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FULL RESEARCH PAPER
Prevention

Treatment target achievement after myocardial infarction and ischaemic stroke: cardiovascular risk factors, medication use, and lifestyle: the Tromsø Study 2015–16

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Aims To investigate European guideline treatment target achievement in cardiovascular risk factors, medication use, and lifestyle, after myocardial infarction (MI) or ischaemic stroke, in women and men living in Norway.

Methods and results In the population-based Tromsø Study 2015–16 (attendance 65%), 904 participants had previous validated MI and/or stroke. Cross-sectionally, we investigated target achievement for blood pressure (<140/90 mmHg, <130/80 mmHg if diabetes), LDL cholesterol (<1.8 mmol/L), HbA1c (<7.0% if diabetes), overweight (body mass index (BMI) <25 kg/m^2, waist circumference women <80 cm, men <94 cm), smoking (non-smoking), physical activity (self-reported >sedentary, accelerometer-measured moderate-to-vigorous ≥150 min/week), diet (intake of fruits ≥200 g/day, vegetables ≥200 g/day, fish ≥200 g/week, saturated fat <10E%, fibre ≥30 g/day, alcohol women ≤10 g/day, men ≤20 g/day), and medication use (antihypertensives, lipid-lowering drugs, antithrombotics, and antidiabetics), using regression models. Proportion of target achievement was for blood pressure 55.2%, LDL cholesterol 9.0%, HbA1c 42.5%, BMI 21.1%, waist circumference 15.7%, non-smoking 86.7%, self-reported physical activity 79%, objectively measured physical activity 11.8%, intake of fruit 64.4%, vegetables 40.7%, fish 96.7%, saturated fat 24.3%, fibre 29.9%, and alcohol 78.5%, use of antidiabetics 83.6%, lipid-lowering drugs 81.0%, antihypertensives 75.9%, and antithrombotics 74.6%. Only 0.7% achieved all cardiovascular risk factor targets combined. Largely, there was little difference between the sexes, and in characteristics, medication use, and lifestyle among target achievers compared to non-achievers.

Conclusion Secondary prevention of cardiovascular disease was suboptimal. A negligible proportion achieved the treatment target for all risk factors. Improvement in follow-up care and treatment after MI and stroke is needed.

Keywords Epidemiology • Cardiovascular disease • Myocardial infarction • Stroke • Secondary prevention

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Introduction

Favourable lifestyle changes and medication adherence after cardiovascular disease (CVD) survival are associated with improved prognosis and lower mortality.[1] Despite the known advantages of secondary prevention and emphasis on the use of guidelines in clinical practice,[2,3] large multicentre and registry studies of patients with established CVD[4–7] have shown that treatment targets are often not achieved, increasing the risk of recurrent events. Results from the repeated EUROASPIRE studies,[4,5] the longitudinal CLARIFY study[6] and the REACH registry[7] have shown suboptimal CVD secondary prevention guideline implementation across countries worldwide. These studies recruited hospitalized coronary artery disease (CAD)[4,5] or outpatient CAD[6] or CVD[7] patients, contained limited data on lifestyle factors beyond smoking[4–7] and physical activity,[5] and no data from Norway.

Norwegian register-based studies show an overall declining trend in incidence of myocardial infarction (MI)[8] and ischaemic stroke.[9] However, the risk of recurrent events after both MI[10] and stroke[11] is high, despite 80–100% of patients are prescribed medications in accordance with guideline recommendations at hospital discharge.[10–13] Two Norwegian hospital-based follow-up studies of patients after MI[14] and stroke[13] showed that CVD risk factor control is far from optimal, despite high medication adherence.

There is a need to study CVD secondary prevention in the Norwegian general population, using a holistic approach including guideline implementation of both CVD risk factors, lifestyle factors, and medication use, and to identify characteristics associated with target achievement.

The aim of this study was to investigate target achievement in accordance to the concurrent European Guidelines on CVD prevention in clinical practice[2,3] for secondary prevention including CVD risk factors measurements (blood pressure, lipids, glycated haemoglobin (HbA1c), body mass index (BMI), and waist circumference), medication use (antihypertensives, lipid-lowering drugs, antithrombotics, and antidiabetics), and a broad range of lifestyle factors (smoking, physical activity, diet, and nutrient intake) after incident MI and ischaemic stroke, using a population-based sample. We further investigated differences in women and men, between the diseases, as well as in characteristics and lifestyle factors in target achievers and non-achievers.

Methods

Study population

The Tromsø Study is an ongoing population-based study in Tromsø, the largest municipality of Northern Norway. The 77 000 inhabitants are served by one of Norway's six university hospitals. Seven surveys have been conducted between 1974 and 2016 (Tromsø 1–Tromsø 7), to which total birth cohorts and representative population samples have been invited (attendance 65–79%).[15] Data collection include questionnaires and interviews, biological sampling, and clinical examinations.

Sample

The present analysis includes participants from Tromsø 7, conducted from March 2015 to October 2016. All inhabitants 40 years and older were invited ($N = 32\,591$), of which 65% attended ($N = 21\,083$, aged 40–99 years, 53% women). Prevalence of validated incident MI and ischaemic stroke diagnosis any time between first study entry (Tromsø 1–6) and 2015 was 3% ($n = 637$, 23% women) and 1.5% ($n = 308$, 35% women), respectively. Of these, a total of 2/3 occurred ≤10 years and 1/3 ≤ 5 years before Tromsø 7. Due to diagnosis overlap ($n = 41$), the sample for analysis consisted of 904 participants (27% women) with prevalent MI and/or stroke, of which 14% had diabetes ($n = 116$). The study has been approved by the Regional Committee of Medical and Health Research Ethics (reference REC North 2019/1139), and assessed by the Norwegian Centre for Research Data (NSD Data Protection Services) (reference 886376/NSD). All participants gave written informed consent.

Case validation

Validated CVD endpoints from the Tromsø Study CVD registry were recorded from first study entry up to 31 December 2014, and were available for all participants attending Tromsø 7 and one or more of the previous six surveys. Adjudication of hospitalized and out-of-hospital incident MI and ischaemic stroke was based on information from medical records from hospitals, ambulance services, general practitioners, and nursing homes. Validation of each individual event was based on modified WHO MONICA (Multinational MONItoring of trends and determinants in cardiovascular disease)/MORGAM (Monica Risk, Genetics, Archiving, and Monograph) criteria, described in detail elsewhere.[16]

Clinical examinations and blood samples

Blood pressure was measured on the right arm, three times with 1-min intervals after 2 min seated rest by a Dinamap ProCare 300 monitor (GE Healthcare, Norway), and we used the mean of the two final readings in the analysis. Non-fasting venous blood samples were collected with standard methods, and analysed for low-density lipoprotein (LDL) cholesterol with enzymatic colorimetric methods with commercial kits on a Cobas 8000 c702 (Roche diagnostics, Mannheim, Germany) and HbA1c with high-performance liquid chromatography methods on a Tosoh G8 (Tosoh Bioscience, San Francisco, CA, USA) within 48 h at the Department of Laboratory Medicine, University Hospital of North Norway. BMI (kg/m^2) was calculated by measured height (m) and weight (kg). Waist circumference (cm) was measured at the umbilical level by a measuring tape. Trained personnel performed all measurements.

Questionnaire and accelerometer data

We used questionnaires for data on education ('*What is the highest level of education you have completed?*': primary, secondary, low or high tertiary), self-reported health ('*How do you in general consider your own health to be?*': very bad, bad, neither good or bad, good, and very good), diabetes ('*Do you have, or have you had, diabetes?*': yes, currently), smoking ('*Do you smoke daily?*': yes, currently), and self-reported leisure-time physical activity (Saltin-Grimby Physical Activity Level Scale[17]: sedentary (reading, watching TV, or other sedentary activities) or active (walking, cycling, or other forms of exercise ≥4 h/week; recreational sports, heavy gardening ≥4 h/week; hard exercise or competitive sports several times/week)).

Physical activity was also measured objectively in a randomly selected subsample with an ActiGraph wGT3X-BT accelerometer (ActiGraph, LLC, Pensacola, FL, USA), worn on the hip for 7 consecutive days and nights, described in detail elsewhere.[18] We included data on minutes in moderate-to-vigorous physical activity (MVPA) and steps per day, from participants with valid wear time of four days of at least 10 h.

Dietary data were collected via a previously validated food frequency questionnaire,[19] and food, energy-, and nutrient intakes were calculated using the food database KBS AE14 and KBS software system at University of Oslo (KBS, version 7.3.) based on the Norwegian food composition

tables 2014–15,[20] described in detail elsewhere.[21] We included data on intake of fruit, vegetables, fish, saturated fat, transfat, fibre, and alcohol, in grams per day (g/day) or week (g/week), or energy percentage of total energy intake per day (E%), using only valid data in accordance to Lundblad *et al.*[21]

For use of medication, we combined available data from questionnaires including questions ('*Do you use blood pressure lowering medication?*', '*Do you use lipid-lowering drugs?*', '*Do you use insulin?*', '*Do you use tablet for diabetes?*') and a self-reported list of brand names of regularly used medication coded according to the Anatomical Therapeutic Chemical (ATC) classification system version 2016[22] (antihypertensives ATC C02, C03, C07, C08, and C09, lipid-lowering drugs ATC C10, antithrombotics ATC B01A, and antidiabetics ATC A10, i.e. insulins A10A and oral antidiabetics A10B). Information about dosage was not available.

Analysis

In accordance with the European Guidelines on CVD prevention in clinical practice version 2012[2] and 2016,[3] we present the prevalence of secondary prevention target achievement for blood pressure <140/90 (<130/80 if diabetes) mmHg, LDL cholesterol <1.8 mmol/L, HbA1c <7.0% (i.e. <53 mmol/mol) (if diabetes), normal weight (BMI <25 kg/m^2, waist circumference <80 cm in women and <94 cm in men), non-smoking (no current daily smoking), active physical activity level (self-reported >sedentary, accelerometer-measured minutes in MVPA ≥150/min per week in ≥10 min bouts), healthy diet (intakes of fruits ≥200 g/day, vegetables ≥200 g/day, fish ≥200 g/week, saturated fat <10E%, fibre ≥30 g/day, and alcohol ≤10 g/day for women and ≤20 g/day for men), and use of antihypertensives, lipid-lowering drugs, antithrombotic drugs, and antidiabetics (if diabetes).

Results are presented as overall crude percentages, in strata of sex (age-adjusted) and sex-specific age-groups (40–64 and ≥65 years), in the overall sample (all CVD), and separately for MI and stroke (participants with both excluded). For stroke, the Norwegian LDL cholesterol target (<2.0 mmol/L if not diabetes/high risk) was added as a sensitivity analysis. Logistic regression models with age-adjustment were used to test for evidence of differences between women and men. In separate models, we added disease (MI or stroke, participants with both excluded) to test for evidence for differences in target achievement for each disease.

Further, we present differences in characteristics, medication use, and lifestyle factors (all of the above as well as accelerometer-measured number of daily steps and intake of transfat) for those achieving and not achieving the treatment target for each CVD risk factor separately, including age- and sex-adjusted mean differences or odds ratios with confidence intervals between the groups using linear or logistic regression models, for continuous variables or proportions, respectively. All analyses were performed using Stata version 16 (StataCorp. 2019. Stata Statistical Software: College Station, TX, StataCorp LLC).

Results

Study population

In the total sample of participants with CVD, mean age was 69.6 years with 30.5% in age-group 40–69 years, 31.0% had tertiary education and 46.4% reported good or very good health (*Table 1*). Valid data from accelerometers and FFQ's were available for subsamples ($n = 382$ and $n = 452$, respectively).

Cardiovascular disease risk factors, medication use, and lifestyle factors

Prevalence of target achievement for CVD risk factors varied in the total sample (*Table 2*); the lowest proportion was found for LDL cholesterol (9.0%), followed by waist circumference (15.7%), BMI (21.1%), and blood pressure (55.2%). Among participants with CVD and diabetes, 42.5% reached the HbA1c level target, and 83.6% used antidiabetics. For lifestyle factors, target achievement was lowest for objectively measured physical activity (11.8%), followed by intake of saturated fat (24.3%), fibre (29.9%), vegetables (40.7%), fruits (64.4%), and alcohol (78.5%), self-reported physical activity (79%), non-smoking (86.7%), and intake of fish (96.7%). Approximately three out of four used antithrombotics (74.6%) and antihypertensives (75.9%), and four out of five used lipid-lowering drugs (81.0%). In total, 54.9% used both antihypertensives, lipid-lowering drugs, and antithrombotics combined.

Target achievement and medication use were similar in women and men (*Table 2*), except for abdominal overweight and vegetable intake, which were higher in women ($P < 0.001$ and $P = 0.001$, respectively). In separate analysis of stroke, the use on antihypertensives was lower in women than in men (Supplementary material online, *Table S2*). Target achievement was similar in both diseases (*Table 2*, Supplementary material online, *Tables S1* and *S2*), except for

Table 1 Participant characteristics in women and men with cardiovascular disease combined and separately for myocardial infarction and ischaemic stroke

Characteristics	All	Women		Men	
	CVD N = 904	MI N = 147	Stroke N = 108	MI N = 490	Stroke N = 200
Age at attendance, years	69.6 (10.2)	73.6 (10.4)	69.1 (11.5)	68.8 (9.6)	69.6 (10.2)
Age-group at attendance 40–64 years, %	30.5 (276)	16.3 (24)	36.1 (39)	34.3 (168)	26.0 (52)
Age at diagnosis, years	59.3 (11.3)	64.5 (10.4)	59.6 (13.7)	57.3 (10.5)	61.5 (11.2)
Diabetes, %	14.0 (116)	18.5 (24)	13.5 (12)	14.2 (65)	11.1 (21)
Education tertiary, %	31.0 (264)	13.5 (18)	28.2 (29)	36.3 (169)	30.3 (57)
Self-reported health good/very good, %	46.4 (410)	47.1 (65)	43.0 (46)	47.9 (230)	40.4 (80)

Values are means (standard deviations) and percentages (numbers). The Tromsø Study 2015–16.
CVD, cardiovascular disease (myocardial infarction and/or ischaemic stroke); MI, myocardial infarction.

Table 2 Secondary prevention target achievement for cardiometabolic risk factors, medication use, and lifestyle, in women and men with cardiovascular disease (myocardial infarction and/or ischaemic stroke)

Target achievement, %	All	All women	Women		All men	Men		P*	P**
	N = 904	N = 247	40–64 years N = 62	65+ years N = 185	N = 657	40–64 years N = 214	65+ years N = 443		
Blood pressure	55.2 (453)	52.3 (105)	74.1 (40)	42.2 (65)	56.0 (248)	69.4 (136)	51.0 (212)	0.385	0.647
LDL cholesterol	9.0 (81)	7.0 (17)	9.8 (6)	6.0 (11)	9.7 (64)	10.4 (22)	9.5 (42)	0.212	0.778
HbA1c[a]	42.5 (48)	44.1 (15)	37.5 (3)	46.2 (12)	41.0 (33)	28.0 (7)	46.4 (26)	0.883	0.614
Body mass index	21.1 (188)	23.2 (58)	31.2 (19)	21.4 (39)	20.2 (130)	15.1 (32)	22.4 (98)	0.338	0.059
Waist circumference	15.7 (140)	8.5 (21)	11.7 (7)	7.7 (14)	18.5 (119)	17.9 (38)	18.5 (81)	<0.001	0.235
Antihypertensives	75.9 (686)	73.3 (182)	58.0 (36)	78.9 (146)	77.4 (504)	69.6 (149)	80.1 (355)	0.206	0.017
Lipid-lowering drugs	81.0 (732)	77.5 (190)	77.4 (48)	76.8 (142)	82.4 (542)	85.0 (182)	81.3 (360)	0.102	<0.001
Antithrombotic drugs	74.6 (695)	72.9 (180)	85.5 (53)	68.7 (127)	78.3 (515)	82.7 (177)	76.3 (338)	0.239	0.287
Antidiabetics[a]	83.6 (97)	75.8 (25)	87.5 (7)	69.2 (18)	88.0 (72)	96.0 (24)	84.2 (48)	0.107	0.988
Non-smoking	86.7 (770)	86.6 (208)	75.4 (46)	90.0 (162)	88.3 (562)	81.0 (171)	89.7 (391)	0.496	0.244
Physical activity self-report	79.0 (641)	77.3 (156)	87.9 (51)	71.9 (105)	79.6 (485)	82.5 (170)	78.6 (315)	0.490	0.412
Physical activity accelerometer[b]	11.8 (45)	10.6 (11)	23.8 (5)	7.1 (6)	12.3 (34)	15.0 (9)	11.6 (25)	0.644	0.005
Fruit intake[c]	64.4 (291)	71.4 (73)	67.6 (25)	72.7 (48)	62.8 (218)	56.3 (63)	65.4 (155)	0.108	0.052
Vegetable intake[c]	40.7 (184)	54.5 (57)	67.6 (25)	48.5 (32)	35.9 (127)	33.0 (37)	38.0 (90)	0.001	0.190
Fish intake[c]	96.7 (437)	95.2 (98)	97.3 (36)	93.9 (62)	97.2 (339)	94.6 (106)	98.3 (233)	0.334	0.881
Saturated fat intake[c]	24.3 (110)	18.8 (21)	18.9 (7)	21.2 (14)	24.4 (89)	32.1 (36)	22.4 (53)	0.228	0.306
Fibre intake[c]	29.9 (135)	24.9 (27)	29.7 (11)	24.2 (16)	31.0 (108)	34.8 (39)	29.1 (69)	0.303	0.735
Alcohol intake[c]	78.5 (355)	79.1 (80)	73.0 (27)	80.3 (53)	79.6 (275)	70.5 (79)	82.7 (196)	0.904	0.813

Values are crude (all, age-groups) and age-adjusted (women, men) percentages with numbers of target achievement for blood pressure (<130/80 mmHg if diabetes, <140/90 mmHg if not diabetes), LDL cholesterol (<1.8 mmol/L), HbA1c (<7.0% if diabetes), body mass index (<25 kg/m^2), waist circumference (<80 cm in women, <94 cm in men), medication use (self-reported use of antihypertensives, lipid-lowering drugs, antithrombotic drugs, and antidiabetics (tablets and/or insulin), smoking (never or former smoking), physical activity (self-reported leisure time physical activity>sedentary, accelerometer-measured minutes in moderate-to-vigorous physical activity ≥150 min/week), intake of fruit (≥200 g/day), vegetables (≥200 g/day), saturated fat (<10% of the total energy intake), fibre (≥30 g/day), fish (≥200 g/week) and alcohol (≤20 g/day in men, ≤10 g/day in women). The Tromsø Study 2015–16. Numbers vary due to variation in missing values.

[a]Only participants with diabetes ($n = 116$).

[b]Only valid accelerometer data included ($n = 382$).

[c]Only valid food frequency questionnaire data included ($n = 452$).

*P-values (from logistic regression analysis) for difference between women and men (total), adjusted for age.

**P-value (from logistic regression analysis) for difference between disease (myocardial infarction or stroke) [participants with both diseases ($n = 41$) excluded], adjusted for sex and age.

use of lipid-lowering drugs and antihypertensives, which was higher among participants with MI than stroke ($P < 0.001$ and $P = 0.017$, respectively), and objectively measured physical activity, which was higher among participants with stroke than MI ($P = 0.005$). Using the Norwegian stroke-specific cut-off for LDL cholesterol changed the target achievement from 8.2 to 11.6% (Supplementary material online, *Table S2*).

Target achiever's characteristics

In total, 0.7% of the participants ($n = 6$) achieved the treatment targets for all CVD risk factors combined (Supplementary material online, *Table S3*). In analysis of single CVD risk factor treatment targets, those achieving the target were similar to those who did not achieve the target (*Tables 3* and *4*), with some exceptions. Those who achieved the blood pressure target were younger, and a smaller proportion had diabetes, compared to non-achievers (*Table 3*). Those who achieved the BMI target were older, had lower vegetable intake, a higher proportion had tertiary education, and a lower proportion had diabetes, used antihypertensives, and lipid-lowering drugs, and were non-smokers, compared to non-achievers (*Table 4*). Those who achieved the waist circumference target were more physically active across both measures, a lower proportion were women, had diabetes, used antihypertensives, and were non-smokers, compared to non-achievers (*Table 4*). Achieving the LDL cholesterol treatment target was dependent on lipid-lowering drug use (*Table 3*).

Discussion

The main findings in this study using a general Norwegian population sample of women and men with validated previous MI and ischaemic stroke is that a disappointingly low proportion reached the European treatment targets for secondary prevention. Our results are coherent with previous findings from large international multicentre- and registry studies.[4–7] Of particular worry is that <1% achieved the treatment target of both blood pressure, LDL cholesterol, and overweight combined, which is in line with findings from a nation-wide

Table 3 Characteristics, medication use, and lifestyle factors in study participants with cardiovascular disease (myocardial infarction or/and ischaemic stroke) stratified by target achievement for blood pressure and LDL cholesterol

Characteristics	Blood pressure				LDL cholesterol			
	Met[a] N = 453	Not met[a] N = 367	Diff./OR[b]	CI[b]	Met[a] N = 81	Not met[a] N = 818	Diff./ OR[b]	CI[b]
Age, years	67.2 (10.0)	72.4 (9.5)	-5.1	-6.43, -3.74*	68.8 (9.8)	69.7 (10.2)	-0.7	-3.06, 1.58
Men, %	76.8 (348)	71.9 (264)	1.2	0.83, 1.61	79.0 (64)	72.1 (590)	1.4	0.81, 2.49
Diabetes, %	8.2 (37)	21.5 (79)	0.3	0.21, 0.49*	18.4 (14)	13.7 (102)	1.5	0.79, 2.70
Education tertiary, %	33.6 (146)	28.8 (100)	1.1	0.79, 1.49	28.6 (22)	31.0 (239)	0.8	0.50, 1.42
Antihypertensives, %	76.2 (345)	78.8 (289)	1.0	0.68, 1.35	75.3 (61)	75.9 (621)	1.0	0.57, 1.66
Lipid-lowering drugs, %	84.1 (381)	80.1 (297)	1.1	0.79, 1.67	100.0 (81)	79.1 (647)	1.0	Perfect prediction
Antithrombotic drugs, %	79.3 (359)	77.9 (286)	0.9	0.63, 1.27	80.3 (65)	76.5 (626)	1.2	0.67, 2.12
Antidiabetics,[c] %	81.1 (30)	84.8 (67)	0.7	0.24, 2.02	92.9 (13)	82.4 (84)	1.8	0.21, 15.82
Non-smoking, %	84.4 (378)	90.9 (329)	0.7	0.42, 1.03	83.8 (67)	86.9 (698)	0.8	0.42, 1.49
Physically active, %	80.1 (330)	77.3 (255)	1.0	0.70, 1.47	77.0 (57)	79.4 (581)	0.8	0.47, 1.49
MVPA,[d] min/day	16.2 (18.9)	11.7 (22.7)	-0.4	-4.93, 4.22	13.4 (23.8)	14.2 (21.1)	-4.3	-11.87, 3.34
Steps,[d] steps/day	5482 (2694)	5096 (2746)	-70	-616.62, 476.16	5171 (1925)	5275 (2732)	-119	-1021.47, 781.81
Fruit intake,[e] g/day	314.5 (267.4)	316.7 (235.0)	5.1	-45.38, 55.50	336.4 (191.6)	319.7 (315.9)	15.7	-80.94, 112.34
Vegetable intake,[e] g/day	200.7 (131.6)	192.4 (145.3)	-1.3	-27.99, 25.42	188.3 (113.9)	198.1 (138.0)	-8.1	-50.04, 33.84
Saturated fat intake,[e] g/day	30.3 (13.7)	29.7 (13.1)	0.7	-1.91, 3.31	31.1 (16.2)	29.9 (13.0)	1.0	-3.08, 5.11
Transfat intake,[e] g/day	0.7 (0.4)	0.7 (0.4)	-0.0	-0.09, 0.07	0.7 (0.5)	0.7 (0.4)	0.0	-0.08, 0.17
Fibre intake,[e] g/day	26.9 (9.9)	26.3 (9.7)	-0.1	-2.08, 1.78	26.1 (10.4)	26.8 (9.8)	-0.7	-3.73, 2.41
Fish intake,[e] g/day	137.2 (75.4)	130.7 (68.5)	8.0	-6.45, 21.55	126.9 (71.1)	135.1 (73.4)	-9.2	-31.57, 13.16
Alcohol intake,[e] g/day	6.1 (12.5)	4.7 (12.7)	0.2	-2.44, 2.89	4.7 (17.9)	5.5 (12.4)	0.5	-3.67, 4.66

Diabetes: self-reported current diabetes, smoking: self-reported never or former smoking, physically active: self-reported leisure time physical activity > sedentary, daily minutes in MVPA, and steps per day: measured by accelerometer. Numbers vary due to variation in missing values. The Tromsø Study 2015–16.
Diff, difference; CI, confidence interval; g/day, grams per day; min/day, minutes per day; MVPA, moderate-to-vigorous physical activity; OR, odds ratio.
[a]Values for the met or not met the target achievement groups are crude means (standard deviations), medians (interquartile range), or proportions (numbers).
[b]Values for differences between treatment target achievers and non-achievers are age- and sex adjusted (when applicable) differences in means from linear (continuous variables) or odds ratios from logistic (proportions) regression models, with confidence intervals.
[c]Only participants with diabetes ($n = 116$).
[d]Only valid accelerometer data included ($n = 382$).
[e]Only valid food frequency questionnaire data included ($n = 452$).
*$P < 0.05$ from linear (continuous variables) or logistic (proportions) regression models between treatment target achievers and non-achievers.

Norwegian register-based analysis of CVD risk factor control at admission for acute MI for patients with prior CAD.[23]

Cardiovascular disease risk factor control and medication use

In Norway, register-based studies show that one out of four acute MI hospitalizations are recurrent events,[10,23] despite more than 90% of all patients with MI are prescribed the guideline-recommended medications at hospital discharge,[10,12] and more than 90% of patients also collect their medications at pharmacies within 6 months after the event.[12] Similarly for stroke, as shown in a single-hospital follow-up analysis of patients with ischaemic stroke or TIA in the Norwegian NORSTROKE study, the risk of recurrent events is high, despite high guideline-recommended medication use at hospital discharge.[11] High medication use at discharge was also reported in an analysis from the Nor-COAST multicentre study,[13] which included previously hospitalized patients with stroke from five Norwegian hospitals for repeated post-event follow-up. In Nor-COAST, despite high medication adherence over time, CVD risk factor control was suboptimal.[13] Similarly, the Norwegian NOR-COR study, which included previously hospitalized CAD patients from two hospitals for post-event examination, found CVD risk factors levels to be high despite more than 90% of patients reporting use of antihypertensives and lipid-lowering drugs.[14]

Strikingly, we found that only one in ten were below the threshold for the concurrent LDL cholesterol target, which in the most recent ESC guidelines for the management of dyslipidaemias presented in 2019[24] were further reduced to <1.4 mmol/L for very high CVD risk patients. As the lowering of LDL cholesterol to guideline levels[2,3,24] will have to depend on medication use, there is room for improvement by increase in dosage or change of agent, as more than 80% of the participants in our study reported using lipid-lowering drugs.

The overall medication use in our study was high, but not optimal, and slightly lower than previously found in patient-studies,[4,5,13,14] which could be due to the variation in time since the event in our study of the general population. By follow-up of two MI-cohorts in the Tromsø Study during 1994–2008 and 2007–16, respectively, we have previously found a decrease in medication use but slight overall improvement over time in target achievement for blood pressure[25]

Table 4 Characteristics, medication use, and lifestyle factors in study participants with cardiovascular disease (myocardial infarction or/and ischaemic stroke) stratified by target achievement for general and abdominal overweight

Characteristics	Body mass index				Waist circumference			
	Met[a] N = 188	Not met[a] N = 704	Diff./OR[b]	CI[b]	Met[a] N = 140	Not met[a] N = 750	Diff./ OR[b]	CI[b]
Age, years	71.1 (10.6)	69.2 (10.0)	1.8	0.20, 3.46*	70.1 (10.4)	69.5 (10.1)	1.0	-0.85, 2.83
Men, %	69.2 (130)	73.7 519)	0.8	0.59, 1.20	85.0 (119)	70.7 (530)	2.4	1.48, 3.97*
Diabetes, %	6.9 (12)	15.7 (101)	0.4	0.21, 0.72*	5.2 (7)	15.4 (105)	0.3	0.14, 0.66*
Education tertiary, %	39.0 (69)	29.1 (193)	1.7	1.19, 2.43*	38.4 (51)	29.5 (208)	1.4	0.94, 2.06
Antihypertensives, %	68.6 (129)	78.3 (551)	0.6	0.40, 0.83*	69.3 (97)	77.5 (581)	0.6	0.41, 0.93*
Lipid-lowering drugs, %	76.1 (143)	83.1 (585)	0.7	0.45, 0.99*	78.6 (110)	82.3 (617)	0.8	0.48, 1.18
Antithrombotic drugs, %	78.2 (147)	77.0 (542)	1.2	0.78, 1.72	82.1 (115)	76.3 (572)	1.4	0.90, 2.31
Antidiabetics,[c] %	75.0 (9)	84.2 (85)	0.7	0.16, 3.22	71.4 (5)	84.8 (89)	0.4	0.06, 2.20
Non-smoking, %	77.3 (143)	89.0 (616)	0.4	0.24, 0.58*	79.6 (109)	87.8 (647)	0.5	0.30, 0.80*
Physically active, %	83.5 (137)	78.6 (504)	1.5	0.92, 2.33	87.2 (109)	78.0 (529)	2.0	1.13, 3.49*
MVPA,[d] min/day	13.4 (23.7)	14.3 (21.0)	2.9	-2.51, 8.25	17.3 (28.0)	13.7 (21.6)	6.8	0.84, 12.79*
Steps,[d] steps/day	5619 (2904)	5212 (2595)	454	-178.53, 1088.04	6200 (3016)	5126 (2575)	1050	347.99, 1751.39*
Fruit intake,[e] g/day	297.4 (192.6)	327.0 (327.4)	-29.4	-101.53, 42.83	314.9 (186.2)	322.4 (323.7)	-10.9	-90.75, 69.02
Vegetable intake,[e] g/day	173.9 (120.2)	202.9 (139.1)	-31.4	-62.6, -0.10*	185.2 (128.0)	199.6 (137.8)	-7.4	-42.10, 27.33
Saturated fat intake,[e] g/day	27.3 (12.5)	30.7 (13.4)	-2.88	-5.93, 0.18	28.6 (14.2)	30.3 (13.2)	-2.5	-5.91, 0.85
Transfat intake,[e] g/day	0.6 (0.4)	0.7 (0.4)	-0.1	-0.19, -0.00	0.7 (0.4)	0.7 (0.4)	-0.1	-0.16, 0.05
Fibre intake,[e] g/day	25.5 (7.6)	27.0 (10.2)	-1.3	-3.56, 1.03	28.6 (10.0)	26.4 (9.8)	2.2	-0.35, 4.71
Fish intake,[e] g/day	119.1 (66.1)	137.6 (74.5)	-15.8	-32.45, 0.94	126.4 (67.1)	135.3 (74.4)	-13.9	-32.4, 4.55
Alcohol intake,[e] g/day	6.7 (12.5)	5.3 (12.8)	2.0	-1.09, 5.13	6.8 (12.8)	5.4 (12.9)	0.6	-2.84, 4.05

Diabetes: self-reported current diabetes, smoking: self-reported never or former smoking, physically active: self-reported leisure time physical activity > sedentary, daily minutes in MVPA, and steps per day: measured by accelerometer. Numbers vary due to variation in missing values. The Tromsø Study 2015–16.
Diff, difference; CI, confidence interval; g/day, grams per day; min/day, minutes per day; MVPA, moderate-to-vigorous physical activity; OR, odds ratio.
[a]Values for the met or not met the target achievement groups are crude means (standard deviations), medians (interquartile range), or proportions (numbers).
[b]Values for differences between treatment target achievers and non-achievers are age- and sex adjusted (when applicable) differences in means from linear (continuous variables) or odds ratios from logistic (proportions) regression models, with confidence intervals.
[c]Only participants with diabetes ($n = 116$).
[d]Only valid accelerometer data included ($n = 382$).
[e]Only valid food frequency questionnaire data included ($n = 452$).
*$P < 0.05$ from linear (continuous variables) or logistic (proportions) regression models between treatment target achievers and non-achievers.

and lipid levels.[26] However, we found little difference in change in blood pressure and lipids after incident MI when comparing various time intervals from the event to follow-up.[25,26]

The use of antihypertensives and lipid-lowering drugs was less common after stroke compared to MI, in line with findings from the REACH registry.[7] For those with CVD and diabetes combined, the use of medication was high (as not all patients with diabetes need pharmacological treatment). However, the achievement of HbA1c target was similar to that of the general diabetes population.[27] Diabetes medication use and target achievement were similar to findings from the Norwegian NOR-COR study,[14] and with less than half of those with CVD and diabetes combined reaching the current general target for diabetes control, there is potential for improvement.

Norway has one of the highest per capita gross domestic product in the world, with a well-performing health care system, low level of private financing, and cost-sharing ceilings, and the population health status and healthcare system are similar to that of the other Nordic countries.[28] However, barriers to medication adherence after both MI and stroke are multifactorial,[29–31] therefore, it is important to identify modifiable predictors for adherence, given the undisputable role of pharmacological treatment in secondary prevention of CVD.[32,33]

Lifestyle

Among the lifestyle factors, prevalence of current smoking was lower than in previous studies of patients with CAD[4,5,7,14,23] but higher than reported among patients with stroke in Nor-COAST,[13] and similar to Tromsø Study participants without prevalent CVD.[34] Compared to previous studies of self-reported physical activity levels among patients with CAD,[5,14] we found a higher proportion engaging in physical activity. However, there was a large discrepancy in target achievement defined by self-reported physical activity and objectively measured MVPA (79% vs. 12%). We have previously found weak correlation between ActiGraph measures and physical activity levels measured by the Saltin–Grimby questionnaire, but the questionnaire was found suitable for ranking of physical activity levels when measured against accelerometer.[18] The discrepancy found in this study could partly be explained by the potential of overestimation of favourable health habits in self-report data. Further, questionnaires and accelerometers are not necessarily capturing the same phenomenon

(i.e. habitual physical activity level versus a snapshot of the physical activity level in a particular time period). A high proportion had intakes within that recommended for the foods fish, fruits, and alcohol, while a much lower proportion was within the recommended intakes of the nutrients saturated fat and fibre.

Smoking, physical activity, and diet are modifiable behaviours with a huge potential for decreased risk of experiencing recurrent CVD events. Findings from the international multicentre OASIS trial[1] show that MI patients that continued smoking and did not adhere to diet and physical activity recommendations had a 3.8-fold increased risk of a recurrent MI, stroke, or death compared with those who did not smoke, modified their diet, and engaged in physical exercise. Recent findings from the NOR-COR study show that the strongest modifiable predictors of a recurrent CVD event after MI were smoking, low physical activity levels, not using lipid-lowering drugs, not taking part in cardiac rehabilitation programmes, and having diabetes.[35] An intensified focus on lifestyle modification is warranted.[36] In a study of opinions on CVD secondary prevention among European Society of Cardiology health professionals,[37] the respondents agreed that a key target should be improvement in educational support for patients, with smoking cessation, physical activity increase, dietary improvement, and motivational counselling for behavioural change as the four most sought-after priorities.

Sex differences

Several previous studies have found sex differences in secondary prevention, mainly with worse CVD risk factor management in women compared with men.[12,38,39] This was not supported by this study, where we did not find statistically significant sex differences in treatment target achievement for the main CVD risk factors blood pressure and LDL cholesterol, nor for medication use. The exception was lower use of antihypertensives in women with stroke compared with men. A larger proportion of women than men did not meet the treatment target for abdominal overweight, which is consistent with findings from the most recent EUROASPIRE study of CAD survivors[5] and also with findings from the total population unrelated to disease status.[27]

Who achieves cardiovascular disease risk factor control?

Identification of characteristics associated with CVD risk factor control can help to develop a more targeted secondary prevention strategy. However, in our study, characteristics differed little between target achievers and non-achievers. While use of lipid-lowering drugs was strongly associated with LDL cholesterol control, use of antihypertensives was not associated with achievement of blood pressure control. Older age was associated with normal BMI, while younger age with blood pressure control. Higher physical activity levels were associated with normal waist circumference. None of the dietary factors was associated with CVD risk factor target achievements. The exception was a lower vegetable intake observed among achievers of the BMI target. This may partly be explained by differences in total food intake with body size, as the recommended intakes are in absolute values,[2,3] thus not adjusted for total energy intake for the individual. For blood pressure and overweight, a smaller proportion had diabetes among target achievers than non-achievers. Education was not associated with CVD risk factor control, except for BMI. In the NOR-COR study, no association was found between education and CVD risk factor control, including BMI.[14]

Strengths and limitations

Major strengths of this study are the use of a sample from a large population-based study with reasonably high attendance, and the use of case validation and validated standardized methods to measure the risk factors and a large range of lifestyle factors including calculation of foods and nutrients from extensive food frequency questionnaires, and objective measurements of physical activity.

The main limitation of this analysis is the cross-sectional design, i.e. we could not study the change in risk factors after incident CVD event. Further, only survivors (at the time of the examination) are included, and we can assume that non-attenders (due to death, disease, or other causes) had a less favourable risk profile than attenders. In addition, valid case information was limited to participants that had participated in one or more previous Tromsø Study surveys, increasing the risk of selection bias. Selection bias is common in population-based studies, where attenders tend to be healthier than non-attenders.[40] Thus, our results can be biased towards more favourable risk factors levels than in the total population of people with CVD. Another limitation is that medication use and lifestyle factors were mainly self-reported. However, by combining questionnaire questions and ATC-coded medication lists we eliminated the risk of participants being unaware of the agents in their medications. Further, self-reporting is prone to social desirability bias, leading to overestimation of for example medication adherence, or intakes of healthy foods and physical activity, which could partly explain the discrepancy between medication use and risk factor level, and self-reported and objectively measured physical activity, respectively. However, the participants were blinded to this study research question, thus potential over-reporting is not believed to be related to diagnosis. Lastly, the association between risk factors and potential mediators, such as mental health status, were not examined in this analysis.

Conclusion

In this analysis of CVD secondary prevention using a Norwegian population-based sample, we found that treatment target achievement is suboptimal for CVD risk factors, medication use, and lifestyle, in both women and men. Only a negligible proportion achieved the treatment target for both blood pressure, LDL cholesterol, and overweight combined. In general, characteristics, medication use, and lifestyle differed little between those who achieved the targets compared to those who did not achieve the targets. There is a need for intensified improvement in follow-up care and treatment of patients after MI and stroke.

Supplementary material

Supplementary material is available at *European Journal of Preventive Cardiology* online.

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Conflict of interest: none declared.

Data availability

The data that support the findings of this study are available from the Tromsø Study, but restrictions apply to the availability of these data, which were used under licence for the current study, and so are not publicly available. The data can be made available upon application to the Data and Publication Committee for the Tromsø Study (https://uit.no/research/tromsostudy).

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