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Who is at low risk for cardiovascular disease? An assessment of different definitions

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ABSTRACT

Background: There is little information regarding the determinants and trends of the prevalence of low cardiovascular risk factor (RF) profile in the general population. The aim of this study was to assess the prevalence and trends of low RF profile in the Swiss population according to different definitions.

Methods: Population-based cross-sectional studies conducted in 1984-6 (N=3300), 1988-9 (N=3331), 1992-3 (N=3133) and 2003-6 (N=6170) and restricted to age group 35-75 years. Seven different definitions of low RF profile were used to assess determinants, while two definitions were used to assess trends.

Results: Prevalence of low RF profile varied between 6.5% (95% confidence interval: 5.9-7.1) and 9.7% (9.0-10.5) depending on the definition used. This prevalence was higher than in other countries. Irrespective of the definition used, the prevalence of low RF profile was higher in women and in physically active participants, and decreased with increasing age or in the presence of a family history of cardiovascular disease. Using one definition, the prevalence of low RF profile increased from 3.8% (3.1-4.5) in 1984-6 to 6.7% (6.1-7.3) in 2003-6; using another definition, the results were 5.9% (5.1-6.8) and 9.7% (9.0-10.5), respectively.

Conclusion: Switzerland is characterized by a high and increasing prevalence of low RF profile within the age group 35 to 75, irrespective of the criteria used. This high prevalence might partly explain the low and decreasing trend in cardiovascular mortality rates.

Keywords: epidemiology; cardiovascular risk factors; low risk; Switzerland; population sample.

INTRODUCTION

Cardiovascular Diseases (CVD) are one of the most important causes of death worldwide, with considerable human and financial consequences. While most epidemiological research has focused on high-risk subjects, some authors focused on the other side of the CVD risk spectrum, i.e. on subjects with a low RF profile, characterized by the absence of CVD risk factors, or even presence of favorable CVD “benefic” factors such as a healthy diet or regular physical activity [1-3]. These low RF subjects present with a very low risk of developing CVD [2, 4-6], but comparisons between studies are difficult as several definitions of the low RF profile exist [1-11], which might lead to differing, non-comparable prevalences. Finally, little if no information exists regarding the trends in the prevalence of low RF profile in the general population.

Hence, we used the data from a large, population-based cohort of subjects aged 35 to 75 years to assess 1) the prevalence of low RF subjects according to different definitions and 2) the 20-year trends in the prevalence of selected definitions of low RF subjects by comparing our results with those obtained from the MONICA population surveys conducted between 1984 and 1993, again limited to the age group 35-75.

METHODS

The CoLaus study

The sampling procedure of the Cohorte Lausannoise (CoLaus) study has been described previously [12]. Briefly, the complete list of the Lausanne inhabitants aged 35–75 years (n=56 694) was provided by the population registry of the city and a simple, nonstratified random sample of 35% was drawn. An invitation letter with a quick

description of the study was sent to all randomized participants. Individuals interested were contacted telephonically within 14 days by one of the staff members who provided more information about the study and arranged for an appointment. As the CoLaus study aimed at including only Caucasians to avoid population stratification and to increase genetic homogeneity for association studies, the following inclusion criteria were applied: (i) written informed consent; (ii) age 35–75 years; (iii) willingness to take part in the examination and to have a blood sample drawn and (iv) Caucasian origin, defined as having both parents and grandparents of Caucasian origin. Recruitment began in June 2003 and ended in May 2006. Participation rate was 41% and 6,188 Caucasian participants (3,251 women and 2,937 men) took part in the study.

Risk factor assessment, CoLaus

All participants attended the outpatient clinic of the University Hospital of Lausanne in the morning after an overnight fast (minimum fasting time 8 hours). Data were collected by trained field interviewers in a single visit lasting about 60 min.

Participants received a questionnaire to record information about their lifestyle factors. According to their smoking histories, participants were classified as never, current or former smokers. During a face-to-face meeting, the participants were asked if they or their parents had presented CVD. Personal history of and current treatment for hypertension, hypercholesterolemia or diabetes were also asked. Information on the use of prescription and over the counter drugs, vitamin and mineral supplements, homeopathy or natural remedies was collected, together with their main indications. Collection was done by asking the participant to bring the drugs to the visit. Physical activity was defined as the practice of leisure time physical activity at least twice per week.

Body weight and height were measured in light indoor clothes with shoes off. Body weight was measured in kilograms to the nearest 100g using a Seca® scale, which was calibrated regularly. Height was measured to the nearest 5 mm using a Seca® height gauge. Body Mass Index (BMI) was calculated as weight (kg) divided by the square of the height (m). Overweight was defined as $BMI \geq 25 \text{ kg/m}^2$ and $< 30 \text{ kg/m}^2$, and obesity by a $BMI \geq 30 \text{ kg/m}^2$.

Blood pressure was measured on the left arm, with an appropriately sized cuff, after at least 10 minute rest in the seated position using an Omron® HEM-907 automated oscillometric sphygmomanometer. Three readings were taken and the average of the last two was used to compute systolic (SBP) and diastolic (DBP) blood pressure.

Fasting plasma glucose and total cholesterol levels were measured by the CHUV Clinical Laboratory on fresh blood samples within 2 hours of blood collection. All measurements were conducted in a Modular P apparatus (Roche Diagnostics, Switzerland). The following analytical procedures (with maximum inter and intra-batch CVs) were used: glucose by glucose dehydrogenase (2.1% – 1.0%) and total cholesterol by CHOD-PAP (1.6% – 1.7%).

MONICA population surveys

The MONICA Project (Multinational MONItoring of trends and determinants in Cardiovascular disease)[13, 14] was created in the early 1980s in different centers around the world to monitor over a ten year period trends in cardiovascular disease mortality and incidence. Thirty-one collaborating centers (25 from Europe, one from Canada, one from the US, two from Australia, one from New Zealand and one from China) took part in the

project. In each population, investigators had to satisfy the local requirements for ethical research [14].

In this study, we used the data from the three Swiss MONICA population surveys conducted in the Vaud and Fribourg cantons for the periods 1984-6, 1988-9 and 1992-3. Their main characteristics have been published previously [15]. The initial samples included participants aged between 25 and 75, but in order to be comparable with the CoLaus study we restricted the analysis to participants aged between 35 and 75 years.

Risk factor assessment, MONICA

Body weight and height were measured with participants standing without shoes and heavy outer garments and with empty pockets. Blood samples from non-fasting subjects were used to measure the total cholesterol (TC). Smoking status was initially divided in 4 categories, daily cigarette smokers, non smokers, ex-smokers and “different types” of smokers (occasional, pipe, cigars). For the current analysis, daily and “different types” of smokers were grouped.

The authors of this manuscript have certified that they comply with the Principles of Ethical Publishing in the International Journal of Cardiology [16].

Low risk factor profile

A literature search on Pubmed using the terms “low cardiovascular risk”, “low risk factor”, “favorable risk factor” in association or not with the words “prevalence” and “epidemiology” revealed eleven different definitions for low RF profile [1-11]. Their criteria are summarized in supplementary table 1. Three major CVD risk factors were common to

all definitions: blood pressure (SBP <120 and DBP <80 mm Hg); smoking (absence) and total cholesterol (<200 mg/dL (<5.2 mmol/L)); for total cholesterol, only Yamamoto used a different threshold: 160-240 mg/dL (4.14-6.22 mmol/L). Additional criteria differed according to each author. Most authors also included antihypertensive medication (absence), personal history of diabetes (absence) and BMI (<25 kg/m²) in their criteria. Three studies included electrocardiographic findings, two cholesterol lowering drug treatment and one included personal history of myocardial infarction. Fasting plasma glucose level was a criterion in one study and lifestyle (physical activity and diet) in another. Overall, the number of criteria used to define low RF profile varied between 4 and 11. Noteworthy, a single author (Daviglus) used slightly different sets of criteria to define low RF profile [1, 4, 7, 8] (**table 1**). The prevalence of low RF profile in the CoLaus cohort was computed using the following sets of criteria: Daviglus 2 [7] and 3 [4], Hozawa [5], Yamamoto [3], Giampaoli [2], Stamler [6] and Lowe [9] as they included data available in the CoLaus study. The sets of criteria Daviglus 1 [1] and Daviglus 4 [8] were not retained due to the lack of ECG data and the sets of criteria of Folsom [10] and Mozaffarian [11] were not retained due to the lack of physical activity and dietary data. Similarly, due to limitation in variables from the MONICA surveys, only two sets of criteria were used to assess trends in the prevalence of low RF profile: Lowe (SBP <120 mmHg, DBP <80 mmHg, total cholesterol <200 mg/dl, no smoking) [9] and Daviglus 2 (SBP <120 mmHg, DBP <80 mmHg, total cholesterol <200 mg/dl, no smoking, no use of antihypertensive medication, BMI <25 kg/m²) [7].

Statistical analysis

Statistical analyses were made using Stata v.11.1 (Stata Corp, College Station, TX, USA). The prevalence of participants with low RF profile was determined for each set of criteria and expressed in percentage and (95% confidence interval). Between-group comparisons were performed using Chi-square for qualitative variables or Student's t-test for quantitative variables. Multivariate analysis modeling the likelihood of presenting with low RF profile was conducted using logistic regression adjusting for gender, age and physical activity and the results were expressed as odds ratio (OR) and (95% confidence interval). Standardized estimates of the prevalence of low risk profile were obtained by direct standardization using the Standard European Population as defined by [17]. Statistical significance was considered for $p < 0.05$.

RESULTS

Characteristics of the subjects

Of the initial 6188 participants, 6170 (99.7%, 3241 women and 2929 men) had data for all variables and were included in the analysis. **Table 1** summarizes their clinical characteristics according to gender. Overall, women had a lower BMI, blood pressure and fasting plasma glucose than men, women also smoked less, practiced more physical activity and had less history of MI and CVD than men. Finally, women had higher total and HDL cholesterol levels than men (**table 1**).

Prevalence and trends of low risk factor profile

The prevalence of low RF profile overall and according to different characteristics is summarized in **table 2**. Women had a higher prevalence of a low risk profile; physical

activity was positively associated with low risk, while increasing age, family history of CVD, stroke or MI were associated with a lower prevalence of low RF profile. These findings were further confirmed by multivariate logistic regression adjusting for gender, age and leisure-time physical activity, where subjects with a family history of CVD (coronary heart disease or stroke) had a lower likelihood of presenting with low RF profile: odds-ratios (95% confidence interval) ranging from 0.76 (0.60-0.96) to 0.81 (0.62-1.04). The results were comparable (odds-ratio below 1) for coronary heart disease and stroke taken individually, but did not reach statistical significance (**table 3**).

The trends in the prevalence of low RF profile for period 1984-2006 are summarized in **table 4**. The prevalence of low RF profile remained rather stable between 1984 and 1993 and increased afterwards. Interestingly, the prevalence of low RF profile in the MONICA studies showed the same pattern of associations (higher in women and lower among older participants).

In the CoLaus study, the prevalence of low RF in men and women was higher than in the other studies (**table 5**).

DISCUSSION

To our knowledge, this is the first ever study to compare the results of different definitions of low RF profile in the same population. Our results suggest that the prevalence of low RF profile is rather low and depends on the number of criteria used, as the two studies using the fewest criteria (Lowe and Hozawa) led to the highest prevalence. This is understandable, as the probability of fulfilling all criteria decreases with the number of criteria used. Still, and even more important than the number of criteria used, the age of the participant was the main factor to influence the prevalence of low RF profile. This finding is

in agreement with the literature [18], as it has been shown that CVD risk increases with age, in association with a decrease in the number of normal or optimal level RFs. Overall, our results indicate that the more criteria to define low RF profile or the higher the age of the participants, the lower the prevalence of low RF profile.

The prevalence of low RF profile was higher in CoLaus than in the other studies. Only the studies by Daviglus (set 3) [4] and Yamamoto [3] had a higher prevalence of low RF profile among women. This finding can be explained by the younger age of the participants in both surveys: in the American study, mean (\pm SD) age was 31.0 ± 1.3 years, vs. 53.5 ± 10.7 years in the CoLaus study; in the Japanese study, the age range was 30-69 years, vs. 35-75 years in the CoLaus study. Interestingly, restricting the analysis in the CoLaus study to the 30-69 years age group led to a higher prevalence of low RF profile in women (9.7%) albeit lower than in the Japanese study. One possible explanation might be related to the fact that Asians tend to present with lower BMI levels [19] and probably also with a lower prevalence of CVD risk factors. Overall, our results indicate that, compared to other studies, the prevalence of low RF profile is relatively high in this Swiss population-based sample. This high prevalence of low RF profile among the Swiss might partly explain the low CVD mortality rates observed in Switzerland relative to the other countries [20].

The trends in the prevalence of low RF profile in the Swiss population were assessed using data from the MONICA population studies and the criteria of Daviglus (set 2) [7] and Lowe [9]. The results suggest that the prevalence of low RF profile was stable between 1984 and 1993 and increased afterwards (**table 4**). This favorable change could be due to changes in a single or several risk factor(s), such as smoking (increase in the nineties and decrease afterwards) [21], physical activity (increase) [22] or the maintenance of a

relatively healthy diet [23]. Indeed, in the CoLaus study, the prevalence of low RF profile was higher among participants who practiced leisure physical activity; conversely, no dietary data was available to confirm the last hypothesis. Finally, this increase in the prevalence of low RF profile is in agreement with the decrease in CVD mortality rates observed in Switzerland [24]. Overall, our results indicate that the prevalence of low RF profile is increasing in Switzerland, and that this increase could be due to changes in several RF such as smoking or physical activity, or the maintenance of a healthy diet.

Participants with a family history of cardiovascular disease had a lower likelihood of presenting with a low RF profile. This finding was further confirmed by multivariate adjustment, although the association did not reach statistical significance for coronary heart disease or stroke taken individually, probably due to the small sample size. This finding could partly be explained by worse dietary behaviors or a particular genetic background. The existence of a large genetic database for most of the CoLaus participants and the ongoing follow-up of the entire cohort (which also includes dietary assessment) will allow a better assessment of these hypotheses.

This study has some limitations. First, generalization might be limited by the modest participation rate (41%), but this rate is comparable to other epidemiological studies [25]. Second, it is possible that the CoLaus participants are more health-conscious than the general population, thus biasing the observed prevalences of the low RF profile to higher than actual values; still, all studies which assessed low RF profile did so using volunteers, so this overestimation bias also applies to them. Third, the CoLaus study only included Caucasian participants, and it has been suggested that the prevalence of low RF profile is higher in non-Caucasian populations [5, 26]. Still, most studies which assessed low RF

profile included mostly white, Caucasian participants [2, 6], with the exception of Daviglius [1, 4, 7, 8], Folsom [10] and Lowe [9], so comparison of our results with these studies can still be performed. Finally, it might be questioned whether the CoLaus study is representative of the Swiss population; still, a considerable fraction of the Lausanne inhabitants are actually not native to the Vaud canton: in 2006, out of the 128,231 Lausanne inhabitants, 49,330 (38%) were non-Swiss, 38,513 (30%) came from other cantons, and only 40,388 subjects (32%) were from the Vaud canton. Hence, we do believe that the CoLaus study represents a fairly good sample of the Swiss population. Finally, as the CoLaus study only included participants aged between 35 and 75, the prevalence rates provided only apply to the population within this age range. As the prevalence of low risk profile is dependent on age, younger or older age groups would have higher and lower prevalence rates, respectively.

CONCLUSION

Our results indicate that, in a given population, the prevalence of low cardiovascular risk factor profile varies according to the criteria used. Compared to other countries, the prevalence of low cardiovascular risk factor profile is relatively high and increasing in the Swiss population, which might partly explain the low and decreasing trend in cardiovascular mortality rates.

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TABLES

Table 1: clinical characteristics of the sample, by gender

	Women	Men	P-value
Overweight (%)	28.3	45.5	<0.001
Obese (%)	14.3	16.9	
Current smoker (%)	24.9	29.2	<0.001
Systolic blood pressure (mm Hg)	125 ± 18	132 ± 17	<0.001
Diastolic blood pressure (mm Hg)	78 ± 11	81 ± 11	<0.001
Total cholesterol (mmol/L)	5.61 ± 1.03	5.56 ± 1.04	<0.05
HDL cholesterol (mmol/L)	1.81 ± 0.43	1.44 ± 0.36	<0.001
Fasting plasma glucose (mmol/L)	5.34 ± 1.02	5.78 ± 1.23	<0.001
Physical activity (%) §	57.3	53.5	<0.001
Baseline CVD (%)	5.2	7.9	<0.001

Results are expressed as mean ± standard deviation or as number of participants and (percentage). § defined as the practice of leisure time physical activity at least twice per week. BMI, body mass index; CVD, Cardiovascular Disease; HDL, high density lipoprotein; MI, Myocardial Infarction. Statistical analysis by Chi-square or Student's t-test.

Table 2: Prevalence of low risk, by clinical characteristics

	Daviglus 2	Daviglus 3	Hozawa	Yamamoto	Giampaoli	Stamler	Lowe
	[7]	[4]	[5]	[3]	[2]	[6]	[9]
Prevalence (%)	6.7	6.5	9.4	7.0	6.6	9.3	9.7
	(6.1 – 7.3)	(5.9 – 7.1)	(8.7 – 10.2)	(6.4 – 7.7)	(6.0 – 7.2)	(8.5 – 10.0)	(9.0 – 10.5)
By gender (%)							
Women	9.6	9.4	12.7	9.1	9.5	12.7	12.9
	(8.6 – 10.6)	(8.4 – 10.4)	(11.6– 13.9)	(8.1 – 10.1)	(8.5 – 10.5)	(11.5– 13.8)	(11.8– 14.1)
Men	3.5	3.2	5.7	4.8	3.4	5.5	6.1
	(2.8 – 4.1)	(2.5 – 3.8)	(4.9 – 6.6)	(4.0 – 5.5)	(2.7 – 4.0)	(4.6 – 6.3)	(5.2 – 7.0)
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
By age group (%)							
[35 – 44]	15.0	14.8	19.7	9.4	14.8	19.6	20.0
	(13.3-16.7)	(13.1– 16.5)	(17.8– 21.6)	(8.0 – 10.7)	(13.1– 16.5)	(17.8– 21.5)	(18.2– 21.9)
[45 – 54]	6.5	6.2	9.3	8.5	6.4	9.2	9.6
	(5.4 – 7.7)	(5.1 – 7.3)	(8.0 – 10.7)	(7.2 – 9.8)	(5.3 – 7.6)	(7.8 – 10.5)	(8.2 – 10.9)
[55 – 64]	1.9	1.7	3.4	5.9	1.8	3.2	3.7
	(1.2 – 2.5)	(1.0 – 2.3)	(2.5 – 4.3)	(4.8 – 7.0)	(1.2 – 2.5)	(2.3 – 4.0)	(2.8 – 4.5)
[65 – 75]	0.5	0.3	1.7	2.2	0.5	1.4	2.0
	(0.1 – 0.10)	(0.0 – 0.7)	(0.8 – 2.5)	(1.2 – 3.1)	(0.1 – 1.0)	(0.1 – 2.2)	(1.1 – 2.8)
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Physical activity (%)							

No	5.2 (4.3 – 6.0)	5.0 (4.2 – 5.8)	8.0 (7.0 – 9.0)	5.1 (4.3 – 5.9)	5.1 (4.2 – 5.9)	7.8 (6.8 – 8.8)	8.4 (7.3 – 9.4)
Yes	7.9 (7.0 – 8.8)	7.6 (6.7 – 8.5)	10.6 (9.5 – 11.6)	8.6 (7.6 – 9.5)	7.8 (6.9 – 8.7)	10.4 (9.4 – 11.4)	10.7 (9.7 – 11.8)
P-value	<0.001	<0.001	<0.002	<0.001	<0.001	<0.002	<0.005
Family history of CHD (%)							
No	7.0 (6.3 – 7.8)	6.8 (6.1 – 7.5)	9.9 (9.1 – 10.7)	7.3 (6.5 – 8.0)	6.9 (6.2 – 7.6)	9.7 (8.9 – 10.6)	10.2 (9.4 – 11.1)
Yes	5.3 (4.1 – 6.6)	5.0 (3.8 – 6.2)	7.5 (6.1 – 9.0)	6.1 (4.8 – 7.4)	5.3 (4.1 – 6.6)	7.4 (5.9 – 8.8)	7.7 (6.2 – 9.2)
P-value	<0.05	<0.05	<0.05	<0.20	<0.05	<0.01	<0.01
Family history of stroke (%)							
No	7.1 (6.4 – 7.8)	6.9 (6.2 – 7.6)	10 (9.1 – 10.8)	7.1 (6.4 – 7.8)	7.0 (6.3 – 7.7)	9.8 (9.0 – 10.6)	10.2 (9.4 – 11.1)
Yes	4.4 (3.1 – 5.7)	4.0 (2.7 – 5.2)	6.5 (4.9 – 8.1)	6.5 (4.9 – 8.1)	4.4 (3.1 – 5.7)	6.3 (4.7 – 7.8)	6.7 (5.1 – 8.3)
P-value	<0.005	<0.005	<0.005	<0.50	<0.005	<0.002	<0.002
Family history of CVD (%)							
No	7.5 (6.6 – 8.3)	7.3 (6.5 – 8.1)	10.4 (9.5 – 11.4)	7.5 (6.7 – 8.3)	7.4 (6.6 – 8.1)	10.3 (9.4 – 11.2)	10.7 (9.8 – 11.7)
Yes	5.0 (4.1 – 6.0)	4.7 (3.8 – 5.6)	7.3 (6.2 – 8.5)	6.1 (5.1 – 7.2)	5.0 (4.1 – 6.0)	7.1 (6.0 – 8.3)	7.5 (6.4 – 8.7)
P-value	<0.001	<0.001	<0.001	<0.06	<0.002	<0.001	<0.001

Results are expressed as percentage. Statistical analysis by Chi-square.

Table 3: multivariate analysis of the likelihood of presenting with a low cardiovascular risk factor profile according to presence or absence of a family history of cardiovascular disease.

Family history of	Daviglus 2	Daviglus 3	Hozawa	Yamamoto	Giampaoli	Stamler	Lowe
Coronary heart disease	0.77 (0.58 - 1.02)	0.75 (0.56 - 1.00)	0.77 (0.60 - 0.97)	0.81 (0.62 - 1.04)	0.79 (0.59 - 1.04)	0.76 (0.60 - 0.97)	0.76 (0.60 - 0.96)
Stroke	0.78 (0.55 - 1.10)	0.73 (0.51 - 1.04)	0.79 (0.60 - 1.05)	0.95 (0.72 - 1.26)	0.80 (0.56 - 1.12)	0.78 (0.59 - 1.04)	0.79 (0.60 - 1.05)
Cardiovascular disease	0.77 (0.61 - 0.99)	0.74 (0.58 - 0.95)	0.79 (0.64 - 0.97)	0.82 (0.65 - 1.02)	0.79 (0.62 - 1.01)	0.78 (0.64 - 0.96)	0.79 (0.64 - 0.96)

Results are expressed as odds-ratio and (95% confidence interval) for presence vs. absence of family history. Statistical analysis conducted independently for each condition by logistic regression adjusting for gender, age and physical activity. The significant results have a grey background.

Table 4: Evolution of the prevalence of low risk profile in several population-based studies in Switzerland, 1984-2006.

	Daviglius 2				Lowe			
	1984-6	1988-9	1992-3	2003-6	1984-6	1988-9	1992-3	2003-6
Prevalence (%)	3.8	3.3	3.7	6.7	5.9	4.4	5.0	9.7
	(3.1 - 4.5)	(2.6 - 3.9)	(3.0 - 4.4)	(6.1 - 7.3)	(5.1 - 6.8)	(3.7 - 5.2)	(4.2 - 5.8)	(9.0 - 10.5)
By gender (%)								
Women	6.1	5.1	5.9	9.6	8.5	6.3	7.6	12.9
	(4.9 - 7.4)	(3.9 - 6.2)	(4.6 - 7.1)	(8.6 - 10.6)	(7.1 - 10.0)	(5.0 - 7.6)	(6.2 - 8.9)	(11.8 - 14.1)
Men	1.5	1.6	1.4	3.5	3.4	2.6	2.3	6.1
	(0.9 - 2.1)	(0.9 - 2.2)	(0.7 - 2.0)	(2.8 - 4.1)	(2.5 - 4.3)	(1.8 - 3.5)	(1.5 - 3.1)	(5.2 - 7.0)
By age group (%)								
[35 - 44]	7.0	6.8	7.6	15.0	10.7	8.7	9.7	20.0
	(5.5 - 8.5)	(5.2 - 8.4)	(6.0 - 9.3)	(13.3 - 16.7)	(8.9 - 12.5)	(7.0 - 10.5)	(7.8 - 11.6)	(18.2 - 21.9)
[45 - 54]	2.6	2.2	2.6	6.5	4.3	3.5	3.9	9.5
	(1.5 - 3.6)	(1.2 - 3.1)	(1.6 - 3.7)	(5.4 - 7.7)	(3.0 - 5.7)	(2.3 - 4.7)	(2.7 - 5.2)	(8.2 - 10.9)
[55 - 64]	1.3	0.6	0.3	1.9	2.2	0.8	0.7	3.6
	(0.5 - 2.2)	(0.0 - 1.1)	(0.0 - 0.7)	(1.2 - 2.5)	(1.1 - 3.3)	(0.2 - 1.5)	(0.1 - 1.4)	(2.8 - 4.5)
[65 - 75]	0.0	0.4	0.5	0.5	0.0	0.4	1.1	2.0
		(0.0 - 1.3)	(0.0 - 1.6)	(0.1 - 1.0)		(0.0 - 1.3)	(0.0 - 2.6)	(1.1 - 2.8)
Standardized prevalence	3.2	2.9	3.3	7.1	5.1	4.0	4.5	10.1
	(2.3 - 4.2)	(1.9 - 4.0)	(2.3 - 4.4)	(6.0 - 8.2)	(3.9 - 6.3)	(2.9 - 5.2)	(3.1 - 5.8)	(8.9 - 11.5)

Results are expressed as percentage and (95% confidence interval). The standardized prevalence of low risk profile was obtained by direct standardization using the Standard European Population as defined by [17].

Table 5: Comparison of the prevalence of low risk factor profile between the current study and other studies, using the same criteria to define low risk profile.

Prevalence rates	Daviglus 2	Daviglus 3	Hozawa	Yamamoto	Giampaoli	Stamler	Lowe
This study (%)							
Overall	6.7 (6.1 – 7.3)	6.5 (5.9 – 7.1)	9.4 (8.7 – 10.2)	7.0 (6.4 – 7.7)	6.6 (6.0 – 7.2)	9.3 (8.5 – 10.0)	9.7 (9.0 – 10.5)
Women	9.6 (8.6 – 10.6)	9.4 (8.4 – 10.4)	12.7 (11.6– 13.9)	9.1 (8.1 – 10.1)	9.5 (8.5 – 10.5)	12.7 (11.5– 13.8)	12.9 (11.8– 14.1)
Men	3.5 (2.8 – 4.1)	3.2 (2.5 – 3.8)	5.7 (4.9 – 6.6)	4.8 (4.0 – 5.5)	3.4 (2.7 – 4.0)	5.5 (4.6 – 6.3)	6.1 (5.2 – 7.0)
Original study (%)							
Period of inclusion	1967 – 1973	1967 – 1973	1987 – 1989	1980	1983 – 1997	1967 – 1975	1967 – 1973
Age range (years)	40 – 59	18 – 39	45 – 64	30 – 69	35 – 69	35 – 59 §	40 – 64
Women	4.7	20.1	6.5	14.4	3.5		6.6
Men	2.0		4.6	3.0	1.6		4.8

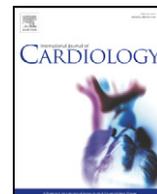
§ pooled data from two cohorts

ANNEXE: PUBLICATION ORIGINALE



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journal homepage: www.elsevier.com/locate/ijcardWho is at low risk for cardiovascular disease? An assessment of different definitions[☆]Antoine Gabioud^a, Gérard Waeber^b, Peter Vollenweider^b, Pedro Marques-Vidal^{a,*}^a Institute of Social and Preventive Medicine (IUMSP), Lausanne University Hospital, Lausanne, Switzerland^b Department of Medicine, Internal Medicine, Lausanne University Hospital (CHUV) and Faculty of Biology and Medicine, Lausanne, Switzerland

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ABSTRACT

Background: There is little information regarding the determinants and trends of the prevalence of low cardiovascular risk factor (RF) profile in the general population. The aim of this study was to assess the prevalence and trends of low RF profile in the Swiss population according to different definitions.

Methods: Population-based cross-sectional studies conducted in 1984–1986 ($N=3300$), 1988–1989 ($N=3331$), 1992–1993 ($N=3133$) and 2003–2006 ($N=6170$) and restricted to age group 35–75 years. Seven different definitions of low RF profile were used to assess determinants, while two definitions were used to assess trends.

Results: Prevalence of low RF profile varied between 6.5% (95% confidence interval: 5.9–7.1) and 9.7% (9.0–10.5) depending on the definition used. This prevalence was higher than in other countries. Irrespective of the definition used, the prevalence of low RF profile was higher in women and in physically active participants, and decreased with increasing age or in the presence of a family history of cardiovascular disease. Using one definition, the prevalence of low RF profile increased from 3.8% (3.1–4.5) in 1984–1986 to 6.7% (6.1–7.3) in 2003–2006; using another definition, the results were 5.9% (5.1–6.8) and 9.7% (9.0–10.5), respectively.

Conclusion: Switzerland is characterized by a high and increasing prevalence of low RF profile within the age group 35 to 75, irrespective of the criteria used. This high prevalence might partly explain the low and decreasing trend in cardiovascular mortality rates.

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1. Introduction

Cardiovascular diseases (CVD) are one of the most important causes of death worldwide, with considerable human and financial consequences. While most epidemiological research has focused on high-risk subjects, some authors focused on the other side of the CVD risk spectrum, i.e. on subjects with a low RF profile, characterized by the absence of CVD risk factors, or even presence of favorable CVD “benefic” factors such as a healthy diet or regular physical activity [1–3]. These low RF subjects present with a very low risk of developing CVD [2,4–6], but comparisons between studies are difficult as several definitions of the low RF profile exist [1–11], which might lead to differing, non-comparable prevalence. Finally, little if no information exists regarding the trends in the prevalence of low RF profile in the general population.

Hence, we used the data from a large, population-based cohort of subjects aged 35 to 75 years to assess (1) the prevalence of low RF subjects according to different definitions and (2) the 20-year trends

in the prevalence of selected definitions of low RF subjects by comparing our results with those obtained from the MONICA population surveys conducted between 1984 and 1993, again limited to the age group 35–75.

2. Methods

2.1. The CoLaus study

The sampling procedure of the Cohorte Lausannoise (CoLaus) study has been described previously [12]. Briefly, the complete list of the Lausanne inhabitants aged 35–75 years ($n=56\,694$) was provided by the population registry of the city and a simple, non-stratified random sample of 35% was drawn. An invitation letter with a quick description of the study was sent to all randomized participants. Individuals interested were contacted telephonically within 14 days by one of the staff members who provided more information about the study and arranged for an appointment. As the CoLaus study aimed at including only Caucasians to avoid population stratification and to increase genetic homogeneity for association studies, the following inclusion criteria were applied: (i) written informed consent; (ii) age 35–75 years; (iii) willingness to take part in the examination and to have a blood sample drawn and (iv) Caucasian origin, defined as having both parents and grandparents of Caucasian origin. Recruitment began in June 2003 and ended in May 2006. Participation rate was 41% and 6188 Caucasian participants (3251 women and 2937 men) took part in the study.

2.2. Risk factor assessment, CoLaus

All participants attended the outpatient clinic of the University Hospital of Lausanne in the morning after an overnight fast (minimum fasting time 8 h). Data were collected by trained field interviewers in a single visit lasting about 60 min.

Participants received a questionnaire to record information about their lifestyle factors. According to their smoking histories, participants were classified as never,

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current or former smokers. During a face-to-face meeting, the participants were asked if they or their parents had presented CVD. Personal history of and current treatment for hypertension, hypercholesterolemia or diabetes were also asked. Information on the use of prescription and over the counter drugs, vitamin and mineral supplements, homeopathy or natural remedies was collected, together with their main indications. Collection was done by asking the participant to bring the drugs to the visit. Physical activity was defined as the practice of leisure time physical activity at least twice per week.

Body weight and height were measured in light indoor clothes with shoes off. Body weight was measured in kilograms to the nearest 100 g using a Seca® scale, which was calibrated regularly. Height was measured to the nearest 5 mm using a Seca® height gauge. Body mass index (BMI) was calculated as weight (kg) divided by the square of the height (m). Overweight was defined as BMI ≥ 25 kg/m² and < 30 kg/m², and obesity by a BMI ≥ 30 kg/m².

Blood pressure was measured on the left arm, with an appropriately sized cuff, after at least 10 min rest in the seated position using an Omron® HEM-907 automated oscillometric sphygmomanometer. Three readings were taken and the average of the last two was used to compute systolic (SBP) and diastolic (DBP) blood pressure.

Fasting plasma glucose and total cholesterol levels were measured by the CHUV Clinical Laboratory on fresh blood samples within 2 h of blood collection. All measurements were conducted in a Modular P apparatus (Roche Diagnostics, Switzerland). The following analytical procedures (with maximum inter and intra-batch CVs) were used: glucose by glucose dehydrogenase (2.1%–1.0%) and total cholesterol by CHOD-PAP (1.6%–1.7%).

2.3. MONICA population surveys

The MONICA Project (Multinational MONitoring of trends and determinants in Cardiovascular disease) [13,14] was created in the early 1980s in different centers around the world to monitor over a ten-year period trends in cardiovascular disease mortality and incidence. Thirty-one collaborating centers (25 from Europe, one from Canada, one from the US, two from Australia, one from New Zealand and one from China) took part in the project. In each population, investigators had to satisfy the local requirements for ethical research [14].

In this study, we used the data from the three Swiss MONICA population surveys conducted in the Vaud and Fribourg cantons for the periods 1984–1986, 1988–1989 and 1992–1993. Their main characteristics have been published previously [15]. The initial samples included participants aged between 25 and 75, but in order to be comparable with the CoLaus study we restricted the analysis to participants aged between 35 and 75 years.

2.4. Risk factor assessment, MONICA

Body weight and height were measured with participants standing without shoes and heavy outer garments and with empty pockets. Blood samples from non-fasting subjects were used to measure the total cholesterol (TC). Smoking status was initially divided in 4 categories, daily cigarette smokers, non smokers, ex-smokers and “different types” of smokers (occasional, pipe, cigars). For the current analysis, daily and “different types” of smokers were grouped.

The authors of this manuscript have certified that they comply with the Principles of Ethical Publishing in the International Journal of Cardiology [16].

2.5. Low risk factor profile

A literature search on Pubmed using the terms “low cardiovascular risk”, “low risk factor”, “favorable risk factor” in association or not with the words “prevalence” and “epidemiology” revealed eleven different definitions for low RF profile [1–11]. Their criteria are summarized in Supplementary Table 1. Three major CVD risk factors were common to all definitions: blood pressure (SBP < 120 and DBP < 80 mm Hg); smoking (absence) and total cholesterol (< 200 mg/dL (< 5.2 mmol/L)); for total cholesterol, only Yamamoto used a different threshold: 160–240 mg/dL (4.14–6.22 mmol/L). Additional criteria differed according to each author. Most authors also included antihypertensive medication (absence), personal history of diabetes (absence) and BMI (< 25 kg/m²) in their criteria. Three studies included electrocardiographic findings, two cholesterol lowering drug treatment and one included personal history of myocardial infarction. Fasting plasma glucose level was a criterion in one study and lifestyle (physical activity and diet) in another. Overall, the number of criteria used to define low RF profile varied between 4 and 11. Noteworthy, a single author (Daviglius) used slightly different sets of criteria to define low RF profile [1,4,7,8] (Supplementary Table 1). The prevalence of low RF profile in the CoLaus cohort was computed using the following sets of criteria: Daviglius 2 [7] and 3 [4], Hozawa [5], Yamamoto [3], Giampaoli [2], Stamler [6] and Lowe [9] as they included data available in the CoLaus study. The sets of criteria Daviglius 1 [1] and Daviglius 4 [8] were not retained due to the lack of ECG data and the sets of criteria of Folsom [10] and Mozaffarian [11] were not retained due to the lack of physical activity and dietary data. Similarly, due to limitation in variables from the MONICA surveys, only two sets of criteria were used to assess trends in the prevalence of low RF profile: Lowe (SBP < 120 mmHg, DBP < 80 mmHg, total cholesterol < 200 mg/dL, no smoking) [9] and Daviglius 2 (SBP < 120 mmHg, DBP < 80 mmHg, total cholesterol < 200 mg/dL, no smoking, no use of antihypertensive medication, BMI < 25 kg/m²) [7].

Table 1
clinical characteristics of the sample, by gender.

	Women (n = 3241)	Men (n = 2929)	p-value
Age (years)	53.5 \pm 10.7	52.6 \pm 10.8	0.001
Body mass index (kg/m ²)	25.1 \pm 4.8	26.6 \pm 4.0	<0.001
BMI status (%)			
Normal	1860 (57.4)	1100 (37.6)	<0.001
Overweight	917 (28.3)	1333 (45.5)	
Obese	464 (14.3)	496 (16.9)	
Smoking status (%)			
Former	903 (27.9)	1129 (38.6)	<0.001
Never	1529 (47.2)	944 (32.2)	
Current	809 (24.9)	855 (29.2)	
Systolic blood pressure (mm Hg)	125 \pm 18	132 \pm 17	<0.001
Diastolic blood pressure (mm Hg)	78 \pm 11	81 \pm 11	<0.001
Total cholesterol (mmol/L)	5.61 \pm 1.03	5.56 \pm 1.04	<0.05
HDL cholesterol (mmol/L)	1.81 \pm 0.43	1.44 \pm 0.36	<0.001
Fasting plasma glucose (mmol/L)	5.34 \pm 1.02	5.78 \pm 1.23	<0.001
Physical activity (%) §	1856 (57.3)	1567 (53.5)	<0.001
Personal history of MI (%)	23 (0.7)	77 (2.6)	<0.001
Baseline CVD (%)	167 (5.2)	230 (7.9)	<0.001

Results are expressed as mean \pm standard deviation or as number of participants and (percentage). § defined as the practice of leisure time physical activity at least twice per week. BMI, body mass index; CVD, cardiovascular disease; HDL, high density lipoprotein; MI, myocardial infarction. Statistical analysis by Chi-square or Student's *t*-test.

2.6. Statistical analysis

Statistical analyses were made using Stata v.11.1 (Stata Corp, College Station, TX, USA). The prevalence of participants with low RF profile was determined for each set of criteria and expressed in percentage and (95% confidence interval). Between-group comparisons were performed using Chi-square for qualitative variables or Student's *t*-test for quantitative variables. Multivariate analysis modeling the likelihood of presenting with low RF profile was conducted using logistic regression adjusting for gender, age and physical activity and the results were expressed as odds ratio (OR) and (95% confidence interval). Standardized estimates of the prevalence of low risk profile were obtained by direct standardization using the Standard European Population as defined by [17]. Statistical significance was considered for *p* < 0.05 .

3. Results

3.1. Characteristics of the subjects

Of the initial 6188 participants, 6170 (99.7%, 3241 women and 2929 men) had data for all variables and were included in the analysis. Table 1 summarizes their clinical characteristics according to gender. Overall, women had a lower BMI, blood pressure and fasting plasma glucose than men, women also smoked less, practiced more physical activity and had less history of MI and CVD than men. Finally, women had higher total and HDL cholesterol levels than men (Table 1).

3.2. Prevalence and trends of low risk factor profile

The prevalence of low RF profile overall and according to different characteristics is summarized in Table 2. Women had a higher prevalence of a low risk profile; physical activity was positively associated with low risk, while increasing age, family history of CVD, stroke or MI were associated with a lower prevalence of low RF profile. These findings were further confirmed by multivariate logistic regression adjusting for gender, age and leisure-time physical activity, where subjects with a family history of CVD (coronary heart disease or stroke) had a lower likelihood of presenting with low RF profile: odds-ratios (95% confidence interval) ranging from 0.76 (0.60–0.96) to 0.81 (0.62–1.04). The results were comparable (odds-ratio below 1) for coronary heart disease and stroke taken individually, but did not reach statistical significance (Table 3).

The trends in the prevalence of low RF profile for period 1984–2006 are summarized in Table 4. The prevalence of low RF profile remained rather stable between 1984 and 1993 and increased afterwards. Interestingly, the prevalence of low RF profile in the MONICA studies showed the

Table 2
Prevalence of low risk, by clinical characteristics.

	Daviglus 2 [7]	Daviglus 3 [4]	Hozawa [5]	Yamamoto [3]	Giampaoli [2]	Stamler [6]	Lowe [9]
Prevalence (%)	6.7 (6.1–7.3)	6.5 (5.9–7.1)	9.4 (8.7–10.2)	7.0 (6.4–7.7)	6.6 (6.0–7.2)	9.3 (8.5–10.0)	9.7 (9.0–10.5)
By gender (%)							
Women	9.6 (8.6–10.6)	9.4 (8.4–10.4)	12.7 (11.6–13.9)	9.1 (8.1–10.1)	9.5 (8.5–10.5)	12.7 (11.5–13.8)	12.9 (11.8–14.1)
Men	3.5 (2.8–4.1)	3.2 (2.5–3.8)	5.7 (4.9–6.6)	4.8 (4.0–5.5)	3.4 (2.7–4.0)	5.5 (4.6–6.3)	6.1 (5.2–7.0)
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
By age group (%)							
[35–44]	15.0 (13.3–16.7)	14.8 (13.1–16.5)	19.7 (17.8–21.6)	9.4 (8.0–10.7)	14.8 (13.1–16.5)	19.6 (17.8–21.5)	20.0 (18.2–21.9)
[45–54]	6.5 (5.4–7.7)	6.2 (5.1–7.3)	9.3 (8.0–10.7)	8.5 (7.2–9.8)	6.4 (5.3–7.6)	9.2 (7.8–10.5)	9.6 (8.2–10.9)
[55–64]	1.9 (1.2–2.5)	1.7 (1.0–2.3)	3.4 (2.5–4.3)	5.9 (4.8–7.0)	1.8 (1.2–2.5)	3.2 (2.3–4.0)	3.7 (2.8–4.5)
[65–75]	0.5 (0.1–1.0)	0.3 (0.0–0.7)	1.7 (0.8–2.5)	2.2 (1.2–3.1)	0.5 (0.1–1.0)	1.4 (0.1–2.2)	2.0 (1.1–2.8)
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
By physical activity (%)							
No	5.2 (4.3–6.0)	5.0 (4.2–5.8)	8.0 (7.0–9.0)	5.1 (4.3–5.9)	5.1 (4.2–5.9)	7.8 (6.8–8.8)	8.4 (7.3–9.4)
Yes	7.9 (7.0–8.8)	7.6 (6.7–8.5)	10.6 (9.5–11.6)	8.6 (7.6–9.5)	7.8 (6.9–8.7)	10.4 (9.4–11.4)	10.7 (9.7–11.8)
P-value	<0.001	<0.001	<0.002	<0.001	<0.001	<0.002	<0.005
By family history of CHD (%)							
No	7.0 (6.3–7.8)	6.8 (6.1–7.5)	9.9 (9.1–10.7)	7.3 (6.5–8.0)	6.9 (6.2–7.6)	9.7 (8.9–10.6)	10.2 (9.4–11.1)
Yes	5.3 (4.1–6.6)	5.0 (3.8–6.2)	7.5 (6.1–9.0)	6.1 (4.8–7.4)	5.3 (4.1–6.6)	7.4 (5.9–8.8)	7.7 (6.2–9.2)
p-value	<0.05	<0.05	<0.05	<0.20	<0.05	<0.01	<0.01
By family history of stroke (%)							
No	7.1 (6.4–7.8)	6.9 (6.2–7.6)	10 (9.1–10.8)	7.1 (6.4–7.8)	7.0 (6.3–7.7)	9.8 (9.0–10.6)	10.2 (9.4–11.1)
Yes	4.4 (3.1–5.7)	4.0 (2.7–5.2)	6.5 (4.9–8.1)	6.5 (4.9–8.1)	4.4 (3.1–5.7)	6.3 (4.7–7.8)	6.7 (5.1–8.3)
P-value	<0.005	<0.005	<0.005	<0.50	<0.005	<0.002	<0.002
By family history of CVD (%)							
No	7.5 (6.6–8.3)	7.3 (6.5–8.1)	10.4 (9.5–11.4)	7.5 (6.7–8.3)	7.4 (6.6–8.1)	10.3 (9.4–11.2)	10.7 (9.8–11.7)
Yes	5.0 (4.1–6.0)	4.7 (3.8–5.6)	7.3 (6.2–8.5)	6.1 (5.1–7.2)	5.0 (4.1–6.0)	7.1 (6.0–8.3)	7.5 (6.4–8.7)
p-value	<0.001	<0.001	<0.001	<0.06	<0.002	<0.001	<0.001

Results are expressed as percentage. Statistical analysis by Chi-square.

same pattern of associations (higher in women and lower among older participants).

In the CoLaus study, the prevalence of low RF in men and women was higher than in the other studies (Table 5).

4. Discussion

To our knowledge, this is the first ever study to compare the results of different definitions of low RF profile in the same population. Our results

suggest that the prevalence of low RF profile is rather low and depends on the number of criteria used, as the two studies using the fewest criteria (Lowe and Hozawa) led to the highest prevalence. This is understandable, as the probability of fulfilling all criteria decreases with the number of criteria used. Still, and even more important than the number of criteria used, the age of the participant was the main factor to influence the prevalence of low RF profile. This finding is in agreement with the literature [18], as it has been shown that CVD risk increases with age, in association with a decrease in the number of normal or optimal level RFs. Overall, our

Table 3
multivariate analysis of the likelihood of presenting with a low cardiovascular risk factor profile according to presence or absence of a family history of cardiovascular disease.

Family history of	Daviglus 2	Daviglus 3	Hozawa	Yamamoto	Giampaoli	Stamler	Lowe
Coronary heart disease	0.77 (0.58–1.02)	0.75 (0.56–1.00)	0.77 (0.60–0.97)	0.81 (0.62–1.04)	0.79 (0.59–1.04)	0.76 (0.60–0.97)	0.76 (0.60–0.96)
Stroke	0.78 (0.55–1.10)	0.73 (0.51–1.04)	0.79 (0.60–1.05)	0.95 (0.72–1.26)	0.80 (0.56–1.12)	0.78 (0.59–1.04)	0.79 (0.60–1.05)
Cardiovascular disease	0.77 (0.61–0.99)	0.74 (0.58–0.95)	0.79 (0.64–0.97)	0.82 (0.65–1.02)	0.79 (0.62–1.01)	0.78 (0.64–0.96)	0.79 (0.64–0.96)

Results are expressed as odds-ratio and (95% confidence interval) for presence vs. absence of family history. Statistical analysis conducted independently for each condition by logistic regression adjusting for gender, age and physical activity.

Table 4
Evolution of the prevalence of low risk profile in several population-based studies in Switzerland, 1984–2006.

	Daviglius 2				Lowe			
	1984–1986	1988–1989	1992–1993	2003–2006	1984–1986	1988–1989	1992–1993	2003–2006
Prevalence (%)	3.8 (3.1–4.5)	3.3 (2.6–3.9)	3.7 (3.0–4.4)	6.7 (6.1–7.3)	5.9 (5.1–6.8)	4.4 (3.7–5.2)	5.0 (4.2–5.8)	9.7 (9.0–10.5)
By gender (%)								
Women	6.1 (4.9–7.4)	5.1 (3.9–6.2)	5.9 (4.6–7.1)	9.6 (8.6–10.6)	8.5 (7.1–10.0)	6.3 (5.0–7.6)	7.6 (6.2–8.9)	12.9 (11.8–14.1)
Men	1.5 (0.9–2.1)	1.6 (0.9–2.2)	1.4 (0.7–2.0)	3.5 (2.8–4.1)	3.4 (2.5–4.3)	2.6 (1.8–3.5)	2.3 (1.5–3.1)	6.1 (5.2–7.0)
By age group (%)								
[35–44]	7.0 (5.5–8.5)	6.8 (5.2–8.4)	7.6 (6.0–9.3)	15.0 (13.3–16.7)	10.7 (8.9–12.5)	8.7 (7.0–10.5)	9.7 (7.8–11.6)	20.0 (18.2–21.9)
[45–54]	2.6 (1.5–3.6)	2.2 (1.2–3.1)	2.6 (1.6–3.7)	6.5 (5.4–7.7)	4.3 (3.0–5.7)	3.5 (2.3–4.7)	3.9 (2.7–5.2)	9.5 (8.2–10.9)
[55–64]	1.3 (0.5–2.2)	0.6 (0.0–1.1)	0.3 (0.0–0.7)	1.9 (1.2–2.5)	2.2 (1.1–3.3)	0.8 (0.2–1.5)	0.7 (0.1–1.4)	3.6 (2.8–4.5)
[65–75]	0.0	0.4 (0.0–1.3)	0.5 (0.0–1.6)	0.5 (0.1–1.0)	0.0	0.4 (0.0–1.3)	1.1 (0.0–2.6)	2.0 (1.1–2.8)
Standardized prevalence	3.2 (2.3–4.2)	2.9 (1.9–4.0)	3.3 (2.3–4.4)	7.1 (6.0–8.2)	5.1 (3.9–6.3)	4.0 (2.9–5.2)	4.5 (3.1–5.8)	10.1 (8.9–11.5)

Results are expressed as percentage and (95% confidence interval). The standardized prevalence of low risk profile was obtained by direct standardization using the Standard European Population as defined by [17].

results indicate that the more criteria to define low RF profile or the higher the age of the participants, the lower the prevalence of low RF profile.

The prevalence of low RF profile was higher in CoLaus than in the other studies. Only the studies by Daviglius (set 3) [4] and Yamamoto [3] had a higher prevalence of low RF profile among women. This finding can be explained by the younger age of the participants in both surveys: in the American study, mean (\pm SD) age was 31.0 ± 1.3 years, vs. 53.5 ± 10.7 years in the CoLaus study; in the Japanese study, the age range was 30–69 years, vs. 35–75 years in the CoLaus study. Interestingly, restricting the analysis in the CoLaus study to the 30–69 years age group led to a higher prevalence of low RF profile in women (9.7%) albeit lower than in the Japanese study. One possible explanation might be related to the fact that Asians tend to present with lower BMI levels [19] and probably also with a lower prevalence of CVD risk factors. Overall, our results indicate that, compared to other studies, the prevalence of low RF profile is relatively high in this Swiss population-based sample. This high prevalence of low RF profile among the Swiss might partly explain the low CVD mortality rates observed in Switzerland relative to the other countries [20].

The trends in the prevalence of low RF profile in the Swiss population were assessed using data from the MONICA population studies and the

criteria of Daviglius (set 2) [7] and Lowe [9]. The results suggest that the prevalence of low RF profile was stable between 1984 and 1993 and increased afterwards (Table 4). This favorable change could be due to changes in a single or several risk factor(s), such as smoking (increase in the nineties and decrease afterwards) [21], physical activity (increase) [22] or the maintenance of a relatively healthy diet [23]. Indeed, in the CoLaus study, the prevalence of low RF profile was higher among participants who practiced leisure physical activity; conversely, no dietary data were available to confirm the last hypothesis. Finally, this increase in the prevalence of low RF profile is in agreement with the decrease in CVD mortality rates observed in Switzerland [24]. Overall, our results indicate that the prevalence of low RF profile is increasing in Switzerland, and that this increase could be due to changes in several RF such as smoking or physical activity, or the maintenance of a healthy diet.

Participants with a family history of cardiovascular disease had a lower likelihood of presenting with a low RF profile. This finding was further confirmed by multivariate adjustment, although the association did not reach statistical significance for coronary heart disease or stroke taken individually, probably due to the small sample size. This finding could partly be explained by worse dietary behaviors or a particular genetic background. The existence of a large genetic database for most of

Table 5
Comparison of the prevalence of low risk factor profile between the current study and other studies, using the same criteria to define low risk profile.

	Daviglius 2	Daviglius 3	Hozawa	Yamamoto	Giampaoli	Stamler	Lowe
Prevalence this study (%)							
Overall	6.7 (6.1–7.3)	6.5 (5.9–7.1)	9.4 (8.7–10.2)	7.0 (6.4–7.7)	6.6 (6.0–7.2)	9.3 (8.5–10.0)	9.7 (9.0–10.5)
Women	9.6 (8.6–10.6)	9.4 (8.4–10.4)	12.7 (11.6–13.9)	9.1 (8.1–10.1)	9.5 (8.5–10.5)	12.7 (11.5–13.8)	12.9 (11.8–14.1)
Men	3.5 (2.8–4.1)	3.2 (2.5–3.8)	5.7 (4.9–6.6)	4.8 (4.0–5.5)	3.4 (2.7–4.0)	5.5 (4.6–6.3)	6.1 (5.2–7.0)
Prevalence original study (%)							
Period of inclusion	1967–1973	1967–1973	1987–1989	1980	1983–1997	1967–1975	1967–1973
Age range (years)	40–59	18–39	45–64	30–69	35–69	35–59 [§]	40–64
Women	4.7	20.1	6.5	14.4	3.5		6.6
Men	2.0		4.6	3.0	1.6		4.8

[§] Pooled data from two cohorts.

the CoLaus participants and the ongoing follow-up of the entire cohort (which also includes dietary assessment) will allow a better assessment of these hypotheses.

This study has some limitations. First, generalization might be limited by the modest participation rate (41%), but this rate is comparable to other epidemiological studies [25]. Second, it is possible that the CoLaus participants are more health-conscious than the general population, thus biasing the observed prevalence of the low RF profile to higher than actual values; still, all studies which assessed low RF profile did so using volunteers, so this overestimation bias also applies to them. Third, the CoLaus study only included Caucasian participants, and it has been suggested that the prevalence of low RF profile is higher in non-Caucasian populations [5,26]. Still, most studies which assessed low RF profile included mostly white, Caucasian participants [2,6], with the exception of Daviglus [1,4,7,8], Folsom [10] and Lowe [9], so comparison of our results with these studies can still be performed. Finally, it might be questioned whether the CoLaus study is representative of the Swiss population; still, a considerable fraction of the Lausanne inhabitants are actually not native to the Vaud canton: in 2006, out of the 128 231 Lausanne inhabitants, 49 330 (38%) were non-Swiss, 38 513 (30%) came from other cantons, and only 40 388 subjects (32%) were from the Vaud canton. Hence, we do believe that the CoLaus study represents a fairly good sample of the Swiss population. Finally, as the CoLaus study only included participants aged between 35 and 75, the prevalence rates provided only apply to the population within this age range. As the prevalence of low risk profile is dependent on age, younger or older age groups would have higher and lower prevalence rates, respectively.

5. Conclusion

Our results indicate that, in a given population, the prevalence of low cardiovascular risk factor profile varies according to the criteria used. Compared to other countries, the prevalence of low cardiovascular risk factor profile is relatively high and increasing in the Swiss population, which might partly explain the low and decreasing trend in cardiovascular mortality rates.

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Authors contributions

AG made part of the statistical analyses and wrote most of the article; PMV collected data, made part of the statistical analysis and wrote part of the article; GW and PV revised the article for important intellectual content. PMV had full access to the data and is the guarantor of the study.

Declaration of interest

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