Hypertension, diabetes and lifestyle in the long-term

- results from a Swiss population-based cohort

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Abbreviations

BMI: body mass index

DEGURBA: European-wide classification of degree of urbanization

DM: diabetes mellitus

HT: hypertension

SAPALDIA: Swiss Cohort Study on Air Pollution and Lung and Heart Disease in Adults

ABSTRACT

Healthy lifestyles are integral in preventing and treating common cardiovascular and metabolic diseases. The aim of this study was to observe smoking habits, alcohol intake, physical activity and body mass index over a 10-year period in a population-based cohort, particularly focusing on participants with hypertension and type 2 diabetes mellitus. Included were 4155 participants from the first (2001-2003) and second (2010-2011) follow-ups of the Swiss Cohort Study on Air Pollution and Lung and Heart Disease in Adults (SAPALDIA). Information was collected via health questionnaire; height and weight were measured. In a healthy lifestyle score one point was attributed per criterion; non-smoking, low risk alcohol consumption, BMI < 25 kg/m², and regular physical activity. Overall in 2010-2011, 16.4% were smokers, 7.7% had at risk alcohol consumption, 25.5% were physically inactive and 57.8% were overweight or obese. Both those with hypertension and diabetes had lower mean healthy lifestyle scores than those without disease. Women with incident hypertension from 2001 to 2011 had lower odds of improving their healthy lifestyle score during this time period compared to those without this disease. In contrast, women with incident diabetes had higher odds of lifestyle score improvement. In men, neither hypertension nor diabetes was associated with change in lifestyle score. Our findings suggest that, irrespective of disease status, preventative attention is needed, particularly in regards to physical activity and bodyweight. These needs could be met by population-based interventions, a necessary and suitable option in both preventing and treating the non-communicable disease epidemic which currently faces countries worldwide.

Key words:

Hypertension, Diabetes, Lifestyle, Prevention, Treatment, Cohort

INTRODUCTION

Hypertension (HT) and type 2 diabetes mellitus (DM) are both chronic diseases which are at least initially largely asymptomatic, require long-term treatment and are components of the metabolic syndrome. Though a panoply of drugs exist to control these pathologies, there is longstanding international consensus regarding the need for lifestyle changes to precede or accompany pharmacological treatment in all individuals with HT or type 2 DM (Inzucchi et al., 2012; Mancina et al., 2013). Indeed, healthy lifestyles are integral not only in preventing, but also in treating these common cardiovascular and metabolic diseases. The blood pressure lowering and the beneficial glycaemic effects of moderation in alcohol intake, physical activity, dietary changes and weight reduction can prevent or delay the onset of HT and DM and reduce the need for pharmacological treatment once these diseases are established (Evert et al., 2013; Inzucchi et al., 2012; Mancina et al., 2013). In addition, smoking cessation is imperative in reducing overall cardiovascular risk in these already at risk groups (Rydén et al., 2013; Mancina et al., 2013). Furthermore, lifestyle interventions are generally cost-effective (Li et al., 2010; Saha et al., 2010), making them a suitable and essential option in mitigating the rising non-communicable disease epidemic. This is particularly relevant for Switzerland, a high income country with universal healthcare coverage, where 80% of direct healthcare costs are brought forth by non-communicable diseases (Wieser et al., 2014).

Though it is clear that lifestyle changes should constitute the forefront of HT and DM treatment, in Switzerland little is known regarding the extent to which individuals with these pathologies adapt their lifestyle in comparison to healthy individuals from the same population. Yet, this type of information would be valuable in guiding preventive efforts. Some regional Swiss data has shown that recommended lifestyle changes are infrequently implemented by individuals with HT or DM (Grange et al., 2015; Nardo et al., 2006). However, to our knowledge no nationwide population-based data has been published to date on the prevalence and longitudinal change of lifestyle factors among individuals with HT or DM. Therefore, the aim of this study was to describe lifestyles (smoking, alcohol intake, physical activity and body mass index (BMI)) and lifestyle change over a 10-year period across Switzerland, in a population-based cohort, with a particular focus on individuals with HT or DM.

METHODS

This analysis was based on the Swiss Cohort Study on Air Pollution and Lung and Heart Disease in Adults (SAPALDIA), a study which included adults randomly selected from eight

areas reflecting the geographic and cultural variety in Switzerland, producing a representative sample of the Swiss adult population at baseline. Baseline assessment was performed in 1991 (SAPALDIA1); first and second follow-ups took place in 2001-2003 (SAPALDIA2) and 2010-2011 (SAPALDIA3) respectively (Ackermann-Lieblich et al., 2005; Martin et al., 1997). Ethical approval was obtained on both national and regional levels. Participants gave written informed consent. Participants were included in this analysis if all questionnaire and clinical data of interest was available (see supplementary Figure 1). This analysis focuses on data from SAPALDIA2 and SAPALDIA3.

Questionnaire and clinical information

Participants provided demographic and health data by answering a standardized questionnaire. Data included age, sex, language (German, French or Italian) and highest education level (primary, secondary including apprenticeships, and tertiary). HT, DM and comorbidities were defined solely on the basis of the following question “Has a doctor ever told you that you have one of the following diseases?” followed by a list including HT, DM, heart failure, angina pectoris, myocardial infarction and stroke. Participants also listed all medications taken. Lifestyle data on smoking (never, former, current), alcohol consumption (number of standard glasses/day) and physical activity (minutes of moderate and vigorous activity per week) was also collected via questionnaire. Height and weight were measured in participants without shoes wearing light clothing. The assessment of HT, DM, medication, alcohol consumption, physical activity and the measuring of weight were introduced in SAPALDIA2. Degree of urbanization (high, medium, low) was attributed on the basis of home address according to the European-wide degree of urbanization (DEGURBA) classification for local administrative units - usually communes. Neighborhood-level socioeconomic index, a 0 to 100 point scale based on rent, crowding, education and occupation of heads of households (Panczak et al., 2012), was allocated on the basis of SAPALDIA2 home addresses.

Lifestyles

Lifestyle recommendations for individuals with HT or DM have remained generally similar over time in regards to smoking cessation, moderation in alcohol consumption, maintenance of physical activity and reduction of excess bodyweight, though these objectives have not always been quantified in the guidelines influencing clinical practice in Switzerland (Rydén et al., 2013; Chalmers, John et al., 1999; Mann et al., 2004; Rydén et al., 2007; Swiss Society of Hypertension, 2015, 2009). For the current study, healthy lifestyles were defined as non-

smoking, low risk alcohol consumption (≤ 1 standard glass/day in women and ≤ 2 glasses/day in men) (Marthaler, Marc, 2013), BMI $< 25 \text{ kg/m}^2$, and regular physical activity (≥ 150 minutes of moderate or ≥ 60 minutes of vigorous physical activity per week or the sum of moderate and vigorous physical activity times two ≥ 150 minutes per week). Unhealthy lifestyles were defined by the non-fulfillment of these criteria. Criteria were considered separately and summarized in a zero to four-point healthy lifestyle score, where one point was attributed for every healthy lifestyle objective successfully met (non-smoking, low risk alcohol consumption, BMI $< 25 \text{ kg/m}^2$ and regular physical activity).

Statistical analysis

Results from descriptive analyses are presented as number and percent or median and interquartile range. In bivariate analysis Chi-squared tests were used. The associations between disease status and healthy lifestyle score and between disease status and increase in healthy lifestyle score were investigated using multivariable linear and logistic regression models respectively. Age, sex, language, highest education level, degree of urbanization and neighborhood-level socioeconomic status were included as covariates using the backwards stepwise method. In order to correct for potential heteroscedasticity, we used robust standard errors in the linear regression model. Participants fulfilling all four healthy lifestyle recommendations at both time points (SAPALDIA2 and SAPALDIA3) were excluded from the logistic regression model, lifestyle improvement being the outcome. Interactions between HT and DM status and between disease status and sex were tested. Stratified results are presented where appropriate. In separate sensitivity analyses, participants taking insulin and participants with concomitant cardiovascular disease (heart failure, angina pectoris, previous myocardial infarction or stroke) at SAPALDIA3 were excluded to determine if association patterns were driven by severity of disease, as the presence of symptoms may have modified lifestyle or lifestyle change. In addition, inverse probability weighting was performed to explore potential selection bias; probability of inclusion in the analytical sample was derived using SAPALDIA1 data (age, sex, language, education level, study center, smoking status and BMI). P-values < 0.05 were considered statistically significant. Statistical analysis was performed using STATA 13 (StataCorp. 2013. Stata: Release 13. Statistical Software. College Station, TX: StataCorp LP.)

RESULTS

The analytical sample consisted of 4155 participants, 50.2% of which were women. At SAPALDIA3, ages ranged from 37 to 81 with a median at 60.3 years. Among participants 30.3% had HT, 7.0% had DM and 4.5% had both. About half of those with HT and a third of those with DM already had the disease at SAPALDIA2 (Table 1).

Table 1. Participant characteristics (SAPALDIA3^a)

	N or median	% or p25, p75
Participation	4155	
Women	2084	50.2
Age	60.3	50.8, 67.9
Language		
German	2266	54.5
French	1331	32.0
Italian	558	13.4
Education		
Primary	184	4.4
Secondary	2674	64.4
Tertiary	1297	31.2
Degree urbanization		
High	1175	28.3
Medium	2398	57.7
Low	582	14.0
Hypertension		
At SAPALDIA2	579	13.9
At SAPALDIA3	1261	30.3
Diabetes		
At SAPALDIA2	90	2.2
At SAPALDIA3	292	7.0
Hypertension & Diabetes		
At SAPALDIA2	45	1.1
At SAPALDIA3	188	4.5

^a Unless noted otherwise

SAPALDIA2 (2001-2003), SAPALDIA3 (2010-2011):

Swiss Cohort Study on Air Pollution and Lung and
Heart Disease in Adults.

Unhealthy lifestyle prevalences

The prevalences at SAPALDIA2 and SAPALDIA3 were respectively; for smoking 22.2% and 16.4%, for BMI ≥ 25 kg/m² 51.0% and 57.8%, for at risk alcohol intake stable at about 8% and for physical inactivity stable at about 26% (Table 2). Of the 83.6% of SAPALDIA3 non-smokers, 46.2% were former smokers. At SAPALDIA3 the prevalences of unhealthy lifestyles were statistically significantly higher in participants with HT compared to those without HT, except for non-smoking where the opposite was true. At SAPALDIA3 smoking and at risk alcohol consumption was equally prevalent in those with and without DM. However, those with DM were statistically significantly more likely to be sedentary and overweight than those without the disease. In both follow-ups, about 80% of participants with disease (be it HT or DM) were overweight or obese compared to about 50% in those without disease (Table 2).

Table 2. Prevalence of unhealthy lifestyles overall and by diagnosis at SAPALDIA2 & SAPALDIA3

	Overall	No Hypertension		Hypertension		No Diabetes		Diabetes	
Smoking									
SAPALDIA2	22.2	23.0	(21.6, 24.4)	17.1	(14.0, 20.2)	22.3	(21.0, 23.5)	17.8	(9.7, 25.8)
SAPALDIA3	16.4	18.2	(16.8, 19.6)	12.2	(10.4, 14.0)	16.5	(15.4, 17.7)	14.0	(10.0, 18.0)
At risk alcohol intake									
SAPALDIA2	8.8	7.9	(7.0, 8.7)	14.3	(11.5, 17.2)	8.7	(7.9, 9.6)	10.0	(3.7, 16.3)
SAPALDIA3	7.7	6.0	(5.1, 6.9)	11.4	(9.7, 13.2)	7.7	(6.8, 8.5)	7.5	(4.5, 10.6)
Physical inactivity									
SAPALDIA2	26.4	25.6	(24.2, 27.0)	31.4	(27.6, 35.2)	26.3	(24.9, 27.7)	32.2	(22.4, 42.1)
SAPALDIA3	25.5	23.5	(22.0, 25.0)	30.1	(27.5, 32.6)	24.9	(23.6, 26.3)	32.9	(27.5, 38.3)
BMI ≥ 25kg/m ²									
SAPALDIA2	51	46.8	(45.1, 48.4)	77.0	(73.6, 80.5)	50.4	(48.8, 51.9)	78.9	(70.3, 87.5)
SAPALDIA3	57.8	49.1	(47.3, 51.0)	77.6	(75.3, 79.9)	55.9	(54.3, 57.5)	82.5	(78.2, 86.9)

Prevalences of unhealthy lifestyles at SAPALDIA2 and SAPALDIA3 in those with or without disease at SAPALDIA2 and SAPALDIA3 are presented as percent (95% confidence interval).

BMI: body mass index; DM: diabetes mellitus; HT: hypertension; SAPALDIA2 (2001-2003), SAPALDIA3 (2010-2011); Swiss Cohort Study on Air Pollution and Lung and Heart Disease in Adults.

Predictors of healthy lifestyle score

In multivariable linear regression, healthy lifestyle scores (one point attributed per healthy lifestyle criterion achieved) at SAPALDIA3 were positively associated with female sex, younger age, German language, higher education, higher neighborhood level socio-economic index and lower urbanization level (Model 1, Table 3). Controlling for these factors, participants with HT alone, DM alone, and both HT and DM at SAPALDIA3 had lower mean healthy lifestyle scores than those not having these diseases (Model 2, Table 3). In this analysis, subjects with both HT and DM did not have a larger decrease in healthy lifestyle score than subjects with only HT or DM; reflected in a statistically significant interaction between HT- and DM-status (coef. interaction term: 0.27, 95% CI 0.07 to 0.47). Two sensitivity analyses, excluding participants taking insulin and participants with concomitant cardiovascular disease (heart failure, angina pectoris or previous myocardial infarction or stroke) at SAPALDIA3, produced similar association patterns. In addition, inverse probability weighing to account for potential selection bias produced very similar results (supplementary Table 1).

Table 3: Independent predictors of healthy lifestyle score at SAPALDIA3

	Model 1 adjusted^a		Model 2 adjusted^a	
	coef. (95% CI)		coef. (95% CI)	
No HT & no DM			Ref.	
HT alone			-0.30	(-0.36, -0.24)
DM alone			-0.30	(-0.46, -0.14)
HT and DM			-0.33	(-0.45, -0.21)
Female sex	0.32	(0.27, 0.37)	0.29	(0.24, 0.34)
Age (per 10 years)	-0.04	(-0.07, -0.02)	0.00	(-0.02, 0.02)
Language				
German	Ref.		Ref.	
French	-0.07	(-0.13, 0.00)	-0.06	(-0.12, 0.00)
Italian	-0.25	(-0.34, -0.17)	-0.25	(-0.34, -0.17)
Education				
Primary	Ref.		Ref.	
Secondary	0.33	(0.21, 0.45)	0.32	(0.20, 0.44)
Tertiary	0.48	(0.35, 0.61)	0.45	(0.32, 0.58)
Degree urbanization				
High	Ref.		Ref.	
Medium	0.08	(0.01, 0.14)	0.07	(0.01, 0.13)
Low	0.1	(0.01, 0.19)	0.09	(0.01, 0.18)
Neighborhood level socioeconomic index (per 10 pts.)	0.07	(0.04, 0.10)	0.07	(0.04, 0.10)

^a Estimates are adjusted for the effects of all other factors for which coefficients are shown. CI: confidence interval; DM: diabetes mellitus; HT: hypertension; SAPALDIA3 (2010-2011): Swiss Cohort Study on Air Pollution and Lung and Heart Disease in Adults.

Changes in healthy lifestyle score from SAPALDIA2 to SAPALDIA3

Excluding participants fulfilling all four healthy lifestyle recommendations at both time-points (n=731) and adjusting for age, language, education, degree of urbanization and neighborhood level socioeconomic status; no association between healthy lifestyle improvement and disease status was found in men. In women, participants with new onset DM from SAPALDIA2 to SAPALDIA3 had higher odds of healthy lifestyle score improvement compared to those without DM. Conversely, women with new onset HT had lower odds of healthy lifestyle score improvement than those without HT. Disease at SAPALDIA2 was not associated with lifestyle score improvement (Table 4). The same association patterns were also observed in sensitivity analyses excluding participants taking insulin and participants with concomitant cardiovascular disease (heart failure, angina pectoris or previous myocardial infarction or stroke) at SAPALDIA3. In addition, inverse probability weighing to account for potential selection bias produced very similar results (supplementary Table 2).

Table 4: Independent predictors of increase in healthy lifestyle score from SAPALDIA2 to SAPALDIA3 stratified by sex

	Women (n=1608)		Men (n=1816)	
	OR^a	(95% CI)	OR^a	(95% CI)
No HT	Ref.		Ref.	
HT at SAPALDIA2	0.88	(0.62, 1.23)	1.07	(0.79, 1.43)
New onset ^b HT	0.57	(0.41, 0.80)	0.97	(0.73, 1.27)
No DM	Ref.		Ref.	
DM at SAPALDIA2	1.57	(0.64, 3.87)	0.61	(0.32, 1.15)
New onset ^b DM	1.78	(1.09, 2.89)	1.18	(0.78, 1.77)

^a adjusted for age, language, education, degree of urbanization and neighborhood level socioeconomic status.

^b diagnosis during the 10-year period between SAPALDIA2 and SAPALDIA3

CI: confidence interval; DM: diabetes mellitus; HT: hypertension; OR: odds ratio; SAPALDIA2 (2001-2003), SAPALDIA3 (2010-2011); Swiss Cohort Study on Air Pollution and Lung and Heart Disease in Adults.

Lifestyle change

For each lifestyle under consideration (smoking, alcohol, physical activity and BMI), using the cut-offs described in the methods, Figure 1 illustrates longitudinal course of lifestyle across both time-points (consistently healthy, changing from unhealthy to healthy, changing from healthy to unhealthy, and consistently unhealthy). In comparison to participants without DM, those with a new diagnosis of DM within the 10-year follow-up period had higher prevalence of change from unhealthy at SAPALDIA2 to healthy at SAPALDIA3 in regards to smoking, alcohol consumption, physical activity and BMI. Irrespective of disease status, the lifestyle where by far the greatest change was observed from healthy to unhealthy and vice versa was regular physical activity. BMI was the lifestyle indicator where the least change from unhealthy to healthy was observed; in addition, BMI < 25 m/kg² remained the criterion the least achieved, particularly in those with disease.

Figure 1 legend: longitudinal course of lifestyle from SAPALDIA2 to SAPALDIA3 (2001-2011; consistently healthy, changing from unhealthy to healthy, changing from healthy to unhealthy, and consistently unhealthy), for smoking, alcohol, physical activity and BMI in percent. No HT and no DM refer to SAPALDIA3. New HT or new DM indicates a new diagnosis within the SAPALDIA2 - SAPALDIA3 interval. Those with HT or DM already at SAPALDIA2 are not represented. BMI: body mass index; DM: diabetes mellitus; HT: hypertension; SAPALDIA: Swiss Cohort Study on Air Pollution and Lung and Heart Disease in Adults.

DISCUSSION

Overall lifestyle prevalences and trends

This analysis from the population-based SAPALDIA cohort highlights the prevalence of unhealthy lifestyles overall and in participants with HT and DM in particular. As a whole, there remains room for improvement in the 16% still smoking, the 8% with at risk alcohol consumption, the 26% physically inactive and particularly in the 58% with BMI ≥ 25 kg/m² in 2010-2011. The prevalence of unhealthy lifestyles in the SAPALDIA cohort, were similar to those from the Swiss Health Survey from the same time periods (see supplementary Table 3), with the exception of BMI. This may be due to methodological differences, since weight and height were measured in our study and asked via questionnaire in the Swiss Health Survey, and individuals tend to overestimate their height and underestimate their weight (Engstrom et al., 2003). In addition, the prevalence of HT and DM in our study was similar to that from the Swiss Health Survey which itself was consistent with prevalence data from a Swiss primary care electronic record database and hospital discharge statistics (Zellweger et al., 2014).

From 2001 to 2011, in the study sample as a whole, a decrease in smoking and an increase in overweight/obesity were observed while prevalence of physical inactivity and at risk alcohol consumption remained stable. In all four lifestyle categories and irrespective of health status, the percentage of people improving lifestyles was below 20%, indicating the difficulty of a change in habits. Decreased smoking prevalence may reflect recent anti-smoking policy or the aging nature of this cohort as smoking prevalence decreased with age in our (results not

shown) and other Swiss data (Storni, Marco et al., 2013). Indeed 46% of the non-smokers in 2010-2011 had previously been smokers at some point in time. BMI < 25 kg/m², an indicator of both physical activity and dietary habits, was the criterion least achieved in 2001 and even less so ten years later. This observation is not surprising; an obesogenic environment, characterized by easy access to highly marketed calorie dense foods which do not lead to satiety (Masciangelo and Golay, 2006) coupled with a sedentary lifestyle as found in about a quarter of Swiss adults, will lead to an increase of BMI over time. Population aging also plays a role in the prevalence of overweight and obesity as BMI tends to increase with age (due to changing body height, weight and composition), peaking at about 60 years and decreasing with older age. However, in adults recommended BMI does not differ with age. Indeed, the manifold negative health consequences of overweight and obesity place a particular burden on the elderly (Han et al., 2011). The high prevalence of overweight and obesity serves as a signpost indicating where added attention is needed.

Determinant of healthy lifestyles

Healthier lifestyles were associated with female sex, younger age, German language group, higher education, higher neighborhood level socio-economic status and lower degree of urbanization, with similar results found in the literature (Adams et al., 2015; Fransen et al., 2014). This highlights the influence of social determinants on health and the need for policies and programs to positively impact “the circumstances in which people are born, grow, work, live and age” (O Solar and A Irwin, 2010), rather than exclusively focusing on individual change. Indeed, as shown in our and other studies, the individual approach which has largely dominated preventive efforts in the West has failed to bring about a reduction in modifiable lifestyle risk factors in at risk populations (Kotseva et al., 2016). On the other hand, the literature supplies ample incentive for creating environments which facilitate healthy lifestyles. Lifestyle interventions are cost-effective (Li et al., 2010; Saha et al., 2010) of which population-based interventions are often the most cost-effective and sustainable in comparison to those targeting individuals or high risk groups alone (Korczak et al., 2011). These population-based interventions include policies, laws, regulations, taxes, subsidies, and structural changings which facilitate healthy behaviors, along with population-wide knowledge and awareness raising campaigns which encourage behavior change. The preventive potential of healthy lifestyles at the population level was recently shown in a meta-analysis reporting a 66% reduction in all-cause mortality resulting from the combination of at least four healthy lifestyles compared to at most one healthy lifestyle over a mean follow up

of 13 years (Loef and Walach, 2012). This is particularly relevant to high income countries like Switzerland where 80% of direct healthcare costs are due to non-communicable diseases, of which cardiovascular diseases carry the greatest financial burden, that is 9.5 billion euros per year (Wieser et al., 2014).

Lifestyle in those with disease

There is international consensus regarding the need for lifestyle changes to precede or accompany pharmacological treatment in all those with HT or DM (Inzucchi et al., 2012; Mancia et al., 2013). However, not surprisingly, unhealthy lifestyles were more often observed in those with disease, as their presence increases the risk of developing HT and DM (Rosenzweig et al., 2008). Furthermore, participants with HT already at SAPALDIA2 and those with a new diagnosis of HT during the 10-year interval to SAPALDIA3 had similar or lower odds of lifestyle improvement over this time period than participants who never had HT, suggesting that diagnosis did not precipitate positive lifestyle change. Concerning the presence of DM (DM since SAPALDIA2 or new onset DM) in comparison to those not having DM, only women with the new onset of DM within the 10-year interval had higher odds of lifestyle improvement; sex differences aside, this may illustrate the difficulty of continuing or maintaining healthy lifestyles in the long-term. This notable difference in lifestyle improvement between women with incident HT and women with incident DM may have been due to perceived gravity of disease, increased gravity of disease or symptoms potentially motivating positive lifestyle change. However, association patterns remained unchanged when excluding those with more severe DM (those taking insulin) and also when excluding those with concomitant cardiovascular disease (heart failure, angina pectoris, myocardial infarction or stroke). Alternatively, differences in lifestyle improvement between women with new HT and women with new DM may have been due to the perceived impact of healthy lifestyles on the respective pathologies or differences in quality of care. Indeed, a retrospective review of Swiss primary care medical charts indicated that 93.3% of newly diagnosed diabetics, compared to 64.4% of hypertensives, received lifestyle advice (Collet et al., 2011). In any case, there is a need for making and sustaining positive lifestyle changes when managing both HT and DM. However, individual change remains challenging (Grange et al., 2015; Nardo et al., 2006) and disease specific interventions impact only a certain target group. On the other hand, population-level interventions have the potential to positively impact all. Since it is the same unhealthy lifestyles which lead to a panoply of cardiovascular and metabolic diseases, targeting structural causes of unhealthy lifestyles in the population

can have far reaching benefits for both primary and secondary prevention. Our data suggests that in the population as a whole as well as in those with DM and HT, overweight and obesity require the most urgent attention for preventive action.

Strengths and limitations

The nature of the population-based SAPALDIA cohort allowed us to control for a wide variety of factors over a long period of time while presenting data which reflects the geographic and cultural diversity within Switzerland. Twenty years after its initiation, individuals still participating in this study may be healthier than the general Swiss population of the same age. However, results after inverse probability weighting suggested that selection bias was non-substantial. Undesirable behaviors, such as smoking, alcohol consumption and physical inactivity may have been under-reported. However, the degree of underestimation in the questionnaire data is likely to be similar in SAPALDIA2 and SAPALDIA3, and thus should not introduce bias in the longitudinal analyses. As the cohort was not specifically designed for this analysis, we lack exact information on date of diagnosis and lifestyle change. Also, we were unable to distinguish between type 1 and type 2 DM, this however is only a minor issue due to the low prevalence of type 1 in comparison to type 2 DM in an aging population (David Cavan et al., 2015). Using a healthy lifestyle score (one point attributed per healthy lifestyle criterion achieved) provided a simple metric for overall lifestyle; however, the scale gives equal weight to each lifestyle (non-smoking, low risk alcohol consumption, BMI<25 kg/m², and regular physical activity), this may not be an accurate reflection of the clinical importance of each criterion. Therefore, individual components of the score were also analyzed separately.

Conclusion

In conclusion, this analysis of a population-based cohort shows room for improvement in the adoption of healthy lifestyles by the general Swiss population. Our results suggest that preventive attention is particularly needed regarding physical activity and bodyweight, as 26% of the study population was physically inactive, and 58% was overweight or obese. Moreover, despite the fact that lifestyle improvements should constitute the cornerstone of treatment for HT and DM, individuals with these diseases generally led less healthy lives than those without disease. Of note, there was little evidence of lifestyle improvements following the diagnosis of HT or DM, except for in women with incident DM during the 10-year follow-up period. Our findings underline the importance of population-based studies in guiding

preventive efforts at the national level. In this respect, our observations emphasize the need for innovative population-based interventions which target diet and physical activity as a necessary and attractive option in both preventing and treating the non-communicable disease epidemic which currently faces countries worldwide.

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