

ORIGINAL ARTICLE

Oral health and cardiovascular disease risk factors and mortality of cerebral haemorrhage, cerebral infarction and unspecified stroke in elderly men: A prospective cohort study

LISE LUND HÅHEIM¹ , PER NAFSTAD^{2,3}, PER E. SCHWARZE², INGAR OLSEN¹, KJERSTI S. RØNNINGEN⁴ & DAG S. THELLE^{5,6}

¹Department of Oral Biology, Dental Faculty, University of Oslo, Norway, ²Department of Chronic Diseases and Ageing (PN), Division of Infection Control and Environmental Health (PES), Norwegian Institute for Public Health, Norway, ³Medical Faculty, Institute of Health and Society, University of Oslo, Norway, ⁴Department of Paediatric Research, Division for Women and Children, Oslo University Hospital, Norway, ⁵Medical Faculty, Institute of Basic Medical Sciences, University of Oslo, Norway, and ⁶Department of Community Medicine and Public Health, University of Gothenburg, Sweden

Abstract

Background: Stroke mortality comprises different specific diagnoses as cerebral infarction, different haemorrhagic conditions and unspecified stroke. This study seeks to explore the prediction of oral health indicators versus known cardiovascular disease risk factors for stroke mortality. **Methods:** Altogether, 12,764 men aged 58 to 77 years were invited to the health screening Oslo II in the year 2000. It included general medical measurements and questionnaire information. Mortality data were supplied by Statistics Norway for the 6530 attending men. Cox proportional hazards regression analyses were used to establish prediction models for mortality. **Results:** Oral health by number of tooth extractions >10 was found to be an independent predictor for cerebral infarction hazard ratio = 2.92, 95% confidence interval (1.24–6.89). This was independent of HDL-Cholesterol (inversely) hazard ratio = 0.21, 95% confidence interval (0.06–0.76), frequent alcohol consumption (drinking 4–7 times per week) hazard ratio = 3.58, 95% confidence interval (1.40–9.13) and diabetes hazard ratio = 4.28, 95% confidence interval (1.68–10.89). Predictors for cerebral haemorrhage were age, hs-C-reactive protein and body mass index (inversely). Age and total cholesterol (inversely) were predictors for unspecified stroke. **Conclusions:** Oral health measured by number of tooth extractions >10 was an independent predictor for cerebral infarction in addition to age, HDL-C, hs-C-reactive protein and diabetes. The pattern of risk factors varied between the specific stroke diagnoses.

Keywords: Stroke, mortality, prospective cohort study, Cox hazards regression analysis, risk factors, oral infection

Introduction

The association between oral health and stroke has been studied using different approaches [1]. Oral health is diagnosed clinically by a partial or full mouth examination. Clinical data may include diagnostic information on bleeding by probing, which indicates gingivitis, the amount of alveolar bone loss and the depth of periodontal pockets indicating periodontitis, and tooth extraction. The study participants give self-reported information that may include number of

natural teeth, dentures, extractions or a combination. Association of any of these oral health factors has been made to total stroke and/or cerebral infarction [2–10]. Both genders were included in these studies except for two on men only [6–7].

Periodontal status grouped as periodontal disease, gingivitis, periodontitis and edentulous were found to be associated with nonfatal and fatal stroke events in the First National Examination Survey (NHANES 1) in 2000 [5]. For incident non-haemorrhagic stroke

Correspondence: Lise Lund Håheim DDS Dr Philos, Department of Oral Biology, Dental Faculty, University of Oslo, P.O.B. 1052 Blindern, Oslo, 0316, Norway. E-mail: a.l.l.haheim@odont.uio.no

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compared to no periodontal disease the relative risk (RR) was 2.11 (95% confidence interval (CI) 1.30–3.42) for periodontitis, but gingivitis and edentulous were non-significant for non-haemorrhagic strokes. Total incident stroke risk for periodontitis was RR=1.66; 95% CI 1.15–2.39 and it was non-significant for gingivitis and edentulous. Joshipura et al. followed the men of their study for 12 years. It was found that men who had 24 teeth or fewer were at higher risk for ischaemic stroke than men with 25 teeth or more, hazard ratio (HR) = 1.57; 95 CI 1.24–1.98 [6]. In addition, they found an association between baseline periodontal disease history and ischaemic stroke, HR=1.33; 95% CI 1.03–1.70. The Scottish Health Study reported that edentate persons had a higher risk for stroke related mortality with HR = 2.97; 95% CI 1.46–6.05 in an adjusted model for analyses with mean 8.0 years of follow-up [4].

In the Veterans Affairs Normative Aging and Dental Longitudinal Study, Jiminez et al. reported on the association between periodontitis and incidence of cerebrovascular disease [7]. They found that a history of periodontal infection rather than current infection measured by alveolar bone loss (comparing highest to lowest category) had an increased risk of a HR = 3.5; 95% CI 1.59–7.81. This association was stronger for men 65 years or younger with HR = 5.81; 95% CI 1.63–20.7.

Sen et al. investigated risk by periodontal disease for recurrent vascular events in patients with stroke and transient ischaemic attacks (TIA) and vascular mortality [8]. The risk level for periodontal disease was attachment loss of 5 mm or more measured around the teeth and other predictors of cardiovascular disease (CVD) as serum interleukin-6 (IL-6), C-reactive protein and soluble intracellular adhesion molecule 1 (sICAM) all known to be associated with CVD risk. Attachment loss of periodontium was associated with recurrent events in stroke and TIA patients, adjusted analyses, HR = 2.8; 95% CI 1.2–6.5. This was associated with significantly elevated levels of IL-6 and sICAM. Holmlund et al. compared risk for myocardial infarction (MI), stroke and heart failure (HF) with respect to patients with periodontitis in a follow-up analysis of mean 15.8 years [9]. They found the number of teeth to be a predictor for MI and HF but not stroke in an incidence and mortality follow-up. The authors concluded that oral health does not seem to be related to all CVD disorders.

Treatment of periodontal disease with the aim of reducing the incidence of ischaemic stroke was investigated by Lee et al. in a follow-up study comparing cases ($n=510,762$) and non-cases (208,674) of periodontal disease for approximately 10 years

[10–27]. Dental prophylaxis and intensive periodontal treatment reduced the risk among cases versus non-cases, HR = 0.7; 95% CI 0.75–0.81. Treatment of oral infections and periodontal infection in particular is important in view of its high prevalence around the world [11]. The oral cavity harbours a very high level of different bacteria with different properties including the ability to invade oral soft tissues and alveolar bone and evade the immune system [12]. Whether these oral health predictors can be viewed as causal factors or associations are unclear and they need to be studied further [13].

The incidence and mortality by different stroke diagnoses with regard to known CVD risk factors were published in 2006 with a 21-year follow-up of the Oslo Study of 1972/73 [14]. Systolic blood pressure was the sole predictor for subarachnoid haemorrhage and diastolic blood pressure and daily smoking for intracerebral haemorrhage. Cerebral infarction predictors were found to be age, total serum cholesterol, glucose, height (inversely), systolic and diastolic blood pressure and daily smoking. Fewer factors (age, diastolic blood pressure and daily smoking) predicted unspecified stroke.

The aim of this study was to assess the strength of the association between oral health factors in addition to known CVD risk factors to mortality across different stroke diagnoses in a 12.5-year follow-up of the Oslo II study of men in 2000, which was the second health screening of the Oslo Study of 1972/73.

Methods

Study cohort

Oslo II was a health study carried out between February and June 2000 [15]. The 12,764 invited men had previously taken part or had been invited but not taken part in the Oslo Study of 1972/73 [16]. This analysis is a prospective mortality follow-up of 6530 men for 12.5 years after the 2000 health screening; see the flowchart in Figure 1. All participants of the Oslo II study gave their written consent to the use of the data and biologic material on the condition that the data inspectorate and the regional ethical review board for medical research, Eastern Norway, had granted the permission, which they did. The Oslo II study followed the ethical principles outlined in the Helsinki declaration for medical research involving people.

Data collection

In the cohort, 6530 men of the 12,764 invited attended the Oslo II health screening in 2000. Information on the health of the participants was provided by

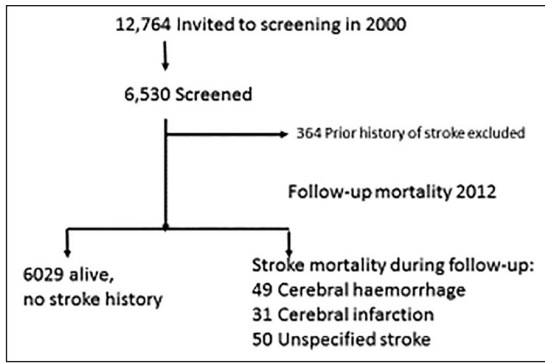


Figure 1. Flow-chart for the Oslo II study on stroke mortality of 12.5 years of follow-up.

questionnaire information, serum samples analyses and anthropologic measurements. Serum samples and ethylenediamine tetra-acetic acid (EDTA) full blood were stored at -80°C for later analyses. At the screening, 364 men reported a prior stroke and among these, 29 men died from stroke during follow-up; five from cerebral haemorrhage, five from cerebral infarction and 19 from unspecified stroke. These were excluded from further analyses. The cause of death data during the follow-up period were linked to the screening data using the unique national identification number that all Norwegians have, hence there is no loss to follow-up with regard to mortality data. Statistics Norway provided the data on cause of death from the time of screening in 2000 to the end of the follow-up period, 31 December 2012 in one linkage.

Covariates

The relation between known confounders recorded in this study for oral disease and for cardiovascular disease to tooth extractions and mortality is illustrated by a direct acyclic graph, Figure 2. General health factors in addition to age were serum estimation at the time of screening of total serum cholesterol, HDL-C, glucose non-fasting and triglycerides, all measured in mmol/l. The participants were asked how often they had drunk alcohol during the last year. The response alternatives were 4–7 times per week, 2–3 times per week, about once per week, 2–3 times per month, about once per month, a few times during the last year, did not drink alcohol last year, or have never drunk alcohol. Drinking 4–7 times per week versus any of the alternatives was used in the analyses, the variable was named Alcohol consumption 4–7 times per week or less.

Further, body mass index (BMI) in kg/m^2 , systolic blood pressure in mm Hg, daily smoking yes/no, diabetes whether type 1 or type 2 and level of education in years as a proxy for socioeconomic status were

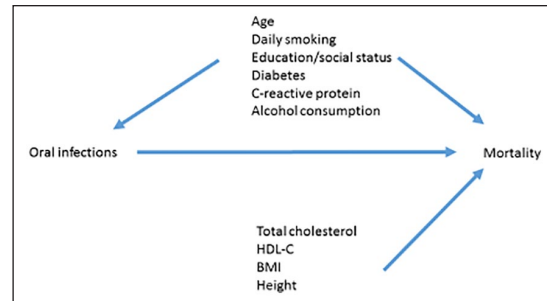


Figure 2. Direct Acyclic Graph (DAG) of the relationship between oral infections and stroke mortality by confounders for oral health and stroke.

included as covariates in the statistical analyses to reduce any selection bias between the study participants. Hs-C-reactive protein was analysed from frozen serum for 5323 participants and the number of participants is reduced in the multivariate analyses compared to univariate analyses. These factors are known to be potential confounders for the different stroke diagnoses as they are for myocardial infarction and CVD overall [1].

Self-reported oral health factors were included in the prediction analyses. The oral health questions asked were: How many teeth have you lost (except deciduous ones)?

Have you ever extracted teeth (except deciduous ones)? If yes, was it due to: Infection of the gums? Toothache in single teeth? Trauma? Other cause?

Do you have infection and /or other disease in the mouth now: Infection of the gums/periodontitis? Toothache in single teeth (except sensitive teeth)? Other infection?

How many times during the last 12 months did you go to the dentist?

Different categories and variables that combined infectious or non-infectious extractions were explored. The total number of tooth extractions was used although the cause for extractions was recorded as periodontal infection, pulpitis, trauma or another reason. The total number of tooth extractions were later converted into a dichotomized variable grouped as >10 extractions versus fewer after sensitivity analyses. Current periodontal infection and total reported oral infection including periodontal (chronic periodontitis) or pulpal (endodontic/periapical) origin and other oral infections were assessed [14].

Definition of outcome

Causes of mortality were diagnoses for stroke as defined by the International Classification of Diseases 10. Due to a few fatal cases of codes I60 subarachnoid haemorrhage ($n=4$), I61 cerebral haemorrhage

Table I. Members of the Oslo II cohort according to stroke status, person years, and relative rate ratio.

Stroke diagnosis	At risk N=6530		Person years (PY)	Relative rate ratio
	<i>n</i>	%		
No stroke history	6166	94.4	809,957	1.0 (ref)
History of stroke	364	5.6	40,264	1.2
Study population, total	6530	100	850,221	
Cerebral haemorrhage (including subarachnoid, intracerebral and other non-traumatic haemorrhage)	49	37.7	4234	1.5
Cerebral infarction	31	23.8	3084	1.3
Unspecified stroke	50	38.5	4930	1.3
Stroke, total	130	100	12,248	1.4

PY: person years.

($n=41$) and I62 other non-traumatic haemorrhage ($n=4$) were grouped and termed cerebral haemorrhage. Code I63 was cerebral infarction and I64 was unspecified cerebral stroke.

Statistical analyses

The rate of disease is presented by the number of men by cause of death or living in cases per 1000 person years (PY). Risk factors are presented by mean and standard deviation or number and percent. Main prediction analyses for the follow-up period were by Cox proportional hazards regression analyses both as age and age-adjusted univariate and multivariate analyses. The backward elimination process was used to explore the pattern of predictors for stroke mortality in the multivariate situation. The Cox analyses results are HR with 95% CI. Kaplan-Meier plots show long-term follow-up in months per stroke diagnoses and persons alive and a test of differences between the groups was performed. Missing data have not been substituted in any way. Results were significant for a p value <0.05 . The last day of follow-up was 31 December 2012. SPSS version 25 was used in the analyses.

Results

Baseline characteristics

Results are reported for 6166 men, of whom 130 died from stroke during follow-up (Table I). The haemorrhagic stroke diagnoses were grouped and 49 men died from a cerebral haemorrhage or subarachnoid haemorrhage during follow-up. In total, 31 men died from cerebral infarction and 50 from unspecified stroke as registered by Statistics Norway.

Basic characteristics comprised oral health and general health factors including known cardiovascular disease risk factors (Table II). Risk-factor patterns

differed between the three stroke categories. Triglycerides, glucose and BMI were higher in cerebral infarction as were daily smoking, diabetes and alcohol consumption. These men also reported the highest level of 77.4% of total reported oral infections and 24.8% reported number of teeth extracted >10 . Periodontal infection was highest for cerebral haemorrhage, 8.9% and in addition hs-C-reactive protein (CRP) 13.4 mmol/l. Men that did not suffer from a fatal stroke had the lowest systolic blood pressure, nearly the lowest number of daily smokers and the lowest level of total reported oral infections, and number of extractions >10 teeth was 11.3%.

Prediction analyses for stroke mortality

Age and age-adjusted univariate Cox analyses for predicting mortality showed age was clearly associated in all stroke groups (Table III). Specific general health risk factors among the 130 men suffering fatal stroke were total serum cholesterol, CRP, daily smoking and diabetes. The oral health factor number of tooth extractions >10 versus fewer was significant. For cerebral haemorrhage CRP, diabetes and number of tooth extractions >10 were significant predictors. For cerebral infarction glucose, HDL-C, BMI, diabetes and number of tooth extractions >10 were identified as predictors. Lastly, total cholesterol only predicted unspecified stroke in addition to age.

A backward elimination model was chosen for the multivariate analyses (Table IV). The start model included all variables presented in the univariate model irrespective of p value. For total stroke age, HDL-C, CRP and diabetes were significant predictors, $p<0.05$. Age, CRP and BMI were significant predictors for cerebral haemorrhage. Cerebral infarction had a number of tooth extractions >10 , HDL-C, alcohol consumption and diabetes as predictors and unspecified stroke had age, total serum cholesterol and BMI. For any of

Table II. Risk factors predictive value for persons dying from stroke by total and by sub-diagnosis and non-stroke in 6166 men aged 58–77 years, 12.5 years follow-up of the Oslo II study.

Risk factor	Any stroke	Intracerebral haemorrhage	Cerebral infarction	Unspecified stroke	No stroke history
	N=130	N=49	N=31	N=50	N=6029
	N	N	N	N	N
	%	%	%	%	%
<i>Oral health indicators</i>					
No. of tooth extraction (>10 vs fewer)	26 20.0	12 24.5	8 25.8	6 12.0	682 11.3
Periodontal infection ^a (yes/no)	8 6.7	4 8.9	2 6.9	2 4.3	364 6.0
Reported oral infection (yes/no)	87 66.9	32 65.3	24 77.4	31 62.0	2,481 41.2
<i>General health factors</i>					
	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD
Age (years)	72.4 3.1	72.6 2.5	71.2 3.8	73.0 2.9	69.0 6.4
Total serum cholesterol (mmol/l)	5.8 1.0	5.9 0.9	5.9 1.2	5.9 1.0	6.00 1.1
Triglycerides (mmol/l)	1.9 1.3	1.8 1.0	2.1 1.1	1.98 1.7	1.9 1.1
Glucose (mmol/l)	6.1 2.1	6.01 2.1	6.5 2.4	5.9 1.9	5.9 1.8
HDL-C (mmol/l)	1.4 0.4	1.4 0.4	1.2 0.3	1.4 0.5	1.42 0.4
Hs-CRP (mmol/l) ^a	7.8 34.7	13.4 57.4	5.7 5.4	3.9 4.8	3.5 7.6
Body mass index (kg/m ²)	26.4 3.7	25.4 3.4	27.7 4.0	26.6 3.6	26.4 3.4
Systolic blood pressure (mm Hg)	147.5 23.3	146.1 22.3	149.0 22.3	147.8 25.2	144.1 20.3
Daily smoker (yes/no)	30 23.1	12 24.5	8 25.8	10 20.0	1,237 20.5
Alcohol consumption (4–7 times per week or less)	20 15.4	7 14.3	7 22.6	6 12.0	731 12.1
Diabetes (Yes/no)	16 12.3	7 14.3	6 19.4	3 6.0	367 6.1
Education (1–12 years)	12.3 3.5	12.4 3.7	12.3 3.4	12.2 3.4	12.1 3.4

^aMissing data for periodontal infection *n*=325; C-reactive protein (CRP) was later analysed for men that had taken part in both the health screenings in 1972/1973 and in 2000, and for this study 4858 serum samples were analysed in total. Numbers analysed for the five groups for disease status above were 108, 39, 28, 41 and 4642 respectively.

the stroke categories one or more of these factors predicted stroke: number of tooth extractions >10, age, total serum cholesterol, HDL-C, CRP, BMI, diabetes and frequent alcohol consumption. There was no significant difference in the Kaplan-Meier plot of cumulative survival between the three specific categories of stroke as shown in Figure 3.

Discussion

The risk-factor patterns by multivariate analyses for the three subtypes of stroke and total stroke were

clearly different. The backward elimination process in the Cox analyses gave us a model of independent predictors. The only oral health factor, number of teeth extracted >10, predicted cerebral infarction, HR = 2.92 (95% CI 1.24–6.89) *p* value=0.014. Of known CVD, independent factors for cerebral infarction were HDL-C (inversely), HR = 0.21 (0.06–0.76), alcohol drinking patterns of 4–7 drinks per week HR = 3.59 (1.40–9.13) and diabetes HR = 4.28 (1.68–10.89). Predictors for cerebral haemorrhage were different with age, CRP and BMI (inversely). The only predictors for unspecified stroke

Table III. Risk factors predictive value in age and age-adjusted univariate proportional hazards regression analyses for mortality of stroke in total and by sub-diagnosis in 6166 men aged 58–77 years, 12.5-year follow-up of the Oslo II study. Results in bold are significant, $p < 0.05$.

Risk factor	Any stroke	Intracerebral haemorrhage	Cerebral infarction	Unspecified stroke
	N=130	N=49	N=31	N=50
	HR 95% CI ^a P value	HR 95% CI P value	HR 95% CI P value	HR 95% CI P value
<i>Oral health indicators</i>				
No. of tooth extraction (> 10 vs fewer)	1.79 (1.16–2.75) 0.008	2.27 (1.18–4.36) 0.014	2.66 (1.18–5.96) 0.018	0.96 (0.41–2.25) 0.920
Periodontal infection (yes/no)	0.89 (0.44–1.83) 0.760	0.66 (0.24–1.83) 0.419	0.88 (0.21–3.68) 0.856	1.40 (0.34–5.77) 0.643
Reported oral infection (yes/no)	1.30 (0.90–1.87) 0.163	1.20 (0.67–2.16) 0.55	2.28 (0.98–5.30) 0.056	1.03 (0.58–1.83) 0.914
<i>General health factors</i>				
Age (years)	1.20 (1.14–1.27) <0.001	1.22 (1.12–1.33) <0.001	1.10 (1.01–1.20) 0.02	1.28 (1.17–1.40) <0.001
Total serum cholesterol (mmol/l)	0.83 (0.70–0.98) 0.029	0.92 (0.70–1.20) 0.526	0.91 (0.65–1.27) 0.578	0.71 (0.54–0.93) 0.014
Triglycerides (mmol/l)	1.04 (0.89–1.22) 0.632	0.89 (0.66–1.22) 0.470	1.18 (0.90–1.54) 0.237	1.07 (0.83–1.38) 0.582
Glucose (mmol/l)	1.07 (0.995–1.15) 0.066	1.05 (0.93–1.20) 0.439	1.14 (1.02–1.27) 0.025	1.03 (0.89–1.19) 0.690
HDL-C (mmol/l)	0.67 (0.42–1.08) 0.100	0.98 (0.48–2.01) 0.954	0.21 (0.07–0.67) 0.008	0.82 (0.39–1.71) 0.594
Hs-CRP ^a (mmol/l)	1.01 (1.01–1.02) <0.001	1.01 (1.01–1.02) <0.001	1.01 (0.99–1.02) 0.229	1.004 (0.98–1.03) 0.731
Body mass index (kg/m ²)	1.02 (0.96–1.07) 0.540	0.92 (0.84–1.01) 0.067	1.13 (1.03–1.25) 0.014	1.04 (0.95–1.13) 0.380
Systolic blood pressure (mm Hg)	1.01 (0.997–1.01) 0.224	1.002 (0.99–1.02) 0.807	1.01 (0.99–1.03) 0.247	1.01 (0.99–1.02) 0.402
Daily smoker (yes/no)	1.62 (1.07–2.44) 0.022	1.73 (0.90–3.32) 0.102	1.77 (0.79–3.98) 0.165	1.42 (0.71–2.85) 0.326
Alcohol consumption (4–7 times per week or fewer)	1.36 (0.84–2.19) 0.209	1.25 (0.56–2.78) 0.587	2.15 (0.93–5.00) 0.074	1.03 (0.44–2.41) 0.953
Diabetes (yes/no)	2.46 (1.46–4.15) 0.001	2.86 (1.28–6.37) 0.010	4.21 (1.73–10.27) 0.002	1.15 (0.36–3.71) 0.811
Education (1–12 years)	1.002 (0.96–1.05) 0.934	1.01 (0.94–1.09) 0.824	1.01 (0.91–1.11) 0.903	0.99 (0.92–1.07) 0.863

^aHR: hazard ratio, CI: confidence interval and CRP: C-reactive protein results for $n=108$ total stroke, haemorrhagic stroke $n=39$, cerebral infarction $n=28$, and unspecified stroke $n=41$ due to missing CRP data.

were age and total serum cholesterol (inversely). Predictors for stroke overall were age, HDL-C (inversely), CRP and diabetes. Triglycerides, non-fasting glucose, systolic blood pressure, education, reported oral infection and periodontal infection were non-significant predictors in age-adjusted analyses. The results with regard to total serum cholesterol and blood pressure were influenced by the degree of secondary prophylactic treatment. In our first follow-up on incidence stroke diagnosis, nonfatal or fatal, results were given for subarachnoid haemorrhage, intracerebral haemorrhage, cerebral infarction and unspecified stroke separately [14]. Results for cerebral infarction in the same backward elimination analyses showed age, total serum cholesterol, non-fasting glucose, height (inversely), systolic

blood pressure, diastolic blood pressure and daily smoking to be independent predictors.

Our study had the power to investigate differences in prediction of factors between oral and known CVD risk factors across stroke subtypes and for total stroke. The follow-up is long and facilitated by the national service of Statistics Norway for mortality statistics. This study included men only and this is a limitation with respect to the generalizability of the results to women. In addition, this is a cohort of elderly men, but these results can be compared with regard to prediction and change with age to earlier published data except for the oral health factors [14]. The CRP analyses of stored frozen serum were short of the full attending cohort and this limited the multivariate analyses. The Oslo II study is a

Table IV. Risk factors predictive value in adjusted multivariate Cox proportional hazards regression analyses by the backward elimination procedure for mortality of stroke in total and by sub-diagnosis in 6166 men aged 58–77 years, 12.5-year follow-up of the Oslo II study.

Risk factor	Any stroke	Intracerebral haemorrhage	Cerebral infarction	Unspecified stroke
	N=98	N=35	N=26	N=37
	HR 95% CI ^a P value	HR 95% CI P value	HR 95% CI P value	HR 95% CI P value
<i>Oral health indicators</i>				
Number of teeth extractions >10			2.92 (1.24–6.89) 0.014	
<i>General health factors</i>				
Age (years)	1.20 (1.13–1.28) <0.001	1.25 (1.12–1.40) <0.001		1.30 (1.16–1.44) <0.001
Total serum cholesterol (mmol/l)				0.65 (0.47–0.89) 0.008
HDL-C (mmol/l)	0.54 (0.31–0.95) 0.032		0.21 (0.06–0.76) 0.017	
Hs-CRP ^a (mmol/l)	1.01 (1.01–1.02) <0.001	1.01 (1.01–1.02) <0.001		
Body mass index (kg/m ²)		0.86 (0.77–0.97) 0.013		
Alcohol consumption (4–7 times per week or fewer)			3.58 (1.40–9.13) 0.008	
Diabetes (yes/no)	2.13 (1.15–3.94) 0.016		4.28 (1.68–10.89) 0.002	

^aHR: hazard ratio, CI: confidence interval and CRP: C-reactive protein results for n=108 total stroke, haemorrhagic stroke n=39, cerebral infarction n=28, and unspecified stroke n=41 due to missing CRP data.

Hs-C-reactive protein (hs-CRP) was analysed from frozen serum for 5323 participants and the number of participants is reduced in the multivariate analyses compared to univariate analyses.

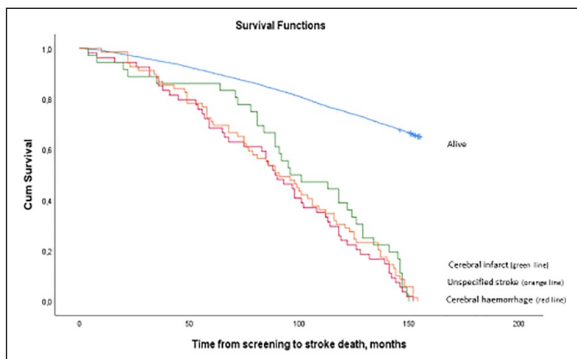


Figure 3. Cumulative survival of mortality by stroke sub-diagnosis in a 12.5-year follow-up of 6166 men with no history of stroke of the Oslo II study in 2000.

follow-up of the well described cohort, the Oslo study of 1972/73 [16].

The difference between the stroke diagnoses reflects the specific subtypes to a great extent and assists in an improved understanding of the pathophysiology. The results may reflect that the study includes elderly men and that stroke is an age-related disease. Our result on number of extractions >10 teeth of HR = 2.92 for cerebral infarction mortality is in line with other studies such as NHANES 1, the study by Jiminez et al. and

the Scottish Health Study [4, 7, 17]. That oral infection, which here is represented by a high number of extracted teeth, independently predicts cerebral infarction is important as it raises the question of whether oral infections are involved in the disease processes, which could be either through atherosclerosis and/or thrombosis. Prediction by oral health factors has also been studied with regard to atherosclerosis [18] and markers of inflammation [19]. Several studies looked at CVD as the outcome [17, 9–27]. Thus, there are a number of studies on prediction by oral health factors, indicating an association and possibly a causal relation between oral infection studied by different clinical parameters to incidence and mortality of CVD with sub-diagnoses.

Conclusions

In conclusion, this study shows that a high number of tooth extraction, more than 10 teeth extracted, predicts cerebral infarction independent of known CVD risk factors as frequent alcohol consumption (4–7 times per week), diabetes, low HDL-C level and age. This result is important in view of our understanding of which factors predict cerebral infarction mortality.

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Conflict of interest

No conflict of interest was reported by the authors with respect to the research, authorship, and/or publication of this article.

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ORCID iD

Lise Lund Håheim  <https://orcid.org/0000-0002-2012-6220>

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