2011).

DISCUSSION

This study aimed to assess the changes in compliance with the SSN guidelines over the last twenty-four years in Geneva. The results indicate that compliance with at least three guidelines was rather low and remained so over the 24 years period. Conversely, an increase in compliance was found for generations aged [35-44] and [45-54] in 1993.

Trends in compliance with dietary guidelines

Compliance with the SSN guidelines was low and remained so during the 24-year study period: the percentage of subjects complying with at least 3 guidelines was 26.2% in 1993 and 24.9% in 2016. Those findings agree with a prospective study conducted in the neighbour city of Lausanne, where only 25.2% of the population complied with at least three guidelines[27]. There are few studies worldwide assessing trends in global compliance with dietary guidelines. A likely explanation for the low improvement in global compliance is that the increase in compliance with some guidelines (i.e. fruits and vegetables) was compensated by the decrease in compliance with other guidelines (i.e. dairy)[27].

Compliance with fruits and vegetables guidelines increased in all studied groups, a finding also found in France28 and in the United States[11], but not in New Zealand[10]. The increase in compliance with the vegetable guideline is likely due to the increased availability of vegetables in Switzerland between 1961 and 2007[29]. Conversely, the increase in compliance with the fruits guideline could not be explained by increased availability, as it actually decreased during the same period[29], from 138 in 1961 to 79 kg/capita/year in 200730. Indeed, Switzerland produces less than 50% of all foodstuffs of plant origin consumed[31], and the price of fruits has increased almost 70% between 1982 and 2017[31]. An alternative explanation would be that Geneva inhabitants increased buying fruits and other foods from food retails in neighboring France, as food prices are considerably lower in France than in Switzerland[32].

Compliance with the dairy products guideline decreased in almost all studied groups, a finding also reported in France[28]. Conversely, dairy consumption remained stable in New Zealand[10] and Germany[9], while it increased in the United States[11]. This decrease in compliance with dairy product intake explains the decrease in calcium intake reported in a previous study conducted in the same population[14]. Dairy products are a good source of high quality proteins, vitamins and minerals[33], have been associated with better nutrient and improved bone health status[34] and might protect against metabolic syndrome[15], cardiovascular disease and type 2 diabetes[34]. Overall, our results indicate that dairy product intake is being neglected by the Geneva population, with possible health consequences on the long term.

Compliance with the meat guideline improved in women and in participants with a university degree. A decrease in meat consumption had also been reported for women in New Zealand[10]. This finding indicates that the more healthy-conscious groups tend to better adhere with dietary guidelines. Indeed, in previous study conducted in Switzerland, persons who reporting adhering to the Swiss food pyramid consumed meat significantly less often than persons not adhering to it[35]. Overall, our results indicate that compliance with the meat improved only slightly over the twenty-four year period study.

Compliance with the fish guideline decreased. When fried fish was excluded, the prevalence of compliance decreased considerably (from 73.3% to 40.2% in 1993); this is likely due to the large proportion of fried fish consumed (between 34% and 41% of all fish). Still, when fried fish was excluded, no change regarding trends in compliance was found, except for an increase in age group [55-64]. Our results are consistent with previous longitudinal studies conducted in New Zealand[10], Germany[9] and France[28], where no changes in reported fish consumption were found. Fish consumption is associated with a lower risk of heart failure[36] and all-cause mortality[37], while fried fish does not protect against heart failure[38] and is associated with an increased risk cardiovascular disease[25, 39]. This deleterious association might be related to the type of frying oil used, as a Spanish study found no association between foods fried in olive or sunflower oil and coronary heart disease[40]. Hence, it would be important that fish consumption be improved in the Geneva population, and that cooking methods other than frying be used.

Generational trends in compliance with dietary guidelines

Compliance with most guidelines improved with time, the sole exceptions being compliance with fish (including fried) and dairy products. Several factors might explain this improvement. First, income tends to increase with age, allowing subjects to buy healthier (and usually more expensive) options; indeed, a previous study has shown that price was one of the main barriers for healthy eating, and that its prevalence decreased with age[41, 42]. Second, as the cost of food is high in Switzerland, people living in Geneva are increasingly buying their foods in nearby France, which might also increase the accessibility to healthier foods[32]. Finally, elderly subjects present more frequently with chronic, non-communicable diseases, the management of which includes dietary therapy; for instance, we have previously shown that subjects with dyslipidemia tend to consume a healthier diet than the general population[43], although no such improvement was found among subjects with type 2 diabetes[44] or hypertension[45]. Overall, our results suggest that compliance with dietary guidelines tends to improve with aging. Still, as our results were based on multiple cross-sectional surveys, it would be of interest to replicate these findings in a prospective study.

Impact of the issuing of the guidelines on compliance

No significant effect of the issuing of the guidelines by the Swiss society of nutrition in 1998 and 2011 was found. A possible explanation is that simple educational measures have little impact on food purchases compared to other measures such as changes in food prices[46, 47]. Indeed, a previous study identified cost as one of the major barriers towards healthy eating[41, 42.] Overall, our results suggest that the issuing of the Swiss dietary guidelines had little if no impact at all regarding healthy eating.

Importance for public health nutrition

Compliance with food-based dietary recommendations positively impacts population health status48. Similarly, fish is a good source of high quality proteins and its consumption is recommended for the prevention of many diseases, especially cardiovascular[15, 33, 37]. Our results suggest that compliance with dietary guidelines has not improved in a large sample of adults representative of the Geneva population and that it would be important to promote healthy eating either by publicizing the guidelines in the lay media or by intervening on food prices, as this approach has been shown to be more efficient than nutritional education[46, 47].

Strengths and limitations

This study has several strengths: data were collected using a validated FFQ and the same standardized methodology was used throughout a 24-year period.

This study also has several limitations. Firstly, the FFQ was not updated and could not take into account possible changes in food availability that occurred during the study period[29]. Still, it would have been complicated to change the FFQ during the study period and to harmonize the findings. Secondly, the guidelines were first issued in 1998, so it is possible that the trends might have been biased by a period (1993-1997) where no guidelines existed. Still, restricting the analysis to the period 1998-2016 led to similar findings (**supplemental tables 2.3.20 to 2.3.28**), and our results suggest that the issuing of the guidelines had little if no effect on compliance. Thirdly, this study only assessed the population of the Geneva canton; as dietary intake differs between linguistic regions in Switzerland49, the generalizability of the findings might be suboptimal. Still, in the absence of similar studies conducted in other cantons, it is currently unknown if trends differ. Finally, food-based dietary guidelines differ slightly between countries (supplemental table S29)50, so our results might not be generalizable to other countries. Nevertheless, this study can be considered as a reference for long-term trends in compliance with healthy diet guidelines.

Conclusion

In the Geneva population, compliance with the Swiss dietary guidelines regarding food intake was rather low and remained so over a 24 years period. Generational trends improved. The issuing of guidelines by the Swiss society of nutrition had no effect on trends.

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SUPPLEMENTAL MATERIAL

Supplemental material for this chapter can be found online
http://www.nature.com/articles/s41430-018-0273-0#Sec23

CHAPTER 2.3

Fifteen-year trends in the prevalence of barriers to healthy eating in a high-income country

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2.3

ABSTRACT

Background: Despite increasing levels of education and income in the Swiss population over time, adherence to dietary guidelines has remained persistently low. This may be due to barriers to healthy eating hampering adherence, but whether barriers have evolved over time has never been assessed.

Objective: To assess 15-year trends in the prevalence of self-reported barriers to healthy eating in Switzerland, overall and according to gender, age, education, and income.

Design: We used data from four Swiss National Health Surveys conducted between 1997 and 2012 (52,238 participants, 54.9% women), assessing trends in prevalence for barriers with prevalence ≥20% ("taste", "price", "daily habits", "time", "lack of willpower", and "limited options in restaurants").

Results: The prevalence of three barriers exhibited an increasing trend until 2007 followed by a decrease in 2012 (from 44% in 1997 to 52% in 2007 and then to 48% in 2012 for "taste"; from 39% to 52% and then to 39% for "price"; from 29% to 34% and then 33% for "time", quadratic trend p<0.0001). "Limited options in restaurants" remained stable up to 2007 (33%) and then decreased to 17% (linear trend p<0.0001). "Daily habits" remained relatively stable across time from 42% in 1997 to 38% in 2012 (linear trend p<0.0001). Conversely, "lack of willpower" decreased steadily over time from 26% in 1997 to 21% in 2012 (linear trend p<0.0001). Trends were similar for all barriers irrespective of gender, age, education, and income.

Conclusion: Between 1997 and 2012, barriers to healthy eating remained highly prevalent (≥20%) in the Swiss population and evolved similarly irrespective of age, gender, education and income.

INTRODUCTION

Healthy eating can lower the risk of developing chronic diseases such as obesity, diabetes, hypertension, myocardial infarction, stroke and many forms of cancer[1, 2] Though different diet types can facilitate healthy eating, all are generally characterized by high intakes of fruits, vegetables, whole grains, nuts and seeds, and low intakes of sugar, red meat and processed foods.[2, 3] Women, older people, those with normal body mass index (BMI) and higher socioeconomic status (SES) are more likely to follow healthy diets.[4, 5] Among the factors influencing healthy eating, evidence points to food price (e.g., healthy foods are too expensive)[6-8], food taste (e.g., healthy foods lack taste)[6, 8, 9], time constraints (e.g., lack of time to prepare/cook healthy foods)[6, 7, 10], and lack of willpower6 - all self-perceived barriers that people identify as impediments to achieve and maintain healthy eating. Hence, despite widespread dietary guidelines and improved nutrition knowledge in the population[11], people face many barriers preventing them from healthy eating.

The Swiss population enjoys a high quality of life, low unemployment and poverty, universal healthcare, and one of the longest life expectancies worldwide.[12] Compared with bordering France or Germany, Switzerland has low cardiovascular disease risk factors and mortality.[13] However, compliance to the Swiss dietary guidelines remains low in the population[14], showing no improvements over time.[15] A previous nationwide study showed that barriers to healthy eating are highly prevalent (³20%) and demographically and socioeconomically patterned in the Swiss population.[16] Still, whether barriers to healthy eating remain constant or evolve over time has never been assessed; such analysis is important given the persistently low compliance to the dietary guidelines, particularly against a backdrop of increasing educational and income levels in the Swiss population. Thus, we used data from the national Swiss Health Surveys (SHS) conducted between 1997 and 2012 to assess the trends in prevalence of barriers to healthy eating in the adult population according to different demographic and socioeconomic indicators.

METHODS

Database and sampling

Data from four consecutive SHS conducted between 1997 and 2012 were used. The SHS is a cross-sectional, nationwide, population-based study conducted every five years by the Swiss Federal Statistical Office. The SHS do not require consent from an Ethics Committee as they are part of the Swiss Federal Government mandate, and the data were anonymized before use.

Selection of participants was based on a stratified random sampling applied to a database of all private Swiss households with a registered landline or portable telephone (>90% of households between 1997 and 2012), which was further expanded by the use of the official population registries available at each Swiss village/city. The first stratum consisted of the seven administrative regions of Switzerland (Leman, Mittelland, Northwest, Zurich, Northeast, Central and South), and the second stratum consisted of the 26 Swiss cantons (equivalent to American states). The primary sampling unit was the household, and the secondary sampling unit was the individual aged ^{3}15 years. For each sampled subject, an invitation letter to participate in the survey was sent, and phone contacts were made if no response to the letter was obtained. Participants were interviewed by phone using computer-assisted telephone interview software, and those aged ≥75 years could opt for a face-to-face interview at home (to accommodate participants with disabilities that may interfere with a phone interview; <5% of total participants chose this between 1997 and 2012). Subsequently, all participants were invited to fill out an additional written questionnaire sent by mail. The interviews were conducted in German, French or Italian—individuals unable to speak any were excluded, as were those with asylum-seeker status or with very poor health. Participation rate was 85% in 1997, 64% in 2002, 66% in 2007, and 53% in 2012. SHS details (in French and German) are available at:

http://www.bfs.admin.ch/bfs/portal/fr/index/infothek/erhebungen__quellen/blank/blank/ess/04.html.

Barriers to healthy eating

Barriers to healthy eating were assessed by the question "Many people, maybe including yourself, place importance in following a healthy diet. Please identify which of the following obstacles prevent you from having a healthy diet" which had 10 different possible items, the responder ticking "yes" or "no" to each of them. The different versions of the items are provided in **supplemental table 2.2.1** and can be summarized as follows: 1) "time"; 2) "limited options in markets"; 3) "limited options in restaurants"; 4) "price"; 5) "no social support"; 6) "social group opposition"; 7) "taste"; 8) "fondness of abundant food"; 9) "daily habits" and 10) "lack of willpower". The questions assessing barriers were set by a multidisciplinary group of experts, but no reference to any previously validated instrument could be found. However, the barriers assessed are similar to those used in other studies[6, 8, 9, 17, 18], none of which had been validated either. Hence, in the absence of a standard, validated instrument, the current questionnaire was the only option for the Swiss population.

Demographic and socioeconomic variables

Data were self-reported. Age was categorized into four groups (18-35, 36-50, 51-65, and >65) for the descriptive and multivariable analyses; for the age-period-cohort analysis, age was categorized into 12 five-year groups (from 18-22 to 73-77). Weight and height were collected and the resulting BMI was categorized as normal or underweight (BMI<25 kg/m^2), overweight (25≤BMI<30 kg/m^2), and obese (BMI≥30 kg/m^2). Smoking status was categorized as current smoker (yes/no); nationality as Swiss/non-Swiss, and living area as urban/rural. Civil status was categorized as married, single, divorced/separated, and widowed. Education was categorized as mandatory (nine years of schooling), secondary, and tertiary. Income (net household income after taxes) was categorized into tertiles for each SHS sample: 1997 (lower: <2778 CHF; middle: 2778-4000 CHF; higher: >4000 CHF); 2002 (lower: <3000 CHF; middle: 3000-4500 CHF; higher: >4500 CHF); 2007 (lower: <3044 CHF; middle: 3044-4667 CHF; higher: >4667 CHF); 2012 (lower: <3333 CHF; middle: 3333-4900 CHF; higher: >4900 CHF). Values expressed in Swiss francs (CHF). 1 CHF = 1.04 US$ or 0.92 €. Occupation was categorized as upper/middle management work, office/non-manual/small independent work, manual work, retired, unemployed, and other (student, homemaker).

Exclusion criteria

Subjects were excluded if they were aged less than 18 years old, if they lacked data for barriers to healthy eating or for the demographic and socioeconomic variables.

Statistical analysis

Statistical analyses were performed using Stata 14 (Stata Corp. College Station, TX, USA). To test for differences in demographic and socioeconomic characteristics of the sample across survey years, we conducted bivariate analyses using Chi-square test for categorical variables and student's t-test for continuous variables. To assess trends in prevalence of barriers to healthy eating, we conducted multivariable analyses using logistic regression adjusting for all demographic and socioeconomic indicators previously mentioned. Linear and quadratic trends were assessed using the contrast post-estimation command. Potential age-period-cohort effects were assessed using the median polish analysis.[19, 20] To reduce the likelihood of type I error due to the high number of tests performed, we considered statistical significance for two-sided tests at p<0.0001. We present the results only for barriers with prevalence ≥20%, which we arbitrarily set as the cutoff for high prevalence.

RESULTS

Sample selection and characteristics

Of the initial 73,067 participants, 52,238 (71.5%) were included in the analysis (17,966 participants were excluded because they lacked information on barriers to healthy eating; **Supplemental figure 2.3.1**). Excluded participants were more likely to be aged over 65, non-Swiss, and single, to have lower education and income, and slightly less likely to be overweight (**Supplemental table 2.3.2**). **Table 2.3.1** summarizes the demographic and socioeconomic characteristics of the included participants by gender and survey year. Between 1997 and 2012, the mean age and the proportion of participants who were overweight or obese and had tertiary education increased; among women, the proportion of participants with higher income also increased (**Table 2.3.1**).

Table 2.3.1. Characteristics of included participants by gender and survey year, Swiss Health Survey, 1997-2012.

	1997		2002		2007		2012		
	Women	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**	**p-value**
N (%)	5,798 (55.7)	4,595 (44.2)	7,656 (55.5)	6,139 (44.5)	7,098 (56.0)	5,573 (44.0)	8,109 (52.7)	7,270 (47.3)	
Age (mean, SD)	46.6 (17.1)	46.9 (17.4)	49.3 (16.3)	49.3 (16.7)	50.3 (17.0)	50.3 (17.2)	48.3 (17.1)	48.8 (17.4)	<0.001
Age groups (n, %)									<0.001
18-35	1,907 (32.9)	1,666 (36.3)	1,864 (24.4)	1,524 (24.8)	1,579 (22.3)	1,183 (21.2)	2,045 (25.2)	1,800 (24.8)	
36-50	1,540 (26.6)	1,313 (28.6)	2,238 (29.2)	2,018 (32.9)	2,114 (29.8)	1,802 (32.3)	2,458 (30.3)	2,189 (30.1)	
51-65	1,285 (22.2)	965 (21.0)	2,045 (26.7)	1,533 (25.0)	1,822 (25.7)	1,497 (26.9)	2,006 (24.7)	1,856 (25.5)	
Above 65	1,066 (18.4)	651 (14.2)	1,509 (19.7)	1,064 (17.3)	1,583 (22.3)	1,091 (19.6)	1,600 (19.7)	1,425 (19.6)	
Body mass index									<0.001
<25 kg/m^2	4,178 (72.1)	2,664 (58.0)	5,322 (69.5)	3,157 (51.4)	4,897 (69.0)	2,801 (50.3)	5,471 (67.5)	3,396 (46.7)	
25–29.9 kg/m^2	1,218 (21.0)	1,637 (35.6)	1,743 (22.8)	2,424 (39.5)	1,601 (22.6)	2,269 (40.7)	1,869 (23.1)	3,024 (41.6)	
≥ 30 kg/m^2	402 (6.9)	294 (6.4)	591 (7.7)	558 (9.1)	600 (8.5)	503 (9.0)	769 (9.5)	850 (11.7)	
Smoker	1,639 (28.3)	1,757 (38.2)	2,028 (26.5)	2,129 (34.7)	1,671 (23.5)	1,701 (30.5)	1,969 (24.3)	2,195 (30.2)	<0.001
Civil status									<0.001
Single	1,440 (24.8)	1,388 (30.2)	1,742 (22.8)	1,608 (26.2)	1,717 (24.1)	1,468 (26.3)	2,079 (25.6)	2,132 (29.3)	
Married	2,982 (51.4)	2,687 (58.5)	4,054 (53.0)	3,743 (61.0)	3,539 (49.9)	3,240 (58.1)	4,425 (54.6)	4,402 (60.6)	
Divorced/separated	623 (10.8)	350 (7.6)	924 (12.0)	558 (9.1)	922 (13.0)	618 (11.1)	966 (11.9)	559 (7.7)	
Widowed	753 (13.0)	170 (3.7)	936 (12.2)	230 (3.7)	920 (13.0)	247 (4.5)	639 (7.9)	177 (2.4)	
Swiss national	5,041 (86.9)	3,925 (85.4)	6,933 (90.6)	5,451 (88.8)	6,451 (90.9)	4,906 (88.0)	7,025 (86.6)	6,035 (83.0)	<0.001
Urban area	4,028 (69.5)	3,076 (66.9)	5,593 (73.1)	4,390 (71.5)	4,944 (69.7)	3,764 (67.5)	5,817 (71.7)	5,185 (71.3)	<0.01
Education									<0.001
Mandatory	1,426 (24.6)	599 (13.0)	1,591 (20.8)	627 (10.2)	1,001 (14.1)	366 (6.6)	1,115 (13.8)	761 (10.5)	
Secondary	3,804 (65.6)	2,670 (58.1)	5,233 (68.4)	3,821 (62.3)	4,171 (58.8)	2,936 (52.7)	4,013 (49.6)	3,163 (43.6)	
Tertiary	568 (9.8)	1,326 (28.9)	829 (10.8)	1,687 (27.5)	1,926 (27.1)	2,271 (40.8)	2,964 (36.6)	3,338 (46.0)	
Income									<0.01
Lower	2,017 (37.6)	1,182 (26.8)	2,737 (37.9)	1,702 (28.6)	2,294 (33.6)	1,394 (25.6)	2,624 (34.0)	1,991 (28.1)	
Middle	1,854 (34.5)	1,396 (31.6)	2,427 (33.6)	1,911 (32.1)	2,487 (36.4)	1,768 (32.5)	2,677 (34.7)	2,298 (32.4)	
Higher	1,498 (27.9)	1,839 (41.6)	2,053 (28.5)	2,343 (39.3)	2,053 (30.0)	2,285 (42.0)	2,419 (31.3)	2,800 (39.5)	

Results are expressed as mean (SD) or as number of participants and (%). Comparison using chi-square or ANOVA. 2 P-value for overall difference across survey years. Mandatory education is nine years. Income: 1997 (lower: <2778 CHF; middle: 2778-4000 CHF; higher: >4000 CHF); 2002 (lower: <3000 CHF; middle: 3000-4500 CHF; higher: >4500 CHF); 2007 (lower: <3044 CHF; middle: 3044-4667 CHF; higher: >4667 CHF); 2012 (lower: <3333 CHF; middle: 3333-4900 CHF; higher: >4900 CHF). Values expressed in Swiss francs (CHF). 1 CHF = 1.04 US$ or 0.92 €

Overall trends

Between 1997 and 2012, participants consistently identified "taste", "price", "daily habits", "time", "lack of willpower", and "limited options" as the most frequent barriers to healthy eating (**Figure 2.3.1**; for the remaining four barriers, see **supplemental figure 2.3.2**). Five of the most frequent barriers increased in prevalence between 1997 and 2007 and decreased afterwards; conversely, "lack of willpower" decreased steadily over time (**Figure 2.3.1**).

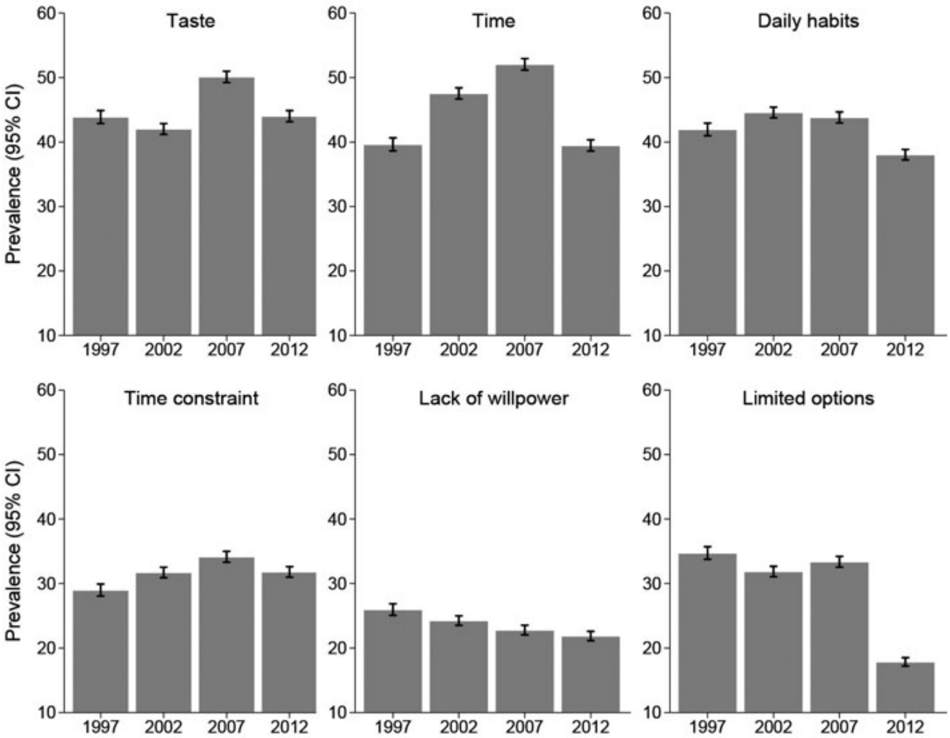

Figure 2.3.1. Overall adjusted prevalence of self-reported barriers to healthy eating by survey year, Swiss Health Survey 1997-2012. Only six most prevalent (≥20%) barriers shown; for remaining four barriers, see **supplemental Figure 2.2.2**. N per year: 1997 (10,393), 2002 (13,795), 2007 (12,671), 2012 (15,379).

Trends by gender and age

Figure 2.3.2 shows the trends in prevalence of self-reported barriers to healthy eating by gender and age groups. Although the prevalences differed between men and women, their trends evolved similarly. Between 1997 and 2007, the prevalences of "price", "daily habits", and "time" increased, but decreased afterwards—markedly so for "price". Differently, "lack of willpower" steadily decreased across the 15-year period (**Figure 2.3.2**). In 2012, men and women were less likely to report "daily habits", "lack of willpower", and "limited options" as barriers, but more likely to report "time", than they were in 1997. Unlike men, in 2012 women were also more likely to report "taste" as a barrier than in 1997 (**Table 2.3.2**; see **supplemental table 2.3.3** for prevalence values).

The prevalences and trends for most barriers to healthy eating tended to differ across age groups—except that of "price", which increased in all ages between 1997 and 2007, but decreased afterwards. Over 15 years, the prevalence of "time" increased in the two younger age groups, remained stable in the 51-65 age group, and decreased in the oldest age group; the prevalence of "daily habits" increased slightly between 1997 and 2002, but decreased afterwards for the three younger age groups; the prevalences of "lack of willpower" and "limited options" decreased for the three younger age groups (**Figure 2.3.2**). As shown in **Table 2.3.2,** in 2012 only the youngest age group was more likely to report "price" as a barrier, and together with the 36-50 age group, more likely to report "time", than in 1997; all age groups were less likely to report "daily habits" (except oldest group), "lack of willpower" (except the youngest group), and "limited options" in 2012 than in 1997 (**Table 2.3.2**; see **Supplemental table 2.3.3** for prevalence values). The median polish analysis indicated no evidence of a birth cohort effect for any of the barriers to healthy eating (see **Supplemental table 2.3.4**).

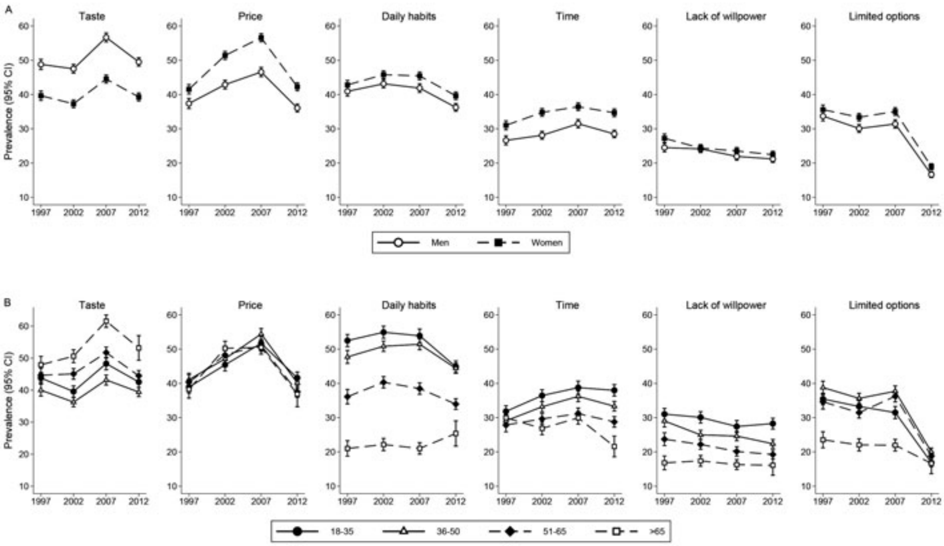

Figure 2.3.2. Adjusted prevalence of se lf-reported barriers to healthy eating in Switzerland, by gender and age, Swiss Health Surveys 1997-2012. Multivariable-adjusted prevalences and 95% confidence intervals obtained from logistic regression adjusting for age, body mass index, smoking, nationality, civil status, living area, education, income, and occupation. N per survey year 1997, 2002, 2007, 2012, respectively: men (4,595; 6,139; 5,573; 7,270), women (5,798; 7,656; 7,098; 8,109); age groups: 18-35 (3,573; 3,388; 2,762; 3,845), 36-50 (2,853; 4,256; 3,916; 4,647), 51-65 (2,250; 3,578; 3,319; 3,862), >65 (1,717; 2,573; 2,674; 3,025).

Table 2.3.2. Multivariable analysis (OR, 95% CI) of trends in prevalence of barriers to healthy eating, stratified by gender and age groups, Swiss Health Survey, 1997-2012

	Taste	**Price**	**Daily habits**	**Time**	**Lack of willpower**	**Limited options**
Men						
1997	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2002	0.95 (0.87, 1.03)	1.27 (1.17, 1.38)	1.11 (1.01, 1.21)	1.09 (1.01, 1.19)	0.97 (0.89, 1.07)	0.82 (0.76, 0.90)
2007	1.37 (1.26, 1.49)	1.50 (1.38, 1.63)	1.04 (0.95, 1.13)	1.30 (1.19, 1.42)	0.85 (0.78, 0.94)	0.88 (0.80, 0.96)
2012	1.02 (0.94, 1.11)	0.96 (0.88, 1.05)	0.80 (0.74, 0.88)	1.12 (1.02, 1.23)	0.81 (0.74, 0.89)	0.38 (0.34, 0.41)
p-value [1]	0.001	0.70	<0.0001	0.0005	<0.0001	<0.0001
p-value [2]	<0.0001	<0.0001	<0.0001	0.0002	0.73	<0.0001
Women						
1997	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2002	0.91 (0.84, 0.98)	1.49 (1.38, 1.60)	1.15 (1.07, 1.25)	1.17 (1.08, 1.27)	0.87 (0.80, 0.94)	0.92 (0.85, 0.99)
2007	1.26 (1.16, 1.36)	1.82 (1.69, 1.96)	1.14 (1.05, 1.24)	1.24 (1.15, 1.34)	0.83 (0.76, 0.91)	0.99 (0.92, 1.08)
2012	1.01 (0.93, 1.10)	1.01 (0.93, 1.09)	0.88 (0.80, 0.95)	1.14 (1.05, 1.24)	0.79 (0.72, 0.87)	0.41 (0.38, 0.45)
p-value [1]	0.007	0.09	0.002	0.0008	<0.0001	<0.0001
p-value [2]	0.03	<0.0001	<0.0001	<0.0001	0.14	<0.0001
Age groups						
18-35						
1997	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2002	0.84 (0.76, 0.93)	1.33 (1.20, 1.47)	1.10 (1.01, 1.22)	1.24 (1.12, 1.37)	0.96 (0.86, 1.07)	0.90 (0.80, 0.99)
2007	1.19 (1.07, 1.32)	1.69 (1.52, 1.88)	1.05 (0.95, 1.17)	1.37 (1.23, 1.53)	0.85 (0.76, 0.95)	0.83 (0.74, 0.93)
2012	0.93 (0.84, 1.03)	1.10 (1.00, 1.22)	0.71 (0.64, 0.79)	1.32 (1.19, 1.47)	0.89 (0.79, 0.99)	0.35 (0.31, 0.39)
p-value [1]	0.45	0.003	<0.0001	<0.0001	0.009	<0.0001
p-value [2]	0.37	<0.0001	<0.0001	0.0008	0.27	<0.0001
36-50						
1997	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2002	1.11 (0.97, 1.27)	1.65 (1.44, 1.89)	1.07 (0.90, 1.27)	1.21 (1.11-1.35)	0.85 (0.76, 0.94)	0.91 (0.77, 1.07)
2007	1.75 (1.53, 2.00)	1.68 (1.47, 1.92)	1.01 (0.84, 1.18)	1.38 (1.24, 1.52)	0.82 (0.74, 0.92)	0.91 (0.77, 1.07)

Table 2.3.2. Continued.

	Taste	**Price**	**Daily habits**	**Time**	**Lack of willpower**	**Limited options**
2012	1.22 (0.99, 1.49)	0.95 (0.77, 1.17)	0.85 (0.77, 0.94)	1.19 (1.05, 1.38)	0.71 (0.63, 0.78)	0.62 (0.47, 0.81)
p-value [1]	0.07	0.17	0.03	<0.0001	<0.0001	<0.0001
p-value [2]	0.94	<0.0001	<0.0001	<0.0001	0.23	<0.0001
51-65						
1997	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2002	1.02 (0.91, 1.14)	1.40 (1.25, 1.57)	1.20 (1.07, 1.35)	1.09 (0.96, 1.23)	0.91 (0.80, 1.04)	0.87 (0.77, 0.98)
2007	1.35 (1.20, 1.52)	1.56 (1.39, 1.76)	1.10 (0.98, 1.24)	1.16 (1.02, 1.32)	0.79 (0.69, 0.91)	1.07 (0.95, 1.21)
2012	0.98 (0.87, 1.11)	0.89 (0.79, 0.99)	0.87 (0.78, 0.98)	1.02 (0.89, 1.16)	0.73 (0.63, 0.84)	0.45 (0.39, 0.52)
p-value [1]	0.22	0.21	0.08	0.56	<0.0001	<0.0001
p-value [2]	<0.0001	<0.0001	<0.0001	0.01	0.95	<0.0001
Above 65						
1997	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2002	0.86 (0.77, 0.95)	1.28 (1.16, 1.42)	1.14 (1.03, 1.25)	1.22 (1.09, 1.35)	0.81 (0.72, 0.90)	0.87 (0.79, 0.96)
2007	1.17 (1.05, 1.30)	1.75 (1.58, 1.93)	1.17 (1.05, 1.29)	1.38 (1.24, 1.54)	0.80 (0.71, 0.89)	0.96 (0.86, 1.06)
2012	1.00 (0.90, 1.11)	0.97 (0.88, 1.08)	0.88 (0.79, 0.97)	1.21 (1.09, 1.35)	0.71 (0.63, 0.79)	0.38 (0.34, 0.43)
p-value [1]	0.0001	0.64	0.21	0.003	0.38	0.0007
p-value [2]	<0.0001	<0.0001	0.39	0.03	0.53	0.03

Results are expressed as odds ratio and (95% confidence interval). Statistical analysis using logistic regression adjusted for age (when stratifying on gender), gender (when stratifying on age), body mass index group, smoking, nationality, area of living, civil status, education, income, and occupation. P-value for: 1 linear trend; 2 quadratic trend.

Trends by education and income

As shown in **Figure 2.3.3**, the trends in barriers to healthy eating evolved similarly across educational and income groups and mirrored the overall trends. In 2012, irrespective of education and income, all participants were less likely to report "limited options" as a barrier than in 1997 (**Table 2.3.3**). Participants in the higher two levels of education and income were also less likely to report "lack of willpower" but more likely to report "time" as barriers than in 1997; conversely, those with mandatory education were less likely to report "time" and "price". In 2012, participants in the highest income group were less likely to report "daily habits" than in 1997 (**Table 2.3.3**; see **supplemental table 2.3.5** for prevalence values).

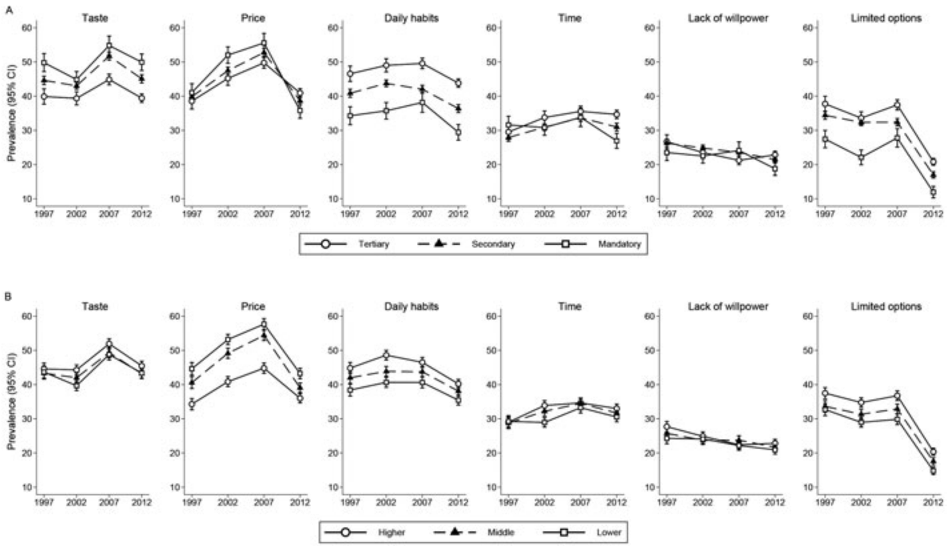

Figure 2.3. Adjusted prevalence of self-reported barriers to healthy eating in Switzerland, by education and income group, Swiss Health Surveys 1997-2012. Multivariable-adjusted prevalences and 95% confidence intervals obtained from logistic regression adjusting for gender, body mass index, smoking, nationality, civil status, living area, education, income, and occupation. Income: 1997 (lower: <2778 CHF; middle: 2778, 4000 CHF; higher: >4000 CHF), 2002 (lower: <3000 CHF; middle: 3000, 4500 CHF; higher: >4500 CHF), 2007 (lower: <3044 CHF; middle: 3044, 4667 CHF; higher: >4667 CHF), 2012 (lower: <3333 CHF; middle: 3333, 4900 CHF; higher: >4900 CHF). Values expressed in Swiss francs (CHF). 1 CHF = 1.04 US$ or 0.92 €. N per survey year 1997, 2002, 2007, 2012, respectively: education, mandatory (2,025; 2,218; 1,367; 1,876), secondary (6,474; 9,054; 7,107; 7,176), tertiary (1,894; 2,516; 4,197; 6,302); income, lower (3,199; 4,439; 3,688; 4,615), middle (3,250; 4,338; 4,255; 4,795), higher (3,337; 4,396; 4,338; 4,219).

Table 2.3.3. Multivariable analysis (OR, 95% CI) of trends in the prevalence of barriers to healthy eating, stratified by educational and income level, Swiss Health Survey 1997-2012.

	Taste	Price	Daily habits	Time	Lack of willpower	Limited options
Education						
Mandatory						
1997	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2002	0.83 (0.72, 0.96)	1.57 (1.36, 1.82)	1.07 (0.91, 1.27)	0.95 (0.81, 1.11)	0.93 (0.77, 1.11)	0.75 (0.62, 0.89)
2007	1.26 (1.08, 1.47)	1.85 (1.58, 2.17)	1.20 (1.00, 1.44)	1.09 (0.92, 1.30)	1.03 (0.85, 1.26)	1.06 (0.88, 1.29)
2012	1.02 (0.87, 1.21)	0.76 (0.64, 0.90)	0.76 (0.63, 0.92)	0.73 (0.6, 0.87)	0.66 (0.53, 0.81)	0.33 (0.26, 0.42)
p-value [1]	0.07	0.01	0.02	0.005	0.0006	<0.0001
p-value [2]	0.84	<0.0001	<0.0001	0.003	0.008	<0.0001
Secondary						
1997	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2002	0.93 (0.87, 1.00)	1.36 (1.27, 1.46)	1.14 (1.07, 1.22)	1.16 (1.08, 1.24)	0.93 (0.87, 1.01)	0.91 (0.85, 0.98)
2007	1.35 (1.25, 1.45)	1.69 (1.57, 1.81)	1.06 (0.99, 1.14)	1.31 (1.22, 1.42)	0.87 (0.81, 0.95)	0.91 (0.85, 0.98)
2012	1.02 (0.95, 1.11)	0.96 (0.89, 1.04)	0.82 (0.76, 0.89)	1.15 (1.06, 1.25)	0.78 (0.71, 0.85)	0.39 (0.35, 0.43)
p-value [1]	0.0005	0.49	<0.0001	<0.0001	<0.0001	<0.0001
p-value [2]	<0.0001	<0.0001	<0.0001	<0.0001	0.37	<0.0001
Tertiary						
1997	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2002	0.97 (0.86, 1.11)	1.34 (1.18, 1.53)	1.10 (0.97, 1.25)	1.22 (1.07, 1.40)	0.83 (0.72, 0.95)	0.82 (0.73, 0.94)
2007	1.26 (1.12, 1.42)	1.60 (1.42, 1.80)	1.13 (1.01, 1.27)	1.30 (1.15, 1.47)	0.73 (0.64, 0.83)	0.97 (0.87, 1.09)
2012	1.00 (0.89, 1.12)	1.09 (0.97, 1.22)	0.89 (0.80, 1.00)	1.26 (1.12, 1.42)	0.81 (0.72, 0.92)	0.42 (0.37, 0.47)
p-value [1]	0.17	0.02	0.07	<0.0001	0.0002	<0.0001
p-value [2]	0.009	<0.0001	<0.0001	0.004	0.0008	<0.0001
Income						
Lower						
1997	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2002	0.84 (0.76, 0.92)	1.40 (1.28, 1.54)	1.12 (1.01, 1.24)	0.98 (0.88, 1.09)	0.99 (0.89, 1.11)	0.84 (0.76, 0.94)
2007	1.24 (1.12, 1.37)	1.68 (1.52, 1.86)	1.12 (1.00, 1.24)	1.19 (1.07, 1.32)	0.89 (0.79, 0.99)	0.88 (0.78, 0.98)
2012	1.01 (0.91, 1.13)	0.90 (0.81, 1.01)	0.90 (0.80, 1.00)	1.04 (0.93, 1.17)	0.83 (0.73, 0.94)	0.35 (0.29, 0.39)
p-value [1]	0.01	0.49	0.07	0.08	0.0007	<0.0001

2.3

Table 2.3.3. Continued.

	Taste	Price	Daily habits	Time	Lack of willpower	Limited options
p-value [2]	0.79	<0.0001	<0.0001	0.15	0.48	<0.0001
Middle						
1997	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2002	0.95 (0.86, 1.05)	1.41 (1.28, 1.55)	1.10 (1.01, 1.21)	1.17 (1.05, 1.29)	0.89 (0.81, 0.98)	0.89 (0.81, 0.99)
2007	1.30 (1.18, 1.43)	1.75 (1.59, 1.93)	1.10 (0.99, 1.21)	1.30 (1.18, 1.44)	0.89 (0.80, 0.99)	0.96 (0.87, 1.06)
2012	1.00 (0.90, 1.11)	0.94 (0.85, 1.04)	0.85 (0.76, 0.94)	1.12 (1.01, 1.24)	0.79 (0.70, 0.88)	0.41 (0.36, 0.46)
p-value [1]	0.06	0.91	0.003	0.01	<0.0001	<0.0001
p-value [2]	0.002	<0.0001	<0.0001	<0.0001	0.72	<0.0001
Higher						
1997	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2002	1.00 (0.91, 1.10)	1.36 (1.23, 1.49)	1.15 (1.05, 1.27)	1.28 (1.16, 1.41)	0.85 (0.77, 0.94)	0.89 (0.81, 0.97)
2007	1.38 (1.25, 1.52)	1.61 (1.46, 1.77)	1.05 (0.95, 1.15)	1.33 (1.21, 1.47)	0.74 (0.67, 0.83)	0.97 (0.88, 1.07)
2012	1.03 (0.93, 1.13)	1.12 (1.01, 1.24)	0.79 (0.71, 0.86)	1.25 (1.13, 1.38)	0.76 (0.69, 0.85)	0.42 (0.38, 0.46)
p-value [1]	0.01	0.001	<0.0001	<0.0001	<0.0001	<0.0001
p-value 2	<0.0001	<0.0001	<0.0001	<0.0001	0.01	<0.0001

Results are expressed as odds ratio (95% confidence interval). Statistical analysis using logistic regression adjusted for age, body mass index, smoking, nationality, area of living, civil status, occupation, education (when stratifying on income), and income (when stratifying on education). P-value for: 1 linear trend; 2 quadratic trend. Income: 1997 (lower: <2778 CHF; middle: 2778-4000 CHF; higher: >4000 CHF); 2002 (lower: <3000 CHF; middle: 3000-4500 CHF; higher: >4500 CHF); 2007 (lower: <3044 CHF; middle: 3044-4667 CHF; higher: >4667 CHF); 2012 (lower: <3333 CHF; middle: 3333-4900 CHF; higher: >4900 CHF). Values expressed in Swiss francs (CHF). 1 CHF = 1.04 US$ or 0.92 €.

DISCUSSION

To our knowledge, this is the first study to examine trends in prevalence of self-reported barriers to healthy eating in a population. Our results show that, over a 15-year period, several barriers remained highly prevalent in the Swiss population, and their trends evolved similarly irrespective of gender, age, education or income.

Overall trends

Between 1997 and 2012, "price" and "taste" remained the two most prevalent barriers to healthy eating. The prevalence of "taste" in 1997 (44%) was higher than in the pan-European survey (31%)[6], and it remained high (48.4%) in 2012. This finding agrees with previous studies showing that taste is one of the most important factors influencing eating behaviour, particularly among men[6, 9, 17]. This barrier persisted over time and increased among women, which may be influenced by the aggressive marketing of fast foods and misleading opinions that healthy eating lacks flavour and enjoyment, exacerbated by the decreasing rate of cooking knowledge and skills in the population.[21, 22]

The prevalence of "price" in 1997 (40%) was much higher than those reported the same year in bordering France (19%), Austria (19%), Germany (9%) and Italy (7%).[6] The increase in prevalence of this barrier between 1997 and 2007 and its subsequent decrease closely resembles the trend in the Swiss consumer price index for the healthier food groups (fresh fruits, vegetables, and fish), but, importantly, not those of less healthy food groups (see **Supplemental figure 2.3.2**). This indicates that the perception of price as a barrier in the population indeed reflects the changing prices of healthy foods.

The prevalences of "daily habits" and "lack of willpower" tended to decrease over time, also for all sociodemographic groups. In 1997, the overall prevalence of "lack of willpower" in Switzerland (26%) resembled those found in bordering countries.[6] The overall decrease in these barriers may indicate increasing awareness of the important role of healthy eating as part of a healthy lifestyle, particularly for long-term chronic disease prevention, as has been observed in other European countries.[23] Another factor may be the growing view of healthy eating as a socially desirable lifestyle practice.[24] These factors may have contributed to increasing willpower to achieve and maintain healthy eating behaviours in an increasingly obesogenic environment.

Conversely, the prevalence of "lack of time" (for food shopping and preparation) increased slightly over time; in 1997, its prevalence (29%) was higher than in bordering Germany (12%) and France (23%), but lower than in Austria (31%) and Italy (36%).[6] The upward trend observed in Switzerland is in line with the increasingly widespread feeling of time scarcity reported in the United States[10, 25], and among younger adults in bordering Italy[26] and France[27], due to people devoting more time to work and leisure, but less time to preparing foods. Among women, the upward trend is likely due to their increased participation in the labour market in the last decades.[28]

The prevalence of "limited options" (in restaurants and cafeterias) as a barrier nearly halved between 1997 and 2012 across all sociodemographic groups. This is likely due to diversification in menus and an increase in the number of foods/meals offered in restaurants and cafeterias in Switzerland, in turn likely driven by globalization and increasing consumer demand for healthier options.[29] However, as reported trends in the USA have indicated, diversification of menu offerings does not necessarily translate to more healthy options.[30, 31] Thus, as the share of the population consuming out-of-home meals continues to increase[32], it is important that diversification and greater offerings in restaurant and cafeteria menus actually introduce more healthy options to customers.

Trends by socio-demographic group

Trends were similar for all barriers irrespective of gender, age, education, and income. Nevertheless, given the persistent inequalities in prevalence of several barriers across demographic and socioeconomic groups, interventions should not only target the whole population, but also selectively target population subgroups that are most vulnerable to face specific barriers to healthy eating. No birth cohort effect was detected. However, the study covered a relatively short period of time (15 years), so future studies should assess the existence of birth cohort effects over longer periods.

Consequences for public health nutrition

Our results showed that barriers to healthy eating evolve dynamically across all sociodemographic groups. This finding indicates that regular monitoring of the prevalence of these barriers is needed and that nutrition interventions should adapt accordingly. Additionally, the prevalence of certain barriers such as price constraint closely respond to food and market price fluctuations, which suggests that price changes have a high impact on self-perceived barriers to healthy eating and thus on eating behaviour. This is important, as most population-level interventions to improve healthy eating to date have focused on nutrition knowledge.[33-35]

To tackle "taste" as a barrier to healthy eating, the food industry should advertise and promote ready-to-eat and easy-to-prepare foods that are healthy and flavorful.[36, 37] To tackle the barrier of "price" - particularly as it disproportionally affects people of lower SES in Switzerland[16] and elsewhere[8, 9, 18] - food policy should subsidize healthy foods or tax unhealthy foods to reduce the price differential between healthy and unhealthy foods, empowering people to choose healthy foods instead.[34, 35] To tackle "time" as a barrier, measures should be implemented to introduce flexible work schedules, to expand childcare, maternity and paternity benefits, and to promote healthy eating behaviours at the workplace.

Strengths and limitations

Our analysis benefits from four large representative samples and provides the first trend analysis of prevalence of barriers to healthy eating in a population. The large sample sizes allowed conducting stratified analyses with adequate statistical power. Several limitations must be acknowledged. First, participants' understanding of "healthy eating" was not assessed, but a study in a Swiss city found that participants had a high level of general nutrition and health knowledge[38], which may indicate adequate understanding of "healthy eating" in the population. Second, participation rates decreased between 1997 (85%) and 2012 (53%), mirroring general decreasing trends found elsewhere.[39] Still, they remained in the upper range of participation rates of national surveys conducted in Europe in the same period.[39] Third, 29% of participants were excluded, and they were more likely to be of lower SES, which is associated with higher prevalence of barriers to healthy eating.[16] Thus, our estimates might be conservative and the true prevalence of the barriers might be even higher. Fourth, the questionnaire on barriers was not formally validated, which was also the case for the questionnaire used in the pan-European survey.[6] Importantly, the barriers assessed in this study were similar to those in the pan-European survey and in other similar studies[6, 8, 9, 17, 18], thus allowing comparisons between surveys. Finally, the lack of a birth cohort effect might be due to the relatively short time period considered (15 years) and to subtle differences that may be undetectable by the median polish analysis.

Conclusion

Between 1997 and 2012, barriers to healthy eating remained highly prevalent (≥20%) in the Swiss population and evolved similarly irrespective of age, gender, education and income.

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SUPPLEMENTAL MATERIAL

Supplemental material for this chapter can be found online
https://academic.oup.com/ajcn/article/105/3/660/4633952#supplementary-data

CHAPTER 2.4

Trends in vitamin, mineral and dietary supplement use in Switzerland: the CoLaus study

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2.4

ABSTRACT

Background: vitamin/mineral (VMS) and dietary supplements (DS) use is common in Switzerland, but nothing is known regarding the factors associated with their initiation, discontinuation or continuation of intake.

Methods: prospective study conducted between 2003-6 and 2009-12 in Lausanne, Switzerland among 4676 participants (2525 women, age range 35-75 years). VMS were defined as single or multivitamin/multimineral preparations; DS were defined as any dietary supplement.

Results: VMS use was 20.6% at baseline and 20.3% at follow-up (p=0.69): 559 (12.0%) participants discontinued; 545 (11.7%) initiated and 404 (8.6%) continued VMS use. On multivariable analysis, men had a lower relative risk ratio (RRR) of discontinuing, initiation or continuing; older age and being physically active were associated with a higher RRR of initiation or continuing; lower education and higher body mass index were associated with a lower RRR of discontinuing or continuing of VMS.

DS use decreased from 10.4% to 6.8% (p<0.001): 405 (8.7%) participants discontinued; 239 (5.1%) initiated and 81 (1.7%) continued DS use. On multivariable analysis, men had a lower RRR of discontinuing, initiation or continuing; older age had a higher RRR of initiation, discontinuing or continuing; being physically active was associated with a higher RRR of initiation or continuing; Swiss citizens and former smokers had a higher RRR of discontinuing.

Conclusion: VMS use is stable in the Lausanne population, while DS use appears to be decreasing. Individuals can be categorized either as users or non-users depending on the study period, and consistent users are only a small fraction of prevalent users.

INTRODUCTION

Vitamin and mineral supplements (VMS) are taken by a significant fraction of the general population[1-5], although their health benefits are questionable.[6-8] If some VMS might be of interest (i.e. iron for anaemia and calcium/vitamin D for osteoporosis), several studies suggested that VMS either have no effect[9] or even increase total mortality.[10] Still, despite recommendations against the use of specific vitamins to prevent disease[11], the prevalence of VMS use is increasing in Europe and the USA.[12-14] Interestingly, VMS and dietary supplements (DS) use appears to be a fairly unstable behaviour in the general population, with high rates of initiation or discontinuing.[15] Several socio-demographic characteristics such as female gender, older age and lower body mass index have been shown to be associated with consistent VMS use[15], but the number of studies that assessed trends and determinants of VMS and DS use are relatively scarce[15, 16].

In a previous study, we showed that a sizable fraction of the Lausanne population consumed VMS or DS.[17] We now assessed trends in VMS and DS use and the factors associated with initiation, discontinuing and persistence of in VMS and DS use in the population of Lausanne, Switzerland.

MATERIALS AND METHODS

Sampling

The CoLaus Study is a prospective study aiming to assess the prevalence of cardiovascular risk factors and to identify new molecular determinants of these risk factors in the population of the city of Lausanne, Switzerland. The sampling procedure of the CoLaus Study has been described previously.[18] In summary, a simple, non-stratified random sample of the overall population of Lausanne was drawn. The following inclusion criteria were applied: (a) written informed consent and (b) willingness to take part in the examination and to provide blood samples. Recruitment began in June 2003 and ended in May 2006 and included 6184 Caucasian participants. The evaluation included an interview, a physical exam, blood sampling and a set of questionnaires. The follow-up was performed between April 2009 and September 2012, five and a half years on average after the collection of baseline data and was similar to the baseline evaluation.

Vitamin/mineral and dietary supplements

Vitamin/mineral supplements were defined as previously.[17] VMS and DS, including omega-3 supplements, were identified. Specific combinations of calcium and vitamin D were also identified.

For each group (VMS and DS) users were categorized as never (absent at baseline and follow-up), initiators (absent at baseline but present at follow-up), discontinuers (present at baseline but absent at follow-up) and continuers (present at baseline and follow-up) as performed in other studies conducted in antihypertensive drug treatment[19, 20]. In the prospective survey, drugs prescribed by a doctor were differentiated from those bought over-the-counter. As calcium + vitamin D supplements might be prescribed for osteoporosis prevention and iron ± vitamin B_{12} for anaemia, sensitivity analyses were carried excluding participants taking such combinations. Also for sensitivity analyses, participants were categorized as never, inconsistent (initiators or discontinuers) or consistent (continuers) users, as performed previously.[15]

Other data

Educational level was categorized into mandatory school, apprenticeship, high school and university. Marital status was categorized into single/divorced/widowed and married/cohabitating. Country of birth was categorized into Swiss-born and born in another country. Smoking status was defined as never, former and current. A participant was considered as physically active if he/she practiced at least twice per week leisure-time physical activities with a minimal duration of 20 minutes.

As presence of cardiovascular risk factors has been associated with initiation or maintenance of VMS[15], awareness of hypertension, dyslipidemia or diabetes was considered if the participant responded positively to the questions "did a doctor tell you that you were hypertensive / had high cholesterol levels / were diabetic?" respectively. No data was collected regarding other diseases such as arthrosis, cancer or osteoporosis.

Body weight and height were measured with participants standing without shoes in light indoor clothes. Body weight was measured in kilograms to the nearest 100 g using a Seca® scale, which was calibrated regularly. Height was measured to the nearest 5 mm using a Seca® height gauge. Overweight was defined as body mass index (BMI) ≥25 and <30 kg/m^2 and obesity as BMI≥30 kg/m^2. As the number of underweight (BMI<18.5 kg/m^2) participants was very small (N=83 or 1.8% of the total sample), they were included in a "normal + underweight" category.

Statistical analysis

Participants were excluded if (a) they did not participate in the follow-up survey and (b) they had any missing socio-demographic data. Statistical analyses were performed using Stata version 13.1 for windows (Stata Corp, College Station, TX, USA). Descriptive results were expressed as number of participants (percentage) or as mean±standard deviation. Bivariate analyses were performed using chi-square for categorical variables and Student's t-test or analysis of variance for continuous variables. For continuous variables, post-hoc pairwise comparisons using the method of Scheffe were performed when the results of the ANOVA were statistically significant. In agreement with a previous study[15], multivariable analysis was performed with multinomial logistic regression using never users as the reference; the results were expressed as relative risk ratio (RRR) and 95% confidence interval (CI). Multi-collinearity of the dependent variables was tested using the **collin** function of Stata; variance inflation factors between 1.01 and 1.20 were obtained, suggesting that multi-collinearity was not present. Tests were two-sided and statistical significance was assessed for $p<0.05$.

Ethics statement

The CoLaus study was approved by the Institutional Ethics Committee of the University of Lausanne. The study was conducted according to the Declaration of Helsinki and all participants provided written informed consent prior to participating.

RESULTS

Selection procedure and characteristics of participants

Of the initial 6184 participants at baseline, 1501 (24.3%) did not participate in the follow-up survey and 7 (0.1%) had missing socio-demographic data. The selection procedure is summarized in **Figure 2.4.1** and the comparison between included and excluded participants is summarized in **supplemental table 2.4.1.** Excluded participants were older, less frequently women, had a lower educational level, were less frequently born in Switzerland, were more frequently smokers, sedentary or obese and had a higher prevalence of self-reported hypertension and diabetes than included participants. Prevalence of VMS and DS use was also lower among excluded participants (**Supplemental table 2.4.1**).

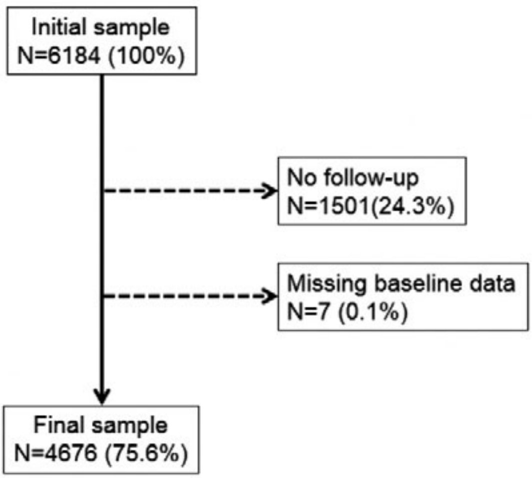

Figure 2.4.1: selection procedure.

Trends and determinants of vitamin/mineral supplement use

Prevalence of VMS use was 20.6% at baseline and 20.3% at follow-up (p=0.69). During the 5.5 year study period, 559 (12.0%) participants discontinued; 545 (11.7%) initiated and 404 (8.6%) continued VMS use, while 3168 (67.8%) did not use any VMS at baseline and follow-up.

The bivariate associations between socio-demographic and clinical factors and being never using, initiating, discontinuing or continuing VMS are summarized in **supplemental table 2.4.2**. Significant associations were found with gender, age, educational level, marital status, Swiss citizenship, physical activity and BMI categories. These associations were partly confirmed by multivariate analysis, the results of which are summarized in **table 2.4.1**. Men had a lower RRR of discontinuing, initiating or continuing VMS use. Older age and being physically active were associated with a higher RRR of initiating and continuing VMS use. Having a lower education or a higher BMI was associated with a lower RRR of discontinuing and continuing VMS use. Finally, presence of reported dyslipidemia was associated with a higher RRR of continuing VMS use (**table 2.4.1**). Similar findings were obtained when the analysis was split by gender (not shown).

Table 2.4.1: Multivariable associations between socio-demographic and clinical variables with changes in vitamin supplement use occurring between 2003–2006 and 2009–2012, CoLaus study, Lausanne, Switzerland, all participants.

	Initiators	**Discontinuers**	**Maintainers**
Gender (man vs. woman)	0.37 (0.30 - 0.46) ***	0.38 (0.31 - 0.47) ***	0.22 (0.17 - 0.29) ***
Age groups			
[35-45[	1 (ref.)	1 (ref.)	1 (ref.)
[45-55[	1.80 (1.38 - 2.36) ***	1.04 (0.82 - 1.31)	2.09 (1.44 - 3.04) ***
[55-65[	2.25 (1.71 - 2.96) ***	0.99 (0.77 - 1.28)	4.56 (3.19 - 6.50) ***
[65+	2.36 (1.70 - 3.28) ***	1.10 (0.80 - 1.53)	6.35 (4.28 - 9.44) ***
Education			
University	1 (ref.)	1 (ref.)	1 (ref.)
High school	0.99 (0.75 - 1.31)	0.77 (0.59 - 1.01)	1.03 (0.75 - 1.42)
Apprenticeship	0.81 (0.62 - 1.06)	0.78 (0.60 - 1.00) *	0.66 (0.48 - 0.91) **
Basic	0.85 (0.61 - 1.17)	0.57 (0.41 - 0.78) ***	0.52 (0.35 - 0.78) ***
Marital status (married/cohab vs. other)	0.81 (0.66 - 0.98) *	0.89 (0.73 - 1.08)	0.78 (0.62 - 0.98)
Nationality (Swiss vs. other)	1.16 (0.94 - 1.44)	1.04 (0.85 - 1.28)	1.23 (0.96 - 1.59)
Smoking			
Never	1 (ref.)	1 (ref.)	1 (ref.)
Former	1.05 (0.85 - 1.31)	1.21 (0.97 - 1.49)	1.29 (1.00 - 1.66)
Current	0.95 (0.75 - 1.21)	0.98 (0.78 - 1.25)	1.05 (0.79 - 1.41)
Physically active (yes vs. no)	1.30 (1.07 - 1.59) **	1.05 (0.87 - 1.28)	1.44 (1.13 - 1.82) **
BMI groups			
Normal	1 (ref.)	1 (ref.)	1 (ref.)
Overweight	0.82 (0.66 - 1.02)	0.83 (0.67 - 1.02)	0.68 (0.53 - 0.88) **
Obese	0.81 (0.60 - 1.10)	0.59 (0.42 - 0.82) **	0.65 (0.45 - 0.94) *
Hypertension (yes vs. no)	1.14 (0.91 - 1.44)	1.11 (0.87 - 1.41)	0.88 (0.67 - 1.15)
Dyslipidemia (yes vs. no)	0.89 (0.70 - 1.13)	1.08 (0.85 - 1.37)	1.34 (1.04 - 1.73) *
Diabetes (yes vs. no)	1.53 (0.99 - 2.37)	1.08 (0.65 - 1.81)	1.29 (0.75 - 2.21)

*Abbreviation: BMI, body mass index. Results are expressed as relative risk ratio and (95% confidence interval). Statistical analysis by multinomial logistic regression using never users as reference. *P<0.05; **P<0.01; ***P<0.001.*

Trends and determinants of dietary supplements use

Prevalence of DS use was 10.4% at baseline and decreased to 6.8% at follow-up (p<0.001). During the 5.5 year study period, 405 (8.7%) participants discontinued; 239 (5.1%) initiated and 81 (1.7%) continued DS use, while 3951 (84.5%) did not use any DS at baseline and follow-up.

The bivariate associations between socio-demographic and clinical factors and being never using, initiating, discontinuing or continuing DS are summarized in supplemental table 3. Significant associations were found with gender, age, marital status, Swiss citizenship, smoking status, physical activity and BMI categories. These associations were partly confirmed by multivariate analysis, the results of which are summarized in **table 2.4.2**. Men had a lower RRR of discontinuing, initiating or continuing DS use. Older age was associated with a higher RRR of initiating, discontinuing and continuing DS use. Being physically active was associated with a higher RRR of initiating and continuing DS use. Swiss citizenship and being former smoker was associated with a higher RRR of discontinuing DS use (**Table 2.4.2**). Similar findings were obtained when the analysis was split by gender (not shown).

Table 2.4.2: multivariable associations between socio-demographic and clinical variables with changes in dietary supplement use occurring between 2003-6 and 2009-12, CoLaus study, Lausanne, Switzerland, all participants.

	Initiators	**Discontinuers**	**Continuers**
N	239	405	81
Gender (man vs. woman)	0.41 (0.30 - 0.56) ***	0.30 (0.23 - 0.39) ***	0.30 (0.17 - 0.53) *
Age groups			
[35-45[	1 (ref.)	1 (ref.)	1 (ref.)
[45-55[	1.38 (0.95 - 1.99)	1.47 (1.09 - 1.97) **	2.42 (1.10 - 5.35) *
[55-65[	1.76 (1.22 - 2.55) **	1.77 (1.31 - 2.39) ***	4.53 (2.13 - 9.65) ***
[65+	1.14 (0.70 - 1.87)	1.57 (1.09 - 2.27) *	3.14 (1.29 - 7.62) **
Education			
University	1 (ref.)	1 (ref.)	1 (ref.)
High school	1.02 (0.70 - 1.49)	0.99 (0.73 - 1.35)	1.04 (0.53 - 2.03)
Apprenticeship	0.76 (0.52 - 1.10)	0.79 (0.59 - 1.07)	0.88 (0.46 - 1.68)
Mandatory	0.73 (0.45 - 1.18)	0.77 (0.53 - 1.11)	0.82 (0.36 - 1.84)
Marital status (married/cohab vs. other)	0.75 (0.57 - 0.99) *	1.07 (0.85 - 1.33)	0.81 (0.51 - 1.29)
Born in Switzerland vs. other country	1.37 (1.00 - 1.87) §	1.30 (1.02 - 1.66) *	1.23 (0.73 - 2.08)
Smoking			
Never	1 (ref.)	1 (ref.)	1 (ref.)
Former	1.22 (0.91 - 1.65)	1.31 (1.03 - 1.66) *	1.34 (0.81 - 2.21)
Current	0.75 (0.52 - 1.08)	0.92 (0.69 - 1.21)	0.88 (0.48 - 1.64)
Physically active (yes vs. no)	1.66 (1.23 - 2.24) ***	1.33 (1.06 - 1.66) *	1.84 (1.09 - 3.09) *
BMI groups			
Normal + underweight	1 (ref.)	1 (ref.)	1 (ref.)
Overweight	0.71 (0.52 - 0.98) *	1.00 (0.79 - 1.28)	0.75 (0.45 - 1.27)
Obese	0.82 (0.52 - 1.30)	0.80 (0.55 - 1.16)	0.65 (0.29 - 1.46)
Hypertension (yes vs. no)	0.77 (0.53 - 1.11)	0.91 (0.70 - 1.20)	0.96 (0.55 - 1.67)
Dyslipidemia (yes vs. no)	0.96 (0.68 - 1.35)	1.02 (0.79 - 1.33)	1.24 (0.73 - 2.10)
Diabetes (yes vs. no)	1.38 (0.69 - 2.77)	0.93 (0.51 - 1.70)	0.33 (0.04 - 2.46)

*Abbreviation: BMI, body mass index. Results are expressed as relative risk ratio and (95% confidence interval). Statistical analysis by multinomial logistic regression using never users as reference. *P<0.05; **P<0.01; ***P<0.001.*

Sensitivity analyses

The results of the sensitivity analysis on VMS use excluding calcium and vitamin D or iron and vitamin B_{12} combinations were similar to those obtained when the analysis included all VMS, except that some associations were no longer significant due to smaller sample sizes (not shown).

The results of the sensitivity analysis on never, inconsistent (initiating or discontinuing) and consistent (continuing) use of VMS are summarized in **supplemental tables 2.4.4 and 2.4.5**. On bivariate analysis, inconsistent use of VMS was associated with age, BMI, gender, educational level, marital and physical activity status (**Supplemental table 2.4.4**). Multivariate analysis showed that participants of male gender, lower education, married or obese had a lower RRR of inconsistent users, while older or physically active participants had a higher RRR of inconsistent use (**Supplemental table 2.4.5**). Similar findings were obtained when the analysis was split by gender (not shown).

The results of the sensitivity analysis on never, inconsistent (initiating or discontinuing) and consistent (continuing) use of DS are summarized in **supplemental tables 2.4.6 and 2.4.7**. On bivariate analysis, inconsistent use of DS was associated with age, BMI, gender, educational level, country of birth, smoking, marital and physical activity status (**supplemental table 2.4.6**). Multivariate analysis showed that participants of male gender or of lower education had a lower RRR of inconsistent use, while older, former smoker or physically active participants had a higher RRR of inconsistent use (**Supplemental table 2.4.7**). Similar findings were obtained when the analysis was split by gender (not shown).

DISCUSSION

VMS use changes with time, a sizable number of users discontinuing during a 5.5 year follow-up, being replaced by an almost similar number of previous never users initiating VMS, leading to a relatively stable number of VMS users. Conversely, the prevalence of DS use decreased significantly.

Trends and determinants of vitamin/mineral supplement use

Several cross-sectional and prospective studies have shown an increase in VMS use in the general population or in specific groups. In this study, VMS was relatively stable, the large number of participants discontinuing being compensated by an almost similar number of participants initiating VMS use. Interestingly, a large fraction of initiators was due to calcium and vitamin D combinations ant not to generic VMS, suggesting that this increase was medically driven. These findings are partly in agreement with a previous study[15], with the difference that in the previous study the number of participants initiating VMS outweighed the number of participants discontinuing. Overall, our results indicate that individuals can be categorized either as VMS users or never users depending on the study period, and that VMS continuers are only a small fraction of prevalent VMS users.

Women and older age were significantly associated with both initiating and continuing VMS use, a finding in agreement with the literature.[15] A first explanation is that women and elderly people tend to be more health conscious and to adopt health-promoting behaviours such as VMS use. Another explanation is the prevention of osteoporosis in elderly women by vitamin D + calcium combinations. Indeed, among women, 273 (10.9% of all women, 71.6% of all women initiators) initiated the vitamin D + calcium combination, versus 63 (2.5% of all women, 11.3% of all women discontinuers) who discontinued. Thus, and in agreement with another study[16], our results suggest that most women VMS initiators did so for a medical and not for a personal reason.

Being physically active was associated with both the initiation and the continuation of VMS, a finding also reported elsewhere.[15] Physically active people tend to be more health-conscious and to adopt more frequently healthy eating and VMS use.[21] Whether physically active people initiated VMS to promote their health or to improve physical performance remains to be assessed.

In the sensitivity analyses, participants of lower education had a lower RRR of inconsistent (initiating or discontinuing) or consistent (continuing) VMS use, a finding partly in agreement with a previous study[15], where such associations were found in men only. Interestingly, when inconsistent users were split into initiators and discontinuers, the association with education was for discontinuing VMS only. The lower likelihood of discontinuing VMS among less educated people might be explained by the fact that participants with higher education consume more non-prescribed medicines[22], and thus change consumption more frequently.

Presence of disease has been shown to increase the initiation of VMS by patients[15], although this statement has been challenged.[23] Still, in this study, no consistent associations were found between self-reported hypertension, dyslipidemic or diabetic status and initiation of VMS. Interestingly, participants who reported dyslipidemia had a higher RRR of continuing VMS, a finding also reported elsewhere.[15] Although some studies have shown a small effect of VMS on lipid levels[24] or carotid atherosclerosis[25], still VMS use is not recommended for the primary prevention of cardiovascular disease.[11]

Trends and determinants of dietary supplements use

Contrary to a study conducted in the USA[16] but in agreement with another conducted in Scandinavia[26], the prevalence of DS users decreased. Possible explanations include the absence or low efficiency of DS[27-30] and tighter regulations regarding their health claims.[31] Still, it would be of interest that the decrease observed in this study could be confirmed by other independent studies. As for VMS, our results suggest that only a small fraction of all DS users continuously consumes them.[15] A possible explanation is that people adopt DS based on their health promises[32], then discontinue when these benefits are not met or when side effects occur.[33] Still, as the reasons for discontinuing were not collected, these explanations remain speculative. Also, the diversity of DS precluded any analysis of the associations between discontinuing DS and the type of DS used. Conversely, DS maintenance continuation could be due to the presence of an effect (or to the absence of adverse effects) of DS. Again, the reasons for continuation are unknown and it would be of interest that further studies focus on the reasons for initiating, continuing or discontinuing DS.

Former smokers were more likely to be discontinuers than never or current smokers. It is possible that former smokers initially used DS as aid to prevent smoking relapse or to prevent weight gain induced by quitting smoking, then quit DS due to their relative inefficiency.[34, 35]

Physical activity was associated with DS initiation, discontinuing and continuation. If the findings regarding initiation and continuation are in agreement with the literature[15, 36, 37], the association of physical activity with DS discontinuing was unexpected. A possible explanation is that physically active participants initially relied on DS to boost their performances and discontinued if the DS did not meet their expectations. As no information was collected regarding the reasons for discontinuing, this explanation should be confirmed in other studies.

Implications for public health nutrition

Our findings have several implications for public health nutrition. First, they confirm that both VMS and DS use is an unstable behaviour and that a sizable fraction of that discontinuers are replaced by initiators. Thus, the overall effect of VMS or DS use on health outcomes might be considerably decreased. Indeed, our results may partly explain the lack of effect of VMS on mortality, as VMS intake might not have been consistent throughout the study period. Finally, the "cycling" of VMS or DS could also lead to the sporadic occurrence of side effects due to interactions of VMS or DS with prescribed drugs, with potentially major health consequences.[38]

Study limitations

This study has several limitations worth acknowledging. First, excluded participants differed significantly from the included ones. Thus, it is likely that our results are based on a more health-conscious sample than the general population and that the prevalence estimates for VMS and DS use might be overestimated. Still, our drop-out rate (24.4%) is comparable to the one of a previous study assessing trends in VMS use (23.1%).[15] Second, no data on duration or amount of VMS or DS use was collected; hence, it is possible that our estimates for the prevalence of continuers might be overestimated, as during the follow-up period some participants could have undergone several cycles of use/non-use of VMS or DS. Thus, future studies should consider the number and duration of use/non-use cycles when assessing VMS or DS use. Third, no information was collected regarding the type, intensity, duration and patterns of physical activity, and only the status of being physically active was collected; hence, it is likely that this assessment might be too weak to draw precise conclusions regarding the impact of physical activity on VMS or DS changes. Still, physical activity was significantly associated with initiation of VMS or DS, suggesting that even raw evaluations of physical activity status can be used in such studies. Fourth, changes in the baseline independent variables during follow-up (i.e. age, educational level, BMI changes) were not taken into account in the multinomial logistic model; still using time varying variables would preclude comparison with similar studies[15, 38] and could differ according to the criteria used to define change (i.e. in BMI levels).[39] Finally, only data from Caucasian participants living in a Swiss city was available, and it is currently unknown if our findings apply to other ethnicities or to other countries; for instance, a prospective study conducted in UK women[40] showed a much higher frequency of consistent users (54%, vs. 8.6% in our study), while the frequency of inconsistent (initiation + discontinuation) users was comparable (25%, vs. 23.6% in our study). Thus, the prevalence of never users, initiators, discontinuers and continuers might not be comparable between countries. Still, as the factors associated with VMS and DS use appear to be independent of the cultural and ethnic context[36, 37], they might be extrapolated to other countries.

Conclusion

In this population-based sample of the city of Lausanne, the prevalence of VMS use remained stable, but this apparent stability was due to high and comparable discontinuing and initiation rates. Conversely, DS use appears to be decreasing. Being physically active favours the initiation of VMS or DS, and older age favours the initiation of VMS.

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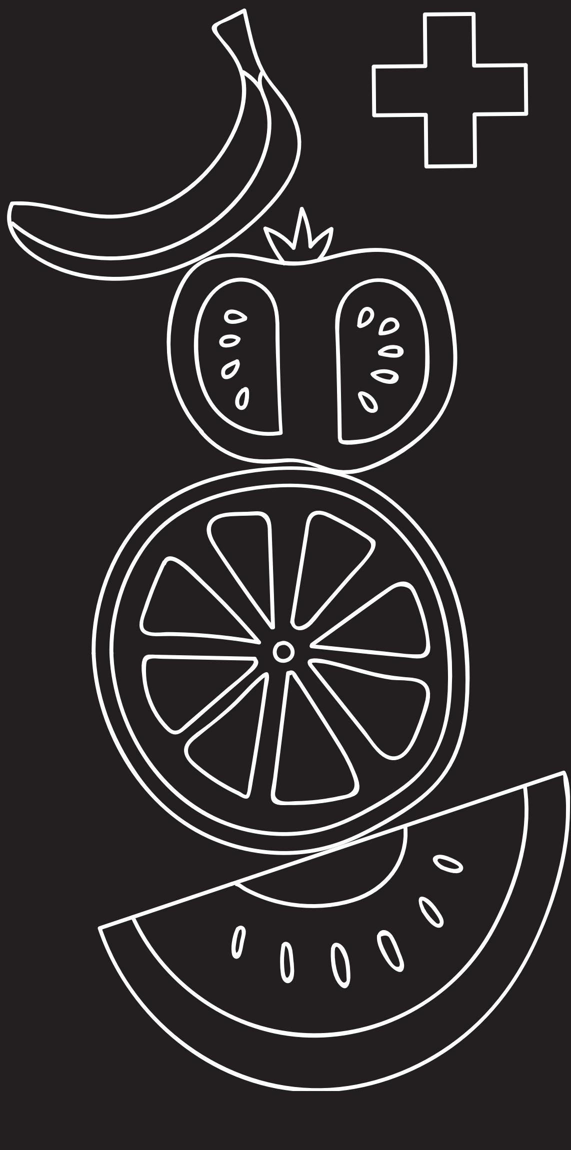
SUPPLEMENTAL MATERIAL

Supplemental material for this chapter can be found online
http://www.nature.com/articles/ejcn2016137#supplementary-information

CHAPTER 3



Dietary intake and cardiovascular risk factors

3

CHAPTER 3.1

Socio-demographic and lifestyle determinants of dietary patterns in French-Speaking Switzerland

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3.1

ABSTRACT

Background: Food intake is a complex behaviour which can be assessed using dietary patterns. Our aim was to characterize dietary patterns and associated factors in French-speaking Switzerland.

Methods: cross-sectional study conducted between 2009 and 2012 in the city of Lausanne, Switzerland, including 4,372 participants (54% women, 57.3±10.3 years). Food consumption was assessed using a validated food frequency questionnaire. Dietary patterns were assessed by principal components analysis.

Results: Three patterns were identified: "Meat & fries"; "Fruits & Vegetables" and "Fatty & sugary". The "Meat & fries" pattern showed the strongest correlations with total and animal protein and cholesterol carbohydrates, dietary fibre and calcium. The "Fruits & Vegetables" pattern showed the strongest correlations with dietary fibre, carotene and vitamin D. The "Fatty & sugary" pattern showed the strongest correlations with total energy and saturated fat. On multivariate analysis, male gender, low educational level and sedentary status were positively associated with the "Meat & fries" and the "Fatty & sugary" patterns, and negatively associated with the "Fruits & Vegetables" pattern. Increasing age was inversely associated with the "Meat & fries" pattern; smoking status was inversely associated with the "Fruits & Vegetables" pattern. Being born in Portugal or Spain was positively associated with the "Meat & fries" and the "Fruits & Vegetables" patterns. Increasing body mass index was positively associated with the "Meat & fries" pattern and inversely associated with the "Fatty & sugary" pattern.

Conclusions: Three dietary patterns, one healthy and two unhealthy, were identified in the Swiss population. Several associated modifiable behaviours were identified; the information on socio- demographic determinants allows targeting of the most vulnerable groups in the context of public health interventions.

INTRODUCTION

Dietary intake is one of the major determinants of health, and it has been repeatedly shown that improving dietary intake leads to an improvement in morbidity and mortality.[1] Dietary intake is a complex behaviour, which cannot be reduced to the consumption of single types of foods or nutrients.[2] Indeed, the variety of foods, nutrients and their interactions considerably complicate the analysis of the associations between individual foods or nutrients and diseases. Hence, multivariate, dimension-reducing approaches such as dietary patterns have been proposed. Dietary patterns could resolve concerns about food and nutrient interactions and provide a more accurate picture of an individual's dietary behaviour.[2, 3] Dietary patterns have been suggested to be advantageous over individual foods and nutrients regarding the associations between diet and chronic diseases such as diabetes.[4] Furthermore, dietary patterns provide the background to identify specific food combinations that are either protective or deleterious, thus fostering further research regarding individual foods and dietary guidelines.[5] Dietary patterns are also easier to apply in public health policies, as they correspond to "foods that are actually consumed in various characteristic combinations".[6] Indeed, several individual, lifestyle and socio-demographic factors associated with dietary patterns have been identified: age and education are positively associated with a healthy dietary pattern (mainly characterized by a high intake of fruits, vegetables or fish)[7, 8], while male gender is usually associated with more unhealthy patterns (characterized by high intake of fat, red meat or convenience foods).[7] Identification of groups with the (un)healthier dietary patterns would allow better public health policies regarding diet.[9]

Previous studies conducted in Switzerland[10, 11] assessed differences in single foods or nutrients between socio-demographic and socioeconomic groups. A study in Geneva assessed trends for dietary patterns[12], and it would be of interest if such patterns could be replicated in another Swiss city using the same methodology of data collection. Hence, we aimed to assess dietary patterns and their main determinants in a cross-sectional, population-based sample in Switzerland.

MATERIALS AND METHODS

The Cohorte Lausannoise (CoLaus) study.

The CoLaus study is a population-based study assessing the clinical, biological and genetic determinants of cardiovascular disease in the city of Lausanne, Switzerland. Its aims and sampling strategy have been reported previously.[13] The source population was defined as all subjects aged between 35 and 75 years registered in the population register of the city, which also includes information on age and sex. A simple, non-stratified random sample of 19,830 subjects (corresponding to 35% of the source population) was drawn and the selected subjects were invited to participate. The following inclusion criteria were applied: (a) written informed consent; (b) willingness to take part in the examination and to provide blood samples.

The baseline study was conducted between 2003 and 2006 and the first follow-up visit was conducted between April 2009 and September 2012 and included all participants willing to be re-contacted. At follow-up, participants attended a single visit, which included an interview, a dietary assessment, a physical exam, and blood and urine collections in the fasting state. For this study, only data from the follow-up examination was used as dietary intake assessment was first introduced at this time point.

Socio-demographic and anthropometric data

Age (range: 41-79 years) was categorized into 10-year age groups: 40-49; 50-59; 60-69 and 70-79. Educational level was categorized as low (primary), middle (apprenticeship or secondary school) and high (university). Country of birth was categorized into 6 groups: Switzerland, the four most common countries (providing at least 100 participants) including France, Italy, Portugal and Spain, and other. Analysis according to country of birth was considered as important as a previous study showed considerable differences in dietary intake between these groups.[14] Smoking status was defined as never, former (irrespective of the time since quitting) and current (irrespective of the amount smoked). Body weight and height were measured using standard procedures[13] and body mass index (BMI) was defined as weight (kg)/height(m)^2. Overweight was defined as 25≤BMI<30 kg/m^2 and obesity as BMI≥30 kg/m^2.

Physical activity assessment

Physical activity was assessed by a questionnaire[15] validated in the population of Geneva. This self-reported questionnaire assesses the type and duration of 70 kinds of (non)professional activities and sports during the previous week. Sedentary status was defined as spending more than 90% of the daily energy in activities below moderate- and high-intensity (defined as requiring at least 4 times the basal metabolic rate, BMR). [16, 17] BMR multiples are close to Metabolic Equivalent of Task (MET) multiples, although MET multiples do not consider participant sex, age or height.

Dietary assessment

Dietary intake was assessed using a self-administered, semi-quantitative food frequency questionnaire (FFQ) which also includes portion size.[18] This FFQ was validated in the Geneva population.[18, 19] Briefly, this FFQ assesses the dietary intake of the previous 4 weeks and consists of 97 different food items accounting for more than 90% of the intake of calories, proteins, fat, carbohydrates, alcohol, cholesterol, vitamin D and retinol, and 85% of fibre, carotene and iron. To our knowledge, there is no FFQ (validated or not) assessing dietary intake for the whole year in Switzerland. Hence, this FFQ provides the best dietary assessment currently available for French speaking Switzerland. 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 bigger) compared to a reference size. Each participant brought along her/his filled-in FFQ, which was checked for completion by trained interviewers on the day of the visit. Dietary patterns were assessed using consumption frequencies, defined as "never these last 4 weeks"=0; "once/month"=1/28; "2–3/month"=2.5/28; "1–2/week"=1.5/7; "3–4 times/week"=3.5/7; "once/day"=1 and "2+/day"=2.5. The 97 items were then grouped into 40 food and nutrient groups, including vitamin and food supplements (**Supplemental table 3.1.1**). Conversion into nutrients was performed based on the French CIQUAL food composition table[20] taking into account portion size. The use of a French food composition table was motivated by the fact that no adequate Swiss food composition table existed when the FFQ was constructed and validated. Reference portions were defined by the use of common measures such as "one slice" (of bread); "one yogurt cup" (for peas or berries); "one tablespoon"; "one serving" (for tomatoes or bananas) or "one glass" (of water or of wine, as size depends on the type of beverage). The reference portion was defined as the median of portion size distribution in the validation paper, and the "smaller" and "bigger" portions were defined as the first and the third quartiles of the distribution.[21] Total energy intake (TEI) was computed and alcohol consumption was included in this calculation.

Participants were considered to be on a diet if they responded positively to the question "are you currently on a diet", irrespective of the type of diet considered (for slimming, diabetes, high cholesterol, other).

Exclusion criteria

Participants were excluded if they presented at least one of the following characteristics: 1) No FFQ completed; 2) Less than 30 items consumed according to the completed FFQ; 3)No smoking or education data.

Statistical analysis

Statistical analyses were performed using Stata version 14.2 for windows (Stata Corp, College Station, Texas, USA). Descriptive results were expressed as number of participants (percentage) or as average±standard deviation. Bivariate analyses were performed using chi-square for categorical variables and Student's t-test or analysis of variance for continuous variables.

Dietary patterns were assessed by principal components analysis (PCA) with varimax rotation as done in previous studies.[7, 22-24] The Kaiser-Meyer-Olkin (KMO) and the Bartlett test for sphericity were applied to assess the appropriateness of applying PCA to the dataset. The Bartlett test compares the correlation matrix between the different items to be included in the PCA to the identity matrix. A non-significant Bartlett test indicates that the variables are highly correlated and that information compression using PCA is not useful. The KMO was 0.755, which was above the suggested minimum of 0.5 [25] and comparable to values reported in the literature.[7, 24] The Bartlett test for sphericity yielded a p-value of <0.0001. Hence, both KMO and the Bartlett tests indicated that the data were suitable for PCA.

The number of dietary patterns to be retained was determined based on the same criteria as described by others[8, 22], namely 1) analysis of the scree plot; 2) an eigenvalue higher than one and 3) the interpretability of the dietary pattern. For interpretation purposes, varimax rotation was performed. Items with absolute factor loading >0.30 were considered to characterize the dietary patterns[1], although all items were used to calculate dietary pattern scores. As suggested previously[24], the associations between dietary patterns and nutrients were assessed using Pearson correlations and corresponding 95% confidence intervals, applying Fisher's z transformation and the **corrci** command of Stata. Bivariate comparison of correlation coefficients was performed using Steiger's method and using the **corcor** command of Stata.

Dietary patterns were categorized into quintiles and the distributions of individual and behaviour factors and dietary patterns were compared between the highest quintile and the other four, a method also used elsewhere.[7, 23, 24] Multivariable analysis was performed using Poisson regression for highest quintile vs. the others, as previously reported.[7] Poisson regression was preferred to logistic regression because the outcome of interest was not a rare event (20%), and using logistic regression would overestimate the associations.[26] All variables associated with at least one dietary pattern in the bivariate analysis were included in the multivariate model. Results were expressed as prevalence rate ratio (PRR) and 95% confidence interval. Tests for trends were assessed using the **contrast q.** command of Stata.

As complete physical activity data was only available for a limited number of participants, the initial separate analyses were performed, including or not the sedentary status in the multivariable model. Other sensitivity analyses were performed: 1) excluding participants with a total energy intake <850 or >4500 kcal/day[27]; 2) using food pattern scores as continuous variables. For the latter case, analyses were performed using analysis of variance. Tests for trends were assessed using the **contrast q.** function of Stata. Significance was considered for a two-sided test $p<0.05$.

Ethics approval and consent to participate

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Institutional Ethics Committee of the University of Lausanne. Written informed consent was obtained from all participants.

RESULTS

Selection procedure and characteristics of participants

Of the 5,064 participants available at follow-up, 692 (13.7%) were excluded. The reasons for the exclusion are summarized in **figure 3.1.1** and the main characteristics of participants included and excluded are summarized in **supplemental table 3.1.2**. Excluded participants were older, with a higher BMI, and were more frequently born outside Switzerland, with lower education, current smokers, sedentary and obese. Thus, the analysis included 4,372 participants, 3,936 (90%) of whom had data for physical activity.

Dietary patterns

The results of the principal components analysis are summarized in **table 3.1.1**. Three dietary patterns were identified, explaining 20.9% of the overall variance. The first dietary pattern was named "Meat & fries" (unhealthy) and had high loadings for all kinds of meat and French fries. The second dietary pattern was named "Fruits & Vegetables" (healthy) and had high loadings for fruits and vegetables. The third dietary pattern was named "Fatty & sugary" (unhealthy) and had high loadings for hard fats (i.e. butter, margarine), pastries and sugar-rich foods (**Table 3.1.1**).

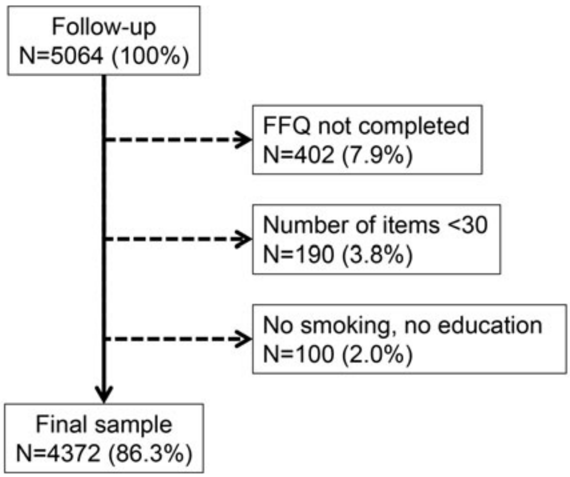

Figure 3.1.1: selection procedure of the participants of the CoLaus study, 2009-2012, Lausanne, Switzerland.

The Pearson correlations, with 95% confidence intervals, between the three dietary pattern scores and selected macro- and micronutrients are provided in **supplemental table 3.1.3**. Almost all correlations were statistically significant. The "Meat & fries" pattern showed the strongest positive correlations with total and animal protein, cholesterol and iron, and inverse correlations with total carbohydrates, dietary fibre and calcium. The "Fruits & Vegetables" pattern showed the strongest positive correlations with vegetable protein, dietary fibre, carotene and vitamin D, the weakest positive correlations with cholesterol, and a negative correlation with alcohol. The "Fatty & sugary" pattern showed the strongest positive correlations with total energy intake and saturated fat, and the weakest positive correlation with vitamin D (**Supplemental table 3.1.3**).

Table 3.1.1: factor loadings derived from principal component analysis and percentage of total variance explained for the three dietary patterns identified, 4,372 participants of the CoLaus study, Lausanne, Switzerland.

Food group	**Item**	**Meat & fries**	**Fruits & vegetables**	**Fatty & sugary**
Dairy	Full fat or semi-skimmed dairy products	-0.076	0.074	0.207
	Low fat dairy products	0.007	0.166	-0.124
	Whole milk cheese	-0.035	0.091	0.259
Bread and cereals	White bread	0.091	-0.137	0.297
	Wholemeal bread	-0.092	0.258	-0.008
	Breakfast cereals	-0.091	0.195	-0.030
	Toasts, crackers	-0.024	0.125	-0.024
Meat	Red meat	0.421	0.008	0.015
	Poultry	0.389	0.104	-0.098
	Processed meat	0.423	-0.039	0.047
	Liver	0.419	0.054	-0.099
Fish	Oily fish	0.118	0.240	-0.148
	Canned or fried fish	0.151	0.106	0.017
	Lean fish & seafood	0.069	0.287	-0.116
Vegetables	Vegetables	0.154	0.366	0.004
	Boiled potatoes	0.091	0.179	0.120
	French fries	0.344	-0.135	0.063
Pasta, other	Sauces (any)	0.041	0.242	0.116
	Cafeteria foods	0.138	-0.032	0.223
	Starchy foods	0.108	0.142	0.159
	Eggs	0.045	0.160	0.074
	Tofu	-0.049	0.147	-0.030
Fruit	Fresh fruit or juice	-0.085	0.358	0.044
	Canned fruit	0.031	0.044	0.126
Fats	Low-cal fat products	-0.013	0.096	0.010
	Hard fats	-0.004	0.026	0.374
	Olive oil	-0.043	0.269	0.093
	Other vegetable oils	0.037	0.090	0.201
Pastries and sweets	Bakery	-0.010	-0.029	0.345
	Chocolate	-0.086	0.022	0.447
	Sugar substitutes	-0.005	0.078	-0.083
Vitamins, supplements	Vitamin supplements	-0.047	0.116	-0.034
	Other supplements	-0.040	0.118	-0.106
Drinks	Sodas	0.101	-0.061	0.206
	Tea & coffee	-0.106	0.170	0.141
	Water	-0.040	0.176	0.007
	Alcoholic drinks	0.100	-0.154	0.081
	% variance explained	**8.1**	**7.2**	**5.6**

Factor loadings with absolute values >0.300 were used to characterize the dietary pattern and are indicated in bold.

Factors associated with dietary patterns

Bivariate and multivariate associations between participants' characteristics and the three dietary patterns identified are summarized in **tables 3.1.2** and **3.1.3**, respectively. In multivariate analysis, male gender was positively associated with the "Meat & fries" and the "Fatty & sugary" patterns and inversely associated with the "Fruits & Vegetables" pattern. Increasing age was inversely associated with the "Meat & fries" pattern. Being born in Portugal or Spain was positively associated with the "Meat & fries" and the "Fruits & Vegetables" patterns. Lower educational level was positively associated with the "Meat & fries" pattern and inversely associated with the "Fruits & Vegetables" pattern. Smoking status was inversely associated with the "Fruits & Vegetables" pattern; being on a diet was positively associated with the "Fruits & Vegetables" pattern and inversely associated with the "Meat & fries" and the "Fatty & sugary" patterns. Increased BMI was positively associated with the "Meat & fries" pattern and inversely associated with the "Fatty & sugary" pattern.

Sensitivity analyses

The results after excluding participants without data on sedentary status are summarized in **supplemental tables 3.1.5** (for highest quintile vs. others) and **3.1.6** (for dietary pattern scores as continuous variables). The results after excluding participants with extreme reported energy intakes are summarized in **supplemental tables 3.1.7** (for highest quintile vs. others) and **3.1.8** (for dietary pattern scores as continuous variables). The results after excluding participants with extreme reported energy intakes or without data for sedentary status are summarized in **supplemental tables 3.1.9** (for highest quintile vs. others) and **3.1.10** (for dietary pattern scores as continuous variables). Overall, the findings were similar to those reported for the whole sample, with sedentary status being positively associated with the "Meat & fries" pattern (and to a lesser degree to the "Fatty & sugary" pattern) and inversely associated with the "Fruits and Vegetables" pattern.

Table 3.1.2: Distribution of sociodemographic and lifestyle characteristics across highest and lowest quintiles of dietary patterns scores identified among 4,372 participants the CoLaus study, 2009-2012, Lausanne, Switzerland.

	Meat & fries		Fruits & vegetables		Fatty & sugary	
	Q_{1-4}	Q_5	Q_{1-4}	Q_5	Q_{1-4}	Q_5
Gender						
Woman	2034 (86.2)	325 (13.8)	1742 (73.8)	617 (26.2)	1952 (82.8)	407 (17.3)
Man	1465 (72.7)	549 (27.3)	1757 (87.2)	257 (12.8)	1547 (76.8)	467 (23.2)
p-value	<0.001		<0.001		<0.001	
Age group (years)						
40-49	961 (75.1)	318 (24.9)	1057 (82.6)	222 (17.4)	1018 (79.6)	261 (20.4)
50-59	1050 (78.0)	297 (22.0)	1082 (80.3)	265 (19.7)	1072 (79.6)	275 (20.4)
60-69	991 (85.1)	173 (14.9)	888 (76.3)	276 (23.7)	964 (82.8)	200 (17.2)
70-79	497 (85.3)	86 (14.7)	472 (81.0)	111 (19.0)	445 (76.3)	138 (23.7)
p-value	<0.001		0.001		0.012	
Country of birth						
Switzerland	2387 (83.9)	458 (16.1)	2329 (81.9)	516 (18.1)	2286 (80.3)	559 (19.7)
France	222 (76.6)	68 (23.5)	225 (77.6)	65 (22.4)	215 (74.1)	75 (25.9)
Italy	173 (81.6)	39 (18.4)	173 (81.6)	39 (18.4)	167 (78.8)	45 (21.2)
Portugal	108 (54.0)	92 (46.0)	145 (72.5)	55 (27.5)	163 (81.5)	37 (18.5)
Spain	85 (63.4)	49 (36.6)	101 (75.4)	33 (24.6)	110 (82.1)	24 (17.9)
Other	524 (75.7)	168 (24.3)	526 (76.0)	166 (24.0)	558 (80.6)	134 (19.4)
p-value	<0.001		<0.001		0.188	
Education						
University	787 (80.1)	195 (19.9)	745 (75.9)	237 (24.1)	789 (80.4)	193 (19.7)
High school	952 (81.7)	214 (18.3)	914 (78.4)	252 (21.6)	940 (80.6)	226 (19.4)
Apprenticeship	1279 (81.9)	282 (18.1)	1311 (84.0)	250 (16.0)	1241 (79.5)	320 (20.5)
Primary	481 (72.4)	183 (27.6)	529 (79.7)	135 (20.3)	529 (79.7)	135 (20.3)
p-value	<0.001		0.001		0.887	

Table 3.1.2: Continued.

	Meat & fries		Fruits & vegetables		Fatty & sugary	
	Q_{1-4}	Q_5	Q_{1-4}	Q_5	Q_{1-4}	Q_5
Smoking status						
Never	1457 (80.6)	350 (19.4)	1410 (78.0)	397 (22.0)	1480 (81.9)	327 (18.1)
Former	1354 (81.4)	309 (18.6)	1299 (78.1)	364 (21.9)	1321 (79.4)	342 (20.6)
Current	688 (76.2)	215 (23.8)	790 (87.5)	113 (12.5)	698 (77.3)	205 (22.7)
p-value	0.005		<0.001		0.014	
On a diet						
No	2361 (78.9)	632 (21.1)	2478 (82.8)	515 (17.2)	2319 (77.5)	674 (22.5)
Yes	1138 (82.5)	242 (17.5)	1021 (74)	359 (26)	1180 (85.5)	200 (14.5)
p-value	0.006		<0.001		<0.001	
BMI categories						
Normal	1657 (83.7)	322 (16.3)	1549 (78.3)	430 (21.7)	1555 (78.6)	424 (21.4)
Overweight	1305 (77.5)	378 (22.5)	1368 (81.3)	315 (18.7)	1345 (79.9)	338 (20.1)
Obese	537 (75.5)	174 (24.5)	582 (81.9)	129 (18.1)	599 (84.3)	112 (15.8)
p-value	<0.001		0.031		0.005	
Sedentary						
No	1379 (81.2)	319 (18.8)	1317 (77.6)	381 (22.4)	1362 (80.2)	336 (19.8)
Yes	1778 (79.4)	461 (20.6)	1814 (81.0)	425 (19.0)	1772 (79.1)	467 (20.9)
p-value	0.160		0.008		0.409	

BMI, body mass index; Q_{1-4}, first to fourth quintiles; Q_5, fifth quintile. Analysis performed on 4,372 participants, except for sedentary status (N=3,936). Results are expressed as number of participants and (row percentage). Statistical analysis performed using chi-square.

Table 3.1.3: multivariable analysis of the associations between personal and behavioural factors and being in the highest quintile of the three dietary patterns identified, 4,372 participants of the CoLaus study, 2009-2012, Lausanne, Switzerland.

	Meat & fries	**Fruits & vegetables**	**Fatty & sugary**
Gender			
Woman	1 (ref.)	1 (ref.)	1 (ref.)
Man	1.89 (1.64 - 2.19)	0.48 (0.42 - 0.56)	1.37 (1.19 - 1.57)
p-value	<0.001	<0.001	<0.001
Age group			
40-49	1 (ref.)	1 (ref.)	1 (ref.)
50-59	0.92 (0.78 - 1.08)	1.15 (0.96 - 1.38)	1.03 (0.87 - 1.22)
60-69	0.71 (0.59 - 0.87)	1.36 (1.13 - 1.64)	0.93 (0.77 - 1.13)
70-79	0.71 (0.55 - 0.91)	1.15 (0.91 - 1.47)	1.28 (1.03 - 1.58)
p-value for trend	0.001	0.116	0.072
Country of birth			
Switzerland	1 (ref.)	1 (ref.)	1 (ref.)
France	1.51 (1.16 - 1.95) **	1.07 (0.83 - 1.40)	1.39 (1.09 - 1.77) **
Italy	0.98 (0.70 - 1.36)	1.19 (0.85 - 1.65)	1.04 (0.76 - 1.42)
Portugal	2.04 (1.56 - 2.67) ***	2.05 (1.49 - 2.80) ***	0.90 (0.62 - 1.30)
Spain	1.93 (1.42 - 2.63) ***	1.50 (1.05 - 2.16) *	0.92 (0.60 - 1.39)
Other	1.52 (1.26 - 1.83) ***	1.13 (0.94 - 1.35)	1.09 (0.90 - 1.33)
Education			
University	1 (ref.)	1 (ref.)	1 (ref.)
High school	1.00 (0.82 - 1.22)	0.81 (0.68 - 0.97)	1.06 (0.87 - 1.29)
Apprenticeship	1.07 (0.88 - 1.30)	0.61 (0.50 - 0.74)	1.15 (0.96 - 1.39)
Primary	1.26 (0.99 - 1.60)	0.61 (0.48 - 0.78)	1.22 (0.96 - 1.57)
p-value for trend	0.045	<0.001	0.077
Smoking status			
Never	1 (ref.)	1 (ref.)	1 (ref.)
Former	0.92 (0.79 - 1.07)	1.08 (0.93 - 1.25)	1.13 (0.97 - 1.31)
Current	1.13 (0.95 - 1.34)	0.64 (0.52 - 0.79)	1.19 (0.99 - 1.41)
p-value for trend	0.162	<0.001	0.059
On a diet			
No	1 (ref.)	1 (ref.)	1 (ref.)
Yes	0.85 (0.73 - 0.99)	1.44 (1.25 - 1.65)	0.66 (0.56 - 0.78)
p-value	0.032	<0.001	<0.001
BMI categories			
Normal	1 (ref.)	1 (ref.)	1 (ref.)
Overweight	1.21 (1.03 - 1.41)	0.94 (0.81 - 1.10)	0.89 (0.77 - 1.03)
Obese	1.43 (1.18 - 1.74)	0.85 (0.69 - 1.04)	0.74 (0.60 - 0.92)
p-value for trend	<0.001	0.120	0.006

*Analysis performed on 4,372 participants. Results are expressed as prevalence rate ratios and (95% confidence interval) of being in the last quintile relative to the other four. Statistical analysis performed using Poisson regression adjusting for the variables listed in the tables. All variables were simultaneously included in the model. For country of birth, significant associations are indicated as follows: *, p<0.05; **, p<0.01; ***, p<0.001.*

DISCUSSION

This is one of the few studies to characterize empirically-derived dietary patterns in the French-speaking Swiss population. Three patterns were identified, and several socio-demographic and lifestyle factors were found to be associated with them.

Dietary patterns

Three patterns were identified; based on the dietary guidelines of the International Agency for Research on Cancer[28], one was termed as healthy ("Fruits & Vegetables") and two as unhealthy ("Meat & fries" and "Fatty & sugary"). The three patterns explained 20.9% of the overall variance in food consumption; this relatively low percentage of explained variance is likely due to the large number of food groups included in the PCA[3] but is similar to other studies[7, 24], including one conducted in Geneva using the same FFQ.[12] Also, the patterns identified in this study were almost identical to those reported in Geneva[12] and comparable to dietary patterns reported in other countries. For instance, the "Meat & fries" pattern was identical to one described in Puerto Rico[29] and involved several components shared with the "Western" pattern identified in Sweden.[24] The "Fruits & Vegetables" pattern shared the same components as the "Healthy" pattern described in a Swedish study[30] and the "Olive oil and vegetables" identified in Italy.[31] Finally, the "Fatty & sugary" pattern involved most components of the "convenience foods" identified in France[8], the "Eggs and sweets" identified in Italy[31] some components of the "Western" pattern identified in Brazil[32] and the "Continental" pattern identified in Sweden.[24] Overall, our results suggest that, notwithstanding different dietary assessment methods, the dietary patterns identified in this study share several characteristics with other patterns identified in other settings.

3.1

Factors associated with dietary patterns

Women had higher PRRs and scores for the "Fruits & Vegetables" pattern and lower PRRs and scores for the "Meat & fries" and the "Fatty & sugary" patterns, a finding in agreement with the literature.[7, 33] These findings confirm the higher importance of diet for women compared to men, a finding also reported when assessing compliance to dietary recommendations.[11]

Elderly subjects had higher PRRs and scores for the "Fruits & Vegetables" pattern and lower PRRs and scores for the "Meat & fries" pattern, a finding in agreement with the literature.[33] The "Meat & fries" dietary pattern was associated with an increasing allostatic load[29] risk for diabetes[34] and acute myocardial infarction[35], while patterns such as the "Fruits & Vegetables" pattern have been shown to be protective.[35] Thus, the unhealthy dietary patterns in younger participants might favour the increase in the prevalence of obesity and cardiovascular risk factors (namely diabetes) in this group.[36] Conversely, the higher PRR and scores for the "Fatty & sugary" pattern among the eldest group could be due to several factors including a decreased sense of taste[37] or a decreased financial capacity forcing older people to buy less expensive, more sugar and fat rich foods.[38]

Being born in Portugal or Spain was positively associated with both the “Meat & fries” and the “Fruits & Vegetables” patterns. A possible explanation is that migrants from these countries improve their wealth when working in Switzerland, making them buy more meat (a marker of wealth) while maintaining some of their traditional dietary patterns (i.e. Fruits & Vegetables). Indeed, a previous study conducted in Portugal showed that the improvement in overall wealth after joining the EU in the nineties led to a considerable change in diet, shifting from a south European to a more Westernized, protein-rich diet.[39] Conversely, as the “Meat & fries” pattern includes all types of meat, it was not possible to assess if the increase in meat was related to the most expensive parts of meat (beef) or to the cheaper ones such as processed meat.

Highly educated participants had higher PRRs and scores for the “Fruits & Vegetables” pattern and lower PRRs and scores for the “Meat & fries” and to a lesser degree for the “Fatty & sugary” patterns, a finding repeatedly reported in the literature.[7, 30, 33] A likely explanation is that highly educated people are more compliant with dietary recommendations[11], and tend to have a higher income enabling them to buy more fruits and vegetables than less educated people.[38]

Current smokers had lower PRRs and scores for the “Fruits & Vegetables” pattern, a finding also reported previously.[30, 40] Conversely, no significant differences were found for the “Meat & fries” and the “Fatty & sugary” patterns, suggesting that current smoking selectively impairs the consumption of specific foods. Possible explanations include a lower compliance to dietary recommendations[11], tobacco-induced changes in sensory system, gustatory impairment as a consequence of heavy smoking[41] and decreased olfactory capacity[42], making smokers select foods with stronger flavours (i.e. saltier).

Participants reporting being on a diet had higher PRRs and scores for the “Fruits & Vegetables” pattern and lower PRRs and scores for the “Meat & fries” and the “Fatty & sugary” patterns, a finding also reported elsewhere[30] and suggestive for the increased awareness on the importance of dietary intake. Due to the large variation in the type of diets, it was not possible to precisely assess associations between each type of diet and the different dietary patterns.

Sedentary participants had lower PRR for the “Fruits & Vegetables” pattern and tended to present higher PRRs for the unhealthy ones; when the analysis was based on dietary pattern scores, clear differences were found; sedentary participants scoring had higher scores in the “Meat & fries” and the “Fatty & sugary” patterns and lower ones in the “Fruits & Vegetables” pattern. Such findings have been repeatedly reported in the literature.[30, 40] Overall, our results reinforce the fact that dietary patterns are closely related to several lifestyle characteristics.

Obese participants had lower PRRs for the “Fatty & sugary” pattern and higher PRRs for the “Meat & fries” pattern, and these associations persisted after excluding participants reporting to be on a diet. The most likely explanation is a reporting bias; obese participants may underreport the intake of foods which they consider as obesogenic. Interestingly, a negative association between BMI and the "Fatty & sugary" pattern was observed, but a positive association with the "Meat & fries" was found. This former association might be due to the fact that most people do not consider meat as obesogenic, although the increased consumption of meat has been shown to be associated with obesity.[43] Finally, a significant negative association between BMI categories and the "Fruits & Vegetables" pattern was found after excluding participants with extreme energy intakes, a finding also reported previously.[23] Overall, our results indicate that increased BMI is associated with unhealthy dietary patterns, and this association might be partly blurred by reporting bias.

Impact for dietary policies

Several modifiable behaviours were associated with dietary patterns, allowing for a better targeting of the most vulnerable groups in the context of public health interventions, although such modifications have been questioned.[44] For instance, smokers should be urged to increase vegetable consumption, while the promotion of physical activity would allow tackling both sedentary status and the associated dietary patterns.

Strengths and limitations

This study has several limitations. First, the cross-sectional setting of the study only allows establishing associations, and no causal inferences can be drawn. Second, excluded participants differed significantly from those whom the dietary patterns were computed accordingly; hence, dietary patterns were derived from a healthier sample and might not fully represent the true dietary patterns in the general population. Still, the patterns identified were similar to those reported in other studies, and could serve as a foundation for future studies on dietary behaviours in French-speaking Switzerland. Third, only urban citizens were queried, and we have no information regarding dietary patterns of rural inhabitants. Still, according to the Swiss federal office of statistics, in 2014, 84% of the Swiss population lived in an urban setting[45], so our results apply to the majority of the French-speaking Swiss population. Fourth, portion size was self-reported and might have been misevaluated by the participants; still, this is a common issue among self-reported dietary intake and it has been shown that dietary patterns do not change significantly when input variable quantification changes.[46] Finally, the study was conducted in a French-speaking canton; as Switzerland is a multilingual country, it is possible that dietary behaviours in German or Italian -speaking regions may be different, but no data is currently available.

Conclusion

Three dietary patterns, one healthy and two unhealthy, were identified in the French-speaking Swiss population. Several associated modifiable behaviours were identified, and this information allows targeting of the most vulnerable groups in the context of public health interventions.

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SUPPLEMENTAL MATERIAL

Supplemental material for this chapter can be found online
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CHAPTER 3.2

Dietary behaviours influence inflammatory markers: results from the CoLaus Study

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3.2

ABSTRACT

Background: We assessed the effect of single foods, nutrients, dietary patterns and dietary scores on inflammatory markers (CRP, IL-6, TNF-α and leucocyte count).

Methods: Cross-sectional study including 4027 participants (46.5% men, 57.2±10.2 years) conducted between 2009 and 2012 in Lausanne, Switzerland. Dietary intake was collected using a semi-quantitative food frequency questionnaire. Single foods and nutrients, three dietary patterns ("Meat & fries"; "Fruits & vegetables" and "Fatty & sugary" and three dietary scores (two Mediterranean, Alternative Healthy Eating Index - AHEI) were used. Associations were assessed using correlation and multivariable linear regression.

Results: After adjusting on total energy intake, gender and other socio-demographic factors, no individual macro or micronutrient was associated with inflammatory markers. Among single foods, only fruit intake was negatively associated with CRP levels (standardized regression score -0.043, $p<0.01$). The "Fruits & vegetables" pattern, the Mediterranean and the AHEI scores were negatively associated with CRP levels (standardized regression scores: -0.079, -0.043 and -0.067, respectively, all $p<0.01$). When entered simultaneously with fruit intake, the "Fruits & Vegetables" pattern, the Mediterranean and the AHEI scores tended to remain significantly and negatively associated with CRP levels, while the association with fruit intake was no longer significant. No association between all dietary markers and IL-6, TNF-α or leucocyte count was found.

Conclusion: Dietary scores, but not individual foods, are associated with inflammatory markers in the general population.

INTRODUCTION

Inflammatory markers such as C-reactive protein (CRP) and interleukin 6 (IL-6) are predictors of cardiovascular disease (CVD) risk.[1] Indeed, the well-known association between diet and CVD may partly be linked through these inflammatory markers.[2] Several epidemiological studies have identified negative associations between inflammatory levels and specific nutrients such as polyphenols[3; 4], polyunsaturated fatty acids[5], histidine[6] and branched-chain amino acids.[7]

Besides specific nutrients, dietary scores based on the consumption of specific food items have also been linked with inflammatory levels. For example, hypothesis-oriented scores such as the Mediterranean-diet score[8] has been linked with lower platelet and white blood cell counts.[9] Similarly, the Southern European Atlantic diet[10] and the Baltic Sea diet[11] have been associated with lower levels of CRP, while the Alternate Healthy Eating Index (AHEI) of McCullough and coll.[12] was negatively associated with IL-6 levels.[2; 13]

Dietary patterns obtained through principal component analysis (PCA), have also been shown to be associated with inflammatory levels. For example, "prudent"[14] or "health-aware"[15] patterns were negatively associated with CRP levels. Ozawa and coll. used reduced rank regression analysis and identified a "dietary inflammatory pattern" rich in red and processed meat, peas, legumes and fried food, and low in whole grains, which was positively associated with IL-6 levels and other inflammatory markers.[16] However, most studies assessed only a limited number of nutrients or foods, or even focused on a single dietary score or pattern, while studies comparing simultaneously the effect of different dietary parameters on inflammatory markers are scarce.

Hence, our study aimed at assessing the associations between a wide range of dietary parameters (macro- and micronutrients, single foods, dietary patterns and scores) and several inflammatory markers.

PARTICIPANTS AND METHODS

Participants

The CoLaus study is a population-based study assessing the clinical, biological and genetic determinants of cardiovascular disease in the city of Lausanne, Switzerland.[17] The sampling procedure of the CoLaus Study was as follows: the source population was defined as all subjects aged between 35 and 75 years registered in the population register of the city of Lausanne. The register includes all subjects living in this city for more than 90 days. A simple, non-stratified random sample of 19'830 subjects (corresponding to 35% of the source population) was drawn and the selected subjects were invited to participate by letter. If no answer was obtained, a second letter was sent, and if no answer was obtained, the subjects were contacted by phone.

The following inclusion criteria were applied: (a) written informed consent; (b) willingness to take part in the examination and to provide blood samples.

Recruitment began in June 2003 and ended in May 2006, enrolling 6733 total participants who underwent an interview, a physical exam, and a blood analysis. The first follow-up was performed between April 2009 and September 2012, 5.6 years on average after the collection of baseline data. The information collected was similar to that collected in the baseline examination but contained questions regarding food consumption and detailed physical activity information for the first time. We only consider data from the follow-up examination as dietary intake assessment was first introduced here.

Blood samples

Venous blood samples (50 mL) were drawn in the fasting state. High sensitive CRP (hs-CRP) was assessed by immunoassay and latex HS (IMMULITE 1000–High, Diagnostic Products Corporation, LA, CA, USA) with maximum intra- and interbatch coefficients of variation of 1.3% and 4.6%, respectively. Serum samples were kept at -80°C before assessment of IL-6 and TNF-a and sent in dry ice to the laboratory. Levels of these cytokines were measured using a multiplexed particle-based flow cytometric cytokine assay.[18] Milliplex kits were purchased from Millipore (Zug, Switzerland). The procedures closely followed the manufacturer's instructions. The analysis was conducted using a conventional flow cytometer (FC500 MPL, BeckmanCoulter, Nyon, Switzerland). Lower limits of detection (LOD) for IL-6 and TNF-α were 0.2 pg/ml. A good agreement between signal and cytokine was found within the assay range ($R^2 \geq 0.99$). Intra and inter-assay coefficients of variation were respectively 16.9% and 16.1% for IL-6 and 12.5% and 13.5% for TNF-α. For quality control, repeated measurements were conducted in 80 subjects randomly drawn from the initial sample. Spearman rank correlations between duplicate measurements were 0.961 and 0.891 for IL-6 and TNF-α, respectively (all $p<0.001$). Lin's correlation coefficients were 0.971 and 0.945 and intra-class correlation coefficients were 0.972 and 0.946 for IL-6 and TNF-α, respectively (all $p<0.001$), indicating a good reproducibility.

Dietary intake

Dietary intake was assessed using a validated self-administered, semi quantitative Food Frequency Questionnaire (FFQ) which also included portion size.[19] This FFQ has been validated against 24 hour recalls among 626 volunteers from the Geneva population.[20; 21; 22] The FFQ assesses the dietary intake of the previous 4 weeks and consists of 97 different food items accounting for more than 90% of the intake of calories, proteins, fat, carbohydrates, alcohol, cholesterol, vitamin D and retinol, and 85% of fibre, carotene and iron. For each item, seven consumption frequencies were provided 1) "less than once during the last 4 weeks" 2) "once per month"; 3) "2-3 times per month"; 4) "1-2 times per week"; 5) "3-4 times per week"; 6) "once per day" and 7) "2 or more times per day". Participants indicated the average serving size (smaller, equal or bigger) compared to a reference size. Daily consumption of the different food items was computed based on frequency and portion size and expressed in mL (for drinks) or in grams (for other foods). Conversion into nutrients was performed based on the French CIQUAL food composition table[23] taking into account portion size.

Three hypothesis-oriented dietary scores were computed, two based on the Mediterranean diet, the third on a modification of the alternative healthy eating index (AHEI). The first Mediterranean dietary score (hereby designated as "Mediterranean score 1") was derived from Trichopoulou et al.[8], the score ranges between zero and eight. The second Mediterranean dietary score (hereby designated as "Mediterranean score 2") is adapted to the Swiss population and was computed according to Vormund et al.[24] Contrary to the score from Trichopoulou et al, dairy products are considered as beneficial. The score thus ranges between zero and nine. The AHEI was adapted from McCullough et al.[12] In our study, the amount of *trans* fat could not be assessed, and we considered all participants taking multivitamins as taking them for a duration ≥5 years. Thus, the modified AHEI score ranged between 2.5 and 77.5 instead of 2.5 and 87.5 for the original AHEI score.[12] For all three scores, higher values represented a healthier diet.

Dietary patterns were derived using principal components analysis (PCA) based on food consumption frequencies. Three dietary patterns were identified: "Meat & fries", "Fruits & Vegetables" and "Fatty & sugary". Detailed description of assessment and characteristics of the dietary patterns is provided elsewhere.[25]

Other covariates

Socio-demographic and lifestyle data were collected by self-administered questionnaires. Educational level was categorized as low (primary), middle (apprenticeship or secondary school) and high (university). Smoking status was categorized as never, former (irrespective of the time since quitting) and current (irrespective of the amount smoked). Physical activity was assessed by a questionnaire validated in the population of Geneva.[26] This self-reported questionnaire assesses the type and duration of 70 kinds of (non)professional activities and sports during the previous week. Sedentary status was defined as spending more than 90% of the daily energy in activities below moderate- and high-intensity (defined as requiring at least 4 times the basal metabolic rate, BMR)[27] and categorized as a dichotomous variable (yes/no). BMR multiples are close to Metabolic Equivalent of Task (MET) multiples, although MET multiples do not take into account participant sex, age or height.

Body weight and height were measured with participants standing without shoes in light indoor clothing. Weight was measured in kilograms to the nearest 0.1 kg using a Seca™ scale

(Seca, Hamburg, Germany). Height was measured to the nearest 5 mm using a Seca™ height gauge (Seca, Hamburg, Germany). Body mass index (BMI) was defined as weight/height^2 and categorized as normal (BMI<25 kg/m^2); overweight (25≤ BMI <30 kg/m^2) and obese (BMI ≥30 kg/m^2). Due to small numbers (n=72), underweight participants (BMI<18.5 kg/m^2) were included in the "normal" category.

Exclusion criteria

Participants with the following characteristics were excluded: 1) No dietary data; 2) No socio-clinical data; 3) No inflammatory data; 4) Anti-inflammatory drugs; 5) Inflammation (CRP>20 mg/L); 6) Total energy intake (TEI) <850 or >4500 kcal/day. Missing data were not imputed.

Statistical analysis

Statistical analysis was performed using Stata version 15.1 for Windows (Stata Corp, College Station, Texas, USA). Participants characteristics were expressed as number (percentage) for categorical variables or as average ± standard deviation for continuous variables.

Bivariate associations were assessed using Spearman nonparametric rank correlation. Dietary markers significantly associated on bivariate analysis with inflammatory markers were further explored using multivariable analysis. Multivariable analysis was performed using linear regression adjusting for age (continuous), BMI (continuous), gender, smoking (never, former, current), educational level (high, middle, low), physical activity, diabetes (yes/no) and total caloric intake (continuous). Results were expressed as standardized linear regression coefficients, which can be interpreted as multivariable-adjusted correlations. For multivariable analyses, inflammatory markers were log-transformed.

The importance of dietary scores and patterns relative to single foods was further addressed by entering simultaneously in each model one dietary pattern and the foods significantly associated with inflammatory markers. Statistical significance was considered for a two-sided test with p<0.01.

Ethical statement

The institutional Ethics Committee of the University of Lausanne, which afterwards became the Ethics Commission of Canton Vaud (www.cer-vd.ch) approved the baseline CoLaus study (reference 16/03, decisions of 13th January and 10th February 2003); the approval was renewed for the first (reference 33/09, decision of 23rd February 2009) and the second (reference 26/14, decision of 11th March 2014) follow-up. The full decisions of the CER-VD can be obtained from the authors upon request. The study was performed in agreement with the Helsinki declaration and its former amendments, and in accordance with the applicable Swiss legislation. All participants gave their signed informed consent before entering the study.

RESULTS

Characteristics of the participants

Of the initial 5064 participants, 1037 (20.5%) were excluded. The reasons for exclusion are indicated in **figure 3.2.1** and the characteristics of excluded and included participants are summarized in **supplemental table 3.2.1**. Excluded participants were older, had a higher BMI, a lower education, and were prone to smoke, be sedentary and have diabetes.

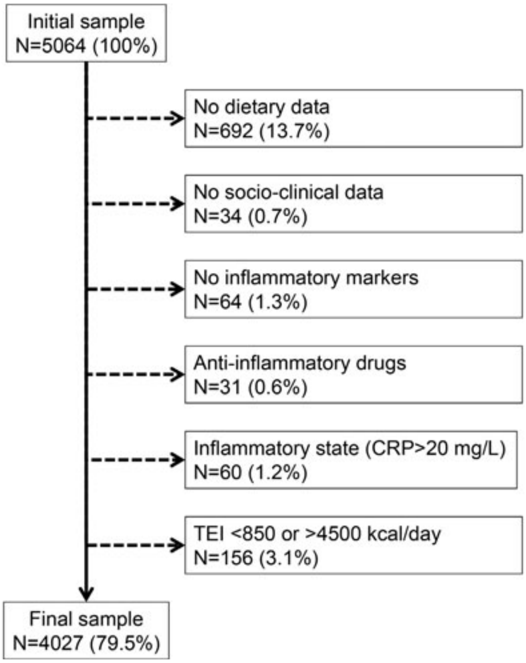

Figure 3.2.1: selection procedure. CRP, C-reactive protein; TEI, total energy intake.

Associations of individual nutrients with inflammatory markers

On bivariate analysis, polyunsaturated fat was positively associated with IL-6, and carotene was negatively associated with CRP and leucocyte count (**Table 3.2.1**). However, these relationships were no longer significant when adjusting for confounders (**Table 3.2.2**).

Associations of single foods with inflammatory markers

On bivariate analysis, fruits, carrots and tofu were negatively associated with CRP and leucocyte count; green salad, bananas, apples and kiwis were negatively associated with leucocyte count, while berries showed a negative association with IL-6 levels (**Table 3.2.1**). After multivariate adjustment, only the negative association between fruits and CRP retained statistical significance (**Table 3.2.2**).

Table 3.2.1: bivariate associations between inflammatory and dietary markers CoLaus study, Lausanne, Switzerland, 2009-2012.

	CRP	IL-6	TNF-α	Leucocytes
Total energy intake	-0.003	0.046	0.018	0.010
Macronutrients				
Total protein	-0.002	0.039	0.024	0.025
Vegetable protein	-0.040	0.030	-0.003	-0.031
Animal protein	0.018	0.031	0.033	0.049
Total carbohydrates	-0.031	0.023	0.008	-0.010
Monosaccharides	-0.036	0.007	-0.001	-0.015
Polysaccharides	-0.018	0.029	0.012	-0.008
Total fat	0.002	0.044	0.019	0.017
Saturated	0.009	0.035	0.035	0.024
Monounsaturated	-0.007	0.045	0.011	0.014
Polyunsaturated	0.034	0.057 *	0.011	0.041
Fibre	-0.049	0.015	-0.006	-0.055 *
Cholesterol	-0.007	0.019	0.003	0.010
Alcohol	-0.022	0.041	0.026	0.010
Micronutrients				
Calcium	-0.016	0.016	0.022	-0.029
Iron	-0.020	0.043	0.008	-0.013
Retinol	0.016	0.017	0.011	0.014
Carotene	-0.059 *	0.021	-0.012	-0.082 *
Vitamin D	-0.027	0.020	-0.002	-0.026
Vitamin A	-0.018	0.028	-0.005	-0.027
Food Items				
Fruits	-0.057 *	-0.009	-0.026	-0.065 *
Vegetables	-0.044	0.049	-0.007	-0.040
Fish	-0.040	0.019	-0.004	-0.020
Green beans	-0.016	0.004	0.000	0.008
Cauliflower	-0.026	0.032	-0.006	-0.022
Tomatoes	0.014	-0.005	0.005	0.009
Carrots	-0.057 *	0.017	0.000	-0.096 *
Green salad	-0.043	0.017	-0.020	-0.058 *
Thick vegetable soup	-0.031	0.032	-0.013	0.001
Tomato sauce	-0.026	0.004	-0.032	0.018
Tofu	-0.089 *	0.015	-0.022	-0.082 *
Bananas, apples	-0.036	-0.014	0.004	-0.054 *
Citrus fruits	-0.020	-0.002	-0.030	-0.022
Peaches, nectarines	0.027	-0.048	0.044	0.021
Berries	0.024	-0.055 *	-0.012	-0.022
Kiwis	-0.031	0.013	0.015	-0.079 *
Fresh fruit juice	-0.045	-0.035	-0.037	-0.011
Patterns				
Meat & fries	0.073 *	0.025	0.010	0.110 *
Fruits & Vegetables	-0.095 *	0.021	-0.036	-0.104 *
Fatty & sugary	0.016	0.002	0.005	0.015
Dietary scores				
Mediterranean §	-0.076 *	0.036	-0.025	-0.039
Mediterranean §§	-0.058 *	0.029	-0.016	-0.043
AHEI	-0.110 *	0.026	-0.020	-0.075 *

AHEI, alternate healthy eating index. §, Trichopoulou; §§, Vormund. Data from 4027 participants. Results are expressed as Spearman correlations. Significant (p<0.01) correlations are indicated with an asterisk.

Table 3.2.2: multivariable associations between selected inflammatory and dietary markers CoLaus study, Lausanne, Switzerland, 2009-2012.

	CRP (log)	IL-6 (log)	Leucocytes
Macronutrients			
Total fat	-	-	-
Monounsaturated	-	-	-
Polyunsaturated	-	0.005	-
Fibre	-	-	-0.028
Micronutrients			
Carotene	-0.037	-	-0.047
Food Items			
Fruits	-0.043 *	-	-0.026
Vegetables	-	-	-
Carrots	-0.037	-	-0.041
Green salad	-	-	-0.043
Tofu	-0.024	-	-0.013
Bananas, apples	-	-	-0.010
Berries		-0.004	
Kiwis	-	-	-0.016
Dietary patterns			
Meat & fries	0.033	-	0.035
Fruits & Vegetables	-0.079 *	-	-0.044
Fatty & sugary	-	-	-
Dietary scores			
Mediterranean §	-0.043 *	-	-
Mediterranean §§	-0.039	-	-
AHEI [1]	-0.067 *	-	-0.041

AHEI, alternate healthy eating index; §, Trichopoulou; §§, Vormund; -, not assessed. Data from 4027 participants. Results are expressed as standardized regression coefficients adjusted for age (continuous), body mass index (continuous), gender, smoking (never, former, current), educational level (high, middle, low), physical activity, diabetes (yes/no) and total caloric intake (continuous). Significant (p<0.01) associations are indicated with an asterisk.

Associations of dietary patterns and scores with inflammatory markers

On bivariate analysis, the “Meat & fries” pattern was positively associated and the “Fruits & Vegetables” pattern was negatively associated with CRP levels and leucocyte count (**Table 3.2.1**). After multivariable adjustment, only the negative associations between the “Fruits & Vegetables” pattern and CRP levels remained (**Table 3.2.2**).

On bivariate analysis, both Mediterranean scores and the AHEI were negatively associated with CRP levels; the AHEI was also negatively associated with leucocyte count (**Table 3.2.1**). After multivariable adjustment, only the negative associations between Trichopoulou’s Mediterranean score and the AHEI with CRP levels remained (**Table 3.2.2**).

When entered simultaneously with fruit intake, the “Fruits & Vegetables” pattern, the Trichopoulou’s Mediterranean score and the AHEI tended to remain significantly and negatively associated with CRP levels, while the association with fruit intake was no longer significant (**Supplemental table 3.2.2**).

DISCUSSION

This study is one of the few that compared the associations between different dietary parameters and inflammatory markers in the general population. Our results show that (un)healthy dietary behaviours are associated with inflammatory markers, while individual nutrients or foods aren't.

Associations of individual nutrients with inflammatory markers

Only a limited number of macro- and micronutrients were associated with inflammatory markers on bivariate analysis, and no significant association remained after adjustment for confounders. These findings are in agreement with Scottish study[15], which also failed to find any significant association between several micronutrients (flavonoids and antioxidants) and inflammatory markers. In addition, the lack of association between vitamin D intake and inflammatory markers matches an earlier study on Inuits, whose diet is known to be rich in this component.[28] Overall, our results suggest that most macro and micronutrients are not associated with inflammatory markers. Still, as no information was available regarding polyphenol intake, it was not possible to confirm the existing information on the anti-inflammatory properties of polyphenols.[3; 4]

Associations of single foods with inflammatory markers

Fruit intake was negatively associated with CRP levels, but not with IL-6, TNF-α or leucocyte count. The association with CRP remained after multivariable analysis, a finding in agreement with the literature.[29] A possible explanation is the high polyphenol content of fruits[30], which has been linked with a decrease in inflammation levels.[3; 4] Our results thus stress the need of an adequate consumption of fruit to decrease inflammatory levels.

Associations of dietary patterns and scores with inflammatory markers

The Mediterranean diet score was negatively associated with CRP levels, and this association persisted after multivariable adjustment. These findings are in agreement with previous studies[9; 31], suggesting that the beneficial effect of the Mediterranean diet on CVD might partly be linked to a decreased inflammatory status.

The AHEI was negatively associated with CRP levels. This finding is in agreement with some studies where the AHEI was inversely associated with CRP[32] or IL-6 levels[2; 13], but not with other studies which failed to find any association.[33; 34] A possible explanation for the lack of association in the latter studies is their relatively small sample size (<1000) which might have reduced statistical power.

Of the three dietary patterns obtained, only the "Fruits & Vegetables" one retained its negative association with CRP after multivariable adjustment. These findings are partly in agreement with other studies, which also assessed dietary patterns using PCA. Indeed, both the “health-aware” pattern from the Lothian Birth Cohort study[15] and the “prudent” pattern from the Aberdeen Prospective Osteoporosis Screening Study cohort[14], which scored high in fruits and vegetables, were negatively associated with CRP levels.

Interestingly, the “Fruits & Vegetables” pattern, the Trichopoulou’s Mediterranean score and the AHEI showed stronger negative associations with CRP levels than single fruit intake, indicating that their effects were due to not only a higher fruit intake, but also that other food items related to the pattern/score might intervene. Overall, our results suggest that a diet rich in fruits (but not only) is associated with lower inflammatory levels.

Importance for clinical practice

Many studies have focused on the associations between single nutrients or foods and inflammatory markers. Still, increasing or decreasing the consumption of specific nutrients or even of selected foods might be difficult to achieve in general practice. Our results indicate that dietary recommendations focused on the consumption of several food groups are more important than recommendations focused on specific foods or nutrients.[35] Hence, in clinical practice, generic recommendations could be provided, instead of focusing on specific foods or nutrients, which are difficult to identify and to integrate in a normal diet. This would facilitate dietary counselling by general practitioners, whose nutritional knowledge is usually low.[36]

Similarly, from a public health perspective, simple messages aimed at a healthier eating and increased consumption of fruits and vegetables[37] could be delivered. The impact of such measures in the general population could then be monitored by any of the scores (AHEI, Mediterranean or “Fruits and vegetables”) rather than by complex nutrient assessment.

Strengths and limitations

Our study has several strengths: firstly, it is one of the very few simultaneously comparing the effect of different dietary parameters on inflammatory markers.[15] Secondly, due to the population-based setting, our results can be transposed to other populations and practical recommendations can be used in public health and clinical practice.

This study also has several limitations. First, and as already indicated, no information regarding polyphenols was available. Hence, it was not possible to confirm previous findings.[3; 4] Future studies should rely either on an extensive food composition database or on the direct measurement of polyphenols in serum or urine. Second, the Mediterranean-diet score is based on a Greek population’s food consumption, and the scores obtained cannot be directly transposed to a Swiss population. Finally, we could not calculate the Dietary Inflammatory Index (DII), which is composed by a list of 45 items, mainly specific nutrients and spices[38] and is often used in recent literature on CVD and inflammation.[39] However, this score is based on food items[38] that are rarely collected in epidemiological studies and are dependent on the food composition table. Hence, its interest for public health or clinical practice is limited.

Conclusion

Our results show that healthy dietary behaviours, but not individual foods, are negatively associated with inflammatory markers in the general population.

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SUPPLEMENTAL MATERIAL

Supplemental table 3.2.1: Comparison between excluded and included participants, CoLaus study, Lausanne, Switzerland, 2009-2012.

	Included	Excluded	P-value
Sample size	4027	1037	
Gender (male)	1873 (46.5)	484 (46.7)	0.926
Age (years)	57.2 ± 10.2	60.0 ± 11.3	<0.001
Education			<0.001
High	930 (23.1)	149 (14.4)	
Middle	1083 (26.9)	223 (21.6)	
Low	2014 (50.0)	660 (64.0)	
BMI (kg/m^2)	26.0 ± 4.5	27.0 ± 5.1	<0.001
BMI categories			<0.001
Normal	1816 (45.1)	364 (37.5)	
Overweight	1570 (39.0)	390 (40.1)	
Obese	641 (15.9)	218 (22.4)	
Smoking status			<0.001
Current	1680 (41.7)	355 (36.2)	
Former	1528 (37.9)	355 (36.2)	
Never	819 (20.3)	270 (27.6)	
Sedentary	2078 (56.4)	327 (65.8)	<0.001
Diabetes	385 (9.6)	154 (15.1)	<0.001

BMI, body mass index. Results are expressed as number of participants (percentage) for categorical variables or as average ± standard deviation for continuous variables. Between group comparisons using chi-square for categorical variables or student's t-test for continuous variables.

Supplemental table 3.2.2: multivariate associations between selected dietary patterns or scores with C-reactive protein levels. CoLaus study, Lausanne, Switzerland, 2009-2012.

	Fruits & Vegetables	Mediterranean diet	AHEI
Fruit intake	-0.018 (0.322)	-0.032 (0.063)	-0.015 (0.399)
Selected score/pattern	-0.071 (<0.001)	-0.035 (0.027)	-0.061 (<0.001)

AHEI, alternate healthy eating index. Data from 4027 participants. Results are expressed as standardized regression coefficients and (p-value). Multivariable analysis adjusting for age (continuous), body mass index (continuous), gender, smoking (never, former, current), educational level (high, middle, low), physical activity, diabetes (yes/no) and total caloric intake (continuous).

CHAPTER 3.3

No association between diet markers and incident hypertension in a population-based sample

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3.3

ABSTRACT

Background/aim: Many trials have shown that dietary interventions reduce the incidence of hypertension. Whether these findings also apply in the general population is debated. We assessed the association between dietary markers and incidence of hypertension.

Design: prospective observational study.

Methods: Population-based study conducted between April 2009 and April 2017 in Lausanne, Switzerland. 2079 participants (60.6% women, 53.9±9.0 years, age range 40-80), devoid of hypertension at baseline, were followed for a median time of 63 months. Hypertension was defined as systolic BP≥140 mm Hg or diastolic BP≥90 mm Hg or anti-hypertensive medication. Self-reported dietary intake was assessed using a food frequency questionnaire. Analysis was conducted using logistic regression.

Results: 370 participants (17.8%) developed hypertension. On bivariate analysis, no association was found between all food items, dietary scores and compliance to dietary guidelines and incident hypertension. Similar findings were observed after multivariable analysis

Conclusion: Over a period of 5 years, one sixth of the Swiss population aged 40 to 80 developed hypertension. No association was found between dietary markers and incident hypertension. Current dietary behaviours are insufficient to prevent hypertension in the general population.

INTRODUCTION

Hypertension (HT) is a major problem for public health given its involvement as a risk factor in many diseases like cardiovascular diseases (CVD), renal failure, retinal and cerebral disorder. Moreover, the prevalence of HT has been increasing for years. In Switzerland, hypertension affects between one quarter[1] and one third[2] of the adult population, and its prevalence has remained stable over the last years[3]. Several guidelines have been created for HT prevention and management[4, 5]. These recommend changes in diet. Besides reduction in salt intake, other dietary recommendations include change in fatty acids, fibre, fruit and vegetable intake, and alcohol consumption[4, 5]. Importantly, interventions to reduce HT should not be focused on a particular nutrient like salt, but rather on the diet as a whole. Indeed, the effect of dietary intake is not limited to the sum of the individual effects of nutrients but relies on the complex interactions between nutrients and foods.

Most studies who showed a significant association between dietary intake and incidence of HT were intervention studies comparing a group where a strong and persistent change in dietary intake was applied to a control group[6]. The diets consumed by the intervention group are usually far from usual diets consumed by the general population and cannot be easily implemented in a more generalized setting. Conversely, studies assessing the association between dietary intake and incidence of HT in the general population are less frequent and the associations were considerably weaker[7, 8].

This study aimed at identifying the nutritional determinants of HT in a prospective population-based study conducted in healthy adults aged 40 to 80 years in Lausanne (Switzerland). Our hypothesis was that healthier eating behaviours would reduce the incidence of HT.

PARTICIPANTS AND METHODS

Subjects recruitment

The CoLaus Study (www.colaus.ch) was designed to assess the prevalence of cardiovascular risk factors and to identify new determinants of these risk factors in participants aged 35 to 75 years living in the city of Lausanne (Switzerland). The sampling procedure of the CoLaus Study was as follows: the source population was defined as all subjects aged between 35 and 75 years registered in the population register of the city of Lausanne. The register includes all subjects living in this city for more than 90 days. A simple, non-stratified random sample of 19’830 subjects (corresponding to 35% of the source population) was drawn and the selected subjects were invited to participate by letter. If no answer was obtained, a second letter was sent, and if no answer was obtained, the subjects were contacted by phone. The following inclusion criteria were applied: (a) written informed consent; (b) willingness to take part in the examination and to provide blood samples.

Recruitment began in June 2003 and ended in May 2006, enrolling 6733 total participants who underwent an interview, a physical exam, and a blood analysis. The first follow-up was performed between April 2009 and September 2012, 5.6 years on average after the collection of baseline data. The information collected was similar to that collected in the baseline examination but contained questions regarding food consumption and detailed physical activity information for the first time. The second follow-up was performed between May 2014 and April 2017, 10.9 years on average after the collection of baseline data, using similar methods to those in the first follow-up. As dietary intake was only assessed in the first follow-up, data for the first and the second follow-ups was used. Hence, in this analysis, the first follow-up (2009-2012) was considered as the baseline and age of participants thus ranged between 40 and 80 years.

Blood pressure measurement

Blood pressure (BP) and heart rate were measured thrice on the left arm after at least 10 minutes rest in the seated position using a clinically validated automated oscillometric device (Omron® HEM-907, Matsusaka, Japan) with a standard cuff, or a large cuff if arm circumference was ≥33 cm. The average of the last two BP readings was used. The same methodology was applied in the first and the second follow-ups. HT was defined as mean systolic BP (SBP) ≥140 mm Hg or mean diastolic BP (DBP) ≥90 mm Hg or anti-hypertensive medication. Incident HT was defined as presence of HT at follow-up (2014-2017) among participants without of HT at baseline (2009-2012).

Dietary intake

Dietary intake was assessed using a validated self-administered, semi quantitative Food Frequency Questionnaire (FFQ) which also included portion size 9. This FFQ has been validated against 24 hour recalls among 626 volunteers from the Geneva population[9] and data derived from this FFQ have recently contributed to worldwide analyses[10, 11]. To 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 one year have the same validity as FFQs assessing annual dietary intake[12]. Thus, the FFQ used in this study is the best possible option to assess dietary intake in the Swiss French speaking population. Briefly, this FFQ assesses the dietary intake of the previous 4 weeks and consists of 97 different food items accounting for more than 90% of the intake of calories, proteins, fat, carbohydrates, alcohol, cholesterol, vitamin D and retinol, and 85% of fibre, carotene and iron. 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 indicated the average serving size (smaller, equal or bigger) compared to a reference size. Daily consumption of the different food items was computed based on frequency and portion size and expressed in mL (for drinks) or in grams (for other foods). Conversion into nutrients was performed based on the French CIQUAL (Centre d'Information sur la QUalité des ALiments) food composition table taking into account portion size. No data regarding salt (sodium) content was available. For each food item of interest, gender-specific quartiles were computed.

Three dietary scores were computed, two based on the Mediterranean diet, the third on a modification of the alternative healthy eating index (AHEI). For all three scores, higher values represented a healthier diet. Prior to analysis, gender-specific quartiles for each score were computed.

The first Mediterranean dietary score (hereby designated as "Mediterranean score 1") was derived from Trichopoulou et al.[13]. The score uses consumption frequencies instead of amounts, and assigns a score of 0 or 1 to six food components using their sex-specific medians as cut-off. For four foods (vegetables, fruits, fish and cereals), values above the median were assigned the value of 1, while two foods (meat, dairy products), values below the median were assigned the value of 1. Two other items were considered: ratio of monounsaturated to saturated fats and moderate alcohol consumption (between 5 and 25 g/day for women and 10 and 50 g/day for men). The final score thus ranges between zero and eight.

The second Mediterranean dietary score (hereby designated as "Mediterranean score 2") is adapted to the Swiss population and was computed according to Vormund et al [14]. The scoring system is the same as for the Mediterranean score 1, except that nine items are considered: eight foods (fruits, vegetables, fish, cereal, salads, poultry, dairy products and wine) and monounsaturated fats. Contrary to the score from Trichopoulou et al, dairy products are considered as beneficial. The score thus ranges between zero and nine.

The AHEI was adapted from McCullough et al.[15]. This score is composed of nine items: vegetables, fruit, nuts and soy and alcohol consumption (as number of servings per day); ratio of white to red meat; cereal fibre (g/day); trans fat (% of energy); polyunsaturated to saturated fat ratio; and duration of multivitamin use. For each item, a value between 0 and 10 is given based on the consumption of the item, except for multivitamin use, where a three-value score is used (0, 2.5 and 7.5). In our study, the amount of trans fat could not be assessed, and we considered all participants taking multivitamins as taking them for a duration ≥5 years. Thus, the modified AHEI score ranged between 2.5 and 77.5 instead of 2.5 and 87.5 for the original AHEI score[15].

Participants were dichotomized according to whether they followed the dietary recommendations for fruits, vegetables, meat, fish and dairy products from the Swiss Society of Nutrition [16]. The recommendations were: ≥2 fruit portions/day; ≥3 vegetable portions/day; ≤5 meat portions/week; ≥1 fish portion/week and ≥3 dairy products portions/day.

Covariates

Age was used as a continuous variable. Body weight and height were measured while participants stood without shoes in light indoor attire. Body weight was measured in kilograms to the nearest 100 g using a Seca® scale (Hamburg, Germany) that was frequently calibrated. Height was measured to the nearest 5 mm using a Seca® (Hamburg, Germany) height gauge. Body mass index (BMI) was computed and categorized into normal (<25 kg/m^2), overweight (25-29.9 kg/m^2) and obese (≥30 kg/m^2).

Smoking status was self-reported and categorized as never, former and current. Educational level was categorized as university, high school, apprenticeship and mandatory. Physical activity was assessed by a questionnaire validated in the population of Geneva [17] and sedentary status was defined as spending more than 90% of the daily energy in activities below moderate- and high-intensity (defined as requiring at least 4 times the basal metabolic rate, BMR)[18].

Venous blood samples (50 mL) were drawn in the fasting state. Most biological assays were performed at the clinical laboratory of the Lausanne university hospital (CHUV) within 2 hours of blood collection on fresh samples. Glucose was assessed by glucose dehydrogenase with a maximum inter- and intra-assay CV of 2.1% and 1.0%, respectively. Diabetes was defined as fasting plasma glucose ≥7.0 mmol/L or presence of antidiabetic treatment (oral or insulin).

Exclusion criteria

We applied the following exclusion criteria: 1) No follow-up; 2) HT at the 2009-12 survey; 3) No blood pressure data in the 2009-12 and the 2014-17 surveys; 4) no dietary data; 5) Total energy intake (TEI) <500 or >3500 kcal/d for women and <800 or >4000 kcal/d for men[19] and 6) missing data for covariates (i.e. age, education, BMI, smoking and physical activity).

Ethical considerations

The institutional Ethics Committee of the University of Lausanne, which afterwards became the Ethics Commission of Canton Vaud (www.cer-vd.ch) approved the baseline CoLaus study (reference 16/03, decisions of 13th January and 10th February 2003); the approval was renewed for the first (reference 33/09, decision of 23rd February 2009) and the second (reference 26/14, decision of 11th March 2014) follow-up. The full decisions of the CER-VD can be obtained from the authors upon request. The study was performed in agreement with the Helsinki declaration and its former amendments. All participants gave their signed informed consent before entering the study.

Statistical analysis

Statistical analysis was performed using Stata version 15.1 for Windows (Stata Corp, College Station, Texas, USA). Participants' characteristics were expressed as number (percentage) for categorical variables, or as average±standard deviation for continuous variables. Bivariate analyses comparing the clinical characteristics of participants who developed HT and who did not were conducted using chi-square for categorical variables and student's t-test for continuous variables. Socio-demographic and clinical characteristics differing between participants with and without incident HT and known to affect dietary intake were included as confounding variables.

The incidence of HT was compared between gender-specific quartiles of dietary markers or between compliance/non-compliance to dietary guidelines. Bivariate analyses were conducted using chi-square, while multivariable analysis were conducted using logistic regression, the lowest quartile being used as reference. Multivariable analyses were adjusted for gender (man/woman), age (continuous), BMI categories (normal, overweight and obese), educational level (university, high school, apprenticeship and mandatory), sedentariness (yes/no), diabetes (yes/no) and total energy intake (continuous). Trends were assessed using the contrast p. command of Stata.

Two sensitivity analyses were also performed. The first one included baseline SBP and DBP as continuous covariates for adjustment. The second sensitivity analysis took into account that subjects who did not participate the follow-up differed from those who participated by a number of characteristics. Hence, a propensity score was computed using nonparticipation (coded as yes/no) as the dependent variable and gender, age, BMI, smoking, alcohol consumption, education, and physical activity as the independent variables. For each participant, the probability of nonparticipation was estimated and used in an inverse probability weighting model[20]. Statistical significance was considered for two-sided tests with a p-value <0.05.

RESULTS

Characteristics of the sample

Of the initial 5064 participants, 2079 (41% of the initial sample, 60.6% women, 53.9±9.0 years, age range 40-80) were retained for analysis. The reasons for exclusion are indicated in **figure 3.4.1**. The most frequent reasons for exclusion were baseline HT and lack of follow-up. The characteristics of included and excluded participants are indicated in **supplementary table 3.4.1**. Excluded participants were more frequently men, of lower educational level, obese, former smokers, sedentary or with diabetes than included ones; excluded participants were also older and with a higher BMI.

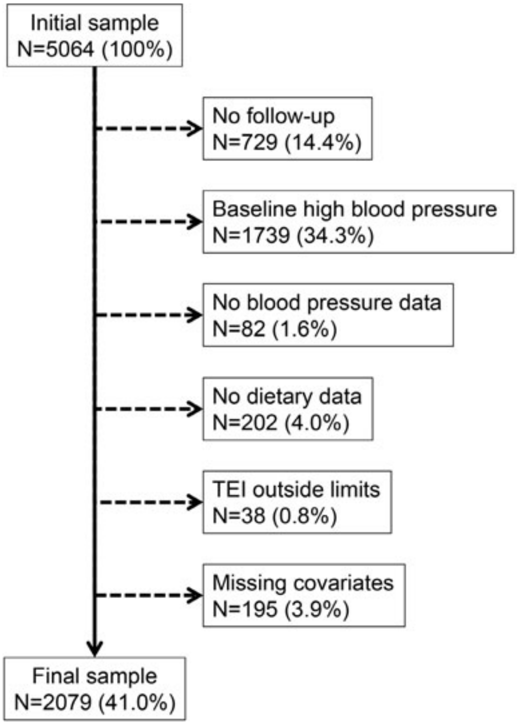

Figure 3.4.1: selection procedure of the participants, CoLaus study, Lausanne, Switzerland.

Dietary determinants of incident hypertension

After a median follow-up time of 64 months [IQR: 61-65], 370 participants (17.8%, 95% CI 16.2-19.5) developed HT. The socio-demographic characteristics of the participants who developed and did not develop HT during follow-up are indicated in **table 3.4.1**. Overall, Participants who developed HT were more frequently men, with a lower educational level, with a sedentary status or with diabetes that participants who did not; participants who developed HT were also older and had a higher BMI.

In both bivariate and multivariable analyses, no association was found between consumption of specific food items or an increasingly healthy diet with incident HT: **tables 3.4.2** (bivariate) and **3.4.3** (multivariable). Sensitivity analyses adjusting for baseline BP levels (**supplementary table 3.4.2**) or using inverse probability weighting (**supplementary table 3.4.3**) led to similar findings.

NO association was found between compliance to dietary guidelines and incident HT, both on bivariate and multivariable analyses (**table 3.4.4**). Sensitivity analyses adjusting for baseline BP levels (**supplementary table 3.4.4**) or using inverse probability weighting (**supplementary table 3.4.5**) led to similar findings.

Table 3.4.1: Characteristics of the participants who developed and did not develop hypertension during follow-up, CoLaus study, Lausanne, Switzerland, 2009-2017.

Hypertension	**No**	**Yes**	**P-value**
Sample size	1709	370	
Gender (male)	652 (38.2)	166 (44.9)	0.017
Age (years)	53.4 ± 8.9	56.0 ± 9.3	<0.001
Education			0.018
University	480 (28.1)	89 (24.1)	
High school	504 (29.5)	92 (24.9)	
Apprenticeship	533 (31.2)	133 (36.0)	
Mandatory	192 (11.2)	56 (15.1)	
BMI (kg/m^2)	24.5 ± 3.8	26.0 ± 3.9	<0.001
BMI categories			<0.001
Normal	1033 (60.4)	157 (42.4)	
Overweight	553 (32.4)	164 (44.3)	
Obese	123 (7.2)	49 (13.2)	
Smoking status			0.145
Never	751 (43.9)	149 (40.3)	
Former	578 (33.8)	145 (39.2)	
Current	380 (22.2)	76 (20.5)	
Sedentary	873 (51.1)	217 (58.7)	0.008
Diabetes	50 (2.9)	28 (7.6)	<0.001

BMI, body mass index. Incident HT was defined as presence of HT at follow-up among participants without HT at baseline. Results are expressed as number of participants (percentage) for categorical variables or as average ± standard deviation for continuous variables. Between group comparisons using chi-square for categorical variables or student's t-test for continuous variables.

Table 3.4.2: Bivariate analysis of the association between quartiles of dietary intake and dietary scores and incident hypertension, CoLaus study, Lausanne, Switzerland, 2009-2017.

	First	**Second**	**Third**	**Fourth**	**P-value**
Food items					
Fruits	95 (18.2)	94 (18.1)	79 (15.2)	102 (19.7)	0.279
Vegetables	98 (18.8)	83 (16.0)	97 (18.7)	92 (17.7)	0.605
Red meat	86 (16.3)	90 (17.4)	95 (18.1)	99 (19.4)	0.622
Processed meat	114 (19.6)	88 (17.9)	77 (15.4)	91 (18.0)	0.368
Fish (all)	94 (18.0)	94 (18.0)	99 (17.9)	83 (17.2)	0.986
Fish (excluding fried)	104 (19.2)	99 (16.8)	77 (17.7)	90 (17.5)	0.781
Dairy products	100 (19.2)	84 (16.2)	87 (16.7)	99 (19.1)	0.470
Refined products	106 (20.1)	98 (17.4)	90 (17.5)	76 (16.0)	0.385
Wholegrain products	102 (18.9)	104 (19.3)	82 (16.0)	82 (16.8)	0.426
Dietary scores					
Mediterranean score 1	144 (18.6)	98 (19.1)	71 (15.3)	57 (17.3)	0.400
Mediterranean score 2	97 (16.8)	141 (19.7)	73 (19.2)	59 (14.6)	0.130
Alternative healthy eating index	98 (17.9)	95 (19.6)	86 (16.7)	87 (17.4)	0.656

Incident hypertension was defined as presence of hypertension at follow-up among participants without hypertension at baseline. Results are expressed as number of participants (percentage). Between group comparisons using chi-square.

Table 3.4.3: Multivariable analysis of the association between quartiles of dietary intake and dietary scores and incident hypertension, CoLaus study, Lausanne, Switzerland, 2009-2017.

	First	Second	Third	Fourth	P-value for trend
Food items					
Fruits	1 (ref.)	1.01 (0.73 - 1.40)	0.85 (0.61 - 1.20)	1.10 (0.78 - 1.55)	0.842
Vegetables	1 (ref.)	0.86 (0.62 - 1.20)	1.06 (0.77 - 1.47)	0.95 (0.67 - 1.33)	0.935
Red meat	1 (ref.)	1.08 (0.77 - 1.50)	1.12 (0.81 - 1.56)	1.22 (0.87 - 1.71)	0.240
Processed meat	1 (ref.)	0.83 (0.60 - 1.13)	0.73 (0.52 - 1.01)	0.86 (0.62 - 1.18)	0.263
Fish (all)	1 (ref.)	1.06 (0.77 - 1.47)	1.04 (0.75 - 1.44)	0.97 (0.69 - 1.37)	0.858
Fish (excluding fried)	1 (ref.)	0.87 (0.64 - 1.19)	0.96 (0.69 - 1.35)	0.98 (0.71 - 1.36)	0.942
Dairy products	1 (ref.)	0.85 (0.61 - 1.19)	0.88 (0.63 - 1.23)	1.00 (0.71 - 1.41)	0.951
Refined products	1 (ref.)	0.90 (0.65 - 1.23)	0.88 (0.63 - 1.21)	0.76 (0.53 - 1.08)	0.134
Wholegrain products	1 (ref.)	1.09 (0.80 - 1.49)	0.85 (0.61 - 1.18)	0.94 (0.67 - 1.33)	0.447
Dietary scores					
Mediterranean score 1	1 (ref.)	1.06 (0.79 - 1.42)	0.86 (0.62 - 1.19)	0.96 (0.68 - 1.37)	0.567
Mediterranean score 2	1 (ref.)	1.20 (0.89 - 1.63)	1.26 (0.87 - 1.80)	0.88 (0.59 - 1.32)	0.612
Alternative healthy eating index	1 (ref.)	1.18 (0.85 - 1.63)	0.94 (0.68 - 1.32)	1.00 (0.70 - 1.41)	0.689

Incident hypertension was defined as presence of hypertension at follow-up among participants without hypertension at baseline. Results are expressed as multivariable-adjusted odds ratio and (95% confidence interval), and comparisons were performed using logistic regression adjusting for gender (man/woman), age (continuous), BMI categories (normal, overweight and obese), educational level (university, high school, apprenticeship and mandatory), sedentariness (yes/no), diabetes (yes/no) and total energy intake (continuous).

Table 3.4.4: Bivariate and multivariable analysis of the association between compliance to dietary guidelines and incident hypertension, CoLaus study, Lausanne, Switzerland, 2009-2017.

Compliance	**No**	**Yes**	**P-value**
Fruits ≥2/day			
Bivariate	210 (17.4)	160 (18.4)	0.548
Multivariable	1 (ref.)	1.09 (0.85 - 1.40)	0.477
Vegetables ≥3/day			
Bivariate	344 (17.9)	26 (16.5)	0.647
Multivariable	1 (ref.)	0.95 (0.61 - 1.50)	0.837
Meat ≤5/week			
Bivariate	149 (18.5)	221 (17.4)	0.527
Multivariable	1 (ref.)	1.00 (0.78 - 1.29)	0.987
Fish ≥1/week			
Bivariate	123 (17.5)	247 (18.0)	0.781
Multivariable	1 (ref.)	1.06 (0.83 - 1.37)	0.623
Fish (excl. fried) ≥2/week			
Bivariate	215 (17.6)	155 (18.1)	0.741
Multivariable	1 (ref.)	1.13 (0.89 - 1.43)	0.324
Dairy ≥3/day			
Bivariate	339 (17.8)	31 (17.6)	0.947
Multivariable	1 (ref.)	0.91 (0.59 - 1.40)	0.663
At least three guidelines §			
Bivariate	282 (17.9)	88 (17.5)	0.820
Multivariable	1 (ref.)	1.01 (0.77 - 1.34)	0.923
At least three guidelines §§			
Bivariate	301 (17.6)	69 (18.5)	0.696
Multivariable	1 (ref.)	1.13 (0.83 - 1.55)	0.425

§, including fried fish; §§, excluding fried fish. Incident hypertension was defined as presence of hypertension at follow-up among participants without hypertension at baseline. For bivariate analyses, results are expressed as number of participants (percentage) and between-group comparisons were performed using chi-square. For multivariable analyses, results are expressed as multivariable-adjusted odds ratio and (95% confidence interval), and comparisons were performed using logistic regression adjusting for gender (man/woman), age (continuous), BMI categories (normal, overweight and obese), educational level (university, high school, apprenticeship and mandatory), sedentariness (yes/no), diabetes (yes/no) and total energy intake (continuous).

DISCUSSION

No association was found between all dietary markers and incidence of HT on bivariate and multivariable analyses. Although these findings do not replicate those from intervention studies[21], they are in agreement with studies conducted in the general population. For instance, in the SUN study[7, 22], no association between Mediterranean diet and incidence of hypertension was found, mostly because of the homogeneity between subjects regarding dietary intake. In the Framingham Offspring study[23], no association between the DASH diet and incidence of hypertension was found after a 13.4 years follow-up. As previously suggested[22, 23], the most likely explanation is that the differences in dietary intake observed in the general population are too small to exert a significant effect on incidence of HT. Another explanation would be the fact that all associations were adjusted for gender, age and BMI, which are major determinants of HT. Indeed, in another study conducted in Switzerland, the association between 24-urinary salt excretion and BP became non-significant after adjusting for BMI[24].

No association was found between wholegrain products and incident HT, a finding contradicting the existing literature[25, 26]. A possible explanation is that our study was considerably smaller (2046 vs. 13,368 and 31,684) and of shorter duration (5.6 vs. 16.3 and 18 years) than the studies that reported the association[25,26]. Similarly, no association was found between meat or processed meat and incident HT, a finding contradicting a recent meta-analysis, where both red processed and unprocessed meat were found to be associated with incident HT[8]. Overall, our study failed to identify an association between specific food items and incident HT. The ongoing follow-up of the cohort will allow a longer follow-up time and might eventually change the conclusions.

No association was found between compliance to the Swiss dietary guidelines and incident HT. A possible explanation is that compliance to the guidelines is rather modest and fluctuates with time[27], with little impact on the development of HT.

Study strengths and limitations

Contrary to most studies that focused on specific foods[26,28-32], this is one of the few prospective studies assessing the association between several markers of dietary intake and incident HT.

This study also has several limitations: first, it was based on a regional sample drawn from the French-speaking part of Switzerland. Hence, it might not be representative of the German or Italian speaking parts of the country, and it would be important that such a study be conducted in those parts of Switzerland. Second, follow-up time was rather short (5.6 years) compared to other studies[23,33], but similar to others[34]. Third, it was not possible to estimate the amount of salt intake, and a previous study has shown that high salt intake is associated with higher SBP and HT levels[35]. Hence, the impact of increased salt intake could not be assessed.

Public health impact

Our results show that current dietary behaviours are insufficient to prevent HT in the general population. If dietary interventions are to be performed in the general population to prevent HT, then the resulting changes need to be considerable. Possible interventions could focus either on reducing salt intake, or promoting (low-fat) dairy products. Indeed, compliance to recommendations for dairy products is low in Switzerland[38], and dairy products have other beneficial effects such as preventing osteoporosis.

Conclusion

Over a period of 5 years, one sixth of the Swiss population aged 40 to 80 developed hypertension. No association was found between dietary markers and incident hypertension. Current dietary behaviours are insufficient to prevent hypertension in the general population.

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SUPPLEMENTAL DATA

Supplemental table 3.4.1: Comparison between excluded and included participants, CoLaus study, Lausanne, Switzerland, 2009-2012.

	Included	**Excluded**	**P-value**
Sample size	2079	2985	
Gender (male)	818 (39.4)	1539 (51.6)	<0.001
Age (years)	53.9 ± 9.0	60.5 ± 10.7	<0.001
Education			<0.001
University	569 (27.4)	510 (17.1)	
High school	596 (28.7)	710 (23.8)	
Apprenticeship	666 (32)	1130 (37.9)	
Mandatory	248 (11.9)	630 (21.1)	
BMI (kg/m2)	24.7 ± 3.9	27.2 ± 4.8	<0.001
BMI categories			<0.001
Normal	1190 (57.2)	990 (33.9)	
Overweight	717 (34.5)	1243 (42.6)	
Obese	172 (8.3)	687 (23.5)	
Smoking status			<0.001
Never	900 (43.3)	1135 (38.8)	
Former	723 (34.8)	1160 (39.6)	
Current	456 (21.9)	633 (21.6)	
Sedentary	1090 (52.4)	1315 (62.6)	<0.001
Diabetes	78 (3.8)	461 (15.5)	<0.001

BMI, body mass index. Results are expressed as number of participants (percentage) for categorical variables or as average ± standard deviation for continuous variables. Between group comparisons using chi-square for categorical variables or student's t-test for continuous variables.

Supplemental table 3.4.2: Multivariable analysis of the association between quartiles of dietary intake and dietary scores and incident hypertension, with further adjustment on baseline blood pressure, CoLaus study, Lausanne, Switzerland, 2009-2017.

	First	Second	Third	Fourth	P-value for trend
Food items					
Fruits	1 (ref.)	1.05 (0.74 - 1.49)	0.89 (0.62 - 1.27)	1.09 (0.75 - 1.57)	0.898
Vegetables	1 (ref.)	0.84 (0.59 - 1.19)	1.11 (0.79 - 1.58)	0.95 (0.66 - 1.38)	0.811
Red meat	1 (ref.)	1.06 (0.74 - 1.51)	1.03 (0.72 - 1.47)	1.17 (0.81 - 1.68)	0.463
Processed meat	1 (ref.)	0.78 (0.55 - 1.10)	0.66 (0.46 - 0.93)	0.85 (0.60 - 1.19)	0.230
Fish (all)	1 (ref.)	0.96 (0.68 - 1.36)	0.97 (0.68 - 1.37)	0.90 (0.62 - 1.30)	0.598
Fish (excluding fried)	1 (ref.)	0.85 (0.61 - 1.19)	0.89 (0.62 - 1.28)	0.96 (0.68 - 1.36)	0.895
Dairy products	1 (ref.)	0.75 (0.53 - 1.07)	0.85 (0.60 - 1.22)	1.00 (0.69 - 1.44)	0.840
Refined products	1 (ref.)	0.81 (0.58 - 1.14)	0.86 (0.61 - 1.22)	0.72 (0.49 - 1.06)	0.134
Wholegrain products	1 (ref.)	1.13 (0.81 - 1.58)	0.76 (0.53 - 1.08)	0.86 (0.59 - 1.24)	0.150
Dietary scores					
Mediterranean score 1	1 (ref.)	1.02 (0.74 - 1.40)	0.79 (0.56 - 1.12)	0.92 (0.63 - 1.34)	0.417
Mediterranean score 2	1 (ref.)	1.19 (0.86 - 1.64)	1.21 (0.82 - 1.79)	0.85 (0.56 - 1.31)	0.501
Alternative healthy eating index	1 (ref.)	1.29 (0.91 - 1.82)	0.97 (0.68 - 1.39)	1.00 (0.69 - 1.45)	0.648

Incident hypertension was defined as presence of hypertension at follow-up among participants without hypertension at baseline. Results are expressed as multivariable-adjusted odds ratio and (95% confidence interval), and comparisons were performed using logistic regression adjusting for gender (man/woman), age (continuous), BMI categories (normal, overweight and obese), educational level (university, high school, apprenticeship and mandatory), sedentariness (yes/no), diabetes (yes/no), total energy intake (continuous), systolic and diastolic blood pressure at baseline (continuous).

Supplemental table 3.4.3: Multivariable analysis of the association between quartiles of dietary intake and dietary scores and incident hypertension, with inverse probability weighting for exclusion, CoLaus study, Lausanne, Switzerland, 2009-2017.

	First	Second	Third	Fourth	P-value for trend
Food items					
Fruits	1 (ref.)	1.02 (0.73 - 1.41)	0.85 (0.60 - 1.20)	1.11 (0.79 - 1.57)	0.813
Vegetables	1 (ref.)	0.85 (0.61 - 1.19)	1.03 (0.73 - 1.43)	0.93 (0.65 - 1.33)	0.957
Red meat	1 (ref.)	1.00 (0.71 - 1.42)	1.15 (0.82 - 1.60)	1.23 (0.88 - 1.73)	0.166
Processed meat	1 (ref.)	0.84 (0.61 - 1.16)	0.73 (0.52 - 1.02)	0.80 (0.58 - 1.12)	0.140
Fish (all)	1 (ref.)	1.08 (0.77 - 1.51)	1.08 (0.78 - 1.51)	0.97 (0.68 - 1.39)	0.879
Fish (excluding fried)	1 (ref.)	0.87 (0.63 - 1.19)	0.97 (0.68 - 1.36)	0.96 (0.69 - 1.34)	0.993
Dairy products	1 (ref.)	0.83 (0.60 - 1.17)	0.88 (0.63 - 1.23)	1.00 (0.71 - 1.42)	0.925
Refined products	1 (ref.)	0.89 (0.64 - 1.23)	0.85 (0.61 - 1.19)	0.75 (0.52 - 1.07)	0.113
Wholegrain products	1 (ref.)	1.07 (0.78 - 1.48)	0.83 (0.59 - 1.16)	0.92 (0.64 - 1.30)	0.361
Dietary scores					
Mediterranean score 1	1 (ref.)	1.10 (0.82 - 1.48)	0.88 (0.63 - 1.22)	0.92 (0.64 - 1.33)	0.433
Mediterranean score 2	1 (ref.)	1.20 (0.88 - 1.62)	1.22 (0.85 - 1.76)	0.90 (0.60 - 1.34)	0.632
Alternative healthy eating index	1 (ref.)	1.24 (0.89 - 1.72)	0.89 (0.63 - 1.26)	1.01 (0.71 - 1.44)	0.609

Incident hypertension was defined as presence of hypertension at follow-up among participants without hypertension at baseline. Results are expressed as multivariable-adjusted odds ratio and (95% confidence interval), and comparisons were performed using logistic regression adjusting for gender (man/woman), age (continuous), BMI categories (normal, overweight and obese), educational level (university, high school, apprenticeship and mandatory), sedentariness (yes/no), diabetes (yes/no) and total energy intake (continuous). Inverse probability weighting using a propensity score for being excluded.

Supplemental table 3.4.4: Multivariable analysis of the association between compliance to dietary guidelines and incident hypertension, with further adjustment on baseline blood pressure, CoLaus study, Lausanne, Switzerland, 2009-2017.

Compliance	No	Yes	P-value
Fruits ≥2/day	1 (ref.)	1.09 (0.83 - 1.42)	0.532
Vegetables ≥3/day	1 (ref.)	1.04 (0.64 - 1.68)	0.889
Meat ≤5/week	1 (ref.)	1.03 (0.79 - 1.35)	0.820
Fish ≥1/week	1 (ref.)	1.05 (0.81 - 1.37)	0.713
Fish (excl. fried) ≥1/week	1 (ref.)	1.12 (0.87 - 1.45)	0.378
Dairy ≥3/day	1 (ref.)	1.03 (0.65 - 1.62)	0.912
At least three guidelines §	1 (ref.)	1.05 (0.77 - 1.42)	0.766
At least three guidelines §§	1 (ref.)	1.05 (0.76 - 1.47)	0.758

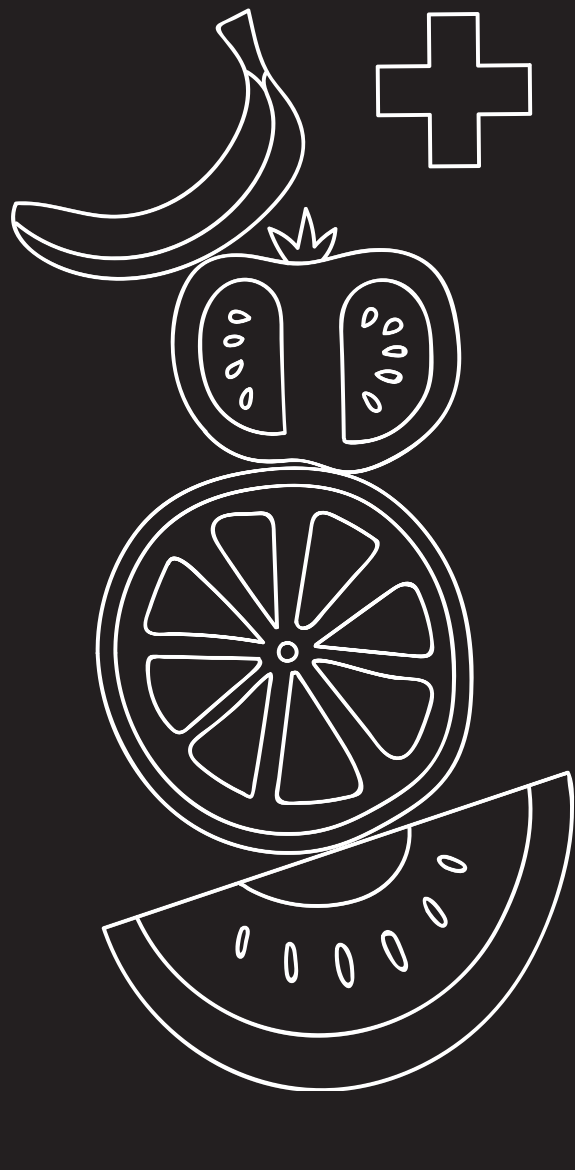
§, including fried fish; §§, excluding fried fish. Incident hypertension was defined as presence of hypertension at follow-up among participants without hypertension at baseline. Results are expressed as multivariable-adjusted odds ratio and (95% confidence interval), and comparisons were performed using logistic regression adjusting for gender (man/woman), age (continuous), BMI categories (normal, overweight and obese), educational level (university, high school, apprenticeship and mandatory), sedentariness (yes/no), diabetes (yes/no), total energy intake (continuous), systolic and diastolic blood pressure at baseline (continuous).

Supplemental table 3.4.5: Multivariable analysis of the association between compliance to dietary guidelines and incident hypertension, with inverse probability weighting for exclusion, CoLaus study, Lausanne, Switzerland, 2009-2017.

Compliance	No	Yes	P-value
Fruits ≥2/day	1 (ref.)	1.09 (0.85 - 1.4)	0.511
Vegetables ≥3/day	1 (ref.)	0.94 (0.59 - 1.48)	0.779
Meat ≤5/week	1 (ref.)	0.95 (0.74 - 1.23)	0.694
Fish ≥1/week	1 (ref.)	1.07 (0.83 - 1.38)	0.598
Fish (excl. fried) ≥1/week	1 (ref.)	1.11 (0.87 - 1.42)	0.400
Dairy ≥3/day	1 (ref.)	0.91 (0.59 - 1.41)	0.676
At least three guidelines §	1 (ref.)	1.01 (0.76 - 1.34)	0.964
At least three guidelines §§	1 (ref.)	1.12 (0.82 - 1.54)	0.473

§, including fried fish; §§, excluding fried fish. Incident hypertension was defined as presence of hypertension at follow-up among participants without hypertension at baseline. Results are expressed as multivariable-adjusted odds ratio and (95% confidence interval), and comparisons were performed using logistic regression adjusting for gender (man/woman), age (continuous), BMI categories (normal, overweight and obese), educational level (university, high school, apprenticeship and mandatory), sedentariness (yes/no), diabetes (yes/no) and total energy intake (continuous), Inverse probability weighting using a propensity score for being excluded.

CHAPTER 4



Dietary prevention of cardiometabolic diseases

4

CHAPTER 4.1

Patients with dyslipidemia on a self-reported diet have a healthier dietary intake than the general population: the CoLaus study

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4.1

ABSTRACT

Background & aims: Dietary measures complement hypolipidemic drug treatment, but little is known regarding the nutritional content of reported hypolipidemic diets in the general population. Thus, we characterized the dietary intake of subjects aged 40e80 years according to awareness of dyslipidemia and presence of a hypolipidemic diet.

Methods: Cross-sectional study conducted between 2009 and 2012 on 4289 participants (2274 women) living in Lausanne, Switzerland; 1370 (32%) reported a diagnosis of dyslipidemia, of whom 242 (18%) reported a hypolipidemic diet. Dietary intake was assessed using a validated food frequency questionnaire.

Results: Compared to participants aware of dyslipidemia not on a diet, those on a diet consumed significantly more fruits (mean ± standard deviation: 2.5 ± 1.9 vs. 1.9 ± 1.7 portions/day), vegetables (1.6 ± 1.0 vs. 1.4 ± 0.9 portions/day) and fish (1.9 ± 1.4 vs. 1.6 ± 1.1 portions/week) and less meat (4.5 ± 2.7 vs. 5.2 ± 2.9 portions/week). They also had a significantly higher intake of total carbohydrates (50.1 ± 8.6 vs. 47.1 ± 8.3% of total energy intake e TEI), monounsaturated (39.9 ± 5.4 vs. 39.4 ± 4.3% total fat) and polyunsaturated (15.6 ± 4.3 vs. 14.2 ± 4.1% of total fat) fatty acids and a lower intake of total fat (34.2 ± 7.4 vs. 36.6 ± 7.0% of TEI) and saturated fatty acids (35.1 ± 6.2 vs. 37.8 ± 5.7% of total fat). Participants aware and on a diet met more nutritional recommendations of the Swiss Society of Nutrition (2.1 ± 1.0 vs. 1.7 ± 0.9, $p < 0.001$) than participants not on a diet.

Conclusion: When implemented, hypolipidemic diets lead to a healthier dietary intake than in the general population.

INTRODUCTION

Cardiovascular disease (CVD) is the main cause of premature death worldwide, with a considerable health and economic burden[1]. Several studies have shown that a healthy diet improves lipids independently of lipid medication.[2, 3] Still, only a limited percentage of patients with dyslipidemia actually comply with dietary guidelines.[4] Several reasons for noncompliance have been identified among patients, namely lack of conviction regarding the efficiency of the diet, lack of motivation to change ones diet, belief that one's diet is already adequate, difficulties in conciliating diet with family life and taking hypolipidemic drugs.[4, 5] Indeed, a recent study conducted in the USA suggested that the quality of dietary intake has decreased among patients on statins, with an increased caloric and fat intake among statin users compared to nonusers.[6] Similarly, the non-provision of dietary counselling by doctors could be related to lack of time, difficulty in implementation and underestimation of the importance of cholesterol management. [7-9]

Switzerland is a small European country characterized by a low mortality from CVD. We have previously shown that compliance with dietary recommendations in the general population was low[10, 11], but to our knowledge no information existed regarding dietary intake and/or compliance with dietary recommendations of patients aware of dyslipidemia. Thus, we aimed to characterize the dietary intake of subjects aged 40-80 years according to awareness of dyslipidemia and presence or absence of a hypolipidemic diet.

PARTICIPANTS AND METHODS

Participants

The rationale, sampling and follow-up procedures of the CoLaus study have been described previously.[12, 13] Briefly, the complete list of Lausanne inhabitants aged 35-75 years (n=56,694) was provided by the population registry of the city. Lausanne is a multicultural city with 40% non-Swiss residents[14] and 80% French speakers.[15] A simple, nonstratified random sample of 35% of the overall population was drawn. The following inclusion criteria were applied: (a) age 35-75 years and (b) willingness to take part in the examination and to donate blood samples. Recruitment began in June 2003 and ended in May 2006. Participation rate was 41%.

The first follow-up took place between April 2009 and September 2012 and included all participants of the baseline study willing to participate to the follow-up[13], corresponding to 75% of the initial baseline sample. We only consider data from the follow- up examination as dietary intake assessment was first introduced here.

Dietary intake

Dietary intake was assessed using a self-administered, validated semi quantitative Food Frequency Questionnaire (FFQ) which also included portion size.[16, 17] This FFQ assesses the dietary intake during the previous 4 weeks of 97 different food items which ac- count for more than 90% of the intake of calories, proteins, fat, carbohydrates, alcohol, cholesterol, vitamin D and retinol, and 85% of fibres, carotene and iron. For each item, consumption frequencies ranging from "less than once during the last 4 weeks" to "2 or more times per day" were provided. Participants were also asked to indicate the average serving size (smaller, equal or bigger) compared to a reference size. The FFQ was checked for completion by trained interviewers the day of the visit. To our knowledge, there is no FFQ (validated or not) assessing dietary intake for the whole year in Switzerland; the other available and validated FFQ also assesses the dietary intake of the previous month.[18] Hence, this FFQ provides the best dietary assessment currently available.

Reported food consumption frequencies were converted into daily or weekly consumptions as follows: "never these last 4 weeks" = 0; "once/month" = 1/28; "2e3/month" = 2.5/28; "1-2/ week" = 1.5/7; "3-4 times/week" = 3.5/7; "once/day" = 1 and "2+/ day" = 2.5. The frequency of consumption of one food category was obtained by summing up all consumption frequencies of the foods in that category.

Conversion into nutrients was performed based on the French CIQUAL food composition table. Two values for total energy intake (TEI) were computed: one including alcohol consumption, the other not. Total protein, carbohydrate and fat were expressed as percentage of TEI (alcohol excluded). Animal protein was expressed as percentage of total protein; simple sugars (disaccharides) were expressed as percentage of total carbohydrates; saturated (SFA), mono- (MUFA) and polyunsaturated (PUFA) fatty acids were expressed as percentage of total fat.

Compliance with the dietary recommendations of the Swiss Society of Nutrition[19-21] was computed as previously described.[10] These recommendations are in agreement with food-based guidelines of other countries and have also been officially endorsed by the Swiss government.[19, 21] The recommendations regarding food intake are: ≥2 fruit portions/day; ≥3 vegetable portions/day; £5 portions meat/week; ≥1 portion fish/ week and ≥3 portions dairy products/day. Compliance with the recommendation for fish was assessed in two ways: considering all types of fish (including fried and canned), or fresh fish only. Regarding nutrient intake, only the following recommendations were considered: total fat < 30% TEI; SFA < 10% TEI; MUFA > 10% TEI; PUFA > 10% TEI; cholesterol < 300 mg/day and fibre > 30 g/day.[19] Alcohol consumption was considered as acceptable if <20 g/day for men and <10 g/day for women.[22] For each recommendation, a binary variable (1=yes, 0=no) was computed, and the total number of recommendations complied to was summed up.

Other methods

All participants attended the outpatient clinic of the University Hospital of Lausanne in the morning after an overnight fast. Participants were seen during a single visit which included an interview, a physical assessment, and blood and urine collections in the fasting state. Data were collected by trained field interviewers in a single visit lasting about 60 min. Participants attending the examination were apparently free from an acute disease. If they presented an acute disease, another examination was scheduled. Participants had to restrain from heavy exercise and to maintain their usual diet the day before testing. Participants were asked regarding their personal and family history of disease. Medicines (either self-prescribed or prescribed by a doctor) were identified by requesting participants to bring all the medicines they were currently taking to the visit.

Nationality was categorized into Swiss and the four most frequent nationalities (providing at least 100 participants): French, Italian, Portuguese and Spanish; the other 20+ nationalities were grouped together as the number of participants for each nationality was small.

Diagnosis of dyslipidemia was defined by a positive answer to the question "Have you ever been told that your cholesterol level was too high (hypercholesterolaemia)". Presence of diet against dyslipidemia was defined as a positive answer to the question "Are you currently on a low-fat diet/diet against cholesterol?". No information was collected whether the diet was self- or doctor- prescribed or regarding noncompliance with a previously pre- scribed diet. Hypolipidemic drug treatment was assessed by asking the participants to bring all self- or doctor-prescribed medicines currently taken. Diagnosis of diabetes was defined by a positive answer to the question "Have you ever been told that you had diabetes?". As management of diabetes includes dietary recommendations[23, 24], it was expected that participants with diabetes would have a higher likelihood of receiving dietary counselling and thus to have a healthier diet than participants without diabetes.

Body weight and height were measured with participants standing barefoot and in light indoor clothes. Body weight was measured in kilograms to the nearest 100 g using a Seca® scale, which was calibrated regularly. Height was measured to the nearest 5 mm using a Seca® height gauge. Overweight was defined as a body mass index (BMI) ≥25 and <30 kg/m^2; obesity was defined as a BMI ≥30 kg/m^2.

Exclusion criteria

Participants were excluded from the main analysis if their total energy intake was less than 850 or over 4500 kcal/day[25] or if they had no data regarding dietary intake or any other variable used in the analysis. Sensitivity analysis was conducted including all participants with available dietary intake, irrespective of the total energy intake.

Statistical analysis

Statistical analyses were performed using Stata version 13.1 for windows (Stata Corp, College Station, Texas, USA). Descriptive results were expressed as number of participants (percentage) or as average ± standard deviation. Bivariate analyses were performed using chi-square or Fisher's exact test for qualitative variables and oneway analysis of variance (ANOVA) or Kruskal-Wallis test for quantitative variables. Multivariate analysis was performed using ANOVA and logistic regression. For ANOVA, post-hoc pairwise comparisons were performed using Scheffe's method. Among participants diagnosed with dyslipidemia, the associations of hypolipidemic drug with dietary intake were assessed by testing an interaction term between self-reported lipid-conscious diet and hypolipidemic drug treatment. For logistic regression, the results were expressed as multivariable-adjusted Odds ratio (OR) and 95% confidence interval (CI). Statistical significance was assessed for $p < 0.05$.

Ethical statement

The CoLaus study was approved by the Institutional Ethics Committee of the University of Lausanne and all participants provided written informed consent prior to being examined.

RESULTS

Characteristics of participants

Of the initial 5064 participants in the first follow-up, 267 (5.3%) were excluded because of improbable total energy intake, and a further 508 (10%) because of missing data, leaving 4289 participants (84.7%) for analysis. Comparison of the characteristics be- tween participants included and excluded from the main analysis is summarized in **supplemental table 4.1.1**. Excluded participants were older, lived less frequently in couple, had a lower educational level, were more frequently smokers, obese and with a personal history of diabetes than included participants. Excluded participants also reported less frequently a diet against dyslipidemia (**Supplemental table 4.1.1**).

Among the 4289 participants included in the analysis, 68% reported no diagnosis of dyslipidemia, 21% reported a diagnosis but no dietary management of dyslipidemia, and 11% reported a diagnosis and dietary management of dyslipidemia. The characteristics of the participants according to diagnosis of dyslipidemia and self-reported diet against dyslipidemia are summarized in **table 4.1.1**. Participants diagnosed with dyslipidemia were older, had a lower educational level, were more frequently former smokers, had more frequently a personal history of CVD or diabetes and were more frequently overweight and obese than participants not diagnosed with dyslipidemia (**Table 4.1.1**). Participants diagnosed with dyslipidemia on a diet were more frequently women, while participants diagnosed but not on a diet were less frequently women than participants not diagnosed with dyslipidemia (**Table 4.1.1**).

Dietary intake

Dietary intake according to diagnosis of dyslipidemia or self- reported diet against dyslipidemia is summarized in **table 4.1.2**. Participants diagnosed with dyslipidemia and on a diet had a higher reported intake of fruits and fish, and a lower reported intake of meat than participants not diagnosed with dyslipidemia. Participants diagnosed with dyslipidemia and not on a diet had a higher reported intake of meat and a lower reported intake of vegetables than participants not diagnosed with dyslipidemia (**Table 4.1.2**).

Participants diagnosed with dyslipidemia and on a diet had a higher consumption of carbohydrates, MUFA, PUFA and fibre, and a lower consumption of total fat, SFA and cholesterol than participants not diagnosed with dyslipidemia. Participants diagnosed with dyslipidemia and not on a diet had a similar nutrient intake than participants not diagnosed with dyslipidemia and had higher alcohol consumption than the others (**Table 4.1.2**).

Similar findings were obtained when the analysis was stratified by gender (**Supplemental tables 4.1.2 and 4.1.3**) or when all participants with available dietary intake were included (**Supplemental table 4.1.4**), except that some associations were no longer significant, such as fibre and alcohol intake in women.

Table 4.1.1: Characteristics of the sample, according to diagnosis and dietary management of dyslipidemia.

	Not aware	**Aware**		
		No diet	**Diet**	**P-value**
N	2919	917	453	
Women (%)	1645 (56.4)	387 (42.2)	242 (53.4)	<0.001
Age (years)	56.1 ± 10.3	59.3 ± 10.2	63.3 ± 9.7	<0.001
Age groups				<0.001
[40-45[	998 (34.2)	196 (21.4)	49 (10.8)	
[50-60[	904 (31.0)	287 (31.3)	109 (24.1)	
[60-70[	699 (24.0)	274 (29.9)	173 (38.2)	
[70+	998 (34.2)	196 (21.4)	49 (10.8)	
Marital status				0.18
Alone	1241 (42.5)	366 (39.9)	176 (38.9)	
In couple	1678 (57.5)	551 (60.1)	277 (61.2)	
Educations				<0.001
High	686 (23.5)	206 (22.5)	69 (15.2)	
Middle	824 (28.2)	212 (23.1)	110 (24.3)	
Low	1409 (48.3)	499 (54.4)	274 (60.5)	
Smoking				0.007
Never	1238 (42.4)	348 (38.0)	188 (41.5)	
Former	1074 (36.8)	377 (41.1)	193 (42.6)	
Current	607 (20.8)	192 (20.9)	72 (15.9)	
History of CVD	68 (2.3)	92 (10.0)	67 (14.8)	<0.001
History of diabetes	119 (4.1)	116 (12.7)	64 (14.1)	<0.001
Hypolipidemic drug treatment §	-	586 (14.2)	352 (38.0)	<0.001
BMI (kg/m^2)	25.6 ± 4.5	27.1 ± 4.5	27.0 ± 4.5	<0.001
BMI categories				<0.001
Normal	1448 (49.6)	310 (33.8)	156 (34.4)	
Overweight	1063 (36.4)	411 (44.8)	199 (43.9)	
Obese	408 (14.0)	196 (21.4)	98 (21.6)	

Results are expressed as number of subjects and (column percentage). BMI, body mass index; CVD; cardiovascular disease. §, among participants aware of dyslipidemia only. Statistical analysis by chi-square or analysis of variance.

T**able 4.1.2**: Food consumption according to diagnosis and dietary management of dyslipidemia.

	Not aware	Aware		P-value	
		No diet	Diet	Unadj.	Adj. §
N	2919	917	453		
Foods					
Fruits / day	2.1 ± 1.7[a]	1.9 ± 1.7[a]	2.5 ± 1.9[b]	<0.001	<0.001
Vegetables / day	1.6 ± 1.0[a]	1.4 ± 0.9[b]	1.6 ± 1.0[a]	<0.001	<0.001
Dairy products / day	1.4 ± 1.1	1.3 ± 1.2	1.5 ± 1.2	0.05	0.16
Bread & cereals / day	1.6 ± 1.0	1.5 ± 1.0	1.7 ± 1.0	0.053	0.20
Pastries / day	0.9 ± 0.8	0.9 ± 0.8	0.9 ± 0.8	0.74	0.78
Meat / week	4.8 ± 2.9[a, b]	5.2 ± 2.9[a]	4.5 ± 2.7[b]	<0.001	0.002
Fish †/ week	1.7 ± 1.6[a]	1.6 ± 1.1[a]	1.9 ± 1.4[b]	0.002	<0.001
Fresh fish / week	1.1 ± 1.0[a]	1.0 ± 0.8[a]	1.2 ± 0.9[b]	<0.001	<0.001
Energy and nutrients					
TEI, w/alcohol (kcal)	1868 ± 634	1899 ± 645	1843 ± 618	0.27	0.86
TEI, wo/alcohol (kcal)	1792 ± 616	1798 ± 619	1762 ± 597	0.57	0.67
Total protein (%E)	16.0 ± 3.3	16.3 ± 3.3	15.7 ± 3.2	0.005	0.07
Animal (%P)	68.3 ± 10.8[a, b]	69.3 ± 10.8[a]	66.8 ± 11.3[b]	<0.001	0.006
Total carbohydrate (%E)	48.0 ± 8.3[a]	47.1 ± 8.3[a]	50.1 ± 8.6[b]	<0.001	<0.001
Simple (%C)	48.6 ± 14.0[a]	47.1 ± 14.2[a]	50.6 ± 14.0[b]	<0.001	0.007
Total fat (%E)	36.0 ± 7.0[a]	36.6 ± 7.0[a]	34.2 ± 7.4[b]	<0.001	<0.001
SFA (%F)	37.1 ± 6.0[a]	37.8 ± 5.7[a]	35.1 ± 6.2[b]	<0.001	<0.001
MUFA (%F)	39.7 ± 4.6[a]	39.4 ± 4.3[a]	39.9 ± 5.4[b]	0.04	0.01
PUFA (%F)	14.3 ± 3.9[a]	14.2 ± 4.1[a]	15.6 ± 4.3[b]	<0.001	<0.001
Fibre (g/day)	16.4 ± 8.6[a]	15.7 ± 8.7[a]	18.0 ± 9.0[b]	<0.001	<0.001
Cholesterol (mg/day)	309 ± 146[a]	316 ± 138[a]	273 ± 127[b]	<0.001	<0.001
Alcohol (g/day)	10 ± 14[a]	13 ± 18[b]	10 ± 17[a, b]	<0.001	0.01
Alcohol (g/day) ‡	12 ± 15[a]	15 ± 19[b]	13 ± 18[a, b]	<0.001	0.008

TEI, total energy intake; %E, as percentage of total energy intake; %P, as percentage of total protein intake; %C, as percentage of total carbohydrate intake; %F, as percentage of total fat intake; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids. Results are expressed as mean ± standard deviation. Statistical analysis by ANOVA or Kruskall-Wallis test (for alcohol). NA, not assessable. §, adjusted for gender, age (continuous), body mass index (normal, overweight, obese), education (low, middle, high), smoking (never, former, current) and personal history of cardiovascular disease (yes/no) or diabetes (yes/no) with post-hoc pairwise comparisons using Scheffe's method; values with different sub- scripts are significantly different at p < 0.05. †, including fried and canned fish; ‡, drinkers only.

Compliance with recommendations

Compliance with the recommendations of the Swiss society of nutrition according to diagnosis of dyslipidemia or self-reported diet against dyslipidemia is summarized in **table 4.1.3**.

Regarding recommendations for foods, participants diagnosed with dyslipidemia and on a diet had higher odds of meeting the recommendations for fruit and fish intake than participants not diagnosed with dyslipidemia. Participants diagnosed with dyslipidemia and not on a diet had lower odds of meeting the recommendations for fruit and vegetable intake than participants not diagnosed with dyslipidemia (**Table 4.1.3**). Among participants diag- nosed with dyslipidemia, presence of a diet was associated with higher odds of meeting at least 3 recommendations, while absence of diet was associated with lower odds of meeting the recommendations (**Table 4.1.3**).

Regarding recommendations for nutrients, participants diagnosed with dyslipidemia and on a diet had higher odds of meeting the recommendations for total fat, SFA and cholesterol, and lower odds of meeting the recommendation for MUFA than participants not diagnosed with dyslipidemia. No differences regarding compliance for PUFA and fibre were found between participants diagnosed and not on a diet and participants not aware of being dyslipidemic (**Table 4.1.3**). Finally, participants diagnosed and not on a diet had lower odds of meeting alcohol recommendations (**Table 4.1.3**).

Similar findings were obtained when the analysis was stratified by gender (**Supplemental tables 4.1.5 and 4.1.6**) or when all participants with available dietary intake were included (**Supplemental table 4.1.7**), except that some associations were no longer significant, such as moderate alcohol consumption in women.

Table 4.1.3: Bivariate and multivariable analysis of compliance with dietary recommendations according to diagnosis and dietary management of dyslipidemia.

	Not aware	Aware		
		No diet	Diet	P-value
Foods	2919	917	453	
Fruits ≥2/day	1249 (42.8)	345 (37.6)	243 (53.6)	<0.001
Vegetables ≥3/day	232 (8.0)	50 (5.5)	40 (8.8)	0.02
Dairy products ≥3/day	260 (8.9)	70 (7.6)	44 (9.7)	0.36
Meat ≤5/week	1766 (60.5)	510 (55.6)	296 (65.3)	0.001
Fish ≥1/week ‡	1947 (66.7)	619 (67.5)	334 (73.7)	0.01
Fish ≥1/week ¶	1167 (40.0)	346 (37.7)	224 (49.5)	<0.001
At least 3 recommendations ‡	729 (25.0)	173 (18.9)	155 (34.2)	<0.001
At least 3 recommendations ¶	527 (18.1)	125 (13.6)	125 (27.6)	<0.001
Nutrients				
Total fat <30% TEI	563 (19.3)	167 (18.2)	126 (27.8)	<0.001
SFA <10% TEI	473 (16.2)	121 (13.2)	135 (29.8)	<0.001
MUFA >10% TEI	2609 (89.4)	822 (89.6)	380 (83.9)	0.002
PUFA >10% TEI	45 (1.5)	11 (1.2)	8 (1.8)	0.67
Cholesterol <300 mg/day	1608 (55.1)	483 (52.7)	301 (66.5)	<0.001
Fibre > 30 g/day	239 (8.2)	83 (9.1)	43 (9.5)	0.52
Moderate alcohol §	2294 (78.6)	676 (73.7)	359 (79.3)	0.006

Table 4.1.3 (cont.): Bivariate and multivariable analysis of compliance with dietary recommendations according to diagnosis and dietary management of dyslipidemia.

	Not aware	Aware	
		No diet	Diet
Foods			
Fruits ≥2/day	1 (ref.)	0.83 (0.71 - 0.98)*	1.39 (1.13 - 1.72)**
Vegetables ≥3/day	1 (ref.)	0.68 (0.49 - 0.95)*	1.06 (0.73 - 1.53)
Dairy products ≥3/day	1 (ref.)	0.86 (0.65 - 1.14)	1.04 (0.73 - 1.48)
Meat ≤5/week	1 (ref.)	0.88 (0.75 - 1.03)	1.17 (0.94 - 1.46)
Fish ≥1/week ‡	1 (ref.)	1.05 (0.89 - 1.23)	1.44 (1.14 - 1.81)**
Fish ≥1/week ¶	1 (ref.)	1.01 (0.86 - 1.19)	1.65 (1.34 - 2.04)***
At least 3 recommendations ‡	1 (ref.)	0.73 (0.60 - 0.89)**	1.44 (1.15 - 1.81)***
At least 3 recommendations ¶	1 (ref.)	0.78 (0.63 - 0.98)*	1.70 (1.33 - 2.17)***
Nutrients			
Total fat <30% TEI	1 (ref.)	0.94 (0.77 - 1.15)	1.52 (1.20 - 1.92)***
SFA <10% TEI	1 (ref.)	0.82 (0.66 - 1.03)	2.16 (1.70 - 2.74)***
MUFA >10% TEI	1 (ref.)	1.08 (0.84 - 1.39)	0.72 (0.54 - 0.96)*
PUFA >10% TEI	1 (ref.)	0.68 (0.34 - 1.35)	1.08 (0.49 - 2.39)
Cholesterol <300 mg/day	1 (ref.)	0.99 (0.84 - 1.16)	1.56 (1.25 - 1.95)***
Fibre > 30 g/day	1 (ref.)	1.10 (0.84 - 1.45)	1.11 (0.78 - 1.59)
Moderate alcohol §	1 (ref.)	0.82 (0.69 - 0.99)*	1.13 (0.88 - 1.46)

*TEI, total energy intake, excluding alcohol; SFA, saturated fat; MUFA, monounsaturated fat; PUFA, polyunsaturated fat. Results are expressed as number of participants (percentage) or as multivariate adjusted odds ratio and (95% confidence interval). Statistical analysis by chi-square or logistic regression adjusting on gender, age ([40-50[, [50-60[, [60-70[and [70+), body mass index (normal, overweight, obese), education (low, middle, high), smoking (never, former, current) and personal history of cardiovascular disease (yes/no) or diabetes (yes/no). ‡, including canned and fried fish; ¶, fresh fish only; §, alcohol consumption <20 g/day for men and <10 g/day for women. *, p<0.05; **, p<0.01; ***, p<0.001.*

DISCUSSION

To our knowledge, this is the first study ever conducted in Switzerland and one of the few in Europe assessing the reported dietary intake among patients diagnosed with dyslipidemia, taking into account the presence/absence of a diet. Our results indicate that patients diagnosed with dyslipidemia and on a diet report a healthier dietary intake, while patients diagnosed with dyslipidemia but not on a diet tend to report a less healthy dietary intake than the general population.

Dietary management of dyslipidemia

Dietary management is a cornerstone of CVD prevention[22] and management of dyslipidemia.[26] A French study conducted in 1998 among 1717 general practitioners reported that almost 96% of them provided dietary recommendations to patients with dyslipidemia.[27] Studies conducted in patients reported lower levels of dietary management: 88% in a study conducted in 2003-2004 among patients with high LDL cholesterol living in New York[28]; a study conducted in 2008-2010 in Spain among patients with hypercholesterolaemia (total cholesterol >200 mg/dL or on drug treatment) showed that 89.8% of then had received dietary advice, but that 15% of them did not follow it.[29] Another French study assessing dietary compliance among patients reporting a diagnosis of dyslipidemia estimated that only 46% of them had a good or pretty good compliance.[30] In this study, only one third of patients diagnosed with dyslipidemia reported being on a diet. Although the findings from the current study cannot be directly compared with the results from other studies, still they suggest that advice from health carers and/or compliance by the patients regarding dietary management of dyslipidemia is low in Switzerland. For instance, a French study reported that although 83% of hypercholesterolemic patients recall they should eat more fish, only 51% actually do so.[4] It is also possible that people reporting being on a diet reported an intake that better reflected what they had been told to eat than what they actually ate.[31] Other explanations for not meeting dietary recommendations include the belief that oneself diet is already acceptable, unwillingness to restrict one's diet, social difficulties in implementing the recommendations or use of lipid lowering drugs.[4] Factors related to healthcare include lack of time, difficulty in implementation of the recommendations and underestimation of the importance of cholesterol management.[7-9]

Overall, our results suggest that there is still room for implementation of dietary management of dyslipidemia among Swiss patients. No information was collected whether the reported diet was self-prescribed or prescribed by a dietician or a doctor. Hence, some of the reported diets might not be optimal neither regarding overall nutritional adequacy, nor in terms of lipid lowering. Further, simple, easy to implement dietary measures have been shown to be effective: a randomized controlled trial showed that a low-intensity dietary counselling provided by primary care physician produced clinically meaningful improvements in both diet and lipids of magnitude similar to changes reported with high intensity interventions.[32]

Dietary intake

Patients diagnosed with dyslipidemia and on a diet reported a higher intake of fruits and fish, and a lower intake of meat than patients not diagnosed with dyslipidemic. These findings are in agreement with the literature, where diets rich in fruits, omega-3 (i.e. from fish) and low in SFA (one of the main sources being meat) have been shown to protect against coronary heart disease (for a review, see Ref. [32]). Still, it was not possible to independently ascertain if participants who reported being on a diet were actually consuming it. Thus, a reporting bias cannot be completely ruled out.

European dietary recommendations to reduce total and LDL cholesterol levels include the reduction of saturated and *trans* fats and cholesterol intake, and the increase in dietary fibre.[26]

The recommendations to reduce triglyceride levels include the reduction of alcohol intake and of mono- and disaccharides, and the replacement of SFA with MUFA or PUFA.[26] Although no information regarding dietary intake of *trans* fatty acids could be obtained, our results indicate that patients diagnosed with dyslipidemia and on a diet were quite compliant to these recommendations, as they presented a higher consumption of MUFA, PUFA and fibre, and a lower consumption of total fat, SFA and cholesterol than participants not aware of being dyslipidemic. Overall, our results suggest that, in this sample, diets implemented against dyslipidemia meet quite well with the current recommendations. The fact that patients diagnosed with dyslipidemia and on a diet did not have reduced alcohol consumption might be related to the fact that most of them presented with hypercholesterolaemia rather than hypertriglyceridemia, but we have no data to confirm this possibility.

Compliance with dietary recommendations

As for dietary intake, patients diagnosed with dyslipidemia and on a diet had higher odds of meeting most Swiss dietary recommendations. Interestingly, no differences were found regarding compliance with vegetables and meat consumption, a finding also reported elsewhere.[34] The lack of difference regarding vegetable intake might be partly related to the already low compliance levels regarding vegetable intake reported previously[10], while the lack of difference regarding meat intake might be due to changes in the type of meat, i.e. replacing poultry for beef or pig. Indeed, participants diagnosed and on a diet consumed less processed meat products and tended to consume less red meat, while the consumption of poultry was similar between groups (**Supplemental table 4.1.8**). This might explain the higher compliance with low fat, low SFA and low cholesterol recommendations among participants diagnosed and on a diet relative to the non-diagnosed group.

In a previous study[10], we reported that migrants have a better compliance regarding dietary recommendations than Swiss born participants. Similar findings were observed among participants diagnosed with dyslipidemia, and no differences were found be- tween migrants and Swiss nationals regarding the distribution of participants not diagnosed, diagnosed on a diet and diagnosed not on a diet (not shown). Thus, our results suggest that migrants with dyslipidemia have the same or perhaps even a better compliance to dietary recommendations than Swiss nationals.

Overall, our results suggest that, among participants diagnosed with dyslipidemia, reporting a diet is favourably associated with a higher compliance with dietary recommendations.

Study limitations

This study has several limitations. Firstly, participants differed significantly from excluded ones regarding several characteristics known to influence dietary intake such as age, education and smoking. Still, sensitivity analyses including all participants led to similar findings, suggesting that our results might be applicable to the general population. Secondly, only awareness of dyslipidemia was considered, and it is known that a significant fraction of the population presents with dyslipidemia without being aware of it. Thus, the presence of an attribution bias cannot be excluded, as a non-negligible fraction of the non-aware group consists of dyslipidemic subjects, whose dietary intake might differ from the non-dyslipidemic ones. This bias might increase the difference between participants diagnosed and on a diet and non-diagnosed participants. Still, the aim of this study was to assess whether diagnosis of dyslipidemia led to dietary management of the condition, and the associated dietary changes, not the association between dietary intake and presence of dyslipidemia as assessed solely by lipid measurement. Thirdly, several factors that could influence the compliance with a lipid-conscious diet such as severity and type of dyslipidemia (i.e. high cholesterol or high triglycerides) were not collected, and it would be of interest that future studies assess the effects of these factors on dietary compliance. Fourthly, the assignment to a diet/non diet group was based on the self- perception of the participants regarding their diet. The perception of the participants could be wrong, or the participants could incorrectly answer positively to the question because of guilt about noncompliance, leading to a reporting bias. Still, this would lead to a decrease in dietary quality and compliance with recommendations; thus, it is possible that the results presented might actually underestimate the quality of the lipid-conscious diet. A sizable fraction of the participants was non-Swiss; hence possible comprehension issues could arise while filling the FFQ. Still, as all participants had already participated in the baseline study and had been faced with large questionnaires in French, we believe that the participants in the second wave of the CoLaus study had an adequate literacy to understand the FFQ. The FFQ only assessed dietary intake from the last 4 weeks, so seasonal variations could not be captured. Still, similar short FFQs have been used in other studies.[35] Finally, the CoLaus study was conducted in an urban setting (Lausanne) and in a French-speaking canton (Vaud); it is thus possible that the results obtained might not be extrapolated to other Swiss cantons or to other countries, due to differences in medical practice. Still, they provide important information regarding the frequency and the characteristics of the dietary management of patients with dyslipidemia, and could serve as reference for comparing the effectiveness of educational campaigns aiming at implementing dietary management of cardiovascular risk factors.

Conclusion

We conclude that in Switzerland, only half of patients diagnosed with dyslipidemia are on a lipid-conscious diet. Presence of a lipid-conscious diet in patients diagnosed with dyslipidemia favourably influences their dietary intake compared to the general population.

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SUPPLEMENTAL MATERIAL

Supplemental material for this chapter can be found online
https://clinicalnutritionespen.com/article/S2405-4577(15)00150-3/addons

CHAPTER 4.2

Dietary intake of subjects with diabetes is inadequate in Switzerland: the CoLaus study

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4.2

ABSTRACT

Purpose: To characterize the dietary intake of subjects aged 40 to 80 years according to self-reported diabetes and presence of an anti-diabetic diet.

Methods: Cross-sectional study conducted between 2009 and 2012 on 4289 participants (2274 women) living in Lausanne.

Results: Of the 299 (7%) participants with self-reported diabetes, only 151 (51%) reported an anti-diabetic diet. Compared to participants not reporting diabetes, participants with self-reported diabetes (with or without a diet) had a higher consumption of artificial sweeteners (0.3±0.7 vs. 0.4±0.8 and 0.8±1.0 times/day) and a lower consumption of honey/jam (0.5±0.5 vs. 0.4±0.4 and 0.4±0.4 times/day) or sugar (0.6±0.9 vs. 0.4±0.7 and 0.2±0.5 times/day) for participants not reporting diabetes, participants with self-reported diabetes not on a diet and on a diet, respectively. Compared to participants not on a diet, participants on a diet had a higher consumption of vegetables (mean±standard deviation: 1.8±1.3 vs. 1.4±1.0 portions/day), while no differences were found regarding all other food groups and nutrients. Participants with self-reported diabetes on a diet had a higher consumption of meat (5.6±3.6 vs. 4.8±2.9 portions/week) and a lower consumption of sugars (44.1±13.7 vs. 48.8±14.0 % total energy intake) than participants not reporting diabetes.

Conclusion: People with diabetes eat less sugars, but do not comply with current advice on fish, nuts, fruits and legumes. Improvement of the dietary intake in persons with diabetes in Switzerland in order to combat future risk of CVD is needed.

INTRODUCTION

The prevalence of diabetes is increasing worldwide.[1] Over time, high blood pressure has maintained its role as the leading risk factor while the mortality burdens of high BMI and glucose increased faster than that of high cholesterol, such that these two risks are now responsible for more deaths than high cholesterol.[2] The Diabetes and Nutrition Study Group (DNSG) of the European Association for the Study of Diabetes (EASD) have issued dietary recommendations aimed at improving the management of patients with diabetes.[3] A study conducted in France showed that diabetic patients have a higher quality diet than individuals without diabetes.[4] Still, an international study reported that the differences in dietary behaviour between diabetic and non-diabetic patients were rather small.[5] Further, despite the fact that diabetic patients are expected to benefit from dietary counselling, compliance of diabetic patients with dietary recommendations is not optimal.[4, 6, 7]

In Switzerland, estimates of the prevalence of diabetes range between 5.4% and 6.3%[8, 9], with an increasing trend[10] possibly related to an increasing prevalence of obesity[11], to changes in food availability[12] or even to the aging of the Swiss population. Almost no data exists regarding dietary management of diabetic patients in Switzerland, and no information exists regarding the exact composition of the diet. The aim of this study was thus to characterize the dietary intake of subjects diagnosed with diabetes according to the presence or absence of an anti-diabetic diet, and to compare it to the diet of subjects not diagnosed for diabetes.

PARTICIPANTS AND METHODS

Participants

The rationale, sampling and follow-up procedures of the CoLaus study have been described previously.[13, 14] The CoLaus study is a prospective, population-based study conducted in the city of Lausanne, Switzerland, aiming to better identify the biological and genetic determinants of cardiovascular disease. Recruitment for the baseline study began in June 2003 and ended in May 2006. The complete list of Lausanne inhabitants aged 35 to 75 years (n=56,694) was provided by the population registry of the city. A simple, nonstratified random sample of 35% of the overall population was drawn and the following inclusion criteria were applied: (a) age 35-75 years and (b) willingness to take part in the examination and to donate blood samples. Participation rate was 41%. The CoLaus Study was approved by the Institutional Ethics Committee of the University of Lausanne and all participants provided written informed consent prior to being examined.

The first follow-up took place between April 2009 and September 2012 and included all participants of the baseline study willing to participate in the follow-up.[14] We only consider data from the follow-up examination as dietary intake assessment was first introduced here.

Examination procedure

All participants attended the outpatient clinic of the University Hospital of Lausanne in the morning after an overnight fast. Participants were seen during a single visit which included an interview, a physical assessment, and blood and urine collections in the fasting state. Data were collected by trained field interviewers in a single visit lasting about 60 min. Participants attending the examination were apparently free from an acute disease. If they presented an acute disease, another examination was scheduled. Participants had to restrain from heavy exercise and to maintain their usual diet the day before testing. Participants were asked about their personal and family history of disease.

Reporting of diabetes was defined as a positive answer to the question "did a doctor tell you that you were diabetic?". Dietary management of diabetes was considered if the participants responded positively to a question on presence of a "low sugar (anti-diabetic) diet". We chose to use self-reported diabetes instead of diagnosed diabetes based on fasting glucose and/or anti-diabetic treatment as a significant fraction of diabetic participants is unaware of his/her status[8] and that dietary measures against diabetes can only be implemented if a diagnosis of diabetes has been performed.

Dietary intake

Dietary intake was assessed at follow-up using a self-administered, semi quantitative Food Frequency Questionnaire (FFQ) which also included portion size.[15] This FFQ has been validated in the Geneva population[15, 16] and several studies have been published previously.[16, 17] This FFQ assesses the dietary intake of the previous 4 weeks and consists of 97 different food items which account for more than 90% of the intake of calories, proteins, fat, carbohydrates, alcohol, cholesterol, vitamin D and retinol, and 85% of fibres, carotene and iron. To our knowledge, there is no FFQ (validated or not) assessing dietary intake for the whole year in Switzerland, the other available (and validated) FFQ assessing the dietary intake of the previous month[18]; hence, this FFQ provides the best dietary assessment available. 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 bigger) compared to a reference size. Each participant brought along her/his filled-in FFQ, which was checked for completion by trained interviewers the day of the visit.

Reported food consumption frequencies were converted into daily or weekly consumptions. Daily consumption frequencies were obtained as follows: “never these last 4 weeks”=0; “once/month”=1/28; “2-3/month”=2.5/28; “1-2/week”=1.5/7; “3-4 times/ week”=3.5/7; “once/day”=1 and “2+/day”=2.5. The frequency of consumption of one food category was obtained by summing up all individual consumption frequencies of foods related to that category. For example, daily fruit consumption was obtained by summing up the daily consumptions of fresh fruits (5 items) and fruit juices (fresh and processed without added sugar).

Two values for total energy intake (TEI) were computed: one including alcohol consumption, the other not. Total protein, carbohydrate and fat were expressed as percentage of TEI (alcohol excluded). Animal protein was expressed as percentage of total protein; simple sugars (disaccharides) were expressed as percentage of total carbohydrates; saturated (SFA), mono-(MUFA) and polyunsaturated (PUFA) fatty acids were expressed as percentage of total fat.

Compliance with the dietary recommendations of the Swiss society of nutrition was computed as previously.[19] The recommendations are: ≥2 fruit portions/day; ≥3 vegetable portions per day; ≤5 portions meat per week; ≥1 portion fish per week and ≥3 portions dairy products per day. Compliance to the recommendation for fish was assessed in two ways: considering all types of fish (including fried and canned), or fresh fish only. For each recommendation, a binary variable (1=yes, 0=no) was computed, and the total number of recommendations complied to was summed up.

Compliance to the dietary recommendations of the Diabetes and Nutrition Study Group (DNSG) of the European Association for the Study of Diabetes[3] was also assessed among diabetic participants reporting an anti-diabetic diet. The DNSG recommends a macronutrient distribution, expressed as %TEI, of 45-60% for carbohydrates, 10-20% for protein and <35% for fat.[3] Also according to the DNSG, fibre consumption should be over 40g per day, and 10-20% of TEI should come from MUFA and up to 10% from PUFA.[3]

Other methods

Body weight and height were measured with participants standing without shoes in light indoor clothes. Body weight was measured in kilograms to the nearest 100 g using a Seca® scale, which was calibrated regularly. Height was measured to the nearest 5 mm using a Seca® height gauge. Overweight was defined as a body mass index (BMI) ≥25 and <30 kg/m²; obesity was defined as a BMI ≥30 kg/m².

Educational level was categorized as low (primary), middle (apprenticeship or secondary school) and high (university). Marital status was categorized into living alone (single, divorced or widowed) and living in a couple. Smoking status was defined as never, former (irrespective of the time since quitting) and current (irrespective of the amount smoked).

Exclusion criteria

Participants were excluded if a) their TEI was <850 or >4500 kcal/day or b) if they had missing data for the dietary intake or any other variable of interest.

Statistical analysis

Statistical analyses were performed using Stata version 13.1 for windows (Stata Corp, College Station, Texas, USA). Descriptive results were expressed as number of participants (percentage) or as average ± standard deviation. Bivariate analyses were performed using chi-square for qualitative variables and Student's t-test for quantitative variables. Multivariate analysis on quantitative data was performed using analysis of variance (ANOVA); post-hoc between groups comparisons were performed using the Scheffe method. Multivariate analysis of qualitative data was performed using logistic regression and results were expressed as Odds ratio (OR) and 95% confidence interval (CI). Statistical significance was assessed for $p<0.05$.

RESULTS

Characteristics of participants

Of the initial 5064 participants in the first follow-up, 267 (5.3%) were excluded because of improbable TEI and a further 508 (10%) because of missing data: 459 (9.1%) for non-filled FFQ; 65 (1.3%) for no data on BMI; 57 (1.1%) for no data on smoking status and 5 (0.1%) for no data on education; percentages add over 10% as some participants fulfilled several criteria for exclusion (**Figure 4.2.1**). Average ±standard deviation follow-up time was 5.5±0.6 years. The characteristics of the participants included and excluded are summarized in **supplemental table 4.2.1.** Excluded participants were older, more frequently single, of lower educational level, more frequently smokers and obese. Excluded participants with self-reported diabetes also reported a lower prevalence of abiding an anti-diabetic diet (**Supplemental table 4.2.1**).

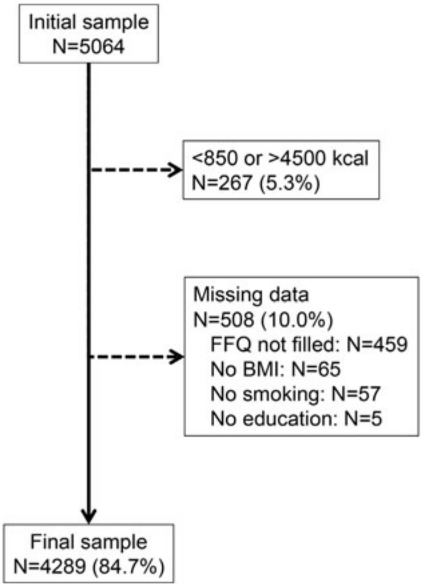

Figure 4.2.1: selection procedure.

The characteristics of the remaining 4289 participants according to their diabetic and dietary status are summarized in **table 4.2.1**. Participants with self-reported diabetes were older, of lower educational level, more frequently obese and reported more frequently a personal history of CVD (**Table 4.2.1**). Of the 299 participants with self-reported diabetes, 216 (72.2%) reported being on an anti-diabetic drug treatment, 50 (23.0%) of whom received insulin therapy. Conversely, no data was available regarding diabetes duration. Participants with self-reported diabetes were also more frequently previous or current smokers, and participants with self-reported diabetes not on a diet were more frequently current smokers than participants with self-reported diabetes on a diet (**Table 4.2.1**).

Table 4.2.1: characteristics of the participants, according to self-reported diagnosis and dietary management of diabetes.

	No diabetes	Self-reported diabetes		P-value
		Not on diet	On diet	
N	3990	148	151	
Women (%)	2190 (54.9)	38 (25.7)	46 (30.5)	<0.001
Age (years)	57.1 ± 10.4	63.3 ± 9.4	64.2 ± 9.1	<0.001
Age groups				
[40-45[	1214 (30.4)	15 (10.1)	14 (9.3)	
[50-60[	1230 (30.8)	36 (24.3)	34 (22.5)	<0.001
[60-70[	1026 (25.7)	59 (39.9)	61 (40.4)	
[70+	520 (13.0)	38 (25.7)	42 (27.8)	
Marital status				
Alone	1673 (41.9)	54 (36.5)	56 (37.1)	0.22
In couple	2317 (58.1)	94 (63.5)	95 (62.9)	
Education				
High	915 (22.9)	28 (18.9)	18 (11.9)	
Middle	1077 (27.0)	36 (24.3)	33 (21.9)	0.001
Low	1998 (50.1)	84 (56.8)	100 (66.2)	
Smoking				
Never	1679 (42.1)	51 (34.5)	44 (29.1)	
Former	1491 (37.4)	62 (41.9)	91 (60.3)	<0.001
Current	820 (20.6)	35 (23.7)	16 (10.6)	
History of CVD	182 (4.6)	17 (11.5)	28 (18.5)	<0.001
BMI (kg/m^2)	25.8 ± 4.3	29.4 ± 5.3	30.1 ± 5.5	<0.001
BMI categories				
Normal	1863 (46.7)	29 (19.6)	22 (14.6)	
Overweight	1548 (38.8)	65 (43.9)	60 (39.7)	<0.001
Obese	579 (14.5)	54 (36.5)	69 (45.7)	

Results are expressed as number of subjects and (column percentage). BMI, body mass index; CVD; cardiovascular disease. Statistical analysis by chi-square or analysis of variance.

Dietary intake and diabetes

The dietary consumption according to presence/absence of diagnosed diabetes or of a reported anti-diabetic diet is summarized in **table 4.2.2**. Compared to participants with self-reported diabetes not on a diet, participants with self-reported diabetes on a diet had a higher consumption of vegetables and fibre, while no differences were found regarding all other food groups and nutrients considered (**Table 4.2.2**). Participants with self-reported diabetes on a diet also had a higher consumption of meat and a lower consumption of sugars than participants not diagnosed with diabetes (**Table 4.2.2**). Similar findings were obtained when the analysis was stratified by gender, except that some differences were no longer significant (**Supplemental tables 4.2.2 and 4.2.3**).

Compared to participants not diagnosed with diabetes, participants with self-reported diabetes (with or without a diet) had a higher consumption of artificial sweeteners and a lower consumption of honey/jam or sugar (**Table 4.2.3**). Similar findings were obtained when the analysis was stratified by gender, except that some differences were no longer significant (**Supplemental table 4.2.4**).

No differences regarding the number of dietary recommendations complied were found between participants with self-reported (with or without a diet) and participants not diagnosed with diabetes (**Table 4.2.2**). Similar findings were observed for individual recommendations, with the exception that participants with self-reported diabetes on a diet had a higher compliance regarding vegetable intake and a lower compliance regarding meat intake (**Table 4.2.4**). Similar findings were obtained when the analysis was stratified by gender, except that some differences were no longer significant (**Supplemental table 4.2.5**). Among participants with self-reported diabetes on a diet, compliance with the dietary recommendations of the DNSG varied considerably depending on the item considered: over 8 out of 10 participants complied with protein and MUFA intake, while only one out of 25 complied with fibre intake (**Figure 4.2.2**); overall, slightly less than 6 out of 10 participants complied with at least 3 of 5 dietary recommendations (**Figure 4.2.2**).

Finally, including the 267 participants with TEI<850 or >4500 /kcal/day led to similar conclusions, except that no differences regarding compliance were found for participants with self-reported diabetes on a diet (**Supplemental tables 4.2.6 to 4.2.8**).

Table 4.2.2: food and dietary consumption according to self-reported diagnosis and dietary management of diabetes.

	No diabetes	Self-reported diabetes		P-value	
		Not on diet	On diet	Unadj.	Adj. §
N	3990	148	151		
Foods					
Fruits / day	2.1 ± 1.7	1.8 ± 1.6	2.2 ± 1.9	0.19	0.45
Vegetables / day	1.5 ± 1.0 [a]	1.4 ± 1.0 [a]	1.8 ± 1.3 [b]	0.01	0.001
Dairy products / day	1.4 ± 1.1	1.5 ± 1.3	1.4 ± 1.3	0.32	0.18
Bread & cereals / day	1.5 ± 1.0	1.6 ± 0.9	1.7 ± 1.0	0.25	0.48
Pastries / day	0.9 ± 0.8	0.9 ± 0.7	0.9 ± 0.9	0.82	0.98
Meat / week	4.8 ± 2.9 [a]	5.4 ± 3.1 [a, b]	5.6 ± 3.6 [b]	<0.001	0.006
Fish †/ week	1.7 ± 1.5	1.7 ± 1.2	1.7 ± 1.2	0.98	0.72
Fresh fish / week	1.1 ± 0.9	1.0 ± 0.9	1.0 ± 0.8	0.25	0.90
Compliance ‡	1.9 ± 1.0	1.8 ± 1.0	1.8 ± 0.9	0.32	0.95
Compliance ¶	1.6 ± 1.0	1.5 ± 1.0	1.5 ± 1.0	0.22	0.98
Energy and nutrients					
Kcalories, w/alcohol	1867 ± 632	1963 ± 695	1909 ± 658	0.15	0.93
Kcalories, wo/alcohol	1787 ± 612	1847 ± 661	1829 ± 643	0.37	0.99
Total protein (%E)	16.0 ± 3.3	16.8 ± 3.7	16.5 ± 3.4	0.005	0.03
Animal (%E)	11.2 ± 3.8	12.0 ± 4.2	11.4 ± 3.8	0.04	0.15
Total carbohydrate (%E)	48.1 ± 8.4	47.0 ± 9.0	47.4 ± 8.1	0.19	0.28

Table 4.2.2. Continued.

	No diabetes	Self-reported diabetes		P-value	
		Not on diet	On diet	Unadj.	Adj. §
Energy and nutrients					
Simple (%E)	23.5 ± 8.4 [a]	21.5 ± 8.7 [a, b]	21 ± 7.9 [b]	<0.001	0.005
Total fat (%E)	35.9 ± 7.1	36.3 ± 7.4	36.1 ± 7.1	0.80	0.77
SFA (%E)	13.3 ± 3.5	14.0 ± 3.8	13.4 ± 3.5	0.08	0.52
MUFA (%E)	14.4 ± 3.8	14.1 ± 3.6	14.2 ± 3.6	0.54	0.88
PUFA (%E)	5.1 ± 1.6 [a]	5.2 ± 1.6 [a, b]	5.5 ± 2.2 [b]	0.008	0.04
Fibre (g/day)	16.3 ± 8.7 [a]	16.0 ± 7.6 [a]	18.8 ± 9.7 [b]	0.002	0.002

%E, as percentage of total energy intake (alcohol excluded); SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids. Results are expressed as mean ± standard deviation. Comparison between groups (no reported diabetes, reported diabetes no diet, reported diabetes on a diet) performed by ANOVA; the p-value reported refers to the overall test. § adjusted for gender, age (continuous), body mass index (normal, overweight, obese), education (low, middle, high), smoking (never, former, current) and personal history of cardiovascular disease (yes/no) with post-hoc pairwise comparisons using Scheffe's method. Values with different subscripts are significantly different at p<0.05. †, including fried and canned fish; ‡ number of dietary recommendations (Swiss society of nutrition) complied to, using any type of fish (including canned and fried). ¶ number of dietary recommendations (Swiss society of nutrition) complied to, using fresh fish only.

Table 4.2.3: consumption of specific foods according to self-reported diagnosis and dietary management of diabetes.

	No diabetes	Self-reported diabetes		P-value	
		Not on diet	On diet	Unadj.	Adj. §
N	3990	148	151		
Chocolate bread	0.1 ± 0.2	0.1 ± 0.3	0.1 ± 0.3	0.06	0.10
Chocolate	0.4 ± 0.5	0.4 ± 0.5	0.3 ± 0.5	0.16	0.59
Honey, jam	0.5 ± 0.5 [a]	0.4 ± 0.4 [b]	0.4 ± 0.4 [b]	0.01	0.007
Artificial sweeteners	0.3 ± 0.7 [a]	0.4 ± 0.8 [b]	0.8 ± 1.0 [b]	<0.001	<0.001
Sugar	0.6 ± 0.9 [a]	0.4 ± 0.7 [b]	0.2 ± 0.5 [b]	<0.001	<0.001

Results are expressed in number of times (consumption occasions) per day and as mean ± standard deviation. Comparison between groups (no reported diabetes, reported diabetes no diet, reported diabetes on a diet) performed by ANOVA; the p-value reported refers to the overall test. § adjusted for gender, age (continuous), body mass index (normal, overweight, obese), education (low, middle, high), smoking (never, former, current) and personal history of cardiovascular disease (yes/no) with post-hoc pairwise comparisons using Scheffe's method. Values with different subscripts are significantly different at p<0.05.

Table 4.2.4: compliance to dietary recommendations of the Swiss society of nutrition, according to self-reported diagnosis and dietary management of diabetes.

	No diab.	Self-reported diabetes		
		No diet	On diet	p-value
Fruits ≥2/day	1710 (42.9)	60 (40.5)	67 (44.4)	0.79
Vegetables ≥3/day	295 (7.4)	11 (7.4)	16 (10.6)	0.34
Dairy products ≥3/day	344 (8.6)	18 (12.2)	12 (8.0)	0.31
Meat ≤5/week	2422 (60.7)	76 (51.4)	74 (49.0)	<0.001
Fish ≥1/week ‡	2699 (67.6)	96 (64.9)	105 (69.5)	0.68
Fish ≥1/week ¶	1623 (40.7)	56 (37.8)	58 (38.4)	0.68
At least 3 recommendations ‡	993 (24.9)	33 (22.3)	31 (20.5)	0.38
At least 3 recommendations ¶	736 (18.5)	22 (14.9)	19 (12.6)	0.11

*Results are expressed as number of participants (percentage) or as multivariate adjusted odds ratio and (95% confidence interval). Comparison between groups (no reported diabetes, reported diabetes no diet, reported diabetes on a diet) performed by chi-square (the p-value reported refers to the overall test) or by logistic regression adjusting on gender, age ([40-50[, [50-60[, [60-70[and [70+), body mass index (normal, overweight, obese), education (low, middle, high), smoking (never, former, current) and personal history of cardiovascular disease (yes/no). ‡ including canned and fried fish; ¶ fresh fish only. *, p<0.05; **, p<0.01; ***, p<0.001.*

Table 4.2.4 (cont.): compliance to dietary recommendations of the Swiss society of nutrition, according to self-reported diagnosis and dietary management of diabetes.

	No diab.	Self-reported diabetes	
		Not on diet	On diet
Fruits ≥2/day	1 (ref.)	1.02 (0.72 - 1.44)	1.11 (0.79 - 1.57)
Vegetables ≥3/day	1 (ref.)	1.26 (0.66 - 2.40)	1.84 (1.05 - 3.20) *
Dairy products ≥3/day	1 (ref.)	1.58 (0.94 - 2.65)	1.01 (0.54 - 1.87)
Meat ≤5/week	1 (ref.)	0.75 (0.54 - 1.06)	0.66 (0.47 - 0.93) *
Fish ≥1/week ‡	1 (ref.)	0.93 (0.65 - 1.32)	1.14 (0.79 - 1.63)
Fish ≥1/week ¶	1 (ref.)	1.10 (0.78 - 1.57)	1.15 (0.81 - 1.62)
At least 3 recommendations ‡	1 (ref.)	1.02 (0.68 - 1.54)	0.87 (0.57 - 1.32)
At least 3 recommendations ¶	1 (ref.)	0.98 (0.61 - 1.58)	0.77 (0.46 - 1.28)

*Results are expressed as number of participants (percentage) or as multivariate adjusted odds ratio and (95% confidence interval). Comparison between groups (no reported diabetes, reported diabetes no diet, reported diabetes on a diet) performed by chi-square (the p-value reported refers to the overall test) or by logistic regression adjusting on gender, age ([40-50[, [50-60[, [60-70[and [70+), body mass index (normal, overweight, obese), education (low, middle, high), smoking (never, former, current) and personal history of cardiovascular disease (yes/no). ‡ including canned and fried fish; ¶ fresh fish only. *, p<0.05; **, p<0.01; ***, p<0.001.*

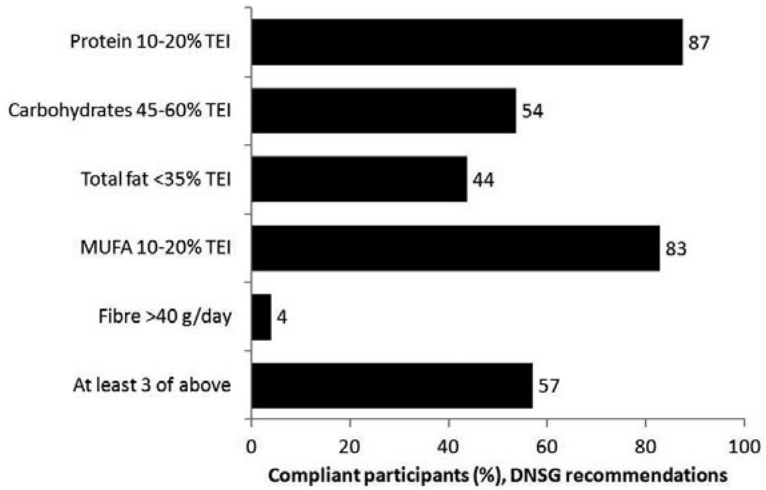

Figure 4.2.2: Compliant participants (%), Diabetes and Nutrition Study Group recommendations. TEI, total energy intake; MUFA, monounsaturated fatty acids.

DISCUSSION

This is the first study in Switzerland, and one of the few studies available assessing the composition of diets against diabetes in an unselected, population-based study. Our results indicate that in Switzerland, anti-diabetic diets appear to be limited to replacing sugar by artificial sweeteners and only partially comply with guidelines regarding dietary management of diabetes.

Dietary management of diabetes

Dietary management, eventually combined with physical activity, has been shown to improve the control of diabetes[20, 21], although the effect of dietary management alone has been seldom studied.[22] Dietary guidelines towards diabetes have been published (for a review, see[23, 24]). The wide ranges for certain nutrients, such as MUFA and carbohydrates, makes them theoretically easier to comply with. Foods, on the other hand, have more solid evidence with respect to CVD prevention among diabetic patients as fish[25]; wholegrain[26]; vegetables, fruits and legumes[27], and nuts.[28] Food-based guidelines might also be easier to implement than nutrient-based guidelines. Still, compliance with the DNSG recommendations varied considerably (**Figure 4.2.2**), and similar findings were obtained regarding compliance to the Swiss dietary recommendations (**Table 4.2.4**).

Participants with self-reported diabetes had a higher meat and protein intake than non-diabetic participants, a finding also reported in a French study.[4] Hyperproteic diets have been recommended for weight loss and diabetes management.[22] They might also be applied to preserve muscle and bone mass, which may be decreased in subjects with poorly controlled diabetes. Indeed, a positive association between markers of iron metabolism and metabolic syndrome was shown in the CoLaus cohort.[29] Thus, the observed increased meat and protein consumption of participants with self-reported diabetes might be more deleterious than helpful regarding the management of their disease. Conversely, no differences were found regarding total carbohydrate intake, although participants with self-reported diabetes reported a lower consumption of simple carbohydrates than participants no diagnosed with diabetes. This lower consumption of simple carbohydrates is probably related to the fact that most participants with self-reported diabetes reported a "low sugar" diet and tended to replace sugar by artificial sweeteners. Interestingly, the complementary consumption of complex carbohydrates by the participants with self-reported diabetes might partly explain their higher fibre consumption.

Higher adherence to the Mediterranean diet has been suggested to improve glycaemic control and cardiovascular risk in persons with established diabetes.[21, 30] Mediterranean diet is rich in several components such as fibre and MUFA. A high compliance to the DNSG recommendations regarding this nutrient was found among diabetic participants on a diet. Conversely, lower compliance rates were found for carbohydrates, total fat and mostly fibre. Participants with self-reported diabetes on a diet had higher fibre consumption; still, fibre intake failed to reach the recommended target values, which are considerably higher than the ones for the general population and thus difficult to implement. Similarly, the relatively low compliance with the fat recommendations might partly be due to the high meat consumption of participants with self-reported diabetes. In summary, our results suggest that the diet of participants with self-reported diabetes should be implemented, namely regarding fibre and meat intake.

Explanations and possible implementation

Our results suggest that dietary measures against diabetes are little implemented in Switzerland, a finding also reported in Hungary[31] and in the Mediterranean area.[32, 33] Indeed, several studies have shown that general practitioners or nurses have little motivation or training to provide adequate dietary counselling[34-36]. In Switzerland, the guidelines for the management of diabetes in clinical setting barely mention dietary measures.[37] Similarly, the recommendations in Switzerland for the treatment of type 2 diabetes focus mainly on drug treatment rather than on lifestyle management.[38] Hence, better training of medical students and doctors regarding dietetic counselling could be of interest, as a previous study conducted among Swiss primary care physicians showed that adherence to dietary counselling improved glycaemic control by diabetic participants.[39]

Several barriers against implementation of a healthy diet by diabetic patients have also been identified. Diabetic patients lack motivation to change their diet[40], prompting them to prefer drugs to lifestyle measures.[41] The low availability of healthy choices in restaurants[42] or difficulties in understanding or applying the recommendations[43, 44] are also indicated. Still, the low quality of the dietary intake among participants diagnosed with diabetes and reporting a diet was somewhat unexpected. In Vaud, diabetic patients have their dietetic consultations reimbursed, contrary to other countries where access to a dietician is conditioned by insurance conditions.[45] Based on the current findings, it seems that diabetic patients either do not receive dietary counselling, do not benefit from dietetic consultations, or are unable to apply the dietary recommendations provided. In the absence of data regarding these issues, future studies should assess the prevalence of diabetic patients benefiting from dietetic consultations.

Study limitations

This study has several limitations worth acknowledging. Firstly, participation rate was low, but comparable to many other European surveys.[46] Secondly, excluded participants differed significantly from included ones regarding several characteristics known to influence dietary intake. It is thus likely that the diets reported are actually better than if the whole sample had been included. Still, inclusion of participants with improbable TEIs (<850 or >4500 kcal/day) led to similar findings. Thirdly, the CoLaus study was conducted in an urban setting (Lausanne) and in a French-speaking canton (Vaud); it is thus possible that the results obtained might not be extrapolated to other parts of Switzerland or to other countries. Still, they provide important information regarding the inadequacy of dietary management of diabetes in a population-based sample, and could serve as reference for future studies in this area. Finally, no information on diabetes control (i.e. HbA_1c levels) was available, so it was not possible to assess if dietary measures were efficient in managing the disease. The ongoing follow-up of the CoLaus participants will enable to answer this question, as HbA_1c measures are performed.

Conclusion

In Switzerland, only half of participants with self-reported diabetes report being on a diet. Most reported diets do not comply with current recommendations.

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SUPPLEMENTAL MATERIAL

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CHAPTER 4.3

Changes in dietary behavior after a coronary event

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ABSTRACT

Background and aims: a healthy diet is recommended for the prevention of coronary artery disease (CAD), but whereas patients with CAD adhere to a healthy diet is unclear. We aimed to assess the impact of a CAD event on dietary intake.

Methods: prospective, population-based, observational study conducted between 2009 and 2017. Dietary intake was assessed using a validated food frequency questionnaire. Three comparisons were performed: 1) between participants with history of CAD and gender- and age-matched controls; 2) before and after the occurrence of a CAD event, and 3) between participants with an incident CAD event and gender- and age-matched controls.

Results: in analysis 1), after multivariable adjustment, participants with history of CAD had a lower total energy intake than controls (adjusted mean±standard error: 1833±36 vs. 1940±26 kcal/day, p=0.022), while no difference was found for all other dietary markers. In analysis 2) (n=87) total energy intake increased (1927±593 vs. 2100±700 kcal/day before and after the event, respectively, p=0.029) and prevalence of low-fat diet decreased (35.6% vs. 21.8%, p=0.036), while no difference was found for all other dietary markers. In analysis 3), participants with incident CAD had higher vegetable protein intake (adjusted mean±standard error 4.8±0.1 vs. 4.5±0.1% of total energy intake, p=0.028), AHEI score (34±1 vs. 31±1, p=0.032), and complied more frequently with vegetables guidelines [odds ratio and 95% confidence interval; 7.64 (1.06-55.2)] than controls, while no differences were found for all other dietary markers.

Conclusions: in Switzerland, secondary prevention of CAD by diet is seldom implemented.

INTRODUCTION

Patients who present with nonfatal cardiovascular disease (CVD)(i.e. coronary artery disease (CAD) or stroke) are urged to adopt healthy lifestyles to prevent recurrence of disease[1]. Such lifestyles include the absence of smoking, a healthy diet[2] and increasing physical activity.[3, 4] Adequate rehabilitation after a CHD event reduces mortality and recurrent events[5-7], however, the reduction in mortality appears to be restricted to before-after studies[8]. Guidelines regarding the secondary prevention of CAD [9] and stroke[10] have been issued. Still, it has been estimated that less than one third of patients with CVD does not benefit from rehabilitation interventions[11], and Switzerland is not an exception.[12]

Studies assessing changes in dietary behavior after a CVD event and their effect are relatively scarce.[13] In the EUROASPIRE study, a large study encompassing 24 European countries, most (>70%) coronary patients reported trying to change their diet by reducing their consumption of salt, fat and sugar, and by increasing their consumption of fruits and fish[14], a finding also reported elsewhere.[15, 16] Still, in the EUROASPIRE study, almost half of obese patients had not followed dietary recommendations since their coronary event and the smoking rate remained high.[14] Further, no significant improvement in smoking and a 7% increase in obesity levels was found between 1999 and 2013.[17] Noteworthy, no information on dietary intake was available.

Thus, we aimed to compare the dietary intake between subjects who presented with a non-fatal CAD event and gender- and age-matched controls using data from the CoLaus study. Our hypothesis was that, despite a serious and life-threatening event, no changes in dietary intake would occur.

MATERIALS AND METHODS

Participants

The CoLaus study is a population-based study assessing the clinical, biological and genetic determinants of cardiovascular disease in the city of Lausanne, Switzerland. Its aims and sampling strategy have been reported previously.[18]

Recruitment began in June 2003 and ended in May 2006, enrolling 6733 total participants who underwent an interview, a physical exam, and a blood analysis. The first follow-up was performed between April 2009 and September 2012, 5.6 years on average after the collection of baseline data; the second follow-up was performed between May 2014 and April 2017, 10.9 years on average after the collection of baseline data. The information collected was similar to that collected in the baseline examination, except that dietary assessment was also performed. Hence, for this study, only data from the follow-up examinations was used.

Dietary intake

Dietary intake of the previous 4 weeks was assessed using a validated, self-administered, semi-quantitative FFQ that also included portion size.[19] This FFQ consists of 97 different food items that account for more than 90% of the intake of calories, proteins, fat, carbohydrates, alcohol, cholesterol, vitamin D and retinol, and 85% of fibre, carotene and iron. 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 indicated the average serving size (smaller, equal or bigger) compared to a reference size. Each participant brought along her/his filled-in FFQ, which was checked for completion by trained interviewers the day of the visit.

Three dietary scores were computed, two based on the Mediterranean diet, the third on a modification of the alternative healthy eating index (AHEI). The first Mediterranean dietary score (hereby designated as "Mediterranean score 1") was derived from Trichopoulou et al.[20], the score ranges between zero and eight. The second Mediterranean dietary score (hereby designated as "Mediterranean score 2") is adapted to the Swiss population and was computed according to Vormund et al.[21] Contrary to the score from Trichopoulou et al, dairy products are considered as beneficial. The score thus ranges between zero and nine. The AHEI was adapted from McCullough et al.[22] In our study, the amount of *trans* fat could not be assessed, and we considered all participants taking multivitamins as taking them for a duration ≥5 years. Thus, the modified AHEI score ranged between 2.5 and 77.5 instead of 2.5 and 87.5 for the original AHEI score.[22] For all three scores, higher values represented a healthier diet.

Naïve dietary patterns were derived using principal components analysis (PCA) based on food consumption frequencies. Three dietary patterns were identified: "Meat & fries", "Fruits & Vegetables" and "Fatty & sugary". Detailed description of assessment and characteristics of the dietary patterns is provided elsewhere.[23]

Participants were dichotomized according to whether they followed the dietary recommendations for fruits, vegetables, meat, fish and dairy products from the Swiss Society of Nutrition.[24] The recommendations were ≥2 fruit portions/day; ≥3 vegetable portions/day; ≤5 meat portions/week; ≥1 fish portion/week and ≥3 dairy products portions/day. As the FFQ queried about fresh and fried fish, two categories were considered: one included and one excluded fried fish. Participants were further dichotomized if they complied with at least three recommendations or not; two categories of compliance to at least three recommendations were created, depending on the type of fish consumed (all or fresh only).

Presence of an on-going diet was assessed by questionnaire. Diets a) to reduce; b) low in fat; c) low in sugar / for diabetes, and d) low in salt were considered.

Coronary artery disease

Prevalent and incident coronary artery events were recorded through a stepwise process. Firstly, relevant medical records were collected in participants who declared, during the baseline and/or follow-up examinations, to have presented a CVD and/or CVD-related procedure during their lifetime, including MI, angina pectoris, stroke, arrhythmia, cardiomyopathy, coronarography and/or percutaneous transluminal coronary angioplasty (PCA) and/or coronary stenting, and coronary artery bypass grafting (CABG). The records were collected from general practitioners, cardiologists, neurologists and/or hospitals (as appropriate), and encompassed medical and/or surgical notes, laboratory, radiological, echocardiographic and electrocardiographic reports. If necessary, the original coronarography (angiogram) and brain CT/MRI exams were collected. Secondly, to retrieve events that may not have been mentioned during interviews, we searched the central medical database of the University Hospital of Lausanne, which corresponds to the main community hospital in the catchment area of the study. Participants with hospital records were identified cross-checking with administrative data and events of interest were detected using the following ICD-10 (International Classification of diseases, Tenth Edition) codes: I20.0, I21.-, I22.-, I24.-, I25.1-, I25.2-, I25.5, I25.6, I25.8, I25.9, I61.-, I62.-, I63.-, I64, I69.1, I69.2, I69.3, I69.4, I69.8, and G45.-. Thirdly, death was established using the population register of the city where the participant was living in case of returned mail, absence of response when calling and/or indication from a relative. Information on its cause was in order and selectively collected from: 1) general practitioners; 2) medical database of the hospital where the death occurred (either in Switzerland or abroad); 3) database of the pre-hospital emergency care unit of the City of Lausanne; 4) database of the University Centre of Legal Medicine of Lausanne and Geneva; 5) official death certificates from the Swiss governmental agency providing death statistics; 6) verbal autopsy with a relative of the dead participant, if all previous steps failed.

Non-fatal MI and other coronary artery disease (CAD) were adjudicated by two cardiologists based mainly upon an international expert consensus document.[25] Unstable angina (UA) was included into MI category in order to correspond with the clinical 'acute coronary syndrome' entity. Diagnosis of UA was based upon the record of a consultation (either outpatient or inpatient) for worsening symptoms and resulting in a change in antianginal medication, unless troponin values were positive. CAD corresponded to subjects who presented typical symptoms (stable angina) and underwent either percutaneous (PCA ± stenting) or surgical (CABG) revascularizations, unless these procedures were directly related to a MI.

History of coronary artery disease at first follow-up was defined as incident cases of CAD between baseline and follow-up and previous history of CAD. Incident cases were defined as an event that occurred between the first and the second follow-up.

Covariates

Smoking status (never smokers, ex-smokers, current smokers) was self-reported. Marital status was categorized as living alone (i.e. being single, divorced and widowed) or in couple (i.e. married or cohabiting). Educational level was categorized as high (university), middle (high school) and low (apprenticeship and mandatory). Participants indicated which medicines they were currently taking, and the following dichotomous categories were created: antihypertensives, hypolipidemics and antidiabetics.

Body weight and height were measured with participants barefoot and in light indoor clothes. Body weight was measured in kilograms to the nearest 100 g using a Seca® scale (Hamburg, Germany). Height was measured to the nearest 5 mm using a Seca® (Hamburg, Germany) height gauge. Body mass index (BMI) was computed and categorized into normal (<25 kg/m^2), overweight (25-29.9 kg/m^2) and obese (≥30 kg/m^2).

Matching

Matching was performed on gender and age using the **rangejoin** command of Stata. A first matching was performed using a ±1 year constraint. If no controls could be found, the constraint was relaxed to ±2 years.

Statistical analysis

Three analyses were performed. The first analysis compared dietary intake at first follow-up between participants with history of CAD and gender- and age-matched controls. The second analysis compared dietary intake at second follow-up between participants who presented with an incident CAD event between the first and the second follow-up and gender- and age-matched controls devoid of history of CAD. The third analysis compared dietary markers at first and second follow-up among participants who presented with an incident CAD event.

Statistical analyses were performed using Stata version 15.1 for windows (Stata Corp, College Station, Texas, USA). Descriptive results were expressed as number of participants (percentage) for categorical variables or as average standard deviation for continuous variables. For the first and second analyses, bivariate comparisons between cases and controls were performed using chi-square or Fisher's exact test for qualitative variables and Student's t-test for continuous variables. Multivariate analyses were performed using conditional logistic regression for categorical variables and the results were expressed as Odds ratio (OR) and 95% confidence interval (CI); for continuous variables, multivariable analyses were performed using a mixed model were the matching group was included in the random part of the model; variable to adjust for were selected based on previous literature and univariate analyses. Multivariable models were adjusted for living in couple (yes, no), educational level (high, middle, low), body mass index (normal, overweight, obese), smoking (never, former, current), and antihypertensive, hypolipidemic and antidiabetic drug treatments.

For the third analyses, exact Mc Nemar's test for categorical variables and paired student's t-test for continuous variables were used. Due to the number of tests performed, statistical significance was assessed for a two-sided test with $p<0.005$.

Exclusion criteria

For the first analysis, participants were excluded if they 1) lacked dietary information; 2) had a total energy intake (TEI) <850 or >4500 kcal/day; 3) lacked any covariate and 4) could not be matched (for participants with CAD). For the second analysis, participants were excluded if they 1) had no follow-up; 2) lacked dietary information; 3) had a total energy intake (TEI) <850 or >4500 kcal/day; 4) lacked any covariate and 5) had a previous history of CAD (for participants without incident CAD). For the third analysis, participants were excluded if they 1) lacked dietary information; 2) had a total energy intake (TEI) <850 or >4500 kcal/day at first or second follow-ups.

Ethical statement

The institutional Ethics Committee of the University of Lausanne, which afterwards became the Ethics Commission of Canton Vaud (www.cer-vd.ch) approved the baseline CoLaus study (reference 16/03, decisions of 13th January and 10th February 2003); the approval was renewed for the first (reference 33/09, decision of 23rd February 2009) and the second (reference 26/14, decision of 11th March 2014) follow-up. All participants gave their signed informed consent before entering the study.

RESULTS

Characteristics of participants

The selection procedure of the participants for the first and the second analyses is provided in **supplementary figures 4.3.1 and 4.3.2**. The socio-demographic and clinical characteristics of cases and controls for the first analysis is provided in **table 4.3.1** and for second analysis in **supplementary table 4.3.1**. For the first analysis, cases tended to be slightly older, had a lower educational level, a higher BMI, a higher prevalence of former smokers, and a higher prevalence of antihypertensive, hypolipidemic and antidiabetic drugs than controls (**Table 4.3.1**). For the second analysis, cases had a higher prevalence of antihypertensive and hypolipidemic drugs than controls, while no differences were found for all other variables studied (**Supplementary table 4.3.1**).

Table 4.3.1: socio-demographic and clinical characteristics of participants with history of coronary heart disease and gender- and age-matched controls, CoLaus study, Lausanne, Switzerland.

	Controls	**Cases**	**P-value**
Sample size	661	356	
Women (%)	277 (41.9)	148 (41.6)	0.918
Age (years)	65.0 ± 9.3	66.2 ± 9.2	0.052
Living in couple (%)	418 (63.2)	210 (59.0)	0.184
Educational level (%)			<0.001
High	117 (17.7)	43 (12.1)	
Middle	206 (31.2)	78 (21.9)	
Low	338 (51.1)	235 (66.0)	
Body mass index	26.1 ± 4.2	27.7 ± 4.8	<0.001
Body mass index categories (%)			<0.001
Normal	275 (41.6)	103 (28.9)	
Overweight	288 (43.6)	160 (44.9)	
Obese	98 (14.8)	93 (26.1)	
Smoking status (%)			0.001
Never	286 (43.3)	112 (31.5)	
Former	264 (39.9)	183 (51.4)	
Current	111 (16.8)	61 (17.1)	
Treatments (%)			
Antihypertensive	223 (33.7)	249 (69.9)	<0.001
Hypolipidemic	146 (22.1)	211 (59.3)	<0.001
Antidiabetic	50 (7.6)	53 (14.9)	<0.001

Results are expressed as number (percentage) for categorical variables or as average ± standard deviation for continuous variables. Between-group comparisons were performed using chi-square for categorical variables and student's t-test for continuous variables.

Dietary intake among participants with history of coronary artery disease

Dietary intake among participants with history of CAD and gender- and age-matched controls is summarized in **tables 4.3.2** (bivariate) and **4.3.3** (multivariable). On bivariate analysis, cases had a lower total energy intake and lower levels of the Mediterranean dietary score, the AHEI and the "Fruits & Vegetables" dietary pattern than controls; conversely, cases had a higher prevalence of low fat and low sugar/diabetic diets and scored less than controls in the "Pastries & fat" dietary pattern (**Table 4.3.2**). After multivariable analysis, cases had a lower total energy intake than controls, while no difference was found for all other dietary markers (**Table 4.3.3**).

Table 4.3.2: bivariate analysis of dietary intake between participants with history of coronary heart disease and gender- and age-matched controls, CoLaus study, Lausanne, Switzerland.

	Controls	Cases	P-value
Sample size	N=661	N=356	
Total energy intake (kcal./day)	1946 ± 643	1821 ± 634	0.003
Macronutrients (% TEI)			
Total protein	15.0 ± 2.9	15.0 ± 2.9	0.663
Vegetable protein	4.7 ± 1.2	4.8 ± 1.3	0.812
Animal protein	10.2 ± 3.3	10.3 ± 3.3	0.765
Total carbohydrates	46.6 ± 8.9	47.1 ± 9.6	0.407
Monosaccharides	22.9 ± 8.0	23.2 ± 9.1	0.633
Polysaccharides	23.5 ± 7.7	23.8 ± 8.8	0.627
Total fat	33.9 ± 6.8	33.1 ± 7.0	0.080
Saturated	12.7 ± 3.5	12.3 ± 3.6	0.055
Monounsaturated	13.4 ± 3.5	13.0 ± 3.5	0.159
Polyunsaturated	4.8 ± 1.6	4.9 ± 1.6	0.719
Dietary scores			
Mediterranean §	4.1 ± 1.5	4.1 ± 1.5	0.515
Mediterranean §§	4.8 ± 1.8	4.5 ± 2.0	0.019
AHEI	33 ± 10	31 ± 10	0.011
Dietary patterns	N=630	N=327	
Meat & Chips	-0.07 ± 1.09	-0.06 ± 1.16	0.866
Fruits & Vegetables	0.07 ± 1.61	-0.18 ± 1.56	0.022
Pastries & Fat	0.19 ± 1.42	-0.06 ± 1.37	0.009
Compliance to dietary guidelines	N=661	N=356	
Fruits	323 (48.9)	160 (44.9)	0.232
Vegetables	50 (7.6)	27 (7.6)	0.991
Meat	413 (62.5)	230 (64.6)	0.503
Fish	435 (65.8)	245 (68.8)	0.331
Fish §	264 (39.9)	127 (35.7)	0.182
Dairy	62 (9.4)	24 (6.7)	0.149
At least three	184 (27.8)	94 (26.4)	0.625
At least three §	133 (20.1)	63 (17.7)	0.350
Presence of a diet			
To reduce	42 (6.4)	18 (5.1)	0.402
Low fat	144 (21.8)	117 (32.9)	<0.001
Low sugar / for diabetes	52 (7.9)	55 (15.5)	<0.001
Low salt	34 (5.1)	28 (7.9)	0.084

TEI, total energy intake. §, excluding fried fish. Results are expressed as number (percentage) for categorical variables or as average ± standard deviation for continuous variables. Between-group comparisons were performed using chi-square for categorical variables and student's t-test for continuous variables.

4.3

Table 4.3.3: multivariable analysis of dietary intake between participants with history of coronary heart disease and gender- and age-matched controls, CoLaus study, Lausanne, Switzerland.

	Controls	Cases	P-value
Sample size	N=661	N=356	
Total energy intake (kcal./day)	1940 ± 26	1833 ± 36	0.022
Macronutrients (% TEI)			
Total protein	14.9 ± 0.1	15.1 ± 0.2	0.337
Vegetable protein	4.7 ± 0.1	4.8 ± 0.1	0.341
Animal protein	10.2 ± 0.1	10.3 ± 0.2	0.624
Total carbohydrates	46.5 ± 0.4	47.2 ± 0.5	0.284
Monosaccharides	22.9 ± 0.4	23.3 ± 0.5	0.464
Polysaccharides	23.5 ± 0.3	23.8 ± 0.5	0.600
Total fat	33.7 ± 0.3	33.4 ± 0.4	0.513
Saturated	12.7 ± 0.1	12.4 ± 0.2	0.259
Monounsaturated	13.3 ± 0.1	13.2 ± 0.2	0.654
Polyunsaturated	4.8 ± 0.1	4.8 ± 0.1	0.982
Dietary scores			
Mediterranean §	4.1 ± 0.1	4.1 ± 0.1	0.738
Mediterranean §§	4.8 ± 0.1	4.6 ± 0.1	0.127
AHEI	32 ± 1	32 ± 1	0.285
Dietary patterns	N=630	N=327	
Meat & Chips	-0.06 ± 0.05	-0.08 ± 0.07	0.818
Fruits & Vegetables	0.03 ± 0.07	-0.08 ± 0.09	0.349
Pastries & Fat	0.17 ± 0.06	-0.01 ± 0.08	0.095
Compliance to dietary guidelines	N=661	N=356	
Fruits	1 (ref.)	0.99 (0.72-1.37)	0.948
Vegetables	1 (ref.)	0.84 (0.46-1.54)	0.581
Meat	1 (ref.)	1.02 (0.73-1.41)	0.923
Fish	1 (ref.)	1.31 (0.93-1.86)	0.121
Fish §	1 (ref.)	0.93 (0.66-1.30)	0.654
Dairy	1 (ref.)	0.88 (0.50-1.54)	0.647
At least three	1 (ref.)	1.14 (0.77-1.67)	0.519
At least three §	1 (ref.)	0.98 (0.65-1.49)	0.941
Presence of a diet			
To reduce	1 (ref.)	0.59 (0.26-1.32)	0.196
Low fat	1 (ref.)	1.19 (0.83-1.70)	0.337
Low sugar / for diabetes	1 (ref.)	1.86 (0.82-4.19)	0.135
Low salt	1 (ref.)	1.45 (0.77-2.75)	0.251

TEI, total energy intake. §, excluding fried fish. Results are expressed as multivariable adjusted odds ratio and (95% confidence interval) for categorical variables and as multivariable adjusted mean±standard error. Between-group comparisons were performed using conditional logistic regression for categorical variables and a mixed model for continuous variables. All models were adjusted for living in couple (yes, no), educational level (high, middle, low), body mass index (normal, overweight, obese), smoking (never, former, current), and antihypertensive, hypolipidemic and antidiabetic drug treatments.

Dietary intake among participants with incident coronary artery disease

Eighty-seven participants developed a CAD event between the first and the second follow-up. Their dietary intake before and after the occurrence of the event is summarized in **table 4.3.4** next page. Total energy intake increased slightly and prevalence of low-fat diet decreased, while no difference was found for all other dietary markers.

Changes in dietary intake among participants with incident coronary artery disease

Dietary intake at second follow-up among participants with incident CAD and gender- and age-matched controls is summarized in **supplementary tables 4.3.2** (bivariate) and **4.3.3** (multivariable). On bivariate analysis, participants with incident CAD had higher vegetable protein intake, a higher AHEI score, complied more frequently with vegetables guidelines and reported more frequently a diet to reduce or a low-fat diet than controls (**supplementary table 2**). Those differences remained after multivariable adjustment except for diet, for which the multivariable models did not converge (**supplementary table 3**).

Table 4.3.4: paired analysis of the dietary intake of participants who developed coronary heart disease between first and second follow-up, CoLaus study, Lausanne, Switzerland (n=87).

	Before	**After**	**P-value**
Total energy intake (kcal./day)	1927 ± 593	2100 ± 700	0.029
Macronutrients (% TEI)			
Total protein	14.8 ± 2.6	15.2 ± 3.8	0.390
Vegetable protein	4.8 ± 1.2	4.8 ± 1.3	0.977
Animal protein	10.1 ± 2.9	10.4 ± 4.3	0.461
Total carbohydrates	45.8 ± 9.2	46.1 ± 10.6	0.780
Monosaccharides	21.7 ± 7.5	22.2 ± 9.9	0.599
Polysaccharides	24.0 ± 7.8	23.8 ± 8.7	0.804
Total fat	34.0 ± 6.4	34.2 ± 7.9	0.753
Saturated	12.9 ± 3.4	12.9 ± 4.1	0.952
Monounsaturated	13.3 ± 3.3	13.6 ± 4.2	0.502
Polyunsaturated	4.9 ± 1.4	4.8 ± 1.5	0.356
Dietary scores			
Mediterranean § (N=79)	4.2 ± 1.5	4.0 ± 1.6	0.504
Mediterranean §§ (N=60)	5.0 ± 2.0	4.9 ± 2.0	0.715
AHEI (N=80)	32 ± 11	34 ± 9	0.198
Compliance to dietary guidelines			
Fruits	40.5 (29.9-51.7)	52.4 (41.2-63.4)	0.064
Vegetables	9.5 (4.2-17.9)	15.5 (8.5-25.0)	0.227
Meat	59.5 (48.3-70.1)	50.0 (38.9-61.1)	0.185
Fish	68.2 (57.2-77.9)	75.3 (64.7-84.0)	0.345
Fish §	36.5 (26.3-47.6)	43.5 (32.8-54.7)	0.286
Dairy	4.8 (1.3-11.9)	12.0 (5.9-21.0)	0.146
At least three	24.1 (15.4-34.7)	28.9 (19.5-39.9)	0.481
At least three §	19.3 (11.4-29.4)	22.9 (14.4-33.4)	0.549
Presence of a diet			
To reduce	5.7 (1.9-12.9)	6.9 (2.6-14.4)	1.000
Low fat	35.6 (25.6-46.6)	21.8 (13.7-32.0)	0.036
Low sugar / for diabetes	13.8 (7.3-22.9)	8.0 (3.3-15.9)	0.267
Low salt	6.9 (2.6-14.4)	5.7 (1.9-12.9)	1.000

Results are expressed as percentage (95% confidence interval) for categorical variables or as average ± standard deviation for continuous variables. Between-group comparisons were performed using exact Mc Nemar's test for categorical variables and paired student's t-test for continuous variables.

DISCUSSION

In agreement with our initial hypothesis, the results indicate that, despite a serious and life-threatening event such as CAD, no substantial changes in dietary intake occur after a coronary event. Our findings add further evidence to the lack of adequate dietary prevention of subsequent cardiovascular events.

Dietary intake among participants with history of coronary artery disease

Participants with history of CAD did not differ from participants devoid of CAD regarding all dietary markers. The sole exception was a reduced total energy intake, which remained statistically significant after multivariable analysis. Still, the absolute difference was small (approximately 100 kcal/day) and could be accounted for by a reporting bias. As participants with history of CAD were more frequently obese, it is possible that they have (un)voluntarily underreported their true dietary intake. A possible explanation for the lack of difference regarding dietary intake between participants with history of CAD and participants devoid of CAD could be the difficulty for the first to put into practice the dietary information received during rehabilitation.[26]

Dietary intake among participants with incident coronary artery disease

In a previous study, we have shown that participants reporting a low-fat diet have a healthier dietary intake than the general population.[27] Hence, it is likely that higher prevalence of a low-fat diet among participants with incident CAD would explain the higher intake of vegetables, vegetable proteins and the higher AHEI score in this group relative to gender- and age-matched controls. Still, dietary intake of participants with incident CAD differed little from controls, suggesting that the changes were modest and likely insufficient to adequately prevent CAD recurrence. Although the compliance to dietary guidelines was relatively low, still it was comparable or event better than reported by an Italian study conducted in patients with acute myocardial infarction[28]: 7.6% vs. 7.7% for vegetables and 68.8% vs. 18.5% for fish. Still, our results show that dietary intake of subjects with CAD is suboptimal and could be improved.

Changes in dietary intake among participants with incident coronary artery disease

There are few studies assessing dietary intake before and after a CAD event. In this study, almost no changes in dietary intake were found after the occurrence of a CAD event. Although the sample size was small (n=87) and might have reduced statistical power, still the changes observed were extremely small and clinically meaningless. For instance, the small increase in total energy intake (+173 kcal/day) after the CAD event could have been due to a better knowledge of the FFQ by the participants, making them report more accurately their dietary intake. Similarly, although the compliance regarding most foods tended to increase, still less than one third of participants complied with at least three recommendations after the event.

The prevalence of diets aimed at reducing cardiovascular risk factors was considerably lower than reported in other studies such as EUROASPIRE[14]: 6.9% vs. 63.3% to reduce weight, 21.8% vs. 78.9% to reduce fat, 8.0% vs. 66.1% to reduce sugar and 5.7% vs. 71.8% (and 29.6% in a French study[29]) to reduce salt. More worryingly, the prevalence of a low-fat diet decreased after the event, suggesting a possible shift towards lipid-lowering drug therapies. Again, our results show that the occurrence of a CAD does not lead to an improvement in dietary intake. Future studies focusing on a larger sample size and a larger panel of questions should identify the reasons for this failure.

Suggestions for clinical practice and public health

Several interventions to promote dietary prevention of CAD could be implemented. Firstly, increased training in dietary counselling could be provided during medical training[30], as a previous study showed that most medical residents in the university hospital of Lausanne lacked training in dietary information and guidelines[31]. Secondly, dietary management of CAD could be implemented during cardiovascular rehabilitation; although dietary counselling is already included in most if not all rehabilitation programs in Switzerland[32], specific methods such as the Health Action Process Approach[33] have been shown to induce persistent improvements in dietary intake and could be tested. Given the underuse of cardiac rehabilitation programs in the French-speaking part of Switzerland[12], a simple increase in the number of patients admitted into rehabilitation might already be of interest. Thirdly, programs aiming at maintaining a healthy lifestyle could be implemented among CAD patients, as many CAD patients fail to translate the dietary information received during rehabilitation into practice after discharge [26]. For instance, nurse-led[34] or community health-worker[34] based interventions have been shown to be effective in changing dietary intake, although for the first study no long-term results (>1 year) were reported. Finally, general campaigns promoting healthy eating would improve dietary intake in the general population and *ipso facto* among CAD patients.

Study limitations

Several limitations should be acknowledged. First, the small sample evaluated challenged the statistical power. Still, the non-significant differences between cases and controls were small and clinically meaningless. More importantly, it was the low rate of compliance with guidelines and the low prevalence of diets among cases that was of concern. Second, the FFQ focused on a limited number of food items (97); hence, some specific foods such as grains and pulses were not evaluated. Still, as the FFQ was applied in both cases and controls, we expect that the magnitude of this reporting bias is the same for both groups. Third, there was little information socio-economic status, a major determinant of a healthy diet. Indeed, healthy diets tend to be more expensive[36], although this statement has been challenged.[37, 38] Interestingly, previous studies have shown that, in Switzerland, the influence of socioeconomic factors on nutrient intake varies according to gender[39] and that people with a low socio-economic status (i.e. migrants from Southern Europe) score higher for both healthy (Fruits and vegetables) and unhealthy (Meat and fries) dietary patterns than people of higher socio-economic status.[23] In this study, we used educational level and marital status as proxies for socio-economic status and included them in the multivariable analyses. Still, further studies should rely on stronger socio-economic markers such as personal or family income to better assess this issue. Finally, no information regarding rehabilitation post CAD was collected, and it has been suggested that rehabilitation improves dietary intake[40], although this statement has been challenged.[26] Further, use of cardiac rehabilitation programs in the French-speaking part of Switzerland is rather low[12]; hence, their impact on diet might be also low. Finally, the results were obtained from participants living in the city of Lausanne, and its generalizability to other Swiss cantons or other countries might be questionable. Still, in the absence of other studies conducted in Switzerland, our findings represent a first step in the evaluation of lifestyle management of CAD in Switzerland. Our findings also suggest that the actual lifestyle management of CAD in the general population might be worse than previously reported.[14]

We conclude that in Switzerland, adequate improvements in diet for secondary prevention of CAD is suboptimal and require further attention. Supporting patients to improve their dietary intake via behaviour changing therapy is recommended.

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SUPPLEMENTAL MATERIAL

Supplemental table 4.3.1: socio-demographic and clinical characteristics of participants with incident coronary heart disease and gender- and age-matched controls, CoLaus study, Lausanne, Switzerland.

	Controls	**Cases**	**P-value**
Sample size	181	92	
Women (%)	46 (25.4)	23 (25.0)	0.941
Age (years)	64.4 ± 9.3	65.5 ± 9.2	0.340
Living in couple (%)	121 (66.9)	57 (62.0)	0.422
Educational level (%)			0.894
High	37 (20.4)	18 (19.6)	
Middle	53 (29.3)	25 (27.2)	
Low	91 (50.3)	49 (53.3)	
Body mass index	26.0 ± 3.7	26.8 ± 3.8	0.103
BMI categories (%)			0.152
Normal	81 (44.8)	30 (32.6)	
Overweight	76 (42.0)	48 (52.2)	
Obese	24 (13.3)	14 (15.2)	
Smoking status (%)			0.313
Never	68 (37.6)	33 (35.9)	
Former	85 (47.0)	38 (41.3)	
Current	28 (15.5)	21 (22.8)	
Treatments (%)			
Antihypertensive	58 (32.0)	48 (52.2)	<0.001
Hypolipidemic	36 (19.9)	46 (50.0)	<0.001
Antidiabetic	17 (9.4)	11 (12.0)	0.509

BMI, body mass index. Results are expressed as number (percentage) for categorical variables or as average ± standard deviation for continuous variables. Between-group comparisons were performed using chi-square for categorical variables and student's t-test for continuous variables.

Supplemental table 4.3.2: bivariate analysis of dietary intake between participants with incident coronary heart disease and gender- and age-matched controls, CoLaus study, Lausanne, Switzerland.

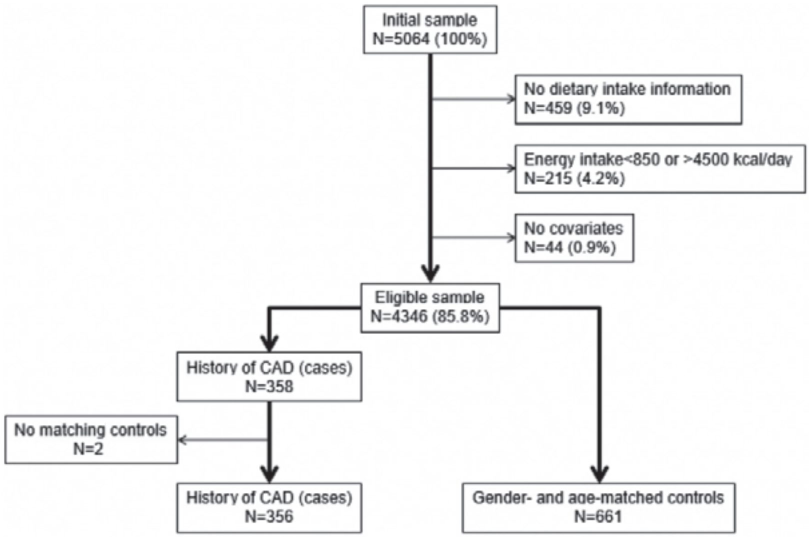
	Controls	**Cases**	**P-value**
Sample size	181	92	
Total energy intake (kcal/day)	2047 ± 660	2037 ± 697	0.911
Macronutrients (% TEI)			
Total protein	15.4 ± 2.7	15.3 ± 3.9	0.794
Vegetable protein	4.5 ± 1.1	4.8 ± 1.2	0.050
Animal protein	11 ± 3.1	10.6 ± 4.5	0.393
Total carbohydrates	44.9 ± 8.4	46.2 ± 10.6	0.248
Monosaccharides	21.9 ± 8	22.0 ± 9.7	0.885
Polysaccharides	22.9 ± 7.8	24.1 ± 8.7	0.234
Total fat	34.9 ± 6.7	33.9 ± 7.8	0.250
Saturated	13.4 ± 3.4	12.6 ± 3.9	0.080
Monounsaturated	13.9 ± 3.6	13.6 ± 4.2	0.507
Polyunsaturated	4.6 ± 1.3	4.8 ± 1.5	0.416
Dietary scores			
Mediterranean §	3.9 ± 1.5	4.0 ± 1.6	0.701
Mediterranean §§	4.8 ± 2.2	4.9 ± 2.0	0.863
AHEI	31 ± 9	34 ± 9	0.040
Compliance to dietary guidelines			
Fruits	86 (48.3)	44 (49.4)	0.865
Vegetables	14 (7.9)	14 (15.7)	0.048
Meat	83 (46.9)	45 (50.6)	0.572
Fish	130 (73.0)	66 (73.3)	0.958
Fish §	86 (48.3)	40 (44.4)	0.549
Dairy	20 (11.3)	11 (12.5)	0.775
At least three	48 (27.1)	24 (27.3)	0.979
At least three §	37 (20.9)	18 (20.5)	0.932
Presence of a diet			
To reduce	4 (2.2)	7 (7.6)	0.048 †
Low fat	12 (6.6)	23 (25.0)	<0.001 †
Low sugar / for diabetes	8 (4.4)	8 (8.7)	0.177 †
Low salt	4 (2.2)	5 (5.4)	0.170 †

TEI, total energy intake. §, excluding fried fish. Results are expressed as number (percentage) for categorical variables or as average ± standard deviation for continuous variables. Between-group comparisons were performed using chi-square or Fisher's exact test (†) for categorical variables and student's t-test for continuous variables.

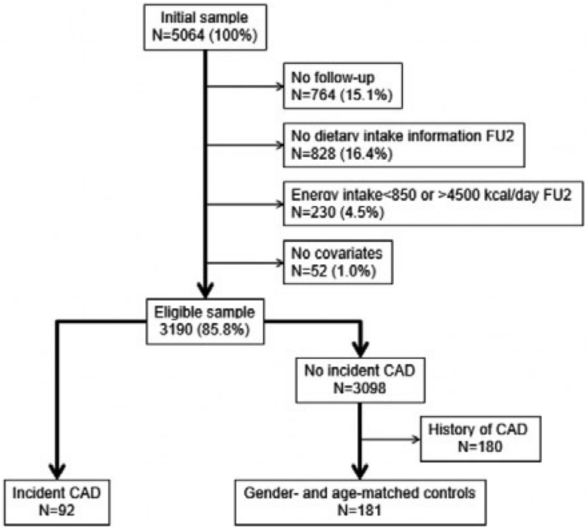
Supplemental table 4.3.3: multivariable analysis of dietary intake between participants with incident coronary heart disease and gender- and age-matched controls, CoLaus study, Lausanne, Switzerland.

	Controls	Cases	P-value
Sample size	181	92	
Total energy intake (kcal/day)	2027 ± 52	2078 ± 72	0.559
Macronutrients (% TEI)			
Total protein	15.5 ± 0.2	15.2 ± 0.3	0.426
Vegetable protein	4.5 ± 0.1	4.8 ± 0.1	0.028
Animal protein	11.1 ± 0.3	10.4 ± 0.4	0.170
Total carbohydrates	44.8 ± 0.7	46.3 ± 1	0.212
Monosaccharides	22 ± 0.7	21.8 ± 0.9	0.848
Polysaccharides	22.7 ± 0.6	24.4 ± 0.9	0.095
Total fat	34.7 ± 0.5	34.3 ± 0.8	0.677
Saturated	13.3 ± 0.3	12.9 ± 0.4	0.356
Monounsaturated	13.9 ± 0.3	13.7 ± 0.4	0.813
Polyunsaturated	4.6 ± 0.1	4.8 ± 0.1	0.275
Dietary scores			
Mediterranean §	3.8 ± 0.1	4.1 ± 0.2	0.249
Mediterranean §§	4.8 ± 0.2	4.9 ± 0.3	0.675
AHEI	31 ± 1	34 ± 1	0.032
Compliance to dietary guidelines			
Fruits	1 (ref.)	1.23 (0.65-2.33)	0.516
Vegetables	1 (ref.)	7.64 (1.06-55.2)	0.044
Meat	1 (ref.)	1.49 (0.81-2.77)	0.202
Fish	1 (ref.)	1.06 (0.55-2.04)	0.873
Fish §	1 (ref.)	0.76 (0.41-1.43)	0.399
Dairy	1 (ref.)	1.53 (0.57-4.08)	0.398
At least three	1 (ref.)	1.26 (0.61-2.62)	0.536
At least three §	1 (ref.)	1.13 (0.51-2.48)	0.767

TEI, total energy intake. §, excluding fried fish. Results are expressed as multivariable adjusted odds ratio and (95% confidence interval) for categorical variables and as multivariable adjusted mean±standard error. Between-group comparisons were performed using conditional logistic regression for categorical variables and a mixed model for continuous variables. All models were adjusted for living in couple (yes, no), educational level (high, middle, low), body mass index (normal, overweight, obese), smoking (never, former, current), and antihypertensive, hypolipidemic and antidiabetic drug treatments. For diets, the model did not converge and results are not presented.



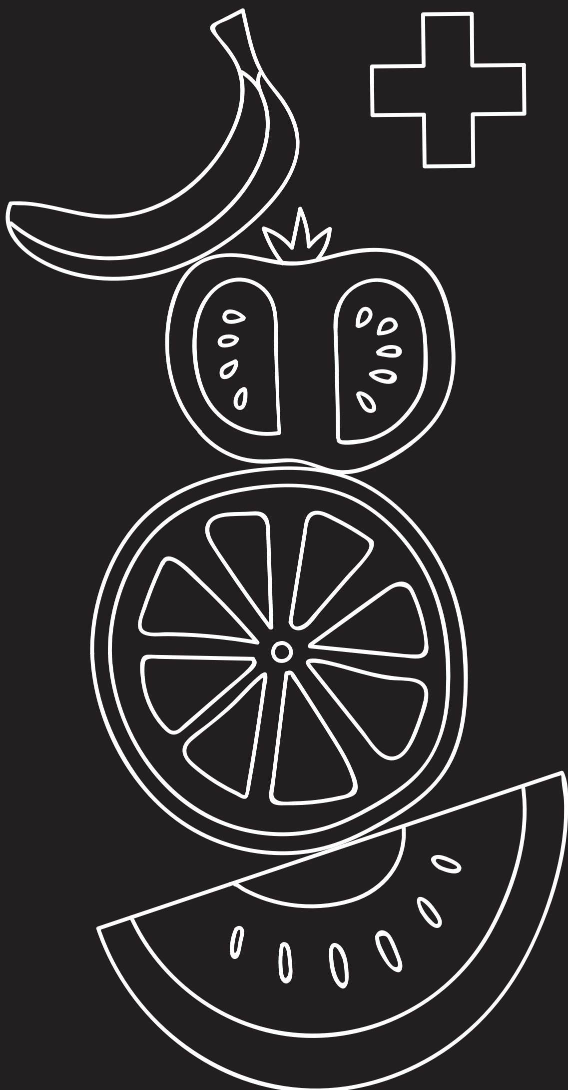
Supplemental figure 4.3.1: selection procedure of the cases and gender- and age-matched controls for the first analysis, CoLaus study, Lausanne, Switzerland.



Supplemental figure 4.3.2: selection procedure of the cases and gender- and age-matched controls for the second analysis, CoLaus study, Lausanne, Switzerland.

4.3

CHAPTER 5



General discussion

5

A healthy diet can contribute to prevent or at least delay the onset of a large range of noncommunicable diseases, including obesity, diabetes, coronary heart disease and cancer. Voluntary and involutary changes towards a healthier eating in the population effectively reduce noncommunicable diseases and provide a safe, and cost-efficient method of disease prevention.

Switzerland has one of the best but also one of the most expensive health systems in the world. The aging of the population combined with the increase in highly technical, expensive treatments continuously raise healthcare costs, a considerable part of which is paid by people *via* health insurance premiums. Between 1995 and 2012, the cost of these premiums has increased much quicker than inflation or salaries: 3.9% per year on average [37], the corresponding yearly increases for salaries and the consumer cost index being 1.4% [38] and 0.7% [39], respectively. This puts a considerable pressure on the Swiss household budget. Indeed, in Switerland, almost two thirds (61.3%) of health expenditures are supported by households (premiums included). An increasing number of people fail to pay the premiums, request financial help or simply do not seek medical treatment. In Switzerland, cantons (the equivalent to US states), not the Federal government, are responsible for the population's health. Cantons are increasingly urged to help failing households: for the Vaud canton, the latest information indicates that the number of people receiving health subsidies increased from 47,897 in 1986 to 200,158 in 2006[9], while the total amount of subsidies increased from 101 million to 526 million CHF during the same period. [10] Although the economic impact of an effective food policy has not been estimated, based on previous literature and knowledge, it could be expected that an adequate policy aimed at improving the dietary intake and lifestyle in general of the population would attenuate the escalating costs of health care in Switzerland.

Still, based on the studies conducted, it appearts that food policies and even dietary prevention of disease does not play a prominent part in the Swiss public health agenda. The first national nutrition survey was conducted in 2014-2015, and no nationwide policy aimed at improving diet has been adopted. Although the national health surveys provide some information regarding dietary intake, still it detailed epidemiological data regarding dietary intake and the dietary prevention of noncommunicable diseases are scarce. Most data come from the French-speaking cantons of Geneva and Vaud, and rely on a FFQ validated in the nineties.

AIMS

The main aim of this thesis was to assess the trends in dietary intake of the adult Swiss population, and how dietary intake impacts cardiovascular risk factors, health and disease. We wanted to know if, despite the lack of a uniform national food policy, dietary intake had improved in the Swiss population. We also wanted to know if diet was used in the management of cardiovascular disease and cardiovascular risk factors, as recommended in the guidelines. [40]

MAIN FINDINGS

Chapter 2: Trends in dietary intake and behaviours in Switzerland

We observed that in the last twenty years, dietary intake improved slightly in the Swiss population. Unfavourable dietary patterns composed of meat, sugary and fatty foods decreased, while a favourable dietary pattern rich in fruits and vegetables increased (**Chapter 2.1**). This trend was paralleled by an increasing compliance to the Swiss guidelines regarding fruits, vegetables and fish intake, and to a lesser degree to the guidelines regarding limited meat intake (**Chapter 2.2**). This improvement occurred despite a high prevalence of barriers to healthy eating (such as price, the belief that healthy foods are tasteless and expensive or a low availability in restaurants and supermarkets) which we observed increased till 2012 but decreased afterwards (**Chapter 2.3**). Still, compliance to the guidelines remained suboptimal and most improvements were modest, less than 1% per year, and compliance to at least three guidelines remained stable. Further, younger generations showed a less favourable dietary pattern and a lower compliance to dietary guidelines than older generations. A possible explanation is that cost of food in Switzerland is rather high, although no differences in the barrier "price" were found between age groups [41] and a previous study has shown that low-cost foods are not worse than branded foods regarding macronutrient content. [42] This unhealthier dietery pattern could compromise the current improvement in dietary intake observed in the Swiss population, although an improvement with time was observed in the generational analyses. The issuing of the Swiss dietary guidelines in 1998 and 2011 had no effect in the trends of compliance, suggesting that these guidelines are either insufficiently publicized in the population, or insufficiently implemented in the public health setting such as food premises, workplaces and schools. Overall, our results indicate that dietary intake has improved slightly in the Swiss population, and that further improvements are possible and needed. Actions promoting the consumption of fruits and vegetables (*via* legislation and economic interventions), the taste of healthy foods (*via* information campaigns) and the dissemination of the dietary guidelines could be used.

In this thesis, we show that regular vitamin or dietary supplement users represent less than one-tenth of the population, half of users being irregular consumers (**Chapter 2.4**). Vitamin and dietary supplements are frequently consumed by the Swiss population, and the reasons for consumption go far beyond scientific evidence. [43] Further, the relatively lax legislation and the absence of adequate monitorization of vitamin and dietary supplements in Switzerland allows the marketing of products with almost "magical" properties [44] and the selling of products non-compliant with the federal legislation [45], despite a consistent lack of evidence regarding benefit. [46] It would be interesting to evaluate if the (ir)regular consumption of vitamin and/or dietary supplements has any effect on multiple health domains, as we failed to find any regarding muscle strength. [46]

Chapter 3: Dietary intake and cardiovascular risk factors

Three dietary patterns were identified, two unfavourable ("Meat & chips", "Fatty & sugary") and one favourable ("Fruits and vegetables"). Women, subjects with higher socio-economic status or subjects with a healthier lifestyle (i.e. no smoking or being physically active) had more favourable dietary patterns (**Chapter 3.1**). Those findings partly explain the better health status of subjects with a high socio-economic status [47], and suggest that studies assessing socio-economic differences in health status should adjust for healthy lifestyles, including diet. On the other way round, studies assessing dietary intake should take into account the socio-economic status of the participants and also adjust for other healthy lifestyles such as lack of smoking and physical activity.

The "Fruits & vegetables" pattern and other markers of a healthy diet (Mediterranean scores and AHEI) were inversely associated with CRP levels, a measure for chronic low-grade inflammation which has been associated to CVD risk (**Chapter 3.2**). The association was stronger for the dietary markers grouping several foods than for each individual food included in the score. This suggests that the joint consumption of different types of foods has a stronger effect than the consumption of a single food. Our results add further emphasis to the importance of a varied, healthy dietary intake [40] rather than focusing on specific foods or nutrients. The lack of association between diet and the other inflammatory markers could be due to issues regarding the measurement of cytokines, which will be discussed later.

Conversely, no association was found between dietary intake and incident hypertension (**Chapter 3.3**). Although important nutrients such as sodium and potassium could not be assessed, our findings suggest that the current range of dietary intake of the Lausanne population is insufficient to prevent the occurrence of hypertension, or that the achievable effect of diet as consumed in the general population (i.e. in the absence of strong changes as achieved by clinical trials) is too small to be of clinical importance.

Chapter 4: Dietary prevention of cardiovascular diseases

Management of cardiovascular risk factors begins by appropriate lifestyle measures, one of which is adopting a healthy diet. In this work, subjects with dyslipidemia showed a healthier dietary intake than the general population, suggesting an adequate implementation of the guidelines to manage this risk factor (**Chapter 4.1**). Conversely, subjects with diabetes tended to report a more unfavourable diet than the general population (**Chapter 4.2)**. The reasons for such a discrepancy (healthier diet among subjects with dyslipidemia but unhealthier in subjects with diabetes) are unclear. S Subjects with diabetes often have more other health issues such as excessive weight, presence of other cardiovascular risk factors, or even organ damage (i.e. chronic kidney disease), which may complicate dietary counselling. [48]

Secondary prevention of CVD relies on the combination of medical treatment and lifestyle changes aiming at a healthier diet and an increased physical activity. [49] [50] Still, subjects who developed a CVD event during the study period failed to report substantial changes in their dietary habits (**Chapter 4.3**). Although we cannot rule out the possibility that the FFQ could not capture minor changes in dietary intake, still our results suggest that the occurrence of a serious event such as CVD does not persuade patients to make major changes in their diet. Possible explanations are that patients do not consider lifestyle changes to play a major role in the recovery or secondary prevention of a CVD event and might rely on pharmacological solution, another explanation is the lack of facilities to help patients change their dietary intake. Indeed, less than half of AMI patients are referred for cardiac rehabilitation in Switzerland[51]. Further, teaching of dietary management of diseases is almost non-existent in the Swiss medical curricula. Reinforcing the teaching of the importance of nutrition and lifestyle in health and diseases in the medical curricula could thus improve dietary management of cardiovascular risk factors. In the same study, over 80% of the residents reported lack of time as a barrier to nutrition intervention. [48] Still, since January 2018, the duration of a fully reimbursable medical consultation in Switzerland is limited to 20 minutes for most patients. [52] Hence, it is likely that any improvement in nutritional knowledge of doctors will be cancelled by the current restrictions regarding patient management. Overall, our results indicate that dietary management of subjects with cardiovascular risk factors is suboptimal in Switzerland. This situation is likely not to improve given the current constraints regarding medical consultations.

METHODOLOGICAL CONSIDERATIONS

Study design and sampling

The research presented in this thesis was based on two surveys. The Bus Santé conducted in Geneva is a multiple cross-sectional study conducted since 1993. It relies on a representative sample of non-institutionalized people living in the canton of Geneva. As for any populational study, the results are dependent on the participation rate. A high participation rate suggests that the study findings can reliably be applied to the whole target population, while a low participation rate suggests the presence of a selection bias, making the results less reliable or generalizable.Participation rates ranged between 50 to 66%, which is in line with other studies conducted in Europe. [53] It is a common feature that survey participants tend to differ from non-participants regarding clinical and socio-demographic characteristics; participants tend to be more health counscious and to adapt healthier lifestyles than non-participants. [54] This issue could be further complicated by diverging trends in participation rates according to educational level, as it has been suggested for Finland [55], but no data is available for Switzerland. Hence, it is likely that the results obtained might overestimate the true status regarding dietary intake in the Swiss population. Correction procedures such as inverse probability weighting have been proposed [56], but the weights can only be built using the data that has been collected and omit all other (non-collected) factors that also differ between participants and non-participants. Still, although those selection/attrition biases might increase the prevalence of healthy eaters in the sample, it is unlikely that they would completely change the observed associations between dietary intake and CV risk factors or inflammatory markers.

The CoLaus study is a prospective cohort constituted in 2003-2006 from a random sample of Lausanne inhabitants aged 35-74. Besides the risk of initial selection bias, the cohort is submitted to attrition as participants are not replaced. As for non-participants, participants who quit during follow-up tend to differ from participants who pursue the study regarding several socio-demographic characteristics. [57] This leads to a progressive selection of the more motivated, more health-counscious participants at the expense of participants with higher levels of risk factors. This unavoidable selection bias could lead to an overestimation of the improvement in dietary intake with time, as participants with unhealthy dietary intake would quit the study more frequently.

Dietary assessment

In both studies, dietary intake was assessed using a validated, 97-item FFQ. This FFQ was validated against 24-h recalls and was shown to underestimate the actual total energy intake by 14% in men and 4% in women. [17] Conversely, the energy contributions of the different macronutrients were similar between the FFQ and the 24-h recalls. [17] The use of the same FFQ by the Bus Santé and the CoLaus studies is a major benefit, as it allows direct comparison of the results between studies. Also, the fact that the FFQ did not change in time allowed the assessment of trends without considering changes in food composition tables or FFQ items.

Conversely, the fact that the FFQ only assesses food intake of the last four weeks could lead to an information bias, as the types of foods consumed would differ according to season. A FFQ assessing the average food intake during the whole year would reduce seasonal variation but would likely be more prone to recall bias, as it would have been more difficult for a participant to recall food intake from a whole year than from the last four weeks. When assessing food intake, the different biases should be evaluated and balanced, such as recall, seasonal, and reporting bias (participants reporting an ideal food intake instead of the real one). Any method of dietary assessment is a compromise between several constraints, and the pros and cons of each method should be thoroughly evaluated. For instance, the fact that the FFQ did not change since its implementation has benefits because it allows the calculation of trends, but on the other side it does not allow the introduction of novel foods that appeared during that period. Hence, temporal trends might be misestimated if novel foods become widespread in the population. Further, the analysis of the FFQ relied on the same food composition database as from its validation, thus preventing the update of nutrient contents or the addition of new nutrients.

Cardiovascular risk factors

Prevalence of cardiovascular risk factors was assessed by objective measurements. This allows a better estimation of the prevalence rates than self-reporting, which leads to an underestimation of prevalence rates [58] and dilutes the associations. Nevertheless, several issues must be raised regarding cardiovascular risk factors assessment. First, diabetes was assessed using fasting glucose levels, and glycated haemoglobin was assessed only in the second follow-up. As recommendations regarding diagnosis of diabetes changed during the first follow-up [59 60], it was decided to keep fasting plasma glucose as the main diagnostic tool for diabetes. Indeed, prevalence of diabetes differs according to the marker used (fasting plasma glucose or glycated haemoglobin) [61], results might also differ when shifting from one definition to another.

Second, hypertension was defined based on a single assessment in time, and not on several multiple measurements separated by several days or weeks as recommended.[62 63] Although using the average of two measurements might reduce measurement error, still this tends to overestimate the prevalence rates for hypertension [64 65], but it would be logistically difficult to measure blood pressure levels on several occasions. Indeed, most epidemiological studies on hypertension prevalence relied on a single assessment in time. [66 67]

Third, although methods to assess high sensitivity CRP levels can now be considered as relatively well standardized, it is not the case for other inflammatory markers such as cytokines. Assessment of interleukin 1b, interleukin 6 or tumor necrosis factor a is not yet standardized for clinical practice. A sizable fraction of participants (>25%) was below detection levels for interleukin 1b, suggesting that the assessment method was unsuitable for most samples. Also, the relatively high CV of the assessments (>10%) suggested a relatively low precision. Unfortunately, there are few studies comparing the precision and accuracy of the different methods to assess cytokines [68 69]; their conclusions were that considerable improvements are yet to be made to make the assessment reliable. Hence, the associations between dietary intake and several inflammatory markers reported in this thesis cannot be transferred to clinical practice and should serve only as hypothesis-generating. Better calibrators, procedures and training [70] are necessary if such cytokine measurements are to enter routine clinical practice.

Causality and residual confounding

Excepting the study on diet and incident hypertension presented in **chapter 3.3**, all studies associating diet and cardiovascular risk factors were cross-sectional. Hence, the issue of causality cannot be established as no time sequence is available and reverse causation cannot be ruled out. Further studies will be conducted using the CoLaus data to assess the effects of diet on the incidence of diabetes, dyslipidemia and heart disease.

Also, several other socio-economic markers not accounted for such as income, place of living, nationality (culinary background) have been shown to be associated with dietary intake. [71] A low income is usually associated with a lower quality diet, as foods of lower nutritional value usually cost less than healthy foods. [72 73] Still, such association has not been consistently found: an inverse association between income and dietary quality was observed among participants aged ≥55 in the Rotterdam study.[74]

Environment can exert an effect on food choices via the availability of (un)healthy food premises. [75] Although food environments cannot be strictly considered as "healthy" or "unhealthy" [76], still several studies suggest that food behaviours tend to cluster. In the Netherlands, a spatial clustering of dietary patterns was found, suggesting regional "food cultures", driven by regional income or educational level. [77]

Nationality and/or ethnicity strongly determine dietary intake. Portuguese and Spanish migrants in Switzerland have a higher intake of fruits & vegetables, but also of meat & chips than the Swiss. [78] Migrants from Surinam report a higher intake of rice and chicken and a lower intake of red meat and vegetables than Dutch. [79] The differences are more important among first generation migrants, while the subsequent generations tend to incorporate the local diet into their own as an acculturation strategy. This dietary acculturation might lead to healthier [80] or unhealthier [81] diets among next-generation immigrants, depending on the country of origin and the country of destination

Importantly, most socioeconomic markers interact, complicating the precise assessment of the associations between a given socioeconomic makers and dietary intake. [82] For instance, in France, a higher income increased the intake of several micronutrients including fiber, protein and folate in low educated, but not in higher educated subjects. [83] Overall, it might not be very important to precisely identify which socioeconomic marker(s) is/are associated with a healthier diet, but rather to propose a set of socioeconomic markers that consistently increase/decrease the quality of the diet. [84]

Generalizability of findings

Switzerland is a multilanguage, multicultural country, composed of 26 cantons with a strong cultural background. Hence, it is likely that the findings obtained for the French-speaking cantons regarding trends in dietary intake cannot be directly extrapolated to the German- or Italian-speaking ones. Indeed, results from the national nutritional survey showed significant differences between Swiss linguistic regions, French and Italian-speaking regions showing a higher consumption of fish and meat than the German-speaking one, while the Italian-speaking region had the lowest consumption of vegetables. [16] While death rates from cardiovascular disease show a South-West to North-East gradient [85], the prevalence of cardiovascular risk factors, namely hypertension and dyslipidemia, is lower in the German-speaking cantons. [86] Still, those findings were based on self-reported data and currently there is no information available regarding the "real" prevalence of cardiovascular risk factors in whole Switzerland. It would be important that the national nutrition survey be repeated on a regular basis, for example every five years (as the national health survey) to assess the trends in dietary intake for the whole country. A possible solution would be to invite the participants of the national health survey to take part in the nutrition survey. This would allow merging the data collected in both surveys and associating dietary intake with disease status

Conversely, it can be expected that the associations between dietary intake and cardiovascular risk factors also hold for the other linguistic regions of Switzerland, as they depend on the type and less on the amount of food consumed.

POPULATION IMPLICATIONS

Dietary intake of the Swiss population has been slightly and slowly improving. This slow rate might not suffice to decrease the incidence of some cardiovascular risk factors such as hypertension, as current dietary intake fails to prevent the development of the disease. Overall, it could be stated that the changes in dietary intake in Switzerland do not allow to tackle the increase in NCDs such as CVD. Still, this statement should be taken *cum grano saltis*, as the trends in food availability for Switzerland are more favourable than for its immediate neighbours.[19] It might thus be speculated that the slow improvement in the dietary intake of the Swiss population contrasts with a worsening of the dietary intake in other countries and might have prevented a further increase in NCDs, had the trends in dietary intake in Switzerland been like its immediate neighbours. Still, given the strong and consistent aging of the Swiss population and the concomitant increase in NCDs, it is urgent to implement policy measures aimed at increasing the consumption of vegetables and at limiting the consumption of meat and sugar- or fat-rich foods.

Based on our findings, several measures could be implemented to improve dietary intake of 1) the Swiss population and 2) subjects at high risk of cardiovascular disease. For the first target, measures reducing the price of fruits and vegetables and promoting healthy foods as tasty foods might be the more cost-efficient. Although most public health interventions have focused on nutritional information, it has been consistently shown that educational measures devoid of accompanying cost reductions do not allow a consistent increase in the consumption of healthy foods. [87 88 89] Still, cost reductions *per se* cannot be considered as a panacea as they have a limited impact [90], and other channels such as the implementation of healthy meals in schools [91] and workplaces [92] or the adoption of adequate front-of-pack labelling [93-95] could be envisaged. Finally, the promotion of a web site providing objective, scientifically-based information regarding healthy eating would be welcomed.

For the second target, emphasis could be put on the postgraduate training of health care providers, namely general practitioners, regarding the dietary management of cardiovascular risk factors. Indeed, most doctors in Switzerland report a low knowledge in diet and nutrition [48] and the current medical curriculum allots little if no time to nutrition. Still, the results of such training might be small, as nutritional counselling would increase the time spent with the patient, and since 1st of January 2018, the Swiss legislation tends to limit the consultation time to 20 minutes [96]; beyond this period, no further reimbursement might be provided. This new legislation would deter most doctors to provide nutritional counseilling, as it would go beyond the 20-minute threshold and thus reduce their income (as the extra time might not be charged). An alternative solution would be to favour access to nutritional counselling provided by dieticians, namely for patients with diabetes. Still, although such infrastructures exist[1], their use is low, likely due to lack of knowledge by the patients and their caregivers. Another possibility would be to increase access to rehabilitation clinics, as a previous study showed that they are underused in the canton of Vaud. [97] Still, this would only apply to patients with a previous CVD and not to subjects with cardiovascular risk factors. Hence, unless a considerable change occurs in the Swiss health system, there are few opportunities to include diet as management of cardiovascular risk factors or cardiovascular disease.

DIRECTIONS FOR FUTURE RESEARCH

Future research should focus on updating and improving the existing tools for dietary assessment in the Swiss population. The available FFQ should be updated by the addition of new items, namely processed foods and pulses. This update should be performed with care, as it would increase the number of items and thus the time needed to fill the FFQ, which may lower compliance. The best option would be to have an updated FFQ, a part of which would allow calculating trends using the previous data, and another part would allow a better assessment

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1 https://www.diabetevaud.ch/professionel/consultation-dietetique-4/

of the current dietary intake. A new food composition database could be used, namely the new Swiss food composition database (naehrwertdaten.ch), which currently has enough information to be used as a reference. Again, care should be taken regarding the correspondence between the items in the FFQ and the foods of the database, so that adequate estimates of nutrient intake could be performed. Collaborative work between dieticians, food technologists and epidemiologists is needed to successfully accomplish this task. The updated FFQ should then be internally validated by repeated measures, and externally validated against other dietary assessment methods, namely repeated 24-h recalls and/or biological assessments. Finally, validated Swiss-German and Swiss-Italian translations of the FFQ should be developed, although this objective might be more complicated due to possible differences in food intake between the different linguistical regions of Switzerland. Hence, and as stated previously, the regular condution of a national nutrition survey would be fundamental to monitor the dietary intake of the Swiss population and to identify possible actionable levers.

In more holistic terms, promotion of healthy eating should identify the main barriers precluding the population from having adequate dietary intake and on the methods to overcome them. Barriers likely differ between countries, as do the methods for overcoming them. Still, using a common set of barriers would facilitate comparison between countries, as it would facilitate setting up common strategies to overcome them. Research on dietary patterns or scores could also be implemented, as they are easier to conceptualize, are closer to the actual intake of a given population and are associated with disease. [98 99]

Finally, if one wants to include diet in the public health and political agenda, the most sucessful method will be to show its that dietary interventions are cost-effective in reducing disease. Indeed, in Switzerland, most if not all political decisions regarding health are based in cost containment rather than on health outcomes.

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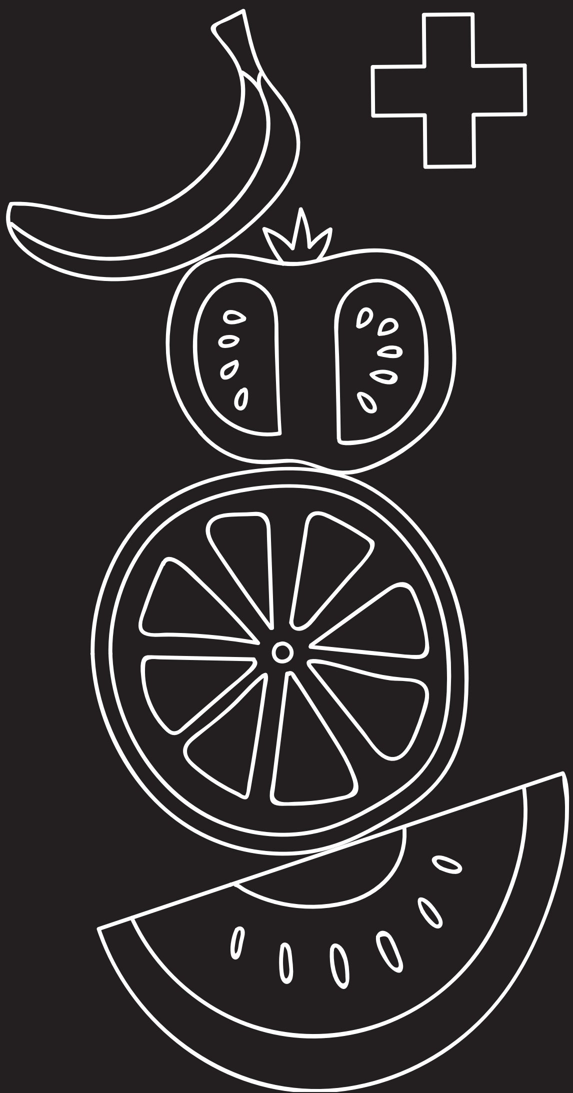
CHAPTER 6



Appendices

6

SUMMARY

Diet is a major component of prevention, management and treatment of most non-communicable disorders and a key element of maintaining health. Dietary policies are essential for health maintenance and disease prevention and should be implemented based preferably on information collected in the target population. Switzerland has the second highest health expenditure worldwide, but little if no dietary preventive measures are implemented at the population level. Likely reasons are separation of competencies between the different political structures in Switzerland and the difficulty in having standardized instruments to assess dietary intake in a multilingual heterogeneous country.

The objective of this thesis was to provide some information to the following issues: a) the dietary intake of the Swiss population; b) the associations between diet and non-communicable diseases, and c) the dietary management of cardiovascular risk factors and cardiovascular disease.

In **chapter 2** of the thesis, we show that dietary patterns have favourably evolved in the population of canton Geneva between 1993 and 2014, while the barriers to healthy eating have decreased in the Swiss population. We then show that compliance to the dietary guidelines of the Swiss Society of Nutrition has slightly improved between 1993 and 2017 in canton Geneva, although compliance to some items such as dairy products and meat failed to improve. We also show that the issuing of dietary guidelines by the Swiss society of nutrition did not impact the compliance rates. The last part of the chapter is dedicated to trends in other dietary related factors such as vitamin, mineral and dietary supplements in canton Vaud, the prevalence of which remained stable (20.6% in 2003-2006 and 20.3% in 2009-2012).

In **chapter 3**, we focus on the associations between dietary intake and several markers of noncommunicable diseases. We show that dietary patterns obtained using principal components analysis are associated with obesity, smoking and socio-economic markers. We also show that a dietary pattern rich in fruits and vegetables is negatively related with inflammatory markers. Conversely, dietary intake appears to have little impact on the incidence of hypertension in a middle-aged population.

In **chapter 4**, we analyse the dietary management of cardiovascular risk factors such as dyslipidemia and type 2 diabetes and on dietary changes after a CVD event. We show that patients with dyslipidemia have a higher consumption of fruits, vegetables, fish, mono- and polyunsaturated fats than the general population. Conversely, only half of patients with type 2 diabetes report being on an anti-diabetic diet. Diabetic patients consume more artificial sweeteners and less sugary products than the general population and, except for a higher consumption of vegetables, no differences were found between diabetic patients reporting or not an anti-diabetic diet. Finally, we show that patients with a CVD event do not change their

dietary intake and lifestyle changes for the secondary and tertiary prevention of cardiovascular disease.

Overall, our results show that dietary intake of the Swiss population could be improved, and that dietary management of cardiovascular risk factors among patients could be implemented.

NEDERLANDSE SAMENVATTING

Voeding is een belangrijk onderdeel in preventie, management en behandeling van de meeste niet-overdraagbare aandoeningen en een onmisbaar element in het behouden van een goede gezondheid. Voedingsbeleid is van essentieel belang voor het behouden van gezondheid en het voorkomen van ziekten en moet bij voorkeur worden uitgevoerd op basis van informatie die is verzameld in de doelpopulatie. Zwitserland heeft de op één na hoogste gezondheidsuitgaven wereldwijd, maar er worden nauwelijks preventieve maatregelen voor het verbeteren van het voedingspatroon geïmplementeerd op bevolkingsniveau. Waarschijnlijke redenen hiervoor zijn de scheiding van bevoegdheden tussen de verschillende politieke structuren in Zwitserland en de uitdaging om voedingsinname te beoordelen met gestandaardiseerde instrumenten in een meertalig heterogeen land.

Het doel van dit proefschrift was om informatie te verstrekken over de volgende onderwerpen: a) de voedingsinname van de Zwitserse bevolking; b) de verbanden tussen voeding en niet-overdraagbare ziekten, en c) het voedingsmanagement van cardiovasculaire risicofactoren en hart- en vaatziekten.

In hoofdstuk 2 van het proefschrift laten we zien dat voedingspatronen in de bevolking van het kanton Genève tussen 1993 en 2014 zijn verbeterd en dat de barrières voor gezonde voeding in de Zwitserse bevolking zijn afgenomen. Vervolgens laten we zien dat de naleving van de voedingsrichtlijnen van de Zwitserse Voedingsmaatschappij in het kanton Genève tussen 1993 en 2017 enigszins is verbeterd, hoewel de naleving van richtlijnen voor sommige producten zoals zuivel en vlees niet is verbeterd. Het laatste deel van het hoofdstuk is gewijd aan trends in andere voeding gerelateerde factoren zoals vitamine, mineralen en voedingssupplementen in kanton Vaud, waarvan de prevalentie stabiel bleef (20,6% in 2003-2006 en 20,3% in 2009-2012).

In hoofdstuk 3 concentreren we ons op de associaties tussen de inname van voeding en verschillende markers van niet-overdraagbare ziekten. We tonen aan dat voedingspatronen geassocieerd zijn met obesitas, roken en sociaaleconomische factoren. Daarnaast laten we zien dat een voedingspatroon dat rijk is aan groenten en fruit gerelateerd is aan lagere inflammatoire markers. Voedingsinname lijkt echter weinig invloed te hebben op de incidentie van hypertensie bij een populatie van middelbare leeftijd.

In hoofdstuk 4 analyseren we de rol van voeding bij personen met cardiovasculaire risicofactoren zoals dyslipidemie en diabetes type 2 en veranderingen in het voedingspatroon na het krijgen van hart- en vaatziekten. We laten zien dat patiënten met dyslipidemie een hogere consumptie van fruit, groenten, vis, enkel- en meervoudig onverzadigde vetten hebben dan de algemene bevolking. Echter, slechts de helft van de patiënten met diabetes type 2 geeft aan een anti-diabetisch dieet te volgen. Diabetische patiënten consumeren meer kunstmatige zoetstoffen en minder suikerhoudende producten dan de algemene bevolking, maar met uitzondering van een hogere consumptie van groenten werden verder geen verschillen gevonden tussen diabetische patiënten die al dan niet een anti diabetisch dieet rapporteerden. Ten slotte laten we zien dat patiënten met hart- en vaatziekten hun voedingsinname en levensstijl niet veranderen voor de secundaire en tertiaire preventie van hart- en vaatziekten.

Over het algemeen laten onze resultaten zien dat de voedingsinname van de Zwitserse bevolking verbeterd zou kunnen worden en dat voedingsbeleid bij patiënten met risicofactoren voor hart- en vaatziekten zou kunnen worden geïmplementeerd.

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PHD PORTFOLIO

Summary of PhD training and teaching

PhD student:	Pedro Marques-Vidal
Erasmus MC Department:	Epidemiology
Research School:	Netherlands Institute of Health Sciences (NIHES)
PhD period:	November 2017 – March 2019
Promotor:	Prof.dr. O.H. Franco
Copromotor:	Dr.ir. T. Voortman

TRAINING	**Year**	**ECTS**
General academic skill courses		
None		
Other courses		
Swiss DRG, Hotel Bellevue Palace, Bern, Switzerland, 16 May,	2018	0.5
International Meeting on Teaching Epidemiology, Universität Zürich, Zürich, Switzerland, 26-27 June	2018	1
Swiss Health Study, Federal office of public health, Campus Liebefeld, Bern, Switzerland, 29 October	2018	0.5
Attended conferences, seminars and workshops		
Europrevent, Ljubljana, Slovenia, April	2018	1
Swiss Society of General and Internal Medicine, Basel, Switzerland, May	2018	1
European Society of Cardiology, Munich, Germany, August	2018	1
Presentations		
Which area of research are most likely to get the interest of the reader in the area of epidemiology (586), Europrevent, Ljubljana, Slovenia, April	2018	0.5
Correlates of wlaking metrics: a population-based Colaus study, EPFL research days, Lausanne, Switzerland, June	2018	0.5
The impact of artificially sweetened beverages on cardiovascular health and outcomes (5267), ESC Congress, Munich, Germany, August	2018	0.5
Prevention of CVD – the European challenges, HUSK3 meeting, Haukeland University Hospital, Bergen, Norway, September 24	2018	0.5

TEACHING

Lectures

Nutritional counselling & Cardiovascular risk scores. Ukrainian Catholic University, School of Rehabilitation Medicine, Lviv, Ukraine, 22-23 March	2018	1
How to read a medical paper, Faculty of Biology and Medicine, University of Lausanne, Lausanne, Switzerland	2017-9	1
How to use a data entry software, Faculty of Biology and Medicine, University of Lausanne, Lausanne, Switzerland	2017-9	1
How to use a statistical software, Faculty of Biology and Medicine, University of Lausanne, Lausanne, Switzerland	2017-9	1
Nutritional epidemiology, University of Lausanne, Lausanne, Switzerland	2018	1
Nutritional epidemiology, HES-Geneva, Geneva, Switzerland	2018	2
Seminars on clinical epidemiology (18 per year), Lausanne University Hospital, Lausanne, Switzerland	2018/9	2

Supervision of practicals and exercises

None

Supervision of students' thesis work

Saman Khalatbari-Soltani (PhD, UNIL, Lausanne)	2017	2
Cédric Gubelmann (MD-PhD, UNIL, Lausanne)	2018	2
Carlos de Mestral (PhD, UNIL, Lausanne)	2018	2
Ana Sofia Quinteiros Fidalgo (MD, UNIL, Lausanne)	2017-8	1
Malik Benmachiche (MD, UNIL, Lausanne)	2018-9	1
Laïla Baratali (MD, UNIL, Lausanne)	ongoing	
Thierry Bonjour (MD, UNIL, Lausanne)	ongoing	
Vanessa Kraege (MD, UNIL, Lausanne)	ongoing	
Plamena Tasheva (MD, UNIL, Lausanne)	ongoing	

ABOUT THE AUTHOR

Pedro Marques-Vidal was born on the 11th of November 1962 in Lisbon, Portugal. After completing medical studies at the faculty of medicine of Purpan in Toulouse, France, he obtained an internship in medical research at the unit 101 of the INSERM. During his internship he obtained a Master of Science in lipid physiopathology, followed by an MD in epidemiology of cardiovascular risk factors and a PhD in lipid biochemistry, all at the University of Toulouse III, France. This was followed by a Master of Science in statistics in medicine, conducted at the Paris XI university, France. In 1995 he obtained an EU fellowship (postdoc) at the Finnish national public health institute, where he studied lipoprotein metabolism and oversaw the quality assessment of high-density lipoprotein measurements for the MONICA survey. He then moved to Portugal where he was nominated professor of informatics and statistics at the Instituto Superior de Ciências da Saúde Egas Moniz, Sobreda da Caparica. During his professorship he was nominated president of the scientific committee of the Nutrition course, and created a research group on biopharmacology, nutrition epidemiology and nutrition safety. He started several studies on obesity and nutritional epidemiology among Portuguese adolescents. He also taught at the faculty of human movement of the Technical University of Lisbon and at the Universidade Lusófona, Lisbon. In 2000 he was nominated director of the Escola Superior de Saúde Egas Moniz at the same institution. In 2003 he moved to the medical faculty of the University of Lisbon, Portugal, where he collaborated in creating the course on nutrition and dietetics. He continued his research on nutritional epidemiology and started research on the impact of malnutrition in the hospital setting. In 2006 he was nominated auxiliary professor of nutrition and public health of the medical faculty of the university of Lisbon. At the end of 2006 he moved to the Institute of Social and Preventive Medicine of the University of Lausanne, Switzerland, where he continued his research on cardiovascular and nutritional epidemiology. In 2014 he was nominated associate professor at the department of internal medicine of the Lausanne university hospital, where he continued his research on the epidemiology of cardiovascular disease, nutrition and physical activity. He is the data manager of the CoLaus prospective study and collaborates within several international consortia on cardiovascular disease.

Propositions accompanying this thesis

EPIDEMIOLOGICAL EVALUATION OF DIETARY INTAKE IN THE SWISS POPULATION

1. There are several barriers against healthy eating, the cost and the hedonic properties of healthy foods being the most common *(This thesis)*

2. Individuals can be categorized either as vitamin supplement users or non-users depening on the study period; consistent users are only a small fraction of the population *(This thesis)*

3. A higher education is associated with healthy eating, but cultural background can attenuate this association *(This thesis)*

4. Diets rich in vegetables and fruits are associated with reduced inflammatory levels *(This thesis)*

5. Dietary management of cardiovascular disease is suboptimal, and subjects do not change their dietary habits after a cardiovascular event *(This thesis)*

6. Food policies should focus on financial incentives and taxes rather than on nutritional education of the population

7. To assess the impact of diet on health, randomized trials with mammoth sample sizes and long study periods will be needed

8. The effects of dietary intake on health should be assessed using all nutritional and dietary information and not based on single nutrients and foods.

9. Omics data is envisioned as the future of nutritional epidemiology, enabling a precise characterization of an individual's response to dietary intake

10. Who sits at the bottom of a well to contemplate the sky, will find it small *(Han Yu)*

11. A journey of a thousand li [miles] begins with a single step *(Lao Tzi)*

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Valeu a pena? Tudo vale a pena
Se a alma não é pequena.

Quem quer passar além do Bojador
Tem que passar além da dor.
Deus ao mar o perigo e o abismo deu,
Mas nele é que espelhou o céu.

Fernando Pessoa, Poema X: Mar Português, Mensagem, 1934