BMJ Nutrition, Prevention & Health

Dietary fibre intake and its association with ultraprocessed food consumption in the general population of Switzerland: analysis of a population-based, cross-sectional national nutrition survey

Katja A Schönenberger ,[1,2] Valentina V Huwiler ,[1,2] Emilie Reber ,[1] Stefan Mühlebach ,[2] Zeno Stanga ,[1] Giulia Pestoni ,[3,4] David Faeh [4,5]

To cite: Schönenberger KA, Huwiler VV, Reber E, *et al*. Dietary fibre intake and its association with ultraprocessed food consumption in the general population of Switzerland: analysis of a population-based, cross-sectional national nutrition survey. *BMJ Nutrition, Prevention & Health* 2024;**7**:e000727. doi:10.1136/bmjnph-2023-000727

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/bmjnph-2023-000727).

For numbered affiliations see end of article.

Correspondence to
Professor David Faeh;
david.faeh@bfh.ch

GP and DF are joint senior authors.

Received 9 July 2023
Accepted 23 November 2023
Published Online First
16 January 2024

ABSTRACT

Objectives The objective of this study was to describe the compliance to dietary fibre recommendations of the Swiss population and to investigate the association between dietary fibre intake and ultraprocessed food (UPF) consumption.

Methods Data were obtained from the cross-sectional Swiss National Nutrition Survey *menuCH*. We summarised the sociodemographic, lifestyle and anthropometric parameters as well as dietary data collected with two 24-hour dietary recalls for the whole population and subgroups according to absolute and relative dietary fibre intake. We analysed the associations between dietary fibre intake and UPF consumption by fitting multinomial logistic regression models. Data were weighted according to the *menuCH* weighting strategy to achieve a representation of the Swiss population.

Results Data obtained from 2057 adults were included in the analysis, of which 87% had a dietary fibre intake of <30 g/day. Participants with high UPF consumption had lower odds of being in the medium or high dietary fibre intake groups than participants with low UPF consumption. The odds of being in the medium or high dietary fibre intake groups decreased linearly across quartiles of UPF consumption (p for trend ≤0.004).

Conclusions Dietary fibre intake is insufficient in all population groups in Switzerland. UPF consumption is inversely and dose dependently associated with dietary fibre intake. To increase dietary fibre intake, public health measures should discourage UPF consumption and increase dietary fibre intake via unprocessed or minimally processed foods.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Scientific evidence has long emphasised the importance of dietary fibre, traditionally sourced from minimally processed or unprocessed foods, in promoting overall health. However, the rise of industrially manufactured ultraprocessed foods (UPFs) has introduced new challenges, as these products often incorporate dietary fibre due to market demands and various regulatory frameworks, even though their impact on health remains a concern.

WHAT THIS STUDY ADDS

⇒ Dietary fibre intake remains insufficient in 87% of the overall Swiss population and across all sociodemographic groups. In addition, dietary fibre intake shows an inverse and dose-dependent association with UPF consumption.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Achieving the recommended dietary fibre intake presents significant challenges and necessitates consumer-friendly guidelines promoting fibre-rich foods; UPFs are not effective sources for this. Therefore, strategies to enhance the appeal of unprocessed foods over UPFs are crucial to elevate fibre intake.

INTRODUCTION

Since the discovery of the association between diets low in dietary fibre and poor health outcomes almost half a century ago, numerous studies have investigated the impact of dietary fibre on chronic non-communicable diseases, mostly cardiometabolic disease and its risk factors, gastrointestinal diseases, and cancer.[1] Western countries have aimed to increase fibre intake in their populations and recommend an intake of approximately 25–35 g/day for adults.[1] Some countries indicate that recommendations refer to naturally occurring dietary fibre from foods such as fruits, vegetables, legumes, and grains.[1] However, there is little further guidance beyond the total amount of dietary fibre to be

consumed, such as types of dietary fibres or the proportions of different food sources that contain dietary fibre to achieve optimal intake.[1]

Industrially manufactured foods are processed in varying degrees. This includes fractioning whole foods into substances, physical modifications such as heat treatments or high pressure, chemical modification, assembly of foods, and frequent use of additives with the aim of producing highly profitable, convenient and extremely hyperpalatable products.[2] Ultraprocessed foods (UPFs) are 'formulations of ingredients, mostly of exclusive industrial use, that result from a series of industrial processes'.[2] The *NOVA* classification categorises foods according to the extent and purpose of food processing: group 1 consists of unprocessed or minimally processed foods; group 2 consists of processed culinary ingredients; group 3 consists of processed foods; and group 4 consists of UPFs.[3] UPFs typically have a high energy density and low satiating capacity, and their consumption is accompanied by an increased intake of added sugar and salt, hydrogenated/saturated fats, flavourings and preservatives.[4–7] Hence, UPFs lower the nutritional quality of the overall diet[5 6 8] and have been associated with all-cause mortality, overweight and obesity, high waist circumference, low high-density lipoprotein cholesterol, metabolic syndrome, cardiovascular disease, cerebrovascular disease, cancer, and depression.[9–11] In Switzerland, UPF consumption is similar to the European average, where daily UPF consumption assessed as average of dietary surveys conducted in the European adult population of 22 countries amounts to 328 g (12% of the total weight of daily food consumption) and 562 kcal (27% of energy intake).[7 12 13]

Food manufacturers often incorporate various forms of isolated dietary fibres or processed dietary fibre-rich foods to UPFs owing to their sales-promoting effect.[14] The European Commission and European Food Safety Authority have authorised a number of health claims for some dietary fibre types related to bowel function, reduction of postprandial glycaemic responses and maintenance of normal blood cholesterol concentrations.[15 16] These health claims underscore the perceived health benefits of specific isolated dietary fibre types. In addition, front-of-pack labels, such as the increasingly common Nutri-Score, consider dietary fibre content as a positive criterion.[17] Despite these considerations, the consumption of UPFs remains a risk factor for obesity, a concern that persists irrespective of the dietary fibre content within these products.[18 19]

From a public health perspective, it is important to gain further insights into how the population covers its dietary fibre needs in order to derive possible interventions and recommendations. Consequently, we aimed to analyse the compliance to dietary fibre recommendations of the overall Swiss population and describe the sociodemographic, anthropometric, lifestyle and dietary characteristics of the study population overall and by absolute and relative dietary fibre intake groups. Furthermore, we aimed to investigate the association between UPF consumption and dietary fibre intake.

METHODS

This work is reported using the Strengthening the Reporting of Observational Studies in Epidemiology—Nutritional Epidemiology guidelines.[20]

Study design and study population

We analysed data from the national nutrition survey *menuCH*, a population-based cross-sectional survey conducted among residents of Switzerland aged 18–75 years from January 2014 to February 2015.[21 22] The stratified random sample from the national sampling frame for person and household surveys was intended to be representative of seven major areas in Switzerland and five predefined age categories. A detailed description of participant recruitment and a flow diagram have been published elsewhere.[21 23] Of the 13 606 individuals invited to participate, 2086 agreed to participate and 2057 had a complete dietary assessment and were included in the analyses.[21]

Dietary assessment

Trained dieticians assessed food consumption through two non-consecutive 24-hour dietary recalls.[22 23] The interviews were distributed across weekdays and seasons.[21] The food consumption of participants was recorded using the trilingual Swiss version (V.0.2014.02.27) of the GloboDiet software (formerly EPIC-Soft, International Agency for Research on Cancer IARC, Lyon, France,[24] adapted for Switzerland by the Federal Food Safety and Veterinary Office, Bern, Switzerland). Data were cleaned after completion of data collection using an updated version (V.0.2015.09.28). Food group-specific descriptors included in the GloboDiet software allowed for standardised descriptions of foods and recipes.[21] FoodCASE software (Premotec GmbH, Winterthur, Switzerland) matched foods, recipes and ingredients from the GloboDiet software with the most appropriate item from the Swiss Food Composition Database (https://naehrwertdaten.ch/de/). The dietary fibre content of 2% of food items in the *menuCH* dataset was missing. We completed dietary fibre content using the Swiss Food Composition Database (https://naehrwertdaten.ch/de/) or manufacturer's nutrition facts label, the German Nutrient Database, or dietary fibre content of a similar product. Quality controls assessing compliance with survey-specific standard operating procedures and data cleaning have been described elsewhere.[21 23] Intake from dietary supplements was not considered.

Dietary fibre intake groups

We categorised the *menuCH* population into groups of low, medium, and high dietary fibre intake using absolute dietary fibre intake (<15 g/day, 15–30 g/day, and

≥30 g/day, respectively) and dietary fibre intake relative to energy intake (<10 g/1000 kcal/day, 10–14 g/1000 kcal/day, and ≥14 g/1000 kcal/day, respectively). We selected the cut-offs for dietary fibre intake according to the DACH (Germany, Austria, Switzerland) Reference Values for Nutrient Intake, reporting a reference value for dietary fibre of 30 g/day,[25 26] and according to the U.S. Food and Nutrition Board, reporting an adequate intake of 14 g/1000 kcal/day of dietary fibre.[27] The cut-offs for low-dietary fibre diets were based on the distribution of dietary fibre intake in the study population.

Food processing classification

The *NOVA* food classification system by Monteiro *et al* was used to classify food items according to the extent and purpose of food processing.[3] We categorised the *menuCH* food items into non-UPFs and UPFs (*NOVA* 4 category). The classification was based on the food and recipes included in each of the GloboDiet subcategories and using food group-specific descriptors. If the degree of processing was unclear, a conservative approach was adopted (ie, foods were classified as non-UPFs). A description of the *menuCH* food items categorised as UPFs has been published elsewhere.[13] We conducted the analyses using quartiles of UPF weight percentage (weight percentage of UPFs relative to the total weight of food consumed) and quartiles of UPF energy percentage (calorie percentage of UPFs relative to the total calories consumed).

Sociodemographic, lifestyle, and anthropometric characteristics

Participants completed a questionnaire providing information on sociodemographic and socioeconomic characteristics, education, self-reported health status, eating habits, smoking and physical activity behaviours.[22] Nationality was categorised into Swiss only, Swiss binational, and non-Swiss; net household income into <6000, 6000 to 13 000, and above 13 000 Swiss Francs/month; and general self-reported health into very bad to medium and good to very good. Physical activity was assessed using the short-form International Physical Activity Questionnaire (IPAQ) and categorised into low, moderate and high according to the IPAQ classifications.[28] The language region was determined based on the residency address.

During face-to-face interviews, body weight, height, waist circumference, and hip circumference were measured in a standardised manner.[22] We used measured body weight, height and waist circumference in our analyses, except for pregnant and lactating women or when measurements were impossible. Self-reported weight (before pregnancy, if applicable) was used in these cases. Body mass index (BMI) was calculated using body weight and height. We then divided the participants into four groups according to WHO definitions (underweight <18.5 kg/m^2, normal weight 18.5–24.9 kg/m^2, overweight 25.0–29.9 kg/m^2, obese >30.0 kg/m^2). We grouped waist circumference group into no increased risk (males ≤94 cm, females ≤80 cm), increased risk (males 94.1–101.9 cm, females 80.1–87.9 cm), and substantially increased risk (males ≥102 cm, females ≥88 cm).[29]

Dietary habits

The alternate healthy eating index (AHEI) was calculated as an index of overall diet quality.[30] The components included in the AHEI score were vegetables, fruits, whole grains, sugar-sweetened beverages and fruit juice, nuts and legumes, red and processed meat, *trans* fat, fish (as a proxy for long-chain *n*-3 fatty acids), polyunsaturated fatty acids, sodium and alcohol. A detailed description of the AHEI calculations for *menuCH* participants has been published previously.[31]

We used the four dietary patterns identified by Krieger *et al*[32] in our analysis. The Swiss traditional pattern was characterised by minimal variation to the average of the *menuCH* population, except for increased chocolate, milk and dairy consumption. Both Western patterns were characterised by a high intake of red and processed meat, with a high intake of soft drinks (Western-soft drinks) or high intake of alcoholic drinks and cereals and starchy food (Western alcohol). The prudent dietary pattern was characterised by a high intake of fruits, vegetables, white meat and fish.[32]

We distinguished between levels of meat consumption using subgroups published by Steinbach *et al*.[33] No-meat eaters reported meat avoidance according to the questionnaire and were corrected by intake recorded from the 24-hour dietary recalls. Low, medium and high meat eaters had an energy contribution from meat of 0%–2.4%, 2.4%–18.7% and 18.7%–48.4%, respectively.[33]

Statistical analysis

We calculated the mean food and nutrient intake of the two dietary recalls for each participant and subsequently used the mean for all statistical analyses. We explored the compliance to dietary fibre recommendations of the overall Swiss population and described the sociodemographic, anthropometric, lifestyle and dietary characteristics of the overall *menuCH* population as well as by absolute and relative dietary fibre intake groups using descriptive statistics. We fitted multinomial logistic regression models to examine the association between absolute and relative dietary fibre intake groups and quartiles of UPF consumption (weight percentage and energy percentage). The models were adjusted for sex, age, education, BMI, physical activity, smoking, recall season, and recall weekday. We calculated *p* values for trends using the medians of UPF quartiles as continuous variables in multinomial logistic regression models.

To make *menuCH* data representative of the general Swiss population, we applied the *menuCH* weighting strategy, as detailed elsewhere.[34] We weighted all statistical analyses for age, sex, marital status, major area of Switzerland based on home address, nationality and household size to consider the sampling design and non-response. We additionally weighted analyses of food and nutrient

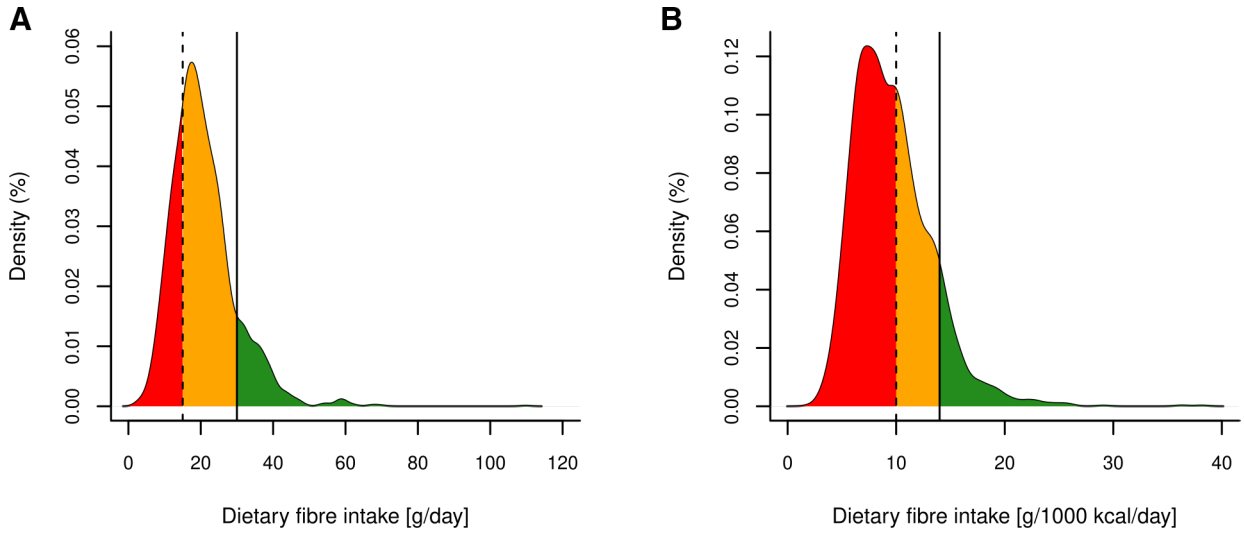

Figure 1 Density plots of absolute (A) and relative (B) dietary fibre intake. The density plot is a smoothed representation of a histogram and shows the distribution of a variable with a total area under the curve of 1. The density is weighted for age group, sex, marital status, major region of Switzerland, nationality, household size, season and weekday according to the *menuCH* weighting strategy.[34] Solid vertical lines represent the Swiss and DACH (Germany, Austria, Switzerland) reference value for dietary fibre of 30 g/day[25 26] and the adequate intake of total dietary fibre of 14 g/1000 kcal/day reported by the U.S. Food and Nutrition Board.[27] Dashed vertical lines represent 15 g/day and 10 g/1000 kcal/day.

intake for the recall season and weekday. For multinomial logistic regression models, we imputed missing data using multivariate imputation by chained equations (m=35). We calculated the variance inflation to detect potential multicollinearity in the regression models.

Statistical analyses were performed using R V.4.1.3[35] with the following packages: *questionr* (V.0.7.7) for weighted frequencies, *spatstat.geom* (V.2.3-1) for weighted median and IQR, *mice* (V.3.14.0) for multivariate imputation by chained equations, *nnet* (V.7.3-17) for multinomial logistic regression models, and *car* (V.3.1.0) for variance inflation factors. The significance level was $p \leq 0.05$ for all analyses.

RESULTS

The data obtained from 2057 individuals were included in the analysis. Figure 1 shows the distribution of absolute and relative dietary fibre intake. The absolute dietary fibre intake recommendation of 30 g/day[25 26] was met by 13% of the population, and the relative dietary fibre intake recommendation of 14 g/1000 kcal/day[27] was met by 11% of the population. Table 1 shows the sociodemographic, lifestyle and anthropometric characteristics of the overall population and stratified by absolute and relative dietary fibre intake. Additional participant characteristics are shown in online supplemental table 1. Compared with the overall study population, participants in the high absolute and relative dietary fibre intake groups tended to be Swiss, have tertiary education, be of normal weight, highly physically active, and non-smokers. In the high absolute dietary fibre intake group, participants tended to be male and between 30 and 59 years old, and participants in the high relative dietary intake group tended to be female and above 60 years old.

Table 2 shows the dietary parameters of the overall population, as well as the absolute and relative dietary fibre intake groups. Participants in the high absolute dietary fibre group tended to have a higher food intake (in weight and in energy) compared with the overall study population. Additionally, they tended to score higher on the AHEI and follow a prudent or Swiss traditional dietary pattern rather than a Western dietary pattern. They also tended to consume more fruits and nuts, vegetables, and cereals, and less meat. Additional dietary parameters are listed in online supplemental table 2.

The linear relationship between dietary fibre intake (absolute and relative) and UPF consumption (weight percentage and energy percentage) is displayed using scatter plots, shown in online supplemental figure 1. Table 3 shows the results of multinomial logistic regression models investigating the associations between dietary fibre intake (absolute and relative) and quartiles of UPF consumption (weight percentage and energy percentage). Participants consuming a high amount of UPFs had lower odds of being in the medium and high dietary fibre intake groups compared with participants consuming a low amount of UPFs. The magnitude of the OR was similar for UPF weight and energy percentage. The odds of being in the medium or high dietary fibre intake group decreased linearly across quartiles of UPF consumption (p for trend ≤0.004).

DISCUSSION

Based on the population-representative Swiss National Nutrition Survey *menuCH*, a large part of the Swiss population (87%) does not reach the national recommendation of 30 g dietary fibre intake per day. When considering dietary fibre intake relative to individual energy intake,

Table 1 Sociodemographic, lifestyle and anthropometric characteristics of the *menuCH* population, overall and by absolute and relative dietary fibre intake groups

		Absolute dietary fibre intake			Relative dietary fibre intake		
	menuCH	**<15 g/day**	**15–30 g/day**	**≥30 g/day**	**<10 g/1000 kcal/day**	**10–14 g/1000 kcal/day**	**≥14 g/1000 kcal/day**
Overall *menuCH* population*, *n* (weighted %)	2057 (100)	527 (25)	1268 (61)	262 (13)	1193 (59)	624 (30)	240 (11)
Sex, *n* (weighted %)							
Female	1124 (50)	327 (59)	692 (49)	105 (39)	565 (43)	399 (59)	160 (63)
Male	933 (50)	200 (41)	576 (51)	157 (61)	628 (57)	225 (41)	80 (37)
Age group, *n* (weighted %)							
18–29 years	400 (19)	105 (19)	255 (19)	40 (15)	266 (21)	100 (16)	34 (14)
30–44 years	533 (30)	146 (33)	315 (28)	72 (33)	338 (33)	138 (25)	57 (28)
45–59 years	625 (30)	163 (28)	376 (30)	86 (33)	357 (29)	193 (31)	75 (29)
60–75 years	499 (22)	113(20)	322 (23)	64 (19)	232 (17)	193 (28)	74 (28)
Language region, *n* (weighted %)							
German	1341 (69)	309 (64)	850 (71)	182 (72)	774 (69)	410 (68)	157 (71)
French	502 (25)	142 (28)	296 (24)	64 (25)	281 (25)	165 (27)	56 (22)
Italian	214 (5.6)	76 (7.6)	122 (5.2)	16 (3.1)	138 (5.9)	49 (4.5)	27 (6.6)
Nation group, *n* (weighted %)							
Swiss only	1492 (61)	378 (61)	914 (61)	200 (65)	860 (60)	452 (62)	180 (66)
Swiss binational	297 (14)	83 (16)	189 (14)	25 (8.7)	178 (14)	92 (14)	27 (11)
Non-Swiss	268 (25)	66 (24)	165 (25)	37 (26)	155 (25)	80 (24)	33 (24)
Education, *n* (weighted %)							
Primary	89 (4.7)	38 (7.0)	46 (4.3)	5 (2.0)	61 (5.7)	23 (3.7)	5 (2.0)
Secondary	968 (43)	276 (48)	589 (42)	103 (35)	567 (43)	287 (42)	114 (40)
Tertiary	997 (53)	213 (45)	630 (53)	154 (63)	563 (51)	314 (55)	120 (57)
NA	3 (0.15)	0 (0)	3 (0.24)	0 (0)	2 (0.21)	0 (0)	1 (0.23)
BMI group, *n* (weighted %)							
Underweight (<18.5 kg/m^2)	51 (2.4)	10 (2.5)	30 (2.1)	11 (3.6)	26 (2.2)	17 (2.5)	8 (3.1)
Normal weight (18.5–24.9 kg/m^2)	1115 (54)	248 (44)	704 (56)	163 (62)	601 (50)	365 (59)	149 (63)
Overweight (25.0–29.9 kg/m^2)	629 (31)	174 (35)	389 (30)	66 (25)	393 (33)	178 (29)	58 (24)
Obese (>30.0 kg/m^2)	262 (13)	95 (18)	145 (11)	22 (9.7)	173 (15)	64 (10)	25 (10)
Physical activity, *n* (weighted %)							
Low	219 (11)	66 (13)	130 (11)	23 (8.4)	152 (14)	53 (9.2)	14 (5.5)
Moderate	487 (24)	118 (24)	301 (24)	68 (27)	265 (22)	169 (28)	53 (25)

Continued

Table 1 Continued

		Absolute dietary fibre intake			Relative dietary fibre intake		
	menuCH	<15 g/day	15–30 g/day	≥30 g/day	<10 g/1000 kcal/day	10–14 g/1000 kcal/day	≥14 g/1000 kcal/day
High	827 (40)	179 (35)	524 (41)	124 (46)	449 (39)	264 (41)	114 (46)
NA	524 (24)	164 (29)	313 (24)	47 (18)	327 (25)	138 (22)	59 (23)
Smoking, *n* (weighted %)							
Current	451 (23)	135 (27)	271 (23)	45 (18)	308 (28)	105 (18)	38 (15)
Former	688 (34)	170 (32)	424 (34)	94 (36)	392 (33)	215 (34)	81 (33)
Never	914 (43)	222 (42)	569 (43)	123 (46)	490 (38)	304 (48)	120 (52)
NA	4 (0.22)	0 (0)	4 (0.35)	0 (0)	3 (0.32)	0 (0)	1 (0.23)
Currently on diet, *n* (weighted %)							
No	1940 (94)	486 (91)	1207 (96)	247 (93)	1139 (96)	586 (93)	215 (90)
Yes	113 (5.4)	41 (8.6)	57 (3.8)	15 (6.9)	51 (4.1)	38 (6.5)	24 (9.4)
NA	4 (0.22)	0 (0)	4 (0.35)	0 (0)	3 (0.32)	0 (0)	1 (0.23)

n are unweighted, percentages are weighted for age group, sex, marital status, major region of Switzerland, nationality and household size according to the *menuCH* weighting strategy.[34] NAs are shown only if any exist. If the percentages do not add up exactly to 100%, this is due to rounding differences.
*Representative for age range 18–75 years.
BMI, body mass index; NA, not applicable.

Table 2 Dietary parameters of the *menuCH* population, overall and by absolute and relative dietary fibre intake groups

	menuCH	Absolute dietary fibre intake			Relative dietary fibre intake		
	(*n*=2057)	<15 g/day (*n*=527)	15–30 g/day (*n*=1268)	≥30 g/day (*n*=262)	<10 g/1000 kcal/day (*n*=1193)	10–14 g/1000 kcal/day (*n*=624)	≥14 g/1000 kcal/day (*n*=240)
Dietary fibre intake (g/day), median (IQR)	19 (15–25)	12 (10–14)	20 (18–24)	36 (32–39)	17 (13–21)	23 (19–28)	31 (24–37)
Dietary fibre intake (g/1000 kcal/day), median (IQR)	9.2 (7.0–12)	6.8 (5.5–8.4)	9.5 (7.6–12)	14 (11–15)	7.4 (6.3–8.6)	12 (11–13)	16 (15–18)
Energy intake (kcal/day), median (IQR)	2111 (1702–2584)	1644 (1379–2023)	2168 (1818–2596)	2698 (2269–3305)	2256 (1813–2714)	1943 (1636–2380)	1833 (1418–2268)
Total intake (g/day), median (IQR)	3372 (2787–3988)	2906 (2382–3576)	3395 (2876–4019)	3948 (3485–4829)	3340 (2798–3959)	3368 (2744–3955)	3581 (2894–4335)
CHO energy percentage, median (IQR)	42 (36–48)	40 (34–47)	43 (37–48)	46 (40–50)	41 (35–47)	43 (38–48)	47 (40–52)
Fat energy percentage, median (IQR)	36 (31–41)	36 (31–42)	36 (31–41)	35 (30–40)	36 (32–41)	36 (31–41)	32 (28–38)
Protein energy percentage, median (IQR)	15 (13–17)	16 (13–19)	15 (13–17)	14 (12–16)	15 (13–17)	14 (13–17)	14 (12–17)
Protein intake(g/kg BW*/day), median (IQR)	1.1 (0.9–1.4)	0.9 (0.8–1.2)	1.1 (0.9–1.4)	1.3 (1.1–1.6)	1.1 (0.9–1.5)	1.1 (0.8–1.3)	1.0 (0.7–1.3)
UPF weight percentage, median (IQR)	9.7 (4.6–18)	11 (5.4–20)	9.8 (4.7–17)	7.1 (3.7–12)	13 (6.9–22)	6.8 (3.6–12)	3.9 (1.9–7.4)
UPF weight percentage quartile, *n* (weighted %)							
Q1	515 (25)	114 (21)	316 (24)	85 (35)	171 (14)	222 (34)	122 (53)
Q2	514 (24)	118 (21)	320 (25)	76 (26)	262 (21)	175 (28)	77 (28)
Q3	514 (25)	133 (25)	323 (26)	58 (22)	330 (27)	156 (25)	28 (13)
Q4	514 (26)	162 (33)	309 (26)	43 (17)	430 (38)	71 (12)	13 (5.5)
UPF energy percentage, median (IQR)	26 (16–37)	30 (18–41)	26 (16–37)	20 (12–29)	31 (20–41)	21 (13–31)	18 (10–23)
UPF energy percentage quartile, *n* (weighted %)							
Q1	515 (24)	99 (18)	325 (25)	91 (35)	194 (16)	214 (33)	107 (45)
Q2	514 (25)	125 (23)	304 (24)	85 (33)	259 (21)	175 (28)	80 (34)
Q3	514 (26)	134 (27)	327 (27)	53 (20)	342 (29)	136 (23)	36 (14)
Q4	514 (25)	169 (33)	312 (25)	33 (12)	398 (34)	99 (15)	17 (6.6)
AHEI†, median (IQR)	45 (36–54)	40 (34–47)	45 (36–54)	55 (46–65)	39 (32–46)	51 (44–59)	61 (52–68)
Dietary patterns‡, *n* (weighted %)							
Prudent	486 (24)	97 (19)	301 (23)	88 (35)	169 (14)	206 (35)	111 (45)
Swiss traditional	744 (35)	155 (29)	477 (36)	112 (41)	411 (33)	252 (38)	81 (32)
Western-soft drinks	383 (20)	129 (26)	233 (19)	21 (9.1)	317 (28)	56 (8.2)	10 (6.3)
Western alcohol	444 (22)	146 (26)	257 (22)	41 (15)	296 (24)	110 (19)	38 (17)
Meat consumption§, *n* (weighted %)							
None	92 (5.1)	13 (2.8)	51 (4.5)	28 (12)	22 (1.9)	36 (7.3)	34 (16)
Low	308 (14)	52 (8.0)	190 (15)	66 (26)	115 (8.6)	122 (21)	71 (27)
Medium	1349 (64)	330 (60)	863 (67)	156 (58)	819 (68)	408 (61)	122 (52)
High	308 (16)	132 (29)	164 (13)	12 (4.1)	237 (21)	58 (10)	13 (4.7)

Continued

Table 2 Continued

	menuCH	Absolute dietary fibre intake			Relative dietary fibre intake		
	(*n*=2057)	<15 g/day (*n*=527)	15–30 g/day (*n*=1268)	≥30 g/day (*n*=262)	<10 g/1000 kcal/day (*n*=1193)	10–14 g/1000 kcal/day (*n*=624)	≥14 g/1000 kcal/day (*n*=240)
Fruits and nuts (g/day), median (IQR)	116 (27–237)	48 (0.0–119)	132 (42–238)	290 (158–432)	69 (4.4–157)	200 (97–319)	290 (193–417)
Vegetables (g/day), median (IQR)	113 (53–197)	71 (28–125)	118 (60–199)	206 (124–295)	87 (41–159)	146 (80–227)	213 (116–313)
Cereals (g/day), median (IQR)	169 (101–259)	118 (69–183)	180 (117–269)	248 (159–410)	166 (100–253)	173 (105–263)	167 (96–253)

n are unweighted, all other results are weighted for age group, sex, marital status, major region of Switzerland, nationality, household size, season and weekday according to the *menuCH* weighting strategy.[34] If the percentages do not add up exactly to 100%, this is due to rounding differences.
*Measured body weight corrected for clothing, if measured body weight was unavailable, self-reported body weight was used (*n*=7), for pregnant and lactating women reported body weight before pregnancy was used (*n*=27)
†Minimum score=0, maximum score=110
‡According to Krieger *et al*.[32]
§According to Steinbach *et al*.[33]
AHEI, Alternate Healthy Eating Index; CHO, carbohydrate; NA, not available; Q, quartile; UPF, ultraprocessed food.

similar results were obtained. UPF consumption was inversely associated with dietary fibre intake in a dose-dependent manner, showing that dietary fibres mainly stem from non-UPFs.

The dietary fibre intake in the *menuCH* study (19 g/day) is comparable to that reported in other European national nutrition surveys. Overall, the recommendation of 30 g dietary fibre per day is hardly reached at the population level.[1 36] For example, the median dietary fibre intake of adults is 24 g/day in Germany[37] and 19 g/day in the UK.[38] In addition, we analysed dietary fibre intake relative to energy intake and found similar results. Even with potentially lower recommendations or recommendations relative to energy intake, a large proportion of the population in our study would still have had insufficient dietary fibre intake.

Altogether, we found that participants with a higher overall food intake and a generally healthy lifestyle were more represented in the group with a high dietary fibre intake. For example, male and younger participants were more likely to be in the high absolute dietary fibre intake group; however, this is mainly attributed to their higher overall food consumption. In contrast, when looking at the relative dietary fibre intake, women and older participants consumed more dietary fibre. Our results suggest that especially people with a low education level, obesity, smokers and, in general, people with a particularly unhealthy lifestyle belong to the group with low fibre intake. Studies that investigated the determinants of low dietary fibre intake reported results consistent with our findings.[39 40]

We observed an inverse and dose-dependent relationship between UPF consumption and dietary fibre intake, suggesting that dietary fibres are mainly consumed via non-UPFs. In the analyses of relative dietary fibre, we observed small OR for the extreme groups (ie, UPF quartile 4 and dietary fibre intake ≥14 g/1000 kcal/day), which must be interpreted with caution. We built these groups despite a rather small *n* (see table 2), caused by the large variability in dietary fibre intake between participants, as we aimed to reflect the recommendations for dietary fibre intake. Using tertiles instead of cut-off values in line with recommendations increased the number of participants in the groups, but did not influence the magnitude of the OR, suggesting the robustness of our findings (data not shown). Nevertheless, when interpreting our results, the focus should be on the overall negative association between UPF consumption and dietary fibre intake. Our results are not aligned with those of a previous ecological study from Europe, which found no association between UPF consumption (in terms of energy percentage) and dietary fibre intake.[12] However, this study analysed country-level data rather than individual consumption data, possibly leading to an ecological fallacy and results not directly comparable to ours.

To improve the intake of dietary fibres in the population, public health measures may aim to increase dietary fibre intake through unprocessed or minimally processed

Table 3 Association between dietary fibre intake and ultraprocessed food consumption

	Absolute dietary fibre intake			Relative dietary fibre intake				Absolute dietary fibre intake			Relative dietary fibre intake		
	<15 g/d	15–30 g/d	≥30 g/d	<10 g/1000 kcal/d	10–14 g/1000 kcal/d	≥14 g/1000 kcal/d		<15 g/d	15–30 g/d	≥30 g/d	<10 g/1000 kcal/d	10–14 g/1000 kcal/d	≥14 g/1000 kcal/d
UPF weight percentage	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**UPF energy percentage**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Q1 0.0–4.5	1 –	1 –	1 –	1 –	1 –	1 –	Q1 0.0–16	1 –	1 –	1 –	1 –	1 –	1 –
Q2 4.5–9.3	1 –	0.97 (0.70–1.33)	**0.57** **(0.37–0.87)**	1 –	**0.56** **(0.42–0.75)**	**0.31** **(0.21–0.46)**	Q2 16–26	1 –	0.79 (0.57–1.09)	0.74 (0.49–1.12)	1 –	**0.62** **(0.46–0.82)**	**0.62** **(0.43–0.90)**
Q3 9.3–17	1 –	0.99 (0.72–1.36)	**0.47** **(0.31–0.73)**	1 –	**0.44** **(0.33–0.58)**	**0.14** **(0.09–0.22)**	Q3 26–36	1 –	**0.73** **(0.53–1.00)**	**0.41** **(0.26–0.63)**	1 –	**0.39** **(0.29–0.51)**	**0.18** **(0.11–0.28)**
Q4 17–92	1 –	**0.67** **(0.49–0.92)**	**0.22** **(0.14–0.35)**	1 –	**0.15** **(0.10–0.20)**	**0.04** **(0.02–0.07)**	Q4 26–95	1 –	**0.59** **(0.43–0.81)**	**0.17** **(0.10–0.29)**	1 –	**0.22** **(0.16–0.30)**	**0.07** **(0.04–0.13)**
p for trend	–	**0.004**	**<0.001**	–	**<0.001**	**<0.001**	*p* for trend	–	**<0.001**	**<0.001**	–	**<0.001**	**<0.001**

Results displayed as OR and 95% CI, statistically significant results printed in bold.
Results are derived from multinomial logistic regression models adjusted for sex, age, education, body mass index (BMI), physical activity, smoking, recall season, recall weekday and weighted for age group, sex, marital status, major region of Switzerland, nationality, household size, season and weekday according to the *menuCH* weighting strategy.[34] *p* for trend was calculated by using the medians of the UPF quartiles as continuous variable in the multinomial logistic regression model.
d, day; Q, quartile; UPF, ultraprocessed food.

foods. Our results suggest that population groups with a low socioeconomic status or unhealthy lifestyle need to be particularly targeted. Therefore, it would be useful to develop alternative or complementary recommendations with practical implications for these groups. Furthermore, recommendations for dietary fibre intake need to be translated into advice that can be easily realised. In fact, it is difficult for consumers to estimate their dietary fibre intake. The benefit of a recommendation without advice on how to achieve an intake of 30 g dietary fibre per day is questionable, and recommendations on the food group level may be more practical. For example, foods with a particularly high dietary fibre content can be promoted by recommending starchy fibre-rich foods such as legumes and whole grains, nuts and seeds, in addition to five portions of fruit and vegetables per day. At the same time, discouraging UPF consumption, for example, through food taxation/subsidisation or labelling of UPFs, might be beneficial to increase consumption of minimally processed or unprocessed foods.

Since 2019, the Swiss Federal Food Safety and Veterinary Office has supported the Nutri-Score, a food-labelling system with a coloured scale from A (green=balanced) to E (red=unbalanced). The score is determined using a scientifically validated formula, in which positive criteria include the content of fruits, vegetables, legumes, nuts, certain oils, dietary fibre, and protein, and negative criteria include sugar, salt, saturated fat and energy.[17] Therefore, adding dietary fibre leads to a 'greener' Nutri-Score,[17] providing an incentive for food manufacturers to add isolated dietary fibres or ultraprocessed fibre rich foods to their products. However, increasing the dietary fibre content by adding dietary fibre at the cost of higher UPF consumption is not likely to benefit consumers. For example, a previously published study reported that adding dietary fibre to ultraprocessed cereal flakes did not affect total postprandial blood glucose or satiety in a healthy population.[41] Currently, the widely used Nutri-Score does not consider the degree of food processing,[17] and UPFs can be found in all Nutri-Score categories. More than a quarter of Nutri-Score A products and more than half of Nutri-Score B products belong to *NOVA* class 4.[42] Front-of-pack labelling with the Nutri-Score could be complemented with an indicator for the processing level, such as the new graphically modified Nutri-Score recently tested by Srour *et al*.[43] Finally, dietary fibre content should be included in the nutrition facts labels to allow consumers identifying fibre-rich products and estimate dietary fibre intake (eg, 5–8 g fibre/100 g).

Strengths and limitations

The association between UPFs and dietary fibre intake has been poorly studied. We used individual consumption data, and due to the applied weighting strategy, the sample is representative of the Swiss population aged 18–75 years. The 24-hour dietary recalls allowed for a more accurate classification of non-UPFs versus UPFs than food frequency questionnaires. Furthermore, we conducted data analysis with both UPF energy and weight percentage, taking energy-free UPFs into account.

Besides the cross-sectional design and residual confounding, the study might be limited by participation bias, since participants might have been more interested in health-related topics than the general population. If our results were affected by participation bias, we may have overestimated dietary fibre intake and underestimated UPF consumption. 24-hour dietary recalls can be limited by under-reporting or over-reporting and recall bias. Furthermore, the degree of food processing was sometimes unclear, leading to potential misclassification of some food items within the ultraprocessed and non-ultraprocessed groups. In instances of uncertainty, we adopted a conservative approach which would lead to an underestimation of the observed association.

CONCLUSION

Based on the recommendation of consuming 30 g of dietary fibre per day, our study showed that dietary fibre intake is insufficient in the Swiss population. Similarly, dietary fibre intake relative to energy intake was also insufficient. The recommendation of 30 g of dietary fibre per day is difficult to implement and needs to be translated into consumer-friendly advice for foods that are particularly high in dietary fibre. Our results showed that UPFs are not a good source of dietary fibre. By increasing the proportion of minimally processed or unprocessed products and correspondingly decreasing UPF consumption, we expect an increase in fibre intake. Therefore, it is desirable to make unprocessed products more attractive than UPFs. This could be achieved through public health measures such as food taxation/subsidisation or labelling of UPFs and educational approaches about dietary fibre intake and UPF consumption in schools and the community.

Author affiliations
[1]Department of Diabetes, Endocrinology, Nutritional Medicine and Metabolism (UDEM), University Hospital and University of Bern, Bern, Switzerland
[2]Department of Pharmaceutical Sciences, Division of Clinical Pharmacy and Epidemiology, University of Basel, Basel, Switzerland
[3]Health Department, Nutrition Group, Swiss Distance University of Applied Sciences (FFHS) / University of Applied Sciences and Arts of Southern Switzerland (SUPSI), Zurich, Switzerland
[4]Epidemiology, Biostatistics and Prevention Institute, Division of Chronic Disease Epidemiology, University of Zurich, Zurich, Switzerland
[5]Health Department, Bern University of Applied Sciences, Bern, Switzerland

X Giulia Pestoni @GiuliaPestoni

Acknowledgements We thank Dr. sc. nat. Julia Braun, Division of Chronic Disease Epidemiology, Epidemiology, Biostatistics and Prevention Institute, University of Zurich for the statistical consulting.

Contributors Conceptualisation: KAS, ZS, GP and DF. Data curation: KAS and GP. Formal analysis: KAS. Funding acquisition: KAS, SM, ZS and DF. Methodology: KAS, GP and DF. Supervision: SM, ZS, GP and DF. Visualisation, writing – original draft: KAS. Writing – review and editing: all authors. DF is responsible for the overall content as the guarantor.

Funding This work was supported by the SV Foundation; a third-party grant of the Division of Clinical Pharmacy and Epidemiology, University of Basel (grant number F0119900); and the Department of Diabetes, Endocrinology, Nutritional Medicine

and Metabolism, Inselspital, Bern University Hospital (research fund number WFE-012). The SV Foundation had no role in the design, analysis or writing of this article.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by Cantonal ethics committee of Vaud, ref: Protocol 26/13. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed by Angeline Chatelan, Geneva School of Health Sciences, Switzerland.

Data availability statement Data may be obtained from a third party and are not publicly available. Data may be obtained from the Swiss Federal Food Safety and Veterinary Office.

ORCID iDs
Katja A Schönenberger http://orcid.org/0000-0002-2122-4746
Valentina V Huwiler http://orcid.org/0000-0002-0357-6887
Emilie Reber http://orcid.org/0000-0001-8799-2708
Stefan Mühlebach http://orcid.org/0000-0002-8471-7513
Zeno Stanga http://orcid.org/0000-0002-8630-2477
Giulia Pestoni http://orcid.org/0000-0002-5933-7439
David Faeh http://orcid.org/0000-0003-2630-8102

REFERENCES

1 Stephen AM, Champ MM-J, Cloran SJ, *et al*. Dietary fibre in Europe: current state of knowledge on definitions, sources, recommendations, intakes and relationships to health. *Nutr Res Rev* 2017;30:149–90.
2 Monteiro CA, Cannon G, Levy RB, *et al*. Ultra-processed foods: what they are and how to identify them. *Public Health Nutr* 2019;22:936–41.
3 Monteiro CA, Cannon G, Levy R, *et al*. NOVA. The star shines bright. *World Nutr J* 2016;7:28–38.
4 Fardet A. Minimally processed foods are more satiating and less hyperglycemic than ultra-processed foods: a preliminary study with 98 ready-to-eat foods. *Food Funct* 2016;7:2338–46.
5 Moubarac J-C, Batal M, Louzada ML, *et al*. Consumption of ultra-processed foods predicts diet quality in Canada. *Appetite* 2017;108:512–20.
6 Louzada ML da C, Ricardo CZ, Steele EM, *et al*. The share of ultra-processed foods determines the overall nutritional quality of diets in Brazil. *Public Health Nutr* 2018;21:94–102.
7 Bertoni Maluf VA, Bucher Della Torre S, Jotterand Chaparro C, *et al*. Description of ultra-processed food intake in a Swiss population-based sample of adults aged 18 to 75 years. *Nutrients* 2022;14:4486.
8 Martínez Steele E, Popkin BM, Swinburn B, *et al*. The share of ultra-processed foods and the overall nutritional quality of diets in the US: evidence from a nationally representative cross-sectional study. *Popul Health Metr* 2017;15:6.
9 Pagliai G, Dinu M, Madarena MP, *et al*. Consumption of ultra-processed foods and health status: a systematic review and meta-analysis. *Br J Nutr* 2021;125:308–18.
10 Bonaccio M, Di Castelnuovo A, Ruggiero E, *et al*. Joint association of food nutritional profile by nutri-score front-of-pack label and ultra-processed food intake with mortality: Moli-Sani prospective cohort study. *BMJ* 2022;378:e070688.
11 Wang L, Du M, Wang K, *et al*. Association of ultra-processed food consumption with colorectal cancer risk among men and women: results from three prospective US cohort studies. *BMJ* 2022;378:e068921.
12 Mertens E, Colizzi C, Peñalvo JL. Ultra-processed food consumption in adults across Europe. *Eur J Nutr* 2022;61:1521–39.
13 Pestoni G, Habib L, Reber E, *et al*. Ultraprocessed food consumption is strongly and dose-dependently associated with excess body weight in Swiss women. *Obesity (Silver Spring)* 2021;29:601–9.
14 Yangilar F. The application of dietary fibre in food industry: structural features, effects on health and definition, obtaining and analysis of dietary fibre: a review. *J Food Nutr Res* 2013;1:13–23.
15 European Commission. Commission Regulation (EU) no 432/2012 of 16 may 2012 establishing a list of permitted health claims made on foods, other than those referring to the reduction of disease risk and to children's development and health. *Off J Eur Union* 2012;136:1–40.
16 EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). Scientific opinion on the substantiation of health claims related to dietary fibre (ID 744, 745, 746, 748, 749, 753, 803, 810, 855, 1415, 1416, 4308, 4330) pursuant to article 13(1) of regulation (EC) no 1924/2006. *EFSA Journal* 2010;8:1735.
17 Chantal J, Hercberg S, World Health Organization. Development of a new front-of-pack nutrition label in France: the five-colour nutri-score. *Public Health Panor* 2017;3:712–25.
18 Hall KD, Ayuketah A, Brychta R, *et al*. Ultra-processed diets cause excess calorie intake and weight gain: an inpatient randomized controlled trial of ad libitum food intake. *Cell Metab* 2019;30:67–77.
19 Monteiro CA, Moubarac J-C, Levy RB, *et al*. Household availability of ultra-processed foods and obesity in nineteen European countries. *Public Health Nutr* 2018;21:18–26.
20 Lachat C, Hawwash D, Ocké MC, *et al*. Strengthening the reporting of observational studies in epidemiology-nutritional epidemiology (STROBE-nut): an extension of the STROBE statement. *PLoS Med* 2016;13:e1002036.
21 Chatelan A, Beer-Borst S, Randriamiharisoa A, *et al*. Major differences in diet across three linguistic regions of Switzerland: results from the first national nutrition survey menuCH. *Nutrients* 2017;9:1163.
22 Bochud M, Chatelan A, Blanco J-M. Anthropometric characteristics and indicators of eating and physical activity behaviors in the Swiss adult population: results from menuCH 2014-2015. 2017. Available: http://www.bag.admin.ch/dam/bag/de/dokumente/npp/forschungsberichte/forschungsberichte-e-und-b/schlussbericht-menuch-chuv.pdf.download.pdf/MenuCH1_Report_March2017.pdf [Accessed May 2022].
23 Chatelan A, Marques-Vidal P, Bucher S, *et al*. Lessons learnt about conducting a multilingual nutrition survey in Switzerland: results from menuCH pilot survey. *Int J Vitam Nutr Res* 2017;87:25–36.
24 Slimani N, Casagrande C, Nicolas G, *et al*. The standardized computerized 24-H dietary recall method EPIC-soft adapted for Pan-European dietary monitoring. *Eur J Clin Nutr* 2011;65 Suppl 1:S5–15.
25 Sieber R, Reinli K. Verbrauch an Kohlenhydraten und Nahrungsfasern in der Schweiz. In: *Kohlenhydrate in der Ernährung: Stellungnahme und Empfehlungen der Eidgenössischen Ernährungskommission (EEK) 2009*. 2009. Available: http://www.blv.admin.ch/dam/blv/de/dokumente/das-blv/organisation/kommissionen/eek/kohlenhydrate-in-der-ernaehrung/expertenbericht-kohlenhydrate-ernaehrung.pdf.download.pdf/Kohlenhydrate_de.pdf
26 D-A-CH Referenzwerte Für die Nährstoffzufuhr. Bonn, Germany Deutsche Gesellschaft für Ernährung (DGE), Österreichische Gesellschaft für Ernährung (ÖGE), Schweizerische Gesellschaft für Ernährung (SGE); 2021.
27 Institute of Medicine. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids*. Washington, DC, USA: The National Academies Press, 2005.
28 IPAQ Research Committee. Guidelines for data processing and analysis of the International physical activity questionnaire (IPAQ) – short and long forms; 2005.
29 Lean ME, Han TS, Morrison CE. Waist circumference as a measure for indicating need for weight management. *BMJ* 1995;311:158–61.
30 Chiuve SE, Fung TT, Rimm EB, *et al*. Alternative dietary indices both strongly predict risk of chronic disease. *J Nutr* 2012;142:1009–18.
31 Pestoni G, Krieger J-P, Sych JM, *et al*. Cultural differences in diet and determinants of diet quality in Switzerland: results from the National nutrition survey menuCH. *Nutrients* 2019;11:126.
32 Krieger J-P, Pestoni G, Cabaset S, *et al*. Dietary patterns and their sociodemographic and lifestyle determinants in Switzerland: results from the National nutrition survey menuCH *Nutrients* 2018;11:62.
33 Steinbach L, Rohrmann S, Kaelin I, *et al*. No-meat eaters are less likely to be overweight or obese, but take dietary supplements more

often: results from the Swiss National nutrition survey menuCH. *Public Health Nutr* 2021;24:4156–65.
34 Pasquier J, Chatelan A, Bochud M. *Weighting strategy*. Lausanne, Switzerland: Institute of Social and Preventive Medicine (IUMSP), 2017.
35 R Core Team. R: A language and environment for statistical computing. Vienna, Austria R Foundation for Statistical Computing; 2022. Available: https://www.R-project.org
36 Rippin HL, Hutchinson J, Jewell J, *et al*. Adult nutrient intakes from current national dietary surveys of European populations. *Nutrients* 2017;9:1288.
37 Ergebnisbericht Teil 2: Nationale Verzehrsstudie II, . 2008Available: http://www.mri.bund.de/fileadmin/MRI/Institute/EV/NVSII_Abschlussbericht_Teil_2.pdf [Accessed Jul 2022].
38 Public Health England, Food Standards Agency. National diet and nutrition survey rolling programme years 9 to 11 (2016/2017 to 2018/2019. 2020. Available: http://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/943114/NDNS_UK_Y9-11_report.pdf [Accessed Jul 2022].
39 Fayet-Moore F, Cassettari T, Tuck K, *et al*. Dietary fibre intake in Australia. Paper I: associations with demographic, socio-economic, and anthropometric factors. *Nutrients* 2018;10:599.
40 Seljak BK, Valenčič E, Hristov H, *et al*. Inadequate intake of dietary fibre in adolescents, adults, and elderlies: results of slovenian representative SI. *Nutrients* 2021;13:3826.
41 Hlebowicz J, Wickenberg J, Fahlström R, *et al*. Effect of commercial breakfast fibre cereals compared with corn flakes on postprandial blood glucose, gastric emptying and satiety in healthy subjects: a randomized blinded crossover trial. *Nutr J* 2007;6:22.
42 Romero Ferreiro C, Lora Pablos D, Gómez de la Cámara A. Two dimensions of nutritional value: nutri-score and NOVA. *Nutrients* 2021;13:2783.
43 Srour B, Hercberg S, Galan P, *et al*. Effect of a new graphically modified nutri-score on the objective understanding of foods' nutrient profile and ultraprocessing: a randomised controlled trial. *BMJ Nutr Prev Health* 2023;6:108–18.