Swiss survey on salt intake: main results

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Contents

1 Executive summary

The Swiss Federal Office of Public Health (FOPH) has launched a nationwide strategy on dietary salt reduction for 2008-2012. The aim of this strategy is to reduce intake to less than 8 g/day in the population. The long term goal is to stabilize salt intake to the WHO recommendation of less than 5 g/day.

In this perspective, a nationwide survey was conducted in 2010-2011 to estimate the mean dietary salt intake using a 24-hour urinary collection obtained from a random sample of 1448 people from the population aged 15 years and over in eleven centers from nine cantons (Basel, Fribourg, Geneva, Luzern, St-Gallen, Ticino, Valais, Vaud, Zürich), covering three linguistic regions (French, German and Italian) of Switzerland. Blood pressure was measured five times on two separate days. The first measurement of each day was discarded and the average of 8 measurements used. Hypertension was considered as present if average systolic and/or diastolic blood pressure was $\geq$ 140/90 mm Hg or current antihypertensive treatment was reported.

Urinary salt excretion was 7.8 ± 3.3 g/24h in women and 10.6 ± 4.2 g/24h in men (mean $\pm$ standard deviation). The difference between men and women resulted from a shift of the entire distribution towards higher values among men. Only 21.6% of women and 6.0% of men had urinary salt excretion below the recommended level of 5 g/24h, with similar percentages across age groups. Hence women were three to four times more likely than men to reach the recommended target. This sex difference mainly reflects the higher energy intake in men compared to women. We observed regional differences with salt excretion being 7.2 ± 3.1, 8.1 ± 3.4 and 7.6 ± 3.2 g/24h in women and 10.3 ± 4.3, 10.7 ± 4.1 and 10.5 ± 4.3 g/24h in men from the French-, German- and Italian-speaking regions, respectively. Such differences might reflect region-related dietary habits.

Overall, dietary salt intake in the Swiss population was clearly above the international recommendation of 5g/day, more markedly in men than in women. This justifies the continuation of a national strategy on salt, aiming at decreasing population salt intake. A first objective could be to reduce mean dietary salt intake by 1g/day on five years. The small regional differences do not justify different strategies to reduce salt intake in the population.

Hypertension (i.e. blood pressure $\geq$ 140/90 mm Hg or on treatment) prevalence was 25.6% overall, 19.2% in women and 32.3% in men, similar to figures found in other Swiss studies. The prevalence of hypertension was 3.0% and 2.2% in the 15-29 year-old group and 64.5% and 52.8% in the $\geq$ 60 year old group, in men and women, respectively. This survey confirmed the positive relationship between urinary salt excretion and blood pressure. These results highlight the potential role of lowering salt intake to reduce the burden of hypertension.

The prevalence of overweight and obesity were 32.0% and 13.4% overall, 39.5% and 15.3% in men, and 25.0% and 11.6% in women, respectively. Higher body mass index was clearly associated with higher urinary salt excretion and higher blood pressure. Thus, a decrease in obesity prevalence (as a result of reduced food intake) will probably be associated with a reduction in average population salt intake and hypertension prevalence. Further, these results support the idea that a population strategy targeting multiple cardiovascular risk factors (e.g., associating reduction of dietary salt with reduction of food intake) is more efficient in reducing cardiovascular morbidity and mortality.

The majority of participants (75%) considered that salt has an impact on health. Most participants (81.1%) correctly identified hypertension as a condition having a direct link with salt intake, however only 41% mentioned heart disease, 21.2% myocardial infarction and 21.5% stroke in relation to salt intake. Overall 41.9% of the respondents knew that the recommended maximum daily salt intake is around 5 g/day and 30.5% did not know what the recommendation was. These results show that knowledge of the population on salt-related health consequences is already high, and that simply reinforcing health education through campaigns on the role of salt is unlikely to have any substantial impact.

Among the principal sources of salt in diet, salt in ready-to-eat meals or fast foods was ranked first, salt added to food at the table was ranked second and meat was ranked third by participants. The contribution of breads and cheeses, which are the main sources of salt in the Swiss diet, was underestimated by participants. By contrast, participants seemed to overestimate the contribution of salt added on food at the table. Knowledge on the main sources of dietary salt may therefore be substantially improved by public education campaigns. A strategy including food labelling for salt content could be useful in this context.

Only a minority of respondents reported to usually add salt to food when eating at home (7.4%) or when eating out (4.5%). Overall 58.1% of participants responded that they try to limit their dietary salt intake, but there were large differences across age groups. Whereas less than 40% of people aged 15-29 years reported to limit their salt intake, more than 70% of people aged 60 years or older did so. From these results, we can expect a campaign aiming at reducing the habit of adding salt to food to have low impact.

Among the 458 participants who reported their salt consumption as being “low” or “very low”, only 19.7% (8.3% of men and 28.9% of women) actually had urinary salt excretion below the international recommendation of 5 g/24h. More generally, only about one in five participants appropriately categorized her/his dietary salt intake compared to quintiles of urinary salt excretion in the population. Participants who had high urinary salt excretion tended to underestimate their intake, whereas those who had low urinary salt excretion tended to overestimate it. This underlines the misperception people have of their salt intake and, consequently, the limited ability of individuals to initiate a change in the diet.

This examination survey provides, for the first time, large scale data on 24-hour urinary salt excretion in three linguistic regions of Switzerland using a population-based sample. To recruit participants, we chose a two-stage sampling strategy similar to the one used in the Swiss Health Surveys. Only 9.7%

of contacted households ended up providing a participant in the study, yet a third of the households could not be reached by phone. This limits the external validity of the findings and highlights the difficulty of conducting population-based surveys including 24-hour urine collection. Nevertheless, the hypertension prevalence and blood pressure levels obtained in this survey are in line with previous population-based surveys conducted in Switzerland, taking age structure and region into account. As a proportion of participants seem to have provided incomplete urine collection, we expect dietary salt intake in this study to underestimate the true underlying dietary salt intake of the general population.

These results also suggest that a strategy able to lower dietary salt intake in the Swiss population is likely to have substantial impact on the cardiovascular morbidity and mortality, even when considering the current low absolute risk. Although cardiovascular morbidity and mortality has constantly decreased during the past decades in Switzerland, cardiovascular disease remains the major cause of death in our country, both in men and in women. With the ageing of the Swiss population and the sharp increase in hypertension prevalence with age, the cardiovascular burden is expected to raise in the coming decades.

Most countries that initiated a national strategy to reduce dietary salt intake in the general population adopted a combination of various interventions such as public education campaigns, food labelling regulation and, in collaboration with the food industry, the reduction of the salt content of processed food. Seventy-five to 80% of dietary salt comes from food produced by the industry. It is generally acknowledged that structural modifications (e.g. modified salt content of food) that do not require individual behavioral changes are more efficient to reduce salt intake in the population than measures implying some individual behavioral changes. Although knowledge on salt was not perfect in the Swiss population, the gain that can be expected from public education campaigns alone will be limited compared to the gain that can be expected from modifiying the content of salt in the processed food. As urinary salt excretion was uniformly high, with only mild inter-regional differences, this survey provides strong rationale for the food industry to reduce the salt content of food across Switzerland.

2 Introduction

It has been recently estimated that 54% of stroke and 47% of ischaemic heart disease are attributable to high blood pressure worldwide, with half of this burden occurring in people aged 45-69 years [1]. Most strokes and ischaemic events occur in people before a diagnosed hypertension; thus population-wide strategies aiming at reducing blood pressure are more appropriate than strategies targeting only patients with hypertension.

Current dietary salt consumption in general populations usually varies between 8g and 12g per day [2]. Reducing dietary salt intake by $2.0 - 2.3$ g per day was estimated to decrease systolic blood pressure by about 1-4 mm Hg [3] and reductions of 4-5 g per day were associated with 2-5 mm Hg reductions in systolic blood pressure [4]. A reduction of salt intake of $2.0 - 2.3$ g per day was associated with 20-30% reductions in cardiovascular events and a non-significant 5-7% reduction in all-cause mortality in meta-analyses of randomized controlled trials [3, 5]. Cardiovascular morbidity and mortality has constantly decreased during the past decades in Switzerland, reaching low levels by international comparison [6]. However, cardiovascular disease remains the major cause of death in our country, both in men and in women [7], and hypertension remains one of the most important modifiable risk factors.

Several countries have initiated strategies to reduce dietary salt intake in the general population [8], via a combination of various procedures such as public education, food labelling and collaboration with the food industry to reduce the salt content of processed food. The Swiss Federal Office of Public Health (FOPH) has launched the monitoring of dietary salt intake in the Swiss population within the context of the Salt Strategy, as part of the National Programme on Diet and Physical activity 2008-2012 [9]. The main objective of this Salt Strategy is to reduce mean population dietary salt intake to less than 8g per day in the period 2008-2012 and to achieve the WHO-recommendation of less than 5g per day on the long run [9].

Data on dietary salt intake are lacking at a national level in Switzerland. In 1984, Mordasini et al.[10] measured the sodium-to-creatinine ratio in spot urine from 966 participants aged 18-75 years from various cantons (VD, NE, BE, TG, SH, TI), a subsample of which (n=147) also provided a 24-hour urine collection; mean dietary salt intake was estimated at 11.3 g/day in men and 8.9 g/day in women. Data from a study conducted in Lausanne (Hercules study) in 2008-2009 measuring sodium excretion in 24-hour urine from 416 participants aged 38-78 years estimate dietary salt intake at 8.7 g/day in men and 7.3 g/day in women [1]. Another study conducted in the Geneva general adult population (35-74 years) in a total of 13335 participants between 1993 and 2004 using a validated food frequency questionnaire showed a mean dietary salt intake of 10.6 g/day in men and 8.1 g/day in women [11], with stable results during the 12-years period.

[1] Ref: www.colaus.ch, unpublished results

Considering the need for updated data on dietary salt intake in the Swiss general population, it was decided in 2009 to conduct this national survey using measurement of sodium excretion in 24-hour urine collection; the other objectives were to assess the prevalence of hypertension, overweight and obesity, as well as population knowledge regarding salt and health issues.

3 Methods

3.1 Study centers

The study was coordinated by a Lausanne team and the survey included eleven centers in Switzerland, covering nine cantons: Basel, Fribourg, Geneva, Luzern, St-Gallen, Ticino, Vaud, Valais and Zürich. For geographical reasons, canton of Ticino had three centers located in Locarno, Lugano and Bellinzona. The three main linguistic regions of the country were thus represented. Recruitment started in January 2010 and was completed in August 2011 (except for the canton of Fribourg, for which data are planned to be available by the end of 2011).

3.2 Recruitment

Inclusion and exclusion criteria Inclusion criteria were similar to the Swiss Health Surveys, i.e. participants had to be ≥15 years old and permanent residents in Switzerland. People were excluded from the survey if they were living in institutions, if they had linguistic difficulties preventing them from understanding study objectives, instructions or questions, or if they were not able or not willing to collect 24-hour urine.

Sampling strategy Each study center recruited participants among the population of the corresponding canton and aimed at including the same number of people in each of the eight predefined sex and age strata (15-29, 30-44, 45-59, ≥60 years old in men and women). Participants were recruited using a two-level sampling strategy, similar to the one used in the Swiss Health Surveys. The Swiss Federal Statistical Office provided a list of randomly selected households from the Swisscom fixed line directory *(first level)*, separately for each canton. We sent an information letter to these households and contacted them by phone a few days later; when necessary, as many as three phone call attempts were made on different days. During the phone call, we defined the composition of the household asking for name, firstname, sex and date of birth of every member aged 15 years and older; one person per household was randomly selected *(second level)* and invited to participate in the study. This second level random selection was made using a computer generated random number.

Representativeness of the sample Participation rate was low: only 9.7% of contacted households ended up providing a participant in the study, yet a third of the households could not be reached by phone. Because of important difficulties in recruiting young participants and given the budgetary constraints, we had to complete the study sample by recruiting volunteers in some of the centers, mainly in the 15-29 years old strata, notably from Universities and professional schools. This highlights the difficulties of conducting population-based examination surveys including 24-hour urine collection and limits the representativeness of the study sample as compared to the general Swiss population.

3.3 Data collected

The study consisted of two visits at the study center, before and after the 24-hour urine collection. Participants were given two 3-liter plastic bottles and standardized instructions on how to collect urine. They were asked to first empty their bladder, discard the urine and write down the time (start of the collection). Thereafter, participants were asked to collect all urine during 24-hour in the dedicated plastic bottles that they were advised to keep in the refrigerator. The end of the collection was determined by the last urine void in the clinic at the second visit or, if not possible, the time of the last void. Participants were asked to have their daily activities as usual. In the clinic, the urine was mixed and weighted before aliquots were sampled using yellow 10-mL Monovettes (Sarstedt ®) following a standardized protocole.

Resting blood pressure was measured five times at each visit, in the sitting postition in a quiet environment using an appropriately sized cuff and a validated oscillometric device (Omron HEM-907, Omron Health Care, Matsusaka, Japan) in all centers. A total of 10 blood pressure measurements were taken for each participant. Weight, height and abdominal perimeter were measured at the first visit. Body mass index (BMI) was calculated as weight divided by height in squared meter. At the second visit, participants were asked to fill in a questionnaire about lifestyle, medical history and salt-related health issues; an optional blood sample was also taken. Urine and blood samples were kept in a -20°C freezer in study centers and subsequently sent to the Laboratoire de Chimie Clinique of the Centre Hospitalier Universitaire Vaudois (CHUV, Lausanne, Switzerland) for centralized analyses with standard methods and stringent internal quality controls.

We told participants that the study was about "lifestyle and blood pressure", and we paid attention not to mention salt intake, in order for them not to change their dietary habits before the urine collection. Similarly, the questionnaire was filled out only after participants had completed the urine collection. The study protocol was approved by the ethics committees responsible for each study center. Every study participant gave written informed consent; for participants under 18, the informed consent of a parent was also obtained. Each participant received a compensation of CHF 20.- after having completed the study.

3.4 Statistical analyses

We used mean and standard deviation to describe unadjusted continuous variables. We used count and percentages to describe dichotomous or categorical variables. We conducted multiple linear regression adding selected covariates (e.g. age, sex and linguistic region) in the models for continuous outcome variables. We reported the beta regression coefficients and standard error of interest whenever a model included additional covariates. We conducted multiple logistic regression adding selected covariates in the models for dichotomous outcome variables. In some cases, we reported odds ratio and

95% confidence interval whenever a model included additional covariates. We used 0.05 as a cut-off for statistical significance and did not adjust for multiple testing.

4 Main results

4.1 Participants

A total of 1448 participants completed the study, divided as follows: 198 in Basel, 116 in Geneva, 194 in Luzern, 161 in St-Gallen, 216 in Ticino, 196 in Vaud, 99 in Valais and 268 in Zürich. Main characteristics of participants are described in Table 1. People from the Italian-speaking region were intentionally oversampled, in order to obtain more stable estimates and a better comparison with the other regions. Eighty-six percent of participants had Swiss nationality (including a few binational people) and 13.7% were non-Swiss, less than the current proportion of 22.4% of non-Swiss permanent residents (Federal Statistical Office 2011, www.bfs.admin.ch). Foreigners were underrepresented probably because they are less likely to appear in the Swisscom directory, and because they would have greater difficulties in understanding the study purpose for language reasons, notably during the phone recruitment. Mean age of participants according to sex, age groups and linguistic regions is given in table 2.

Table 1: Characteristics of participants

	Linguistic region							
	French		**German**		**Italian**		**Total**	
	No.	%	No.	%	No.	%	No.	%
Sex								
Men	201	48.9	400	48.7	105	48.6	706	48.8
Women	210	51.1	421	51.3	111	51.4	742	51.2
Age category of participants								
15-29 years	94	22.9	200	24.4	53	24.5	347	24.0
30-44 years	103	25.1	175	21.3	53	24.5	331	22.9
45-59 years	95	23.1	204	24.8	52	24.1	351	24.2
60 years and over	119	29.0	242	29.5	58	26.9	419	28.9
Nationality								
Missing data	1	0.2	2	0.2	0	0.0	3	0.2
Swiss	351	85.4	707	86.1	189	87.5	1247	86.1
Other	59	14.4	112	13.6	27	12.5	198	13.7
Country of birth								
Missing data	1	0.2	1	0.1	1	0.5	3	0.2
Switzerland	300	73.0	647	78.8	182	84.3	1129	78.0
Other	110	26.8	173	21.1	33	15.3	316	21.8
Smoking status								
Missing data	2	0.5	8	1.0	6	2.8	16	1.1
Never smokers	202	49.1	462	56.3	124	57.4	788	54.4
Current smokers	87	21.2	130	15.8	33	15.3	250	17.3
Former smokers	120	29.2	221	26.9	53	24.5	394	27.2
Total	411	100.0	821	100.0	216	100.0	1448	100.0

Source: OFSP

Table 2: Mean age of participants

	Mean age of participants (years)										
	Men					Women					
	15-29	30-44	45-59	≥60	**Total Men**	15-29	30-44	45-59	≥60	**Total Women**	**Total**
Linguistic region											
French (n=411)	21.6	38.7	53.4	67.7	**46.6**	20.7	38.3	52.7	70.0	**46.8**	**46.7**
German (n=821)	25.0	38.1	52.5	70.4	**49.2**	24.9	37.7	52.8	71.2	**47.0**	**48.1**
Italian (n=216)	20.3	37.8	51.3	70.6	**46.2**	22.1	38.7	52.6	67.9	**45.3**	**45.7**
Total (n=1448)	23.3	38.2	52.5	69.7	**48.0**	23.4	38.1	52.7	70.4	**46.7**	**47.3**

Source: OFSP

4.2 Estimation of dietary salt intake using 24-hour urine collection

4.2.1 Urinary excretion of NaCl

We chose to measure excretion of sodium in 24-hour urine collection, a method widely recognized as a proxy for dietary salt intake. We used the following conversion factor: 1 mmol of sodium (Na) corresponds to 0.0584 g of cooking salt (NaCl). Data on urinary sodium excretion were available for a total of 1447 participants.

Table 3: Mean urinary salt excretion (g NaCl/24h)

	Mean urinary NaCl excretion (g/24h)										
	Men					Women					
	15-29	30-44	45-59	≥60	**Total Men**	15-29	30-44	45-59	≥60	**Total Women**	**Total**
Linguistic region											
French (n=411)	9.3	10.6	11.3	10.1	**10.3**	6.7	7.9	7.8	6.4	**7.2**	**8.7**
German (n=820)	9.7	11.5	11.4	10.4	**10.7**	8.3	8.3	8.7	7.2	**8.1**	**9.4**
Italian (n=216)	10.7	10.7	11.3	9.5	**10.5**	7.7	8.2	7.0	7.4	**7.6**	**9.0**
Total (n=1447)	9.8	11.1	11.3	10.2	**10.6**	7.8	8.2	8.2	7.0	**7.8**	**9.1**

Source: OFSP

Table 3 shows mean 24-hour urinary salt excretion in g/24h according to sex and age categories for each linguistic region. As expected, mean ±SD salt consumption was significantly higher in men (10.6±4.2 g/24h) than in women (7.8±3.3 g/24h). This sex difference, which mainly reflects the higher energy intake in men compared to women, was observed in every age category, although less marked in younger people. There was a quadratic relationship with age, similar in men and women, i.e. middle-aged people showed the highest salt intake. We observed regional differences with mean ±SD salt excretion being 7.2±3.1, 8.1±3.4 and 7.6±3.2 g/24h in women and 10.3±4.3, 10.7±4.1 and 10.5±4.3 g/24h in men from the French-, German- and Italian-speaking regions, respectively. Such differences might reflect different region-related dietary habits. Upon adjustement for age, sex and BMI, mean ±SE urinary salt excretion in the German-speaking region (9.3±0.1 g/24h) was significantly higher than in the French- (8.7±0.2 g/24h), but similar to the Italian- (9.2±0.2 g/24h) speaking regions. Adjusted for age, sex, BMI and linguistic region, there was no significant difference in mean ±SE urinary salt excretion according to nationality: 9.1±0.1 g/24h in Swiss people vs 9.3±0.3 g/24h in non-Swiss residents. Similarly and adjusted for the same variables, people born abroad tended to have a similar salt excretion (9.3±0.2 g/24h) than people born in Switzerland (9.1±0.1 g/24h).

The main objective of the Swiss Salt Strategy is to reduce mean population salt intake to less than 8 g/day in the period 2008-2012, and to achieve WHO recommandation of less than 5 g/day on the long run [9]. This survey showed that only 14.0% of the participants eat less than 5g of salt per day (Table 4). Women currently were much more likely to comply with this recommendation than men (age-, BMI- and linguistic region-adjusted OR 3.7, 95% CI: 2.6-5.4). Participants from the German-speaking region were less likely to reach this recommendation than people from the French-speaking region (age-, sex- and BMI-adjusted OR 0.7, 95% CI: 0.5-0.9).

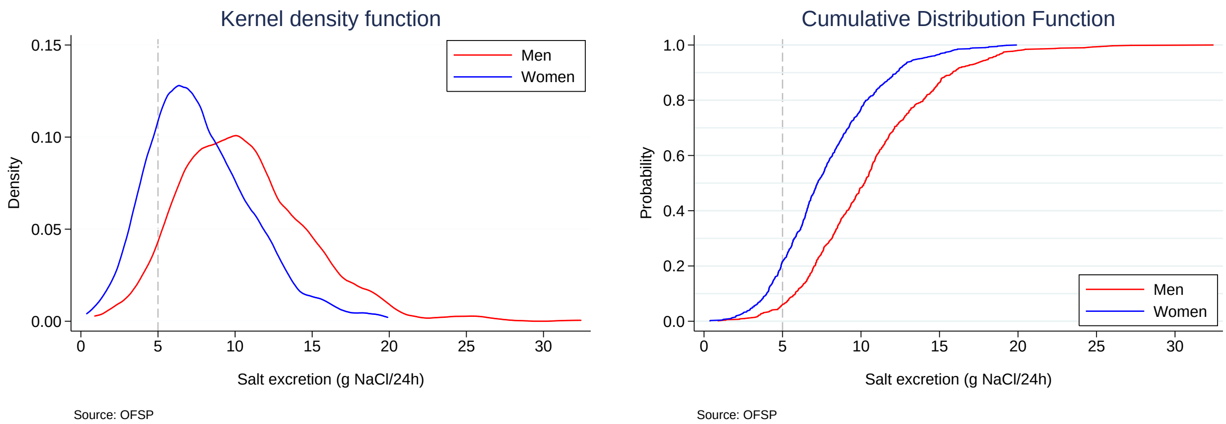
Table 4: Proportion of participants with salt excretion below 5 g/day

	Proportion of subjects with NaCl excretion $<$ 5 g/24h (in %)										
	Men					Women					
	15-29	30-44	45-59	≥60	**Total Men**	15-29	30-44	45-59	≥60	**Total Women**	**Total**
Linguistic region											
French (n=411)	6.4	4.1	2.2	11.9	**6.5**	31.9	13.0	24.5	40.0	**27.6**	**17.3**
German (n=820)	8.7	5.3	4.0	4.6	**5.5**	19.4	17.3	13.5	25.2	**19.0**	**12.4**
Italian (n=216)	7.7	8.7	3.8	6.7	**6.7**	7.4	20.0	30.8	21.4	**19.8**	**13.4**
Total (n=1447)	7.9	5.4	3.5	6.8	**6.0**	20.9	16.5	19.0	29.1	**21.6**	**14.0**

Source: OFSP

Figure 1 shows distribution curves of urinary NaCl excretion for men and women; vertical dashed lines represent the international recommendation of 5g/24h. Kernel density graph (left panel) shows that the great majority of participants stands to the right of this vertical line; moreover, there is an entire shift towards higher, and slightly wider, salt excretion levels in men as compared to women. On the cumulative distribution graph (right panel), only about 20% of women and about 5% of men have a urinary salt excretion below the recommended threshold.

Figure 1: Urinary salt excretion (g NaCl/24h) distribution according to sex



4.2.2 Assessment of 24-hour urine collection quality

It is important to evaluate the quality of urine collections, in order to assess validity of salt excretion measurement. Performing a 24-hour urine collection might be difficult, and a proportion of samples are likely to be incomplete. Duration and volume of collection, as well as creatinine excretion corrected for body weight, are useful parameters for quality control purposes. Mean duration of collection (1442 minutes) was similar in men and women, across age groups and linguistic regions.

Mean urinary volume, corrected for 24 hours (1440 minutes), is show in Table 5. Participants from the German-speaking region had a significantly higher urinary volume (mean±SD 2136±943 ml/24h) than participants from the French- (1684±769 ml/24h) and the Italian- (1665±831 ml/24h) speaking regions; these differences resist to adjustment for age, sex and BMI. This tendency was observed in all but one age categories and is consistent across all of the four German-speaking centers, suggesting that people from the German-speaking region tend to drink more than people from other Swiss regions. Moreover, women had a significantly higher urinary volume (mean±SD 1990±930 ml/24h) than men (1882±882 ml/24h). This probably reflects the fact that women tend to drink more than men.

Table 5: Mean urinary volume (ml/24h)

	Mean urine volume (ml/24h)										
	Men					Women					
	15-29	30-44	45-59	≥60	**Total Men**	15-29	30-44	45-59	≥60	**Total Women**	**Total**
Linguistic region											
French (n=411)	1524	1813	1731	1733	**1703**	1352	1730	1902	1662	**1666**	**1684**
German (n=820)	1961	2282	2139	1937	**2059**	2078	2373	2348	2063	**2209**	**2136**
Italian (n=216)	1615	1416	1597	1559	**1551**	1314	1820	1847	2098	**1773**	**1665**
Total (n=1447)	1782	1992	1948	1831	**1882**	1777	2091	2153	1947	**1990**	**1937**

Source: OFSP

Urinary excretion of creatinine is an indirect measure of muscle mass; it is expressed here as mmol per kilogram of body weight per 24 hours. Although normal values are not well defined, it allows comparison between different groups of participants. As expected, creatinine excretion was higher in men than in women and decreased with age (Table 6). Adjusted for age, sex and BMI, urinary creatinine excretion was homogenous across linguistic regions.

Table 6: Mean urinary excretion of creatinine (mmol/kg/24h)

	Mean urinary creatinine excretion (mmol/kg/24h)										
	Men					Women					
	15-29	30-44	45-59	≥60	**Total Men**	15-29	30-44	45-59	≥60	**Total Women**	**Total**
Linguistic region											
French (n=411)	0.229	0.205	0.192	0.168	**0.197**	0.165	0.168	0.142	0.123	**0.149**	**0.172**
German (n=817)	0.209	0.205	0.189	0.162	**0.188**	0.169	0.162	0.146	0.120	**0.149**	**0.168**
Italian (n=216)	0.216	0.219	0.204	0.169	**0.200**	0.179	0.153	0.156	0.127	**0.153**	**0.176**
Total (n=1444)	0.216	0.207	0.192	0.164	**0.192**	0.170	0.162	0.146	0.122	**0.150**	**0.170**

Source: OFSP

4.2.3 Urinary excretion of NaCl after exclusion of incomplete collections

Data on urinary excretion of NaCl were reanalysed after exclusion of participants for which the 24-hour urine collection was considered as incomplete, i.e. if: (1) urinary volume was less than 300 ml/24h (n=3, one man and 2 women), (2) participants reported not having collected all 24-hour urine (n=29, 7 men and 22 women), or (3) urinary excretion of creatinine was equal to or below the 5th percentile in both sex categories, i.e. 0.121 mmol/kg/24h in men and 0.082 mmol/kg/24h in women (n=77, 37 men and 40 women). The last condition was arbitrarily chosen in order to eliminate collection most likely to be incomplete. A total of 97 participants (42 men and 55 women) were excluded from the following analysis, some of them for more than one exlusion criteria. Mean urinary NaCl excretion after exclusion of these participants (Table 7) was 9.4 g/24h (10.8 in men and 8.0 in women), i.e. higher, although not significantly, than values presented in Table 3 (mean 9.1 g/24h, 10.6 in men and 7.8 in women).

Table 7: Mean urinary salt excretion (g NaCl/24h), incomplete collections excluded

	Mean urinary NaCl excretion (g/24h), incomplete excluded										
	Men					Women					
	15-29	30-44	45-59	≥60	**Total Men**	15-29	30-44	45-59	≥60	**Total Women**	**Total**
Linguistic region											
French (n=385)	9.5	10.6	11.3	10.4	**10.4**	6.9	7.8	8.3	6.7	**7.4**	**8.9**
German (n=757)	10.2	11.7	11.6	10.8	**11.0**	8.5	8.3	8.9	7.6	**8.3**	**9.6**
Italian (n=208)	10.7	10.7	11.3	9.7	**10.5**	7.7	8.7	7.0	7.8	**7.8**	**9.2**
Total (n=1350)	10.0	11.1	11.4	10.5	**10.8**	7.9	8.2	8.4	7.3	**8.0**	**9.4**

Source: OFSP

Measurement of NaCl excretion in 24-hour urine in this survey probably underestimates dietary salt intake in the Swiss population for the following reasons: (1) a proportion of NaCl intake is not excreted in urine (extra-renal losses), estimated around 5% [10, 12], (2) some of the 24-hour urine collections may have been incomplete (we arbitrarily estimated that proportion at about 6.7% (97/1447)), and (3) participation rate was low, and we probably expect a participation biais, if any, towards people with a healthier lifestyle.

4.3 Blood pressure and hypertension

4.3.1 Mean systolic and diastolic blood pressure

Blood pressure was measured five times during each study visit, in a sitting position, using an automatic oscillometric device (Omron HEM-907). The first blood pressure measurement, at each visit, was significantly higher than the second measurement (i.e. about 3 mm Hg higher) and was discarded, as is the standard procedure in population-based surveys. Average systolic and diastolic blood pressure levels by age, sex and linguistic regions are presented in Tables 8 and 9. Adjusted for age, sex and BMI, participants from the German-speaking region had significantly higher mean ±SE systolic (125.5± 0.4 mm Hg) and diastolic (74.8±0.3 mm Hg) blood pressure than participants from the French- (121.9±0.6 and 73.6±0.4 mm Hg) and the Italian- (121.4±0.9 and 70.6±0.6 mm Hg) speaking regions.

Table 8: Mean systolic blood pressure on eight measures

	Mean systolic blood pressure (mm Hg)										
	Men					Women					
	15-29	30-44	45-59	≥60	**Total Men**	15-29	30-44	45-59	≥60	**Total Women**	**Total**
Linguistic region											
French (n=409)	118	125	129	135	**127**	109	108	117	130	**117**	**122**
German (n=820)	124	127	133	139	**132**	112	114	122	133	**120**	**126**
Italian (n=216)	118	125	129	132	**126**	107	109	114	131	**115**	**120**
Total (n=1445)	121	126	131	137	**130**	110	111	119	132	**119**	**124**

Source: OFSP

Table 9: Mean diastolic blood pressure on eight measures

	Mean diastolic blood pressure (mm Hg)										
	Men					Women					
	15-29	30-44	45-59	≥60	**Total Men**	15-29	30-44	45-59	≥60	**Total Women**	**Total**
Linguistic region											
French (n=409)	67	76	81	77	**75**	68	69	75	75	**72**	**74**
German (n=820)	70	77	82	78	**77**	69	73	75	75	**73**	**75**
Italian (n=216)	63	75	79	72	**72**	64	66	69	73	**68**	**70**
Total (n=1445)	68	76	81	77	**76**	68	71	74	74	**72**	**74**

Source: OFSP

4.3.2 Hypertension prevalence

Hypertension was defined here as mean systolic blood pressure ≥ 140 mmHg (eight measures) or mean diastolic blood pressure ≥ 90 mmHg (eight measures) or self-reported current anti-hypertensive treatment.

The overall prevalence of hypertension in the study population was 25.6% (Table 10). As expected, it increased with age, and was higher in men (32.3%) than in women (19.1%); this sex difference was less marked in people aged 60 years and older, reflecting the loss of hormonal protection after menopause. Adjusted for age, sex and BMI, people from the German-speaking region had a higher prevalence of hypertension than people from the French- (p=0.016) and the Italian- (p=0.013) speaking regions. Among participants who were unaware of being hypertensive (n=1122), 8.6% had newly identified hypertension based on eight measurements. Among untreated participants (n=1215), hypertension prevalence was 11.4%.

Table 10: Prevalence of measured hypertension (defined as blood pressure $\geq$ 140/90 mm Hg or on antihypertensive treatment)

	Prevalence of measured hypertension (in %)										
	Men					Women					
	15-29	30-44	45-59	≥60	**Total Men**	15-29	30-44	45-59	≥60	**Total Women**	**Total**
Linguistic region											
French (n=411)	2.1	10.2	26.1	64.4	**27.9**	2.1	0.0	12.2	51.7	**18.1**	**22.9**
German (n=821)	4.3	13.0	44.0	67.9	**36.8**	2.8	5.1	18.3	56.8	**21.4**	**28.9**
Italian (n=216)	0.0	8.7	30.8	50.0	**23.8**	0.0	0.0	11.5	39.3	**12.6**	**18.1**
Total (n=1448)	3.0	11.4	37.2	64.5	**32.3**	2.2	2.7	15.6	52.8	**19.1**	**25.6**

Source: OFSP

4.3.3 Association between urinary salt excretion and blood pressure

We found a significant positive association between urinary salt excretion and average blood pressure. Adjusted for age and linguistic region, each additional gram of salt excreted in 24-hour urine was associated with higher systolic blood pressure in men (beta coefficient±SE: 0.346±0.111 mm Hg/g NaCl, p=0.002) and in women (0.364±0.143 mm Hg/g NaCl, p=0.011). Upon further adjustment for BMI, these values were 0.223±0.118 mm Hg/g NaCl (p=0.059) in men and 0.234±0.148 mm Hg/g NaCl (p=0.116) in women. The positive association between urinary salt excretion and average systolic blood pressure was stronger at older ages: adjusted for age, sex, linguistic region and BMI, beta coefficient±SE was 0.089±0.096 mm Hg/g NaCl (p=0.351) in people aged <50 years, and 0.518±0.168 mm Hg/g NaCl (p=0.002) in people aged ≥50 years.

Similarly, adjusted for age and linguistic region, each additional gram of salt excreted in 24-hour urine was associated with higher diastolic blood pressure in men (0.303±0.088 mm Hg/g NaCl, p=0.001) and in women (0.372±0.100 mm Hg/g NaCl, p<0.001). Upon further adjustment for BMI, these values were 0.086±0.091 mm Hg/g NaCl (p=0.347) in men and 0.154±0.100 mm Hg/g NaCl (p=0.123) in women.

4.4 Anthropometric data

4.4.1 Body weight, height and body mass index

Weight and height of participants are presented in Table 11 and Table 12, respectively. Adjusted for age and sex, participants from the Italian-speaking region had significantly lower mean±SE body weight than participants from the French- (70.1±0.9 vs 72.5±0.7 kg) and from the German- (73.8±0.5 kg) speaking regions. Adjusted for the same variables, participants from the German-speaking region were significantly taller (mean±SE: 170.7±0.2 cm) than participants from the French- (169.2±0.3 cm) and the Italian- (168.9±0.4 cm) speaking regions.

Table 11: Mean body weight

	Mean body weight (kg)										
	Men					Women					
	15-29	30-44	45-59	≥60	**Total Men**	15-29	30-44	45-59	≥60	**Total Women**	**Total**
Linguistic region											
French (n=411)	70.7	80.9	81.8	83.5	**79.5**	62.1	63.5	69.4	67.3	**65.7**	**72.4**
German (n=818)	75.8	84.5	85.0	81.7	**81.7**	63.9	66.9	68.8	66.4	**66.4**	**73.9**
Italian (n=216)	70.7	83.5	86.3	74.4	**78.4**	58.4	63.7	62.5	62.7	**61.9**	**69.9**
Total (n=1445)	73.6	83.2	84.3	81.2	**80.6**	62.6	65.3	68.1	66.1	**65.5**	**72.9**

Source: OFSP

Table 12: Mean body height

	Mean body height (cm)										
	Men					Women					
	15-29	30-44	45-59	≥60	**Total Men**	15-29	30-44	45-59	≥60	**Total Women**	**Total**
Linguistic region											
French (n=411)	177.5	178.7	173.5	173.3	**175.6**	165.3	164.7	163.6	160.3	**163.3**	**169.3**
German (n=818)	178.6	180.4	176.5	173.1	**176.6**	167.6	167.0	164.7	160.9	**165.0**	**170.6**
Italian (n=216)	176.3	176.5	175.6	172.4	**175.0**	165.1	164.3	165.5	159.2	**163.5**	**169.1**
Total (n=1445)	177.9	179.3	175.5	173.1	**176.1**	166.7	165.9	164.5	160.5	**164.3**	**170.0**

Source: OFSP

BMI is defined as weight divided by height in squared meter. Normal range is 18.5 - 24.9 kg/m^2; overweight is defined as BMI 25.0 - 29.9 kg/m^2 and obesity is defined as BMI ≥30.0 kg/m^2 [13].

As shown in Table 13, mean BMI slightly increased with age and was significantly higher in men (26.0 kg/m^2) than in women (24.3 kg/m^2). Adjusted for age and sex, participants from the Italian-speaking region had significantly lower mean±SE BMI than those from the German- and French-speaking regions (24.4±0.3, 25.2±0.2 and 25.2±0.2 kg/m^2, respectively). In all linguistic regions, mean BMI in men was above the normal range of 24.9 kg/m^2, in all but the youngest age category. Women from the French- and German-speaking regions in the two oldest age categories, also had a mean BMI above the normal range.

Table 13: Mean body mass index

	Mean body mass index (kg/m^2)										
	Men					Women					
	15-29	30-44	45-59	≥60	**Total Men**	15-29	30-44	45-59	≥60	**Total Women**	**Total**
Linguistic region											
French (n=411)	22.5	25.3	27.1	27.7	**25.8**	22.8	23.4	25.9	26.2	**24.7**	**25.2**
German (n=818)	23.7	25.9	27.3	27.2	**26.2**	22.7	24.0	25.4	25.7	**24.5**	**25.3**
Italian (n=216)	22.8	26.8	27.9	24.9	**25.5**	21.4	23.7	22.7	24.7	**23.2**	**24.3**
Total (n=1445)	23.2	25.8	27.3	27.0	**26.0**	22.5	23.8	25.1	25.7	**24.3**	**25.1**

Source: OFSP

4.4.2 Prevalence of overweight and obesity

The prevalence of overweight and obesity were 32.0% and 13.4% overall, 39.5% and 15.3% in men, and 25.0% and 11.6% in women, respectively (Table 14). Upon adjustment for age and linguistic region, men had a significantly higher risk of being overweight than women, whereas the risk of being obese tended to be higher, but this was not significant. Upon adjustment for sex and linguistic region, the risk of being overweight or obese significantly increased with age.

Table 14: Proportion of participants in each BMI category

	BMI categories (in %)			
	Normal weight ($BMI < 25$)	Overweight ($25 \leq BMI < 30$)	Obesity ($BMI \geq 30$)	**Total**
Sex				
Men (n=704)	45.2	39.5	15.3	100.0
Women (n=741)	63.4	25.0	11.6	100.0
Strata				
M15-29 (n=165)	73.9	22.4	3.6	100.0
M30-44 (n=149)	48.3	39.6	12.1	100.0
M45-59 (n=170)	32.4	42.9	24.7	100.0
M$\geq$ 60($n = 220$)	31.4	49.5	19.1	100.0
W15-29 (n=182)	81.9	12.1	6.0	100.0
W30-44 (n=182)	69.2	21.4	9.3	100.0
W45-59 (n=179)	57.5	27.9	14.5	100.0
W$\geq$ 60($n = 198$)	46.5	37.4	16.2	100.0
Linguistic region				
French (n=411)	55.7	29.2	15.1	100.0
German (n=818)	51.8	35.2	13.0	100.0
Italian (n=216)	62.5	25.5	12.0	100.0
Total (n=1445)	54.5	32.0	13.4	100.0

Source: OFSP

4.4.3 Waist circumference

Participants had their waist circumference measured during the first visit. Measurement was taken at the level of the ombilic on the participant standing. We categorized waist circumference into normal, increased and substantially increased using cut-offs proposed by the WHO [14]. The risk of metabolic complication was shown to be increased if waist circumference is >94 cm in men or >80 cm in women; moreover, this risk was shown to be substantially increased if waist circumference is >102 cm in men or >88 cm in women [14].

Mean waist circumference was 94.6cm in men and 85.1cm in women (Table 15). As expected, it was larger in men than in women and increased with age in both men and women. Adjusted for age and sex, participants from the French-speaking region had significantly higher mean±SE waist circumference (91.4±0.6 cm) than participants from the German- (89.6±0.4 cm) and the Italian- (87.3±0.8 cm) speaking regions.

Table 15: Mean waist circumference (cm)

	Mean waist circunference (cm)										
	Men					Women					
	15-29	30-44	45-59	≥60	**Total Men**	15-29	30-44	45-59	≥60	**Total Women**	**Total**
Linguistic region											
French (n=410)	83.4	94.4	96.9	102.5	**94.8**	81.5	84.0	90.5	94.1	**87.8**	**91.2**
German (n=819)	85.2	94.0	98.9	99.7	**95.0**	79.2	83.3	86.4	89.8	**84.7**	**89.7**
Italian (n=216)	81.5	94.1	99.8	95.6	**92.8**	77.3	81.4	79.6	86.2	**81.2**	**86.9**
Total (n=1445)	84.1	94.2	98.5	99.9	**94.6**	79.5	83.2	86.5	90.6	**85.1**	**89.7**

Source: OFSP

Table 16 shows the proportion of subjects in each of the waist circumference category. Adjusted for age and linguistic region, women had a higher risk than men to have a substantially increased metabolic risk according to their waist circumference (OR 1.62, 95% CI: 1.27-2.06). Adjusted for age and sex, participants from the German- (OR 0.65, 95% CI: 0.50-0.85) and the Italian- (OR 0.45, 95% CI: 0.30-0.67) speaking regions had a lower risk of having a substantially increased metabolic risk according to their waist circumference than participants from the French-speaking region.

Table 16: Proportion of subjects in each waist circumference category

	Waist circumference categories (in %)			
	normal (≤94cm in men, ≤80cm in women)	increased (94.1-102cm in men, 80.1-88cm in women)	substantially increased (>102cm in men, >88cm in women)	**Total**
Linguistic region				
French (n=410)	41.5	21.5	37.1	100.0
German (n=819)	46.5	23.9	29.5	100.0
Italian (n=216)	56.9	21.3	21.8	100.0
Strata				
M15-29 (n=165)	86.7	7.3	6.1	100.0
M30-44 (n=149)	56.4	28.2	15.4	100.0
M45-59 (n=170)	37.1	27.6	35.3	100.0
M$\geq$ 60$(n = 220)$	33.2	24.5	42.3	100.0
W15-29 (n=182)	63.7	20.9	15.4	100.0
W30-44 (n=181)	47.0	22.1	30.9	100.0
W45-59 (n=179)	37.4	25.1	37.4	100.0
W$\geq$ 60$(n = 199)$	21.6	26.1	52.3	100.0
Sex				
Men (n=704)	51.6	22.0	26.4	100.0
Women (n=741)	42.0	23.6	34.4	100.0
Total (n=1445)	46.6	22.8	30.5	100.0

Source: OFSP

4.4.4 Association between body mass index and blood pressure

We observed a significant positive association between BMI and average blood pressure. Adjusted for age and linguistic region, each additional kg/m^2 was associated with higher systolic blood pressure in men (beta coefficient±SE: 0.436±0.115 mm Hg/(kg/m^2), p<0.001) and in women (0.361±0.100 mm Hg/(kg/m^2), p<0.001). Adjusted for age and linguistic region, each additional kg/m^2 was associated with higher diastolic blood pressure in men (beta coefficient±SE: 0.662±0.089 mm Hg/(kg/m^2), p<0.001) and in women (0.580±0.067 mm Hg/(kg/m^2), p<0.001).

4.4.5 Association between body mass index and urinary salt excretion

We observed a significant positive association between BMI and urinary salt excretion. Adjusted for age and linguistic region, each additional kg/m^2 was associated with higher urinary salt excretion in men (beta coefficient±SE: 0.371±0.037 g NaCl/(kg/m^2), p<0.001) and in women (0.191±0.025 g NaCl/(kg/m^2), p<0.001).

4.5 Knowledge and behaviors towards salt

4.5.1 Knowledge on salt and salt-related health conditions

Overall 41.9% of the respondents knew that the recommended maximum daily salt intake is around 5 g/day and 30.5% did not know what the recommendation was (Table 17). Older people, especially women, tended to answer correctly to this question more frequently than younger people. Adjusted for age and sex, participants from the French-speaking region were less likely to answer correctly than participants from the German- (p=0.053) and above all from the Italian- (p=0.006) speaking regions. Almost one in three participants reported not to know what the recommended maximum daily salt intake was.

Table 17: Recommended maximum daily salt intake as reported by participants

	Recommended maximum daily salt quantity (in %)					
	Don't know	5g	7.5g	10g	15g	**Total**
Sex						
Men (n=706)	32.4	40.1	19.5	6.9	1.0	100.0
Women (n=742)	28.7	43.7	20.6	6.3	0.7	100.0
Strata						
M15-29 (n=165)	30.3	35.8	23.6	9.7	0.6	100.0
M30-44 (n=149)	36.9	34.2	18.8	10.1	0.0	100.0
M45-59 (n=172)	32.0	45.9	14.0	5.2	2.9	100.0
M$\geq 60 (n = 220)$	31.4	42.7	21.4	4.1	0.5	100.0
W15-29 (n=182)	30.8	29.7	31.3	7.7	0.5	100.0
W30-44 (n=182)	30.8	41.8	17.6	7.7	2.2	100.0
W45-59 (n=179)	31.3	46.9	16.2	5.6	0.0	100.0
W$\geq 60 (n = 199)$	22.6	55.3	17.6	4.5	0.0	100.0
Linguistic region						
French (n=411)	35.8	36.7	22.9	4.4	0.2	100.0
German (n=821)	27.8	43.0	19.7	8.5	1.0	100.0
Italian (n=216)	31.0	47.7	16.2	3.7	1.4	100.0
Total (n=1448)	30.5	41.9	20.1	6.6	0.8	100.0

Source: OFSP

Three quarters of participants considered that salt has a direct impact on health (Table 18); women gave more often the right answer than men (p=0.008), as did participants from the French-speaking region as compared to those from the German- (p<0.001) and Italian- (p=0.002) speaking regions.

Table 18: Salt has an impact on health

	Salt has an impact on health (row %)			
	Don't know	No	Yes	**Total**
Sex				
Men (n=706)	16.0	12.2	71.8	100.0
Women (n=742)	11.5	10.5	78.0	100.0
Strata				
M15-29 (n=165)	12.7	10.9	76.4	100.0
M30-44 (n=149)	12.1	12.1	75.8	100.0
M45-59 (n=172)	16.3	9.9	73.8	100.0
M$\geq 60(n=220)$	20.9	15.0	64.1	100.0
W15-29 (n=182)	11.5	9.9	78.6	100.0
W30-44 (n=182)	11.5	9.3	79.1	100.0
W45-59 (n=179)	11.7	12.8	75.4	100.0
W$\geq 60(n=199)$	11.1	10.1	78.9	100.0
Linguistic region				
French (n=411)	10.2	6.6	83.2	100.0
German (n=821)	13.6	14.9	71.5	100.0
Italian (n=216)	20.4	6.9	72.7	100.0
Total (n=1448)	13.7	11.3	75.0	100.0

Source: OFSP

When different propositions were presented, more than 80% of participants correctly identified hypertension as a disease having a direct link with salt intake (Table 19); women were more aware than men of this link (p<0.001), and participants from the German-speaking region were less aware than participants from other regions (p<0.01). But although hypertension is a major risk factor for cardiovascular disease, a much smaller proportion of participants correctly reported a link between salt intake and heart diseases, myocardial infarction and stroke (41.0%, 21.2% and 21.5% respectively), with no major difference between sex. The great majority of participants correctly classified diabetes, irritable bowel disease and tuberculosis as not directly related to salt consumption.

Participants were asked to report the main source of salt in the diet of a standard person living in Switzerland. Salt in ready-to-eat meals or fast foods was ranked first, salt added to food at the table was ranked second and meat was ranked third by participants (Table 20). Only 6% of the participants selected bread as being the main source of salt and 2.1% selected cheese, which suggests that participants tended to underestimate the contribution of breads and cheeses as important sources of salt in the Swiss diet; by contrast, participants seemed to overestimate the contribution of salt added to food at the table.

Table 19: Diseases reported as having a direct link with salt

	Diseases having a direct link with salt consumption (in %)									
	None	HT	Heart	DM	Colon	Obesity	MI	Stroke	TB	Others
Sex										
Men (n=706)	6.4	77.3	38.2	8.5	6.4	21.0	21.0	21.2	0.8	8.4
Women (n=742)	3.5	84.6	43.5	6.1	6.9	26.8	21.4	21.7	0.3	10.4
Strata										
M15-29 (n=165)	4.2	72.1	47.9	7.9	4.8	20.6	26.7	23.6	1.2	11.5
M30-44 (n=149)	4.7	84.6	43.0	4.7	6.7	24.8	24.8	21.5	0.0	11.4
M45-59 (n=172)	7.6	81.4	39.5	12.2	11.0	25.0	21.5	25.0	1.7	7.0
M≥60 (n=220)	8.2	73.2	26.8	8.6	3.6	15.5	13.6	16.4	0.5	5.0
W15-29 (n=182)	3.8	82.4	45.6	4.9	6.0	23.1	26.4	21.4	0.5	12.6
W30-44 (n=182)	4.4	86.3	44.0	6.0	8.2	26.4	22.5	18.7	0.5	12.1
W45-59 (n=179)	2.2	84.9	46.4	6.1	6.1	26.3	22.9	22.9	0.0	10.6
W≥60 (n=199)	3.5	84.9	38.7	7.0	7.0	31.2	14.6	23.6	0.0	6.5
Linguistic region										
French (n=411)	0.5	84.9	44.3	8.5	4.9	33.3	20.2	21.9	0.5	9.0
German (n=821)	7.9	77.3	36.3	6.8	8.2	17.8	21.1	21.9	0.7	10.2
Italian (n=216)	1.9	88.0	52.3	6.5	4.2	29.6	23.6	19.0	0.0	6.9
Total (n=1448)	4.9	81.1	41.0	7.3	6.6	24.0	21.2	21.5	0.6	9.4

HT, hypertension; Heart, heart disease; DM, diabetes mellitus; Colon, irritable bowel disease; Obesity, overweight and obesity; MI, myocardial infarction; TB, tuberculosis.
Source: OFSP

Table 20: Reported main source of salt in daily diet of a standard person living in Switzerland

	Principal source of salt (in %)								
	Don't know	Soup	Cheese	Meat	Bread	Mineral water	Ready meals	Added to meals	**Total**
Sex									
Men (n=706)	12.3	1.1	2.3	10.9	7.1	0.8	40.5	24.9	100.0
Women (n=742)	11.1	0.3	2.0	8.1	5.0	1.1	48.1	24.4	100.0
Strata									
M15-29 (n=165)	9.7	0.6	1.2	7.3	10.3	1.8	47.3	21.8	100.0
M30-44 (n=149)	6.7	0.7	1.3	13.4	7.4	1.3	41.6	27.5	100.0
M45-59 (n=172)	12.8	1.2	2.3	6.4	7.6	0.6	45.9	23.3	100.0
M≥60 (n=220)	17.7	1.8	3.6	15.5	4.1	0.0	30.5	26.8	100.0
W15-29 (n=182)	8.2	0.5	1.1	4.9	9.3	2.2	47.8	25.8	100.0
W30-44 (n=182)	8.2	0.0	2.7	5.5	3.3	1.6	52.7	25.8	100.0
W45-59 (n=179)	9.5	0.0	0.0	8.9	5.0	0.6	51.4	24.6	100.0
W≥60 (n=199)	17.6	0.5	4.0	12.6	2.5	0.0	41.2	21.6	100.0
Linguistic region									
French (n=411)	15.3	0.5	3.9	5.4	5.1	1.5	44.0	24.3	100.0
German (n=821)	7.4	0.9	1.5	12.3	7.2	0.4	48.4	22.0	100.0
Italian (n=216)	20.8	0.5	1.4	6.5	3.2	2.3	30.1	35.2	100.0
Total (n=1448)	11.7	0.7	2.1	9.5	6.0	1.0	44.4	24.7	100.0

Ready meals, ready-to-eat meals or fast food; Added to meals, salt added to food at the table.
Source: OFSP

4.5.2 Reported behaviors towards salt

Only a minority of respondents reported to usually add salt to food when eating at home (7.4%) or when eating out (4.5%), as shown in Tables 21 and 22.

Table 21: Add salt to food when eating at home

	Add salt on food when eating at home (in %)				
	Never	Occasionally	Usually	Always	**Total**
Sex					
Men (n=705)	50.6	40.6	7.4	1.4	100.0
Women (n=738)	59.6	34.3	4.9	1.2	100.0
Strata					
M15-29 (n=164)	39.6	47.0	12.2	1.2	100.0
M30-44 (n=149)	50.3	38.9	10.1	0.7	100.0
M45-59 (n=172)	54.1	39.0	5.2	1.7	100.0
M$\geq 60 (n = 220)$	56.4	38.2	3.6	1.8	100.0
W15-29 (n=182)	40.7	48.9	8.8	1.6	100.0
W30-44 (n=181)	58.0	32.6	8.3	1.1	100.0
W45-59 (n=177)	66.1	31.6	1.7	0.6	100.0
W$\geq 60 (n = 198)$	72.7	24.7	1.0	1.5	100.0
Linguistic region					
French (n=409)	52.1	39.9	7.1	1.0	100.0
German (n=820)	57.1	36.3	5.9	0.7	100.0
Italian (n=214)	54.2	36.4	5.1	4.2	100.0
Total (n=1443)	55.2	37.4	6.1	1.3	100.0

Source: OFSP

Table 22: Add salt to food when eating out

	Add salt on food when eating out (in %)				
	Never	Occasionally	Usually	Always	**Total**
Sex					
Men (n=704)	53.7	41.5	4.1	0.7	100.0
Women (n=735)	61.9	33.9	3.3	1.0	100.0
Strata					
M15-29 (n=164)	45.7	49.4	4.3	0.6	100.0
M30-44 (n=149)	55.0	37.6	6.7	0.7	100.0
M45-59 (n=172)	54.1	41.3	2.9	1.7	100.0
M$\geq 60 (n = 219)$	58.4	38.4	3.2	0.0	100.0
W15-29 (n=182)	52.7	39.6	7.1	0.5	100.0
W30-44 (n=181)	58.0	35.9	3.9	2.2	100.0
W45-59 (n=176)	63.1	34.1	2.3	0.6	100.0
W$\geq 60 (n = 196)$	73.0	26.5	0.0	0.5	100.0
Linguistic region					
French (n=409)	59.4	36.4	2.7	1.5	100.0
German (n=818)	57.3	38.0	4.3	0.4	100.0
Italian (n=212)	57.1	38.2	3.3	1.4	100.0
Total (n=1439)	57.9	37.6	3.7	0.8	100.0

Source: OFSP

Overall 58.1% of participants responded that they try to limit their dietary salt intake, but there were large differences across age groups (Table 23). Whereas less than 40% of people aged 15-29 years reported to limit their salt intake, more than 70% of people aged 60 years or older did so.

Table 23: Proportion of respondents reporting to try to limit salt quantity in their diet

	Try to limit the salt quantity (in %)										
	Men					Women					
	15-29	30-44	45-59	≥60	**Total Men**	15-29	30-44	45-59	≥60	**Total Women**	**Total**
Linguistic region											
French (n=409)	43.5	46.9	58.7	81.4	**59.0**	44.7	61.1	67.3	78.0	**63.6**	**61.4**
German (n=819)	29.3	39.0	59.0	67.9	**51.3**	28.7	52.0	63.7	82.9	**57.0**	**54.2**
Italian (n=214)	34.6	60.9	60.0	66.7	**55.8**	66.7	76.7	72.0	92.9	**77.3**	**66.8**
Total (n=1442)	34.1	45.0	59.1	71.4	**54.1**	38.5	58.8	65.9	82.8	**61.9**	**58.1**

Source: OFSP

Participants were asked what type(s) of salt they generally use at home (Table 24). Proportion of respondents reporting to use salt without complements, salt with iodine, salt with iodine and fluorine, and spicy salt were 34.2%, 36.3%, 31.4% and 37.3%, respectively. Only 5.4% of participants reported not to know the type of salt they use. Participants from the German-speaking region reported less frequently to use salt without complements (30.6%, $p<0.05$), but more frequently to use salt with iodine (42.4%, $p<0.001$) or spicy salt (46.9%, $p<0.001$) than participants from the other regions.

Table 24: Type of salt used at home

	Type of salt used at home (in %)				
	No complements	With iodine	With iodine and fluorine	Spicy salt	Don't know
Linguistic region					
French (n=411)	38.4	29.0	28.2	26.3	9.0
German (n=821)	30.6	42.4	31.8	46.9	3.7
Italian (n=216)	39.8	27.3	35.6	21.8	5.1
Strata					
M15-29 (n=165)	33.9	39.4	21.2	38.8	8.5
M30-44 (n=149)	40.3	32.2	28.2	36.9	5.4
M45-59 (n=172)	41.3	32.0	28.5	29.1	5.2
M$\geq 60 (n=220)$	28.2	32.3	30.9	26.4	10.0
W15-29 (n=182)	38.5	30.2	24.2	41.8	9.3
W30-44 (n=182)	29.7	44.5	35.2	45.6	2.7
W45-59 (n=179)	33.5	43.0	36.3	44.1	1.1
W$\geq 60 (n=199)$	31.2	37.2	43.7	37.7	0.5
Sex					
Men (n=706)	35.3	33.9	27.5	32.2	7.5
Women (n=742)	33.2	38.7	35.0	42.2	3.4
Total (n=1448)	34.2	36.3	31.4	37.3	5.4

Source: OFSP

4.5.3 Participants' perception of their dietary salt consumption

The majority of respondents classified their own salt consumption as medium, in all groups (Table 25). The proportion of participants classifying their salt consumption as low or very low tended to increase with age, both in men and in women, whereas younger people tended more frequently than older people to classify it as high or very high.

Table 25: Personal estimation of salt consumption (row %)

	Personal estimation of salt consumption (row %)						
	Unknown	Very low	Low	Medium	High	Very high	**Total**
Sex							
Men (n=706)	4.8	5.8	23.4	55.1	10.1	0.8	100.0
Women (n=742)	1.3	7.4	26.7	56.2	7.4	0.9	100.0
Strata							
M15-29 (n=165)	8.5	1.8	13.9	57.0	17.0	1.8	100.0
M30-44 (n=149)	2.7	1.3	18.1	62.4	14.1	1.3	100.0
M45-59 (n=172)	4.1	8.1	23.3	56.4	7.6	0.6	100.0
M$\geq 60 (n = 220)$	4.1	10.0	34.1	47.7	4.1	0.0	100.0
W15-29 (n=182)	1.6	3.8	14.8	62.6	14.3	2.7	100.0
W30-44 (n=182)	2.2	3.3	24.7	59.3	9.3	1.1	100.0
W45-59 (n=179)	1.7	7.3	29.6	55.3	6.1	0.0	100.0
W$\geq 60 (n = 199)$	0.0	14.6	36.7	48.2	0.5	0.0	100.0
Linguistic region							
French (n=411)	4.1	6.1	20.2	61.8	6.8	1.0	100.0
German (n=821)	2.8	6.2	27.3	52.5	10.1	1.1	100.0
Italian (n=216)	1.9	9.3	25.9	56.0	6.9	0.0	100.0
Total (n=1448)	3.0	6.6	25.1	55.7	8.7	0.9	100.0

Source: OFSP

Among the 458 participants who reported their salt consumption as being "low" or "very low", only 19.7% (8.3% of men and 28.9% of women) actually had urinary salt excretion below the international recommendation of 5 g/24h (data not shown).

Figure 2 shows percentiles 25, 50 and 75 of urinary salt excretion corresponding to each of the five self-reported salt consumption categories. Median urinary salt excretion was 6.7, 8.2, 8.7, 9.9 and 9.8 g/24h in people estimating their consumption as "very low", "low", "medium", "high" and "very high", respectively.

Figure 3 shows the proportion of participants who classified their dietary salt intake in the corresponding sex-specific quintiles of 24-hour urinary salt excretion. This figure reflects the adequacy of participants' perception of their own salt intake. Proportions of respondents who estimated their own salt consumption within the corresponding quintile was (red lines): 33.3% (95% CI: 24.0–43.7), 20.9% (16.9–25.5), 20.3% (17.6–23.3), 21.4% (14.6–29.7) and 46.2% (19.2–74.9), respectively in each self-reported salt consumption category. Overall, only about one in five participants appropriately categorized her/his dietary salt intake compared to quintiles of urinary salt excretion in the population. This underlines the misperception people generally have of their salt intake.

Figure 2: Urinary salt excretion in each self-reported salt consumption category

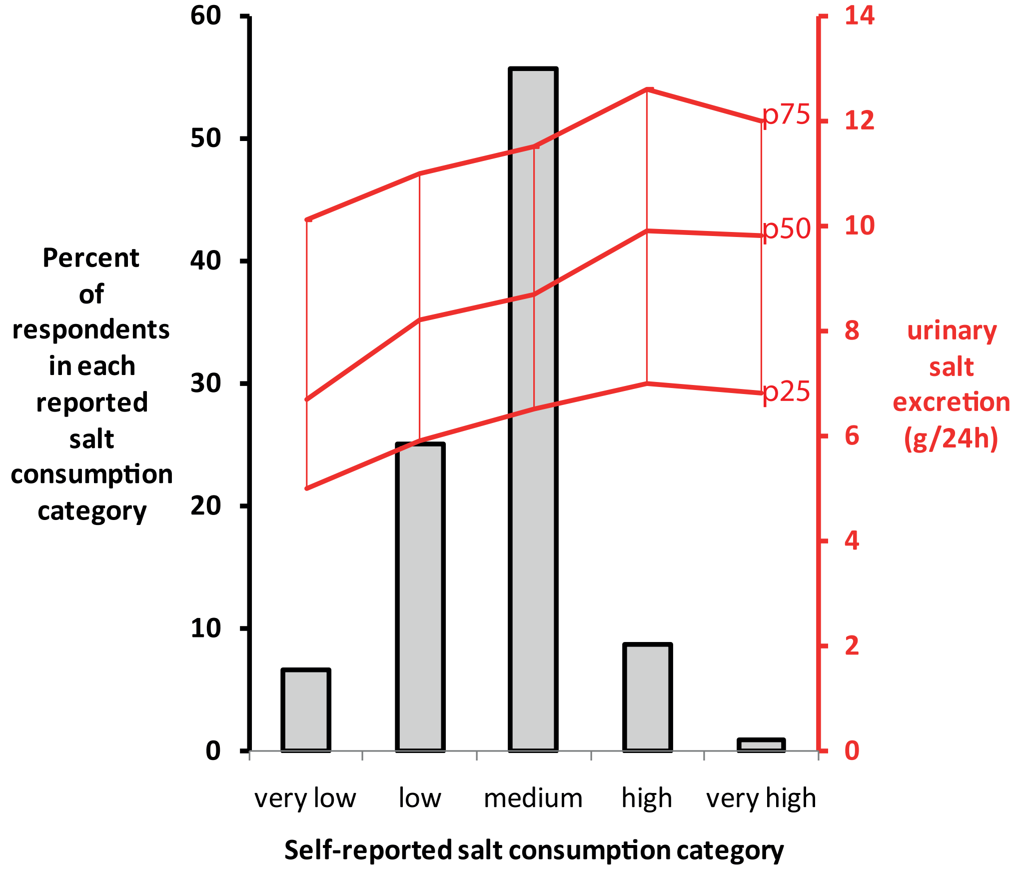
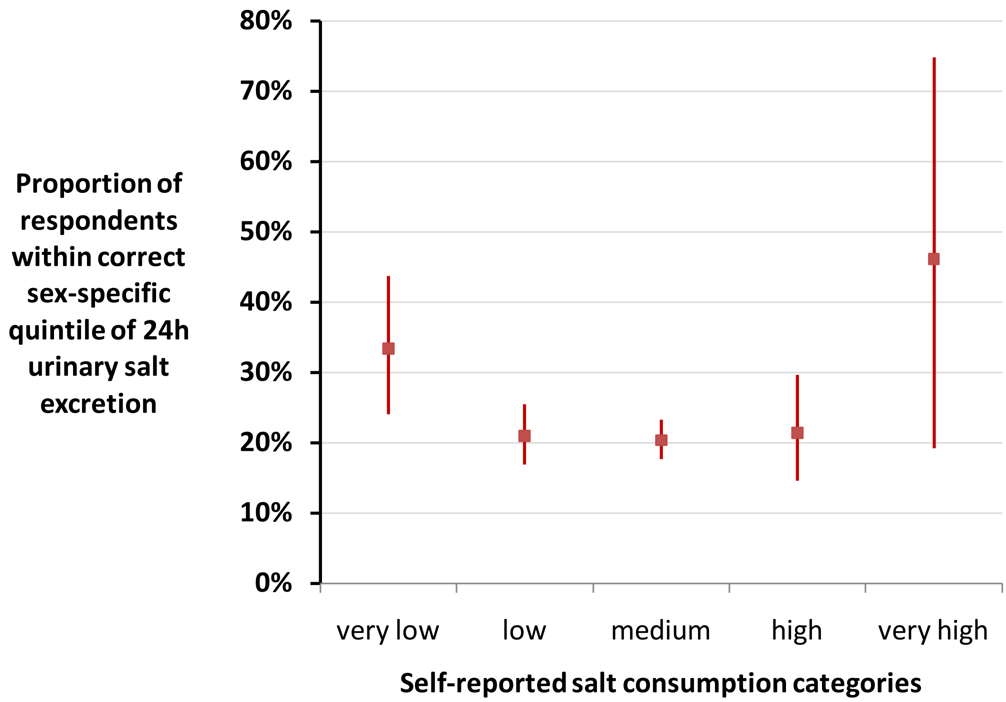


Figure 3: Discrepancy between self-reported assessment of dietary salt intake and urinary salt excretion



5 Discussion

Urinary salt (i.e. sodium chloride) excretion in 24-hour urine was used as a proxy for dietary salt intake. We assessed the quality of urine collections using 24-hour urine volume, duration of the urine collection and urinary creatinine excretion in mmol per kg body weight per 24-hour. Globally, these indicators suggested a good quality of urine collections in this survey. Urinary salt excretion was 7.8 ± 3.3 g/24h in women and 10.6 ± 4.2 g/24h in men (mean $\pm$ standard deviation). The difference between men and women resulted from a shift of the entire distribution towards higher values among men, and not from a few men having very high urinary salt excretion levels. Only 21.6% of women and 6.0% of men had urinary salt excretion below the recommended level of 5 g/24h, with similar percentages across age groups. Hence women were three to four times more likely than men to reach the recommended target. This sex difference mainly reflects the higher energy intake in men compared to women. We observed regional differences with salt excretion being 7.2 ± 3.1, 8.1 ± 3.4 and 7.6 ± 3.2 g/24h in women and 10.3 ± 4.3, 10.7 ± 4.1 and 10.5 ± 4.3 g/24h in men from the French-, German- and Italian-speaking regions, respectively. Such differences might reflect region-related dietary habits.

Overall, dietary salt intake in the Swiss population was clearly above the international recommendation of 5g/day, more markedly in men than in women. This justifies the continuation of a national strategy on salt, aiming at decreasing population salt intake. A first objective could be to reduce mean dietary salt intake by 1g/day on five years. The small regional differences do not justify different strategies to reduce salt intake in the population.

Hypertension prevalence, defined as blood pressure $\geq 140/90$ mm Hg or being on treatment, was 25.6% overall, 19.2% in women and 32.3% in men, similar to figures found in other Swiss studies [15]. The prevalence of hypertension was 3.0% and 2.2% in the 15-29 year-old group and 64.5% and 52.8% in the ≥ 60 year old group, in men and women, respectively. This survey confirmed the positive relationship between urinary salt excretion and blood pressure. These results highlight the potential role of lowering salt intake to reduce the burden of hypertension in the population.

The prevalence of overweight and obesity were 32.0% and 13.4% overall, 39.5% and 15.3% in men, and 25.0% and 11.6% in women, respectively. Higher body mass index was clearly associated with higher urinary salt excretion and higher blood pressure. Thus, a decrease in obesity prevalence (as a result of reduced food intake) will probably be associated with a reduction in average population salt intake and hypertension prevalence. Further, these results support the idea that a population strategy targeting multiple cardiovascular risk factors (e.g., associating reduction of dietary salt with reduction of food intake) is more efficient in reducing cardiovascular morbidity and mortality.

The majority of participants (75%) considered that salt has an impact on health. Most participants (81.1%) correctly identified hypertension as a conditon having a direct link with salt intake, however only 41% mentioned heart disease, 21.2% myocardial infarction and 21.5% stroke in relation to salt intake. Overall 41.9% of the respondents knew that the recommended maximum daily salt intake is around 5 g/day and 30.5% did not know what the recommendation was. Although participants from the French-speaking region associated more frequently salt intake with an impact on health than those from the German- and Italian-speaking regions, these differences are not large enough to justify a different education campaign approach across linguistic regions. These results show that knowledge of the population on salt-related health consequences is already high, and that simply reinforcing health education through campaigns on the role of salt is unlikely to have any substantial impact.

Among the principal sources of salt in diet, salt in ready-to-eat meals or fast foods was ranked first, salt added to food at the table was ranked second and meat was ranked third by participants. The contribution of breads and cheeses, which are the main sources of salt in the Swiss diet, was underestimated by participants. By contrast, participants seemed to overestimate the contribution of salt added on food at the table. Knowledge on the main sources of dietary salt may therefore be substantially improved by public education campaigns. A strategy including food labelling for salt content could be useful in this context.

Only a minority of respondents reported to usually add salt to food when eating at home (7.4%) or when eating out (4.5%). Overall 58.1% of participants responded that they try to limit their dietary salt intake, but there were large differences across age groups. Whereas less than 40% of people aged 15-29 years reported to limit their salt intake, more than 70% of people aged 60 years or older did so. From these results, we can expect a campaign aiming at reducing the habit of adding salt to food to have low impact.

More than one respondent in three (37.3%) reported to use spicy salt at home, especially participants from the German-speaking region (46.9%). This highlights the fact that spicy salt should also be considered in the iodine substitution strategy, which uses cooking-salt as a vector for iodine supplementation in the Swiss population.

Among the 458 participants who reported their salt consumption as being “low” or “very low”, only 19.7% (8.3% of men and 28.9% of women) actually had urinary salt excretion below the international recommendation of 5 g/24h. More generally, only about one in five participants appropriately categorized her/his dietary salt intake compared to quintiles of urinary salt excretion in the population. Participants who had high urinary salt excretion tended to underestimate their intake, whereas those who had low urinary salt excretion tended to overestimate it. This underlines the misperception people have of their salt intake and, consequently, the limited ability of individuals to initiate a change in the diet.

The inability of the majority of participants to estimate their dietary salt intake may explain apparent discrepancies across responses on knowledge on salt observed in various subgroups and measured urinary salt excretion. For instance, participants from the French-speaking region had lower urinary salt excretion than those from the German-speaking region, but knew less well the recommended dietary salt intake of 5g/day. Similary, participants from the French-speaking region better identified salt intake as having an impact on health than those from the German-speaking region, despite worse knowledge on recommended salt intake.

This examination survey provides, for the first time, large scale data on 24-hour urinary salt excretion in three linguistic regions of Switzerland using a population-based sample. To recruit participants, we chose a two-stage sampling strategy similar to the one used in the Swiss Health Surveys. Only 9.7% of contacted households ended up providing a participant in the study, yet a third of the households could not be reached by phone. This limits the external validity of the findings and highlights the difficulty of conducting population-based surveys including 24-hour urine collection. Nevertheless, the hypertension prevalence and blood pressure levels obtained in this survey are in line with previous population-based surveys conducted in Switzerland, taking age structure and region into account. As a proportion of participants seem to have provided incomplete urine collection, we expect dietary salt intake in this study to underestimate the true underlying dietary salt intake of the general population.

These results also suggest that a strategy able to lower dietary salt intake in the Swiss population is likely to have substantial impact on the cardiovascular morbidity and mortality, even when considering the current low absolute risk. Although cardiovascular morbidity and mortality has constantly decreased during the past decades in Switzerland, cardiovascular disease remains the major cause of death in our country, both in men and in women [7]. With the ageing of the Swiss population and the sharp increase in hypertension prevalence with age, the cardiovascular burden is expected to raise in the coming decades.

Most countries that initiated a national strategy to reduce dietary salt intake in the general population adopted a combination of various interventions such as public education campaigns, food labelling regulation and, in collaboration with the food industry, the reduction of the salt content of processed food. Seventy-five to 80% of dietary salt comes from food produced by the industry [16]. It is generally acknowledged that structural modifications (e.g. modified salt content of food) that do not require individual behavioral changes are more efficient to reduce salt intake in the population than measures implying some individual behavioral changes. Although knowledge on salt was not perfect in the Swiss population, the gain that can be expected from public education campaigns alone will be limited compared to the gain that can be expected from modifiying the content of salt in processed food. As urinary salt excretion was uniformly high, with only mild inter-regional differences, this survey provides strong rationale for the food industry to reduce the salt content of food across Switzerland.

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