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Prevalence and determinants of self-reported low-fat-, low-salt-, and vegetarian diets in patients with cardiovascular disease between 1996 and 2019

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Abstract *Background and aims:* Guidelines no longer recommend low-fat diets and currently recommend more plant-based diets to reduce atherosclerotic cardiovascular disease (ASCVD) risk. Furthermore, these guidelines have consistently recommended salt-reduced diets. This article describes current self-reported use and time-trends in the self-reported use of low-fat, low-salt and vegetarian diets in ASCVD patients and examines patient characteristics associated with each diet.
Methods and results: 9005 patients with ASCVD included between 1996 and 2019 in the UCC-SMART cohort were studied. The prevalence of self-reported diets was assessed and multivariable logistic regression was used to identify the determinants of each diet. Between 1996-1997 and 2018–2019, low-fat diets declined from 22.4 % to 3.8 %, and low-salt diets from 14.7 % to 4.6 %. The prevalence of vegetarian diets increased from 1.1 % in 1996–1997 to 2.3 % in 2018–2019. Patients with cerebrovascular disease (CeVD) and peripheral artery disease or an abdominal aortic aneurysm (PAD/AAA) were less likely to report a low-salt diet than coronary artery disease (CAD) patients (OR 0.62 [95%CI 0.49–0.77] and 0.55 [95%CI 0.41–0.72]).
Conclusion: In the period 1996 to 2019 amongst patients with ASCVD, the prevalence of self-reported low-fat diets was low and decreased in line with changes in recommendations in major guidelines. The prevalence of self-reported vegetarian diets was low but increased in line with societal and guideline changes. The prevalence of self-reported low-salt diets was low, especially in CeVD and PAD/AAA patients compared to CAD patients, and decreased over time. Renewed action is needed to promote low-salt diets in ASCVD patients.
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1. Introduction

Patients with a history of atherosclerotic cardiovascular disease (ASCVD) are at high risk of new cardiovascular events [1]. Important risk factors for a subsequent cardiovascular event include smoking, high systolic blood pressure and low-density lipoprotein (LDL) cholesterol [2]. To lower the risk of recurrent CV events and premature mortality all high-risk patients should be advised to adopt a healthy lifestyle, i.e., quit smoking, increase physical activity and adopt a healthy dietary pattern [3].

Some guideline recommendations for a healthy diet have changed during the last decades. The 2000 and 2006 American Heart Association (AHA) Dietary Guidelines recommended a diet low in fat, with a total fat intake below 30 % and between 25 and 35 % of total energy (%E) respectively [4]. However, a 2016 meta-analysis found no effect of a low-fat diet on CVD or all-cause mortality relative to controls (risk ratio 0.99, 95 % CI 0.94 to 1.05) and concluded that guideline recommendations for total dietary fat reduction were not supported by evidence from trials [5]. Meanwhile, the focus shifted from total fat intake to substituting unsaturated with (poly)unsaturated fats [6]. The most recent 2021 AHA dietary guidelines and European Society of Cardiology (ESC) guidelines on CVD prevention no longer recommend lowering total dietary fat below a specific energy percentage [7].

Observational studies in healthy populations show that plant-based diets are associated with a reduced risk of CVD and type 2 diabetes (T2D) [8,9]. Furthermore, trials in patients with CVD have found that adopting a plant-based diet might lower lipid levels and inflammation [10,11]. Consequently, the major European and American CVD prevention guidelines have moved towards recommending a more plant-based diet. The 2012 ESC Guidelines did not include any key recommendations regarding plant-based and/or animal-based dietary patterns but in the 2021 ESC guidelines, a key recommendation to adopt a more plant-based dietary pattern was added [3]. A similar trend can be observed in the AHA dietary guidelines, which recommended poultry and lean meats in 2000 and currently regard meats as optional, while recommending choosing mostly plant-based sources of protein [7,12].

While dietary recommendations regarding fat and meat intake have changed over the last decades, reducing dietary salt intake has consistently been recommended. Studies have consistently shown that a lower intake of salt is associated with a lower risk of CVD and recent studies have confirmed this relationship to be linear and dose-dependent [13]. The major European and American prevention guidelines have therefore consistently recommended limiting dietary salt intake to reduce CVD risk [3,7,12,14,15].

Lastly, previous studies found that certain demographic patient characteristics (sex and level of education) and medical characteristics (including the presence of hypertension or T2D) might also be associated with adherence to certain diets [16]. Understanding the differences in self-reported dietary habits among patient groups can help clinicians, researchers and policymakers in developing more targeted healthy eating initiatives in line with current guidelines.

It is currently unknown which proportion of patients with established ASCVD follows either a low-fat, low-salt or vegetarian diet. Insight into time trends of these dietary patterns and determinants of self-reported diets in high-risk patients with clinically manifest ASCVD, may guide clinical practice as well as guideline committees and policymakers. The aim of the present study is to describe the prevalence of self-reported low-fat, low-salt and vegetarian diets amongst patients with established ASCVD in the period 1996 to 2019 and to evaluate the determinants of each self-reported diet.

2. Methods

2.1. Study population

Patients with established ASCVD were included from the Utrecht Cardiovascular Cohort – Second Manifestations of ARTerial disease (UCC-SMART) [17]. The UCC-SMART-cohort was established in 1996 and is an ongoing prospective cohort that includes patients with established ASCVD (coronary artery disease (CAD), peripheral arterial disease (PAD), cerebrovascular disease (CeVD), or abdominal aortic aneurysm (AAA)). The cohort recruits on average 300–400 patients with vascular disease yearly. CAD was defined as a diagnosis of myocardial infarction, angina pectoris, coronary artery stenosis, cardiac arrest or cardiac surgery. CeVD included diagnosed transient ischemic attack or ischemic stroke. PAD included Fontaine stage II or higher. AAA was classified as an aneurysm ($\geq$3 cm) of the abdominal artery upon screening or previous (endo)vascular repair. For the current study, we used data from patients who entered the cohort in the period 1996 to 2019 with established ASCVD at baseline (N = 9005). The rationale and design of the UCC-SMART-cohort have previously been described elsewhere [17]. The UCC-SMART-cohort was approved by the Medical Research Ethics Committee and all included patients provided informed consent.

2.2. Data collection

Data in the UCC-SMART cohort were collected in all patients at baseline using standardized questionnaires on medical history, physical examination, standardized blood pressure measurements, laboratory testing and ultrasound of the abdominal aorta artery. In the questionnaire, patients were asked whether they followed any particular diet (Fig. S1). Patients reporting a low-salt diet, as shown in a prior study, had a reduced urinary sodium excretion of 14.2 mmol/L, measured via two 24-h urine collections [18]. Patients that indicated following a diet, were asked to indicate which diet from a list of prespecified diets. Patients were also asked to indicate if they were currently adhering to a vegetarian diet or had ever adhered to one. Lastly, patients were asked whether they consumed eggs or dairy. Patients who reported a vegetarian diet without

consuming eggs or dairy were classified as adhering to both the vegetarian diet and the vegan diet.

2.3. Data analyses

Normally distributed data are presented as mean (standard deviation) and non-normally distributed data are presented as median (interquartile range). Frequency data are reported as absolute count (percentage). Binary logistic regression was used to quantify the relationship between the year of inclusion and the odds of reporting a specific diet. Additionally, the effect of one of the hypothesized determinants on the odds of reporting a specific diet was quantified using logistic regression. Determinants were demographics (age, sex and level of education), lifestyle factors (smoking status, physical activity, alcohol use) and medical history (history of T2D, hypertension, type of CVD and cardiovascular risk factors). Three regression models were fit: a crude model, a model adjusted for age and sex and a model additionally adjusted for year of inclusion to adjust for changes over time (Table S1). Results are reported as odds ratio (OR) [95 % confidence interval]. Additionally, time trends were analysed in subgroups of patients with hypertension and type 2 diabetes (T2D). The estimated Glomerular Filtration Rate (eGFR) was calculated using the 2021 creatinine-based equations [19]. Missing data, except dietary data, were imputed by single imputation using the aregImpute function from the Hmisc package in R-studio. If data on diet was missing (1.9 % of cases), missingness-at-random was not assumed, but rather that patients skipped the question because they followed none of the pre-specified diets. Most variables with missing data had little data missing (<1 %), except for alcohol use (1.0 %), level of education (37 %), and HbA1c (36 %). A complete case analysis was run to ensure the results were not sensitive to the method for dealing with missing data. All analyses were performed using R, version 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria).

3. Results

3.1. Baseline characteristics

From 1996 to 2019, 9005 patients with established ASCVD were enrolled. The average age of patients was 61 ± 10 years and 26 % were female (Table 1). Fifty percent of ASCVD patients had CAD at baseline, 16 % were diagnosed with T2D and 56 % with hypertension (Table 1). Furthermore, 48 % of patients were former smokers and 30 % were current smokers. The average BMI was 26.9 ± 4.1 kg/m^2. Most patients reported not following any specific diet (n = 7711; 86 %). Overall, 946 (11 %) patients reported following a low-fat diet, 669 (7.4 %) a low-salt diet and 118 (1.3 %) a vegetarian diet (Table 1). 7 of the 188 vegetarian patients reported eating no eggs or dairy. There were 415 patients (4.6 %) who reported following two diets and 12 (0.1 %) reported all three diets (Table S2). The most commonly reported combination was the low-fat and low-salt diet (402 patients, 4.4 %, Table S2).

3.2. Self-reported low-fat diet: changes over time and associated patient characteristics

The prevalence of a self-reported low-fat diet declined from 22.4 % in 1996–1997 to 3.8 % in 2018–2019 (OR 0.84 [95%CI 0.82–0.87] per 2 years) (Fig. 1). The odds of reporting a low-fat diet were higher for women than men (adjusted OR (aOR) 1.46 [95%CI 1.26–1.68]) and increased with age (aOR 1.17 per 5-year increase [95%CI 1.13–1.22]) (Table 2). After adjustment for age, sex and inclusion year, patients with a history of T2D or hypertension were more likely to report a low-fat diet than patients without these risk factors (aOR 2.22 [95%CI 1.89–2.60] and 1.51 [95%CI 1.31–1.75] respectively, Table 2). The odds of reporting a low-fat diet were higher for patients with a higher BMI (aOR per 5-point increase 1.19 [95%CI 1.10; 1.29]) and a higher HbA1c (aOR per percentage point 1.21 [95CI% 1.13–1.30]). Lastly, patients with CeVD and PAD/AAA were less likely to report a low-fat diet than patients with CAD (aOR 0.42 [95%CI 0.33–0.51] and 0.51 [95%CI 0.41–0.64] respectively).

3.3. Self-reported low-salt diet: changes over time and associated patient characteristics

The prevalence of a low-salt diet declined from 14.7 % in 1996–1997 to 4.6 % in 2018–2019 (OR 0.92 [95%CI 0.90–0.94] per 2 years) (Fig. 1). Overall, 9 % of ASCVD patients with an SBP above 140 mmHg at baseline reported to follow a low-salt diet. Women were more likely to report a low-salt diet than men (aOR 1.70 [95%CI 1.44–2.01]) and the probability increased with age (aOR 1.23 per 5-year increase [95%CI 1.18–1.29]) (Table 3). After adjustment for age, sex and inclusion year, alcohol use of more than 20 units per week was associated with a lower odds of reporting a low-salt diet compared to 0–10 units per week (aOR 0.52 [95%CI 0.36–0.72]) (Table 3). Current smoking was associated with a lower odds of reporting a low-salt diet relative to non-smoking (aOR 0.51 [95%CI 0.39–0.65]). A history of T2D and hypertension was associated with a higher probability of reporting a low-salt diet compared to absence of these risk factors (aOR 2.09 [95%CI 1.74–2.50]) and aOR 3.28 [95%CI 2.70–4.01], respectively). The probability of a low-salt diet increased per 5-point increase in BMI (aOR 1.12 [95%CI 1.02; 1.23]) and per 5 mmHg increase in SBP (aOR 1.03 [95%CI 1.01–1.05], Table 3). Patients with CeVD and PAD were less likely to report a low-salt diet than patients with CAD (aOR 0.62 [95%CI 0.49–0.77] and 0.55 [95%CI 0.41–0.72] respectively).

3.4. Self-reported vegetarian diet: changes over time and associated patient characteristics

The prevalence of the vegetarian diet increased from 1.1 % in 1996–1997 to 2.3 % in 2018–2019 (OR 1.09 [95%CI 1.03–1.16] per 2 years) (Fig. 1). The percentage of patients reporting having previously adhered to a vegetarian diet increased from 0 to 1.3 %. Women were more likely to report a vegetarian diet than men (aOR 3.25 [95%CI

Table 1 Baseline characteristics of patients included between 1995 and 2019 reporting a low-fat, low-salt and vegetarian diet.

	Low-Fat diet N = 946 (11 %)	Low-Salt diet N = 669 (7.4 %)	Vegetarian diet* N = 118 (1.3 %)	Total N = 9005
Age (years)	63 (9)	64 (9)	60 (11)	61 (10)
Sex (female)	316 (33)	247 (37)	63 (53)	2379 (26)
Level of education				
- Low	274 (29)	201 (30)	26 (22)	2350 (26)
- Medium	411 (43)	271 (41)	33 (28)	3783 (42)
- High	261 (28)	197 (29)	59 (50)	2872 (32)
Alcohol (units/week)				
- 0–10	705 (75)	540 (81)	94 (80)	6464 (72)
- 11–20	170 (18)	93 (14)	17 (14)	1639 (18)
- >20	71 (7.5)	36 (5.4)	7 (6)	902 (10)
Smoking status				
- Never	225 (24)	173 (26)	39 (33)	2016 (22)
- Former	511 (54)	384 (57)	58 (49)	4289 (48)
- Current	210 (22)	112 (17)	21 (18)	2700 (30)
Packyears	14 [1, 29]	11 [0, 25]	6 [0, 21]	14 [2, 31]
Physical activity (METh/wk)				
- 1st tertile	367 (39)	246 (37)	28 (24)	3002 (33)
- 2nd tertile	316 (33)	220 (33)	41 (35)	2981 (33)
- 3rd tertile	263 (28)	203 (30)	49 (42)	3022 (34)
Medical history				
Type of ASCVD				
- CAD	502 (53)	331 (50)	57 (48)	4457 (50)
- CeVD	120 (13)	106 (16)	32 (27)	1949 (22)
- PAD and/or AAA	113 (12)	68 (10)	19 (16)	1266 (14)
- ASCVD at >1 location	211 (22)	164 (25)	10 (9)	1333 (15)
Type 2 Diabetes	275 (29)	196 (29)	9 (8)	1474 (16)
Hypertension	614 (65)	537 (80)	64 (55)	4998 (56)
Cardiometabolic risk factors				
BMI (kg/m^2)	27.2 (4.0)	27.1 (4.2)	25.1 (3.7)	26.9 (4.1)
SBP (mmHg)	143 (22)	145 (23)	135 (21)	96 (12)
HbA1c (%)	5.7 [5.4, 6.3]	5.7 [5.4, 6.3]	5.5 [5.3, 5.7]	5.6 [5.4, 6.0]
Non-HDL–C (mmol/L)	3.6 [2.8, 4.5]	3.5 [2.7, 4.5]	3.2 [2.6, 4.1]	3.4 [2.7, 4.3]
eGFR (mL/min/1.73 m^2)	86 [71, 97]	82 [65, 97]	96 [85, 104]	88 [74, 99]

Baseline characteristics are presented as mean (standard deviation), count (percentage) or median [interquartile range]. Characteristics are presented separately for patients who report a low-fat diet (n = 946, 11 %), low-salt diet (n = 669, 7.4 %) or vegetarian diet (n = 118, 1.3 %) as well as for all included patients (n = 9005). * 7 out of the 118 vegetarian patients reported not consuming eggs or dairy and thus classified as adhering to both the vegetarian diet and the vegan diet. ASCVD = Atherosclerotic (Cardio)Vascular disease. CeVD = Cerebrovascular Disease. PAD = Peripheral Artery Disease. AAA = abdominal aortic aneurysm. BMI = Body Mass Index. SBP = Systolic Blood Pressure. Non-HDL-c = Non-High Density Lipoprotein cholesterol. eGFR = estimated Glomerular Filtration Rate calculated using the 2021 creatinine-based equations without race [19].

2.26–4.69]) (Table 4). After adjustment for age, sex and year of inclusion, patients with a higher level of education were more likely to report a vegetarian diet (aOR 2.52 [1.57–4.14]) (Table 4). Similarly, more physically active patients were more likely to report the vegetarian diet (highest vs lowest tertile: aOR 1.66 [95%CI: 1.03–2.74]). Current smokers were less likely to report a vegetarian diet than non-smokers (aOR 0.45 [95%CI 0.26–0.77]). Patients with T2D were less likely to report a vegetarian diet than those without T2D (aOR 0.43 [95%CI 0.20–0.81]). The odds of a vegetarian diet decreased per 5-point increase in BMI (aOR 0.57 [95%CI 0.44; 0.73]), per 5 mmHg increase in SBP (aOR 0.96 [95%CI 0.91–1.00]) and per percentage-point increase in HbA1c (aOR 0.56 [95%CI 0.38–0.79], Table 4).

4. Discussion

The present study shows that the prevalence of self-reported low-fat, low-salt and vegetarian diets is currently low amongst patients with established ASCVD (2–5 % in 2018–2019). The prevalence of self-reported vegetarian diets has doubled over the last 20 years while the prevalence of the low-salt and low-fat diet decreased three to four-fold. Additionally, patients with CeVD and PAD or an AAA were less likely to report a low-salt and low-fat diet than CAD patients. Patients who currently smoked or used ≥10 units of alcohol per week were less likely to report following one of the three diets. Physical activity reduced the odds of reporting a low-salt or low-fat diet, while increasing the odds of a vegetarian diet. Similarly, older patients and patients with T2D or hypertension were more likely to report the low-fat or low-salt diet, while they were less likely to report the vegetarian diet.

The decreasing prevalence of self-reported low-fat diets is in line with results from a report of the general population in the United States that described a decrease in self-reported low-fat diets from 2.7 % in 2007–2008 to 1.5 % in 2017–2018 [20]. Interestingly, the number of patients with

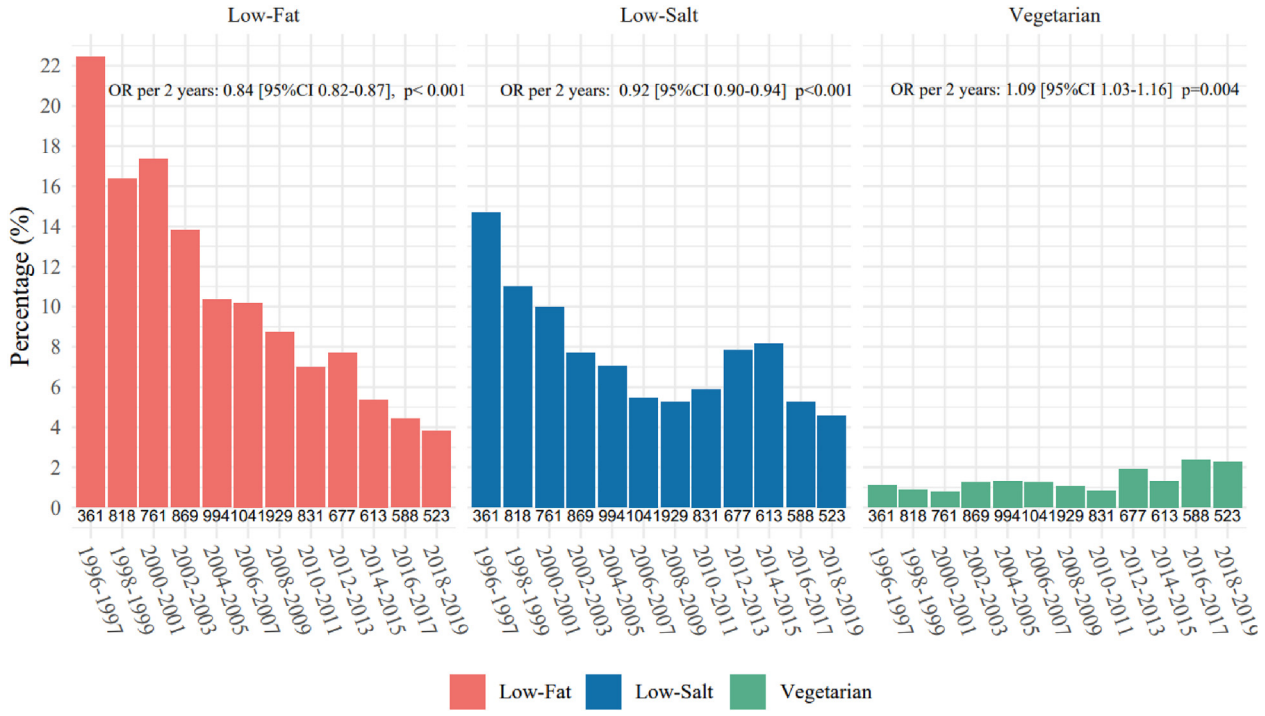

Figure 1 Self-reported diet from 1996 to 2019 in patients with established ASCVD. The proportion of patients reporting a vegetarian diet, low-fat diet or low-salt diet per 2-year period is shown with the absolute number of included patients in that period below the corresponding bars.

ASCVD reporting a low-fat diet in the present study is more than two times higher (3.8 % in 2018–2019) compared to the general population in the United States. This might be explained by the fact that the low-fat diet has been advocated for decades to reduce ASCVD [5]. The decline in the prevalence of the low-fat diet is in line with results from clinical trials which found no evidence of superiority of low-fat diets and changes in guidelines thereafter [3,5,7,12,21,22]. In the Dutch general population, while the total fat intake has fluctuated during the last two decades, saturated and *trans*-fat intake has decreased consistently in the same period, most likely as a result of a nationwide government-led program to reduce saturated fat in food [23,24]. The decreasing prevalence of the low-fat diet, might therefore not necessarily indicate any increase in intake of saturated fat.

In the present study, the prevalence of self-reported low-salt diets decreased over time and only 9 % of patients with a baseline SBP above 140 mmHg reported a low-salt diet. This is lower than the 50–65 % of patients with hypertension who report lowering dietary salt intake [25–30]. The proportion found in this study is more similar to studies in which patients were asked about adhering to a low-salt diet instead of any reduction in dietary salt (16–19 % of patients with hypertension) [31]. These results suggest that a large proportion of patients with hypertension aims to reduce dietary salt intake, but that only a small proportion actually report that as following a low-salt diet. A previous study in 4680 men and women, showed that reporting a low-salt diet is associated with a lower salt-intake as measured using 24-h urinary sodium excretion [18]. Reporting a low-salt diet was associated with 14.2 mmol lower urinary sodium urine per 24 h ($p < 0.001$) [18]. The difference of 14.2 mmol of sodium corresponds to 0.84 g of salt (NaCl) intake [32]. However, while patients who reported a low-salt diet did have a lower salt intake, intake was still above the recommended amount [18]. High sodium and salt content in processed foods, along with salt added during cooking, contributed to this [18]. The low prevalence of the self-reported low-salt diet is in sharp contrast with guidelines, which recommend reducing salt intake throughout the whole diet to lower SBP [3,7]. Reducing dietary salt intake lowers blood pressure on top of blood pressure-lowering medication and a 2.5 g per day reduction is associated with a 15 % reduced risk of CVD [13]. Receiving advice increases the odds of reporting to reduce dietary sodium (OR 4.95 [95%CI 3.93–6.25]) and knowledge regarding dietary salt and hypertension is closely related to actual behavior [33,34]. Cardiac rehabilitation programs typically contain educational sessions about diet for all patients, which might explain why CAD patients were more likely to report low-salt diets than other ASCVD patients. This highlights the importance of effective dietary education about salt and sodium reduction to all ASCVD patients. The low and declining percentage of ASCVD patients who report a low-salt diet warrants renewed attention by healthcare professionals to increase the awareness of and adherence to low-salt diets in high-risk ASCVD patients.

The present study shows an increasing proportion of patients with established vascular disease reporting a vegetarian diet. These results are in line with two previous studies in the general population. A study in apparently

Table 2 The relationship between patient characteristics and the low-fat diet in patients with established ASCVD.

	Model 1 (OR [95%CI])	Model 2 (OR [95%CI])	Model 3 (OR [95%CI])
Age (per 5 years)	1.17 [1.13–1.22]	1.18 [1.14–1.22][a]	1.19 [1.14–1.23][b]
Sex (female)	1.46 [1.26–1.68]	1.51 [1.30–1.74][c]	1.55 [1.33–1.79][d]
Inclusion year (per 2 years)	0.84 [0.82–0.87]	0.84 [0.82–0.86]	*NA*
Level of education			
- Low	reference	reference	reference
- Medium	0.92 [0.79–1.09]	1.04 [0.88–1.22]	1.06 [0.90–1.26]
- High	0.76 [0.63–0.91]	0.88 [0.73–1.05]	0.98 [0.81–1.18]
Alcohol (units/week)			
-0–10	reference	reference	reference
-11–20	0.95 [0.79–1.13]	1.01 [0.84–1.21]	0.98 [0.82–1.18]
- >20	0.70 [0.54–0.89]	0.79 [0.60–1.01]	0.74 [0.56–0.95]
Smoking status			
- Never	reference	reference	reference
- Current	0.67 [0.55–0.82]	0.79 [0.65–0.97]	0.63 [0.52–0.78]
- Former	1.08 [0.91–1.27]	1.12 [0.95–1.33]	1.06 [0.89–1.27]
Packyears (per 5 packyears)	0.98 [0.96–1.00]	0.98 [0.97–1.00]	0.96 [0.95–0.98]
Physical activity			
- 1st tertile	reference	reference	reference
- 2nd tertile	0.85 [0.73–1.00]	0.85 [0.73–1.00]	1.19 [1.01–1.42]
- 3rd tertile	0.68 [0.58–0.81]	0.69 [0.59–0.82]	1.07 [0.89–1.28]
Medical history			
Type of ASCVD			
- CAD	reference	reference	reference
- CeVD	0.52 [0.42–0.63]	0.48 [0.39–0.59]	0.42 [0.33–0.51]
- PAD and/or AAA	0.77 [0.62–0.95]	0.73 [0.59–0.91]	0.51 [0.41–0.64]
- Multiple	1.48 [1.24–1.76]	1.36 [1.14–1.62]	1.07 [0.89–1.29]
Type 2 Diabetes	2.34 [2.01–2.73]	2.18 [1.87–2.55]	2.22 [1.89–2.60]
Hypertension	1.55 [1.35–1.79]	1.39 [1.21–1.60]	1.51 [1.31–1.75]
Cardiometabolic risk factors			
BMI (per 5 kg/m^2)	1.10 [1.01–1.19]	1.13 [1.04–1.22]	1.19 [1.10–1.29]
SBP (per 5 mmHg)	1.05 [1.04–1.07]	1.03 [1.02–1.05]	1.01 [0.99–1.03]
HbA1c (per %-point)	1.28 [1.20–1.37]	1.25 [1.17–1.34]	1.21 [1.13–1.30]
Non-HDL–C (per mmol/L)	1.15 [1.09–1.21]	1.16 [1.10–1.23]	0.99 [0.93–1.06]
eGFR (per 5 mL/min/1.73 m^2)	0.95 [0.93–0.97]	0.96 [0.94–0.98]	0.99 [0.97–1.01]

Odds ratio with 95 % confidence interval indicate the odds of reporting a low-fat diet relative to the reference category or per unit increase. Results from three separate logistic regression models are presented. Model 1: unadjusted. Model 2: adjusted for age and sex. Model 3: adjusted for age, sex and year of inclusion. ASCVD = Atherosclerotic (Cardio)Vascular disease. CeVD = Cerebrovascular Disease. PAD = Peripheral Artery Disease. AAA = abdominal aortic aneurysm. BMI = Body Mass Index. SBP = Systolic Blood Pressure. Non-HDL-c = Non-High Density Lipoprotein cholesterol. eGFR = estimated Glomerular Filtration Rate calculated using the 2021 creatinine-based equations [19].

[a] Only adjusted for sex.
[b] Only adjusted for sex and year of inclusion.
[c] Only adjusted for age.
[d] Only adjusted for age and year of inclusion.

healthy individuals showed that the prevalence of people adhering to a vegetarian diet increased from 0.5 to 1.2 % between 2005 and 2017 [35]. In a study conducted in the United States in 2015, 41 % of respondents were actively reducing meat intake and 4.1 % had reduced meat intake to zero [36]. In the present study, the most important determinants of a vegetarian diet were female sex and level of education, which is consistent with previous studies [35,37]. The presence of T2D and hypertension was associated with a lower probability of reporting a vegetarian diet, while a previous study reported hypertension and T2D as reasons for choosing a vegetarian diet [16]. The present data do not show that patients with certain comorbidities such as type 2 diabetes choose the vegetarian diet to reduce the health impact of these comorbidities. Potentially, ASCVD patients who report a vegetarian diet might have a lower risk of T2D, which might explain the inverse relationship between T2D and the vegetarian diet [38]. Overall, the increasing trend of vegetarian diets might reflect a population-wide trend, which can be attributed to increasing concern about the environmental impact of dietary choices [39]. A recent meta-analysis of observational studies found that following a vegetarian diet compared to a non-vegetarian diet was associated with a reduced risk of CVD in people without CVD (RR 0.85 [95 % CI: 0.79–0.92]) [9]. However, evidence from randomized controlled trials is limited and no trials have assessed the effect of vegetarian diets on the risk of CVD events. Furthermore, few have been conducted in patients with ASCVD, who often use blood pressure and lipid-lowering medication [40]. Therefore, the actual long-term effect of a vegetarian diet on ASCVD risk in patients with and without ASCVD remains unknown.

Strengths of this study include the long period during which several self-reported diets were recorded in a large group of patients with various clinical manifestations of

Table 3 The relationship between patient characteristics and the low-salt diet in patients with established ASCVD.

	Model 1 (OR [95%CI])	Model 2 (OR [95%CI])	Model 3 (OR [95%CI])
Age (per 5 years)	1.23 [1.18–1.29]	1.24 [1.19–1.29][a]	1.24 [1.19–1.29][b]
Sex (female)	1.70 [1.44–2.01]	1.77 [1.50–2.09][c]	1.79 [1.51–2.11][d]
Inclusion year (per 2 y)	0.92 [0.90–0.94]	0.92 [0.89–0.94]	*NA*
Level of education			
- Low	reference	reference	reference
- Medium	0.83 [0.68–1.00]	0.96 [0.79–1.17]	0.98 [0.80–1.19]
- High	0.79 [0.64–0.97]	0.97 [0.79–1.20]	1.04 [0.84–1.28]
Alcohol (units/week)			
-0–10	reference	reference	reference
-11–20	0.66 [0.52–0.82]	0.72 [0.57–0.90]	0.71 [0.56–0.89]
- >20	0.46 [0.32–0.63]	0.53 [0.37–0.74]	0.52 [0.36–0.72]
Smoking status			
- Never	reference	reference	reference
- Current	0.46 [0.36–0.59]	0.57 [0.44–0.73]	0.51 [0.39–0.65]
- Former	1.05 [0.87–1.27]	1.13 [0.93–1.37]	1.10 [0.91–1.34]
Packyears (per 5 p.y.)	0.95 [0.93–0.98]	0.96 [0.94–0.98]	0.95 [0.93–0.97]
Physical activity			
- 1st tertile	reference	reference	reference
- 2nd tertile	0.89 [0.74–1.08]	0.90 [0.74–1.09]	1.07 [0.88–1.30]
- 3rd tertile	0.81 [0.66–0.98]	0.83 [0.69–1.01]	1.03 [0.84–1.27]
Medical history			
Type of ASCVD			
- CAD	reference	reference	reference
- CeVD	0.72 [0.57–0.90]	0.66 [0.52–0.83]	0.62 [0.49–0.77]
- PAD and/or AAA	0.71 [0.54–0.92]	0.66 [0.50–0.86]	0.55 [0.41–0.72]
- Multiple	1.75 [1.43–2.13]	1.58 [1.29–1.93]	1.40 [1.14–1.71]
Type 2 Diabetes	2.29 [1.91–2.73]	2.09 [1.74–2.49]	2.09 [1.74–2.50]
Hypertension	3.53 [2.92–4.31]	3.12 [2.57–3.82]	3.28 [2.70–4.01]
Cardiometabolic risk factors			
BMI (per 5 kg/m^2)	1.05 [0.96–1.16]	1.09 [0.99–1.20]	1.12 [1.02–1.23]
SBP (per 5 mmHg)	1.07 [1.05–1.09]	1.04 [1.03–1.06]	1.03 [1.01–1.05]
HbA1c (%-point)	1.27 [1.17–1.37]	1.23 [1.13–1.33]	1.21 [1.11–1.30]
Non-HDL–C (per mmol/L)	1.01 [0.99–1.03]	1.02 [1.00–10.04]	1.02 [1.00–1.04]
eGFR (per 5 mL/min/1.73 m^2)	0.90 [0.88–0.92]	0.89 [0.87–0.91]	0.90 [0.88–0.92]

Odds ratio with 95 % confidence interval indicate the odds of reporting a low-fat diet relative to the reference category or per unit increase. Results from three separate logistic regression models are presented. Model 1: unadjusted. Model 2: adjusted for age and sex. Model 3: adjusted for age, sex and year of inclusion. ASCVD = Atherosclerotic (Cardio)Vascular disease. CeVD = Cerebrovascular Disease. PAD = Peripheral Artery Disease. AAA = abdominal aortic aneurysm. BMI = Body Mass Index. SBP = Systolic Blood Pressure. Non-HDL-c = Non-High-Density Lipoprotein cholesterol. eGFR = estimated Glomerular Filtration Rate calculated using the 2021 creatinine-based equations[19].

[a] Only adjusted for sex.
[b] Only adjusted for sex and year of inclusion.
[c] Only adjusted for age.
[d] Only adjusted for age and year of inclusion.

vascular disease. A limitation of this study is that the three investigated diets were self-reported by patients in a questionnaire. Previous studies have indicated that patients who report a low-salt diet might only marginally reduce their actual salt intake as measured using urinary sodium excretion [18]. Similarly, certain diets might have been overreported by patients due to social desirability [41]. These two limitations however underline the importance of patient education by, amongst others, physicians: both to increase the number of people initiating a low-salt diet as to improve adherence. In the Netherlands, around 80 % of salt-intake originates from industrially processed high-sodium foods and 20 % from discretionary salt use [42]. Additional information on salt-intake behaviors, being not only the addition of table salt, but also using high-sodium products, and checking of sodium content on labels, was not collected in this survey, but could help identify opportunities to improve healthy eating behavior amongst ASCVD patients. Additionally, this study found that 86 % of patients with CVD report no specific diet. While this finding could be interpreted as alarming, a certain proportion of patients in this category might still adhere to a predominantly healthy diet, but not identify this diet as a specific diet. Data to substantiate or reject this hypothesis is currently however not available.

In conclusion, between 1996 and 2019 the prevalence of self-reported low-fat diets was low and has decreased, while the prevalence of vegetarian diets was low but increased in line with changes in major guidelines. Although guidelines strongly recommend reducing dietary salt intake below 6 g [3,15], the low-salt diet was reported less over time. Furthermore, patients with CeVD and PAD/AAA were less likely to report a low-salt diet. Renewed action is needed to increase awareness of the importance of low-salt diets and promote its adherence in ASCVD patients.

Table 4 The relationship between patient characteristics and the vegetarian diet in patients with established CVD.

	Model 1 (OR, 95%CI)	Model 2 (OR, 95%CI)	Model 3 (OR, 95%CI)
Age (per 5 years)	0.99 [0.91–1.09]	1.01 [0.93–1.10][a]	1.01 [0.92–1.10][b]
Sex (female)	3.25 [2.26–4.69]	3.26 [2.26–4.71][c]	3.25 [2.25–4.69][d]
Inclusion year (per 2 y)	1.09 [1.03–1.16]	1.09 [1.03–1.16]	*N/A*
Level of education			
- Low	reference	reference	reference
- Medium	0.79 [0.47–1.33]	0.95 [0.56–1.61]	0.93 [0.55–1.58]
- High	1.87 [1.19–3.03]	2.67 [1.67–4.38]	2.52 [1.57–4.14]
Alcohol (units/w)			
-0–10	reference	reference	reference
-11–20	0.71 [0.41–1.16]	0.93 [0.53–1.54]	0.96 [0.54–1.59]
- >20	0.53 [0.22–1.06]	0.75 [0.31–1.53]	0.78 [0.32–1.59]
Smoking status			
- Never	reference	reference	reference
- Current	0.40 [0.23–0.67]	0.42 [0.24–0.71]	0.45 [0.26–0.77]
- Former	0.69 [0.46–1.05]	0.86 [0.57–1.32]	0.88 [0.58–1.34]
Packyears (per 5 p.y.)	0.89 [0.83–0.94]	0.90 [0.85–0.96]	0.91 [0.86–0.97]
Physical activity (MET h/week)			
- 1st tertile	reference	reference	reference
- 2nd tertile	1.48 [0.92–2.42]	1.54 [0.95–2.53]	1.37 [0.84–2.27]
- 3rd tertile	1.75 [1.11–2.83]	1.92 [1.21–3.11]	1.66 [1.03–2.74]
Medical history			
Type of ASCVD			
- CAD	reference	reference	reference
- CeVD	1.29 [0.82–1.98]	0.95 [0.6–1.49]	0.98 [0.62–1.54]
- PAD and/or AAA	1.18 [0.68–1.95]	0.97 [0.56–1.62]	1.13 [0.64–1.9]
- Multiple	0.58 [0.28–1.09]	0.56 [0.27–1.06]	0.62 [0.29–1.16]
Type 2 Diabetes	0.42 [0.20–0.78]	0.43 [0.20–0.8]	0.43 [0.20–0.81]
Hypertension	0.95 [0.66–1.37]	0.87 [0.60–1.27]	0.85 [0.58–1.23]
Cardiometabolic risk factors			
BMI (per 5 kg/m^2)	0.51 [0.39–0.67]	0.58 [0.45–0.73]	0.57 [0.44–0.73]
SBP (per 5 mmHg)	0.95 [0.90–0.99]	0.94 [0.90–0.99]	0.96 [0.91–1.00]
HbA1c (%-point)	0.58 [0.40–0.8]	0.55 [0.37–0.77]	0.56 [0.38–0.79]
Non-HDL–C (per mmol/L)	0.94 [0.80–1.09]	0.92 [0.78–1.07]	0.98 [0.83–1.14]
eGFR (per 5 mL/min/1.73 m^2)	1.12 [1.06–1.19]	1.10 [1.03–1.19]	1.08 [1.01–1.17]

The odds ratio with a 95 % confidence interval indicates the odds of reporting a vegetarian diet relative to the reference category or per unit increase. Results from three separate logistic regression models are presented. Model 1: unadjusted. Model 2: adjusted for age and sex. Model 3: adjusted for age, sex and year of inclusion. ASCVD = Atherosclerotic (Cardio)Vascular disease. CeVD = Cerebrovascular Disease. PAD = Peripheral Artery Disease. AAA = abdominal aortic aneurysm. BMI = Body Mass Index. SBP = Systolic Blood Pressure. Non-HDL-c = Non-High Density Lipoprotein cholesterol. eGFR = estimated Glomerular Filtration Rate calculated using the 2021 creatinine-based equations [19].

[a] Only adjusted for sex.
[b] Only adjusted for sex and year of inclusion.
[c] Only adjusted for age.
[d] Only adjusted for age and year of inclusion.

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Declaration of competing interest

The authors report no conflict of interest.

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Appendix A. Supplementary data

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