Occupational noise exposure and risk of incident stroke: an analysis of five Scandinavian cohorts within the NordSound project

SUPPLEMENTAL MATERIAL

Table S1. Detailed information on the cohorts.

Cohort	**Detailed cohort information**	**Key references**	**Funding**
DCH	The inclusion criteria for the Danish Diet Cancer and Health (DCH) cohort were age between 50 and 64 y, residing in the greater Copenhagen or Aarhus area and without a cancer diagnosis. From 1993 to 1997, 160,725 Danes were invited to participate of whom 57,053 participants accepted the invitation and were enrolled in the study. All participants completed detailed questionnaires at enrolment and trained staff members measured height, weight, and waist circumference.	Tjonneland A, Olsen A, Boll K, et al. Study design, exposure variables, and socioeconomic determinants of participation in Diet, Cancer and Health: a population-based prospective cohort study of 57,053 men and women in Denmark. Scand J Publ Health 2007;35:432-41	The Danish Cancer Society
SALT[a]	The Screening Across the Lifespan Twin Study (SALT) included a total of about 45,000 twins born 1958 and earlier from the Swedish Twin Registry who were interviewed 1998-2002. SALT participants who resided in Stockholm County at recruitment (n=7,043) are included in the present project. The interview collected data on zygosity, diseases, use of medication, occupation, education and lifestyle habits. In a subgroup of around 2,500 subjects, a clinical examination was made, including blood sampling and anthropometrics as well as blood pressure measurements.	Zagai U, Lichtenstein P, Pedersen NL, Magnusson PKE. The Swedish Twin Registry: Content and Management as a Research Infrastructure. Twin Res Hum Genet. 2019 Dec;22(6):672-680. doi: 10.1017/thg.2019.99. Epub 2019 Nov 21.	Swedish Environmental Protection Agency, the Swedish Council for Health, Working Life and Social Research and the Swedish Heart-Lung Foundation. The SALT cohort was additionally supported by NIH grant 575 AG-08724. The Swedish Twin Registry is managed by Karolinska Institutet and receives funding through the Swedish Research Council under the grant no 2017-00641.
SNAC-K[a]	The Swedish National Study of Aging and Care in Kungsholmen (SNAC-K) was established 2001-2004 and included 3,363 residents aged 60-104 years in Kungsholmen, Stockholm. The aim was to investigate the ageing process and identify possible preventive strategies to improve health and care in elderly adults. Information was collected through social interviews and clinical examinations, including assessment of physical and cognitive functioning. Follow-up investigations are performed at intervals of three to six years depending on age.	Lagergren M, Fratiglioni L, Hallberg IR, et al. A longitudinal study integrating population, care and social services data. The Swedish National study on Aging and Care (SNAC). Aging Clin Exp Res 2004;16:158–68.	Swedish Environmental Protection Agency, the Swedish Council for Health, Working Life, the Swedish Research Council and Social Research and the Swedish Heart-Lung Foundation. SNAC-K was additionally funded by the Ministry of Health and Social Affairs, Sweden, Stockholm County Council and the participating Municipalities and University Departments.
PPS	The Primary Prevention Study cohort (PPS) consists of a random third of all men in the city of Gothenburg born 1915–1925, recruited in 1970–1973 (n=7,494, participation rate 75%) to study predictors of cardiovascular disease. Participants were examined by health care professionals (e.g. height, weight, systolic and diastolic blood pressures and cholesterol levels) and filled out questionnaires on background data (e.g. occupation, smoking habits, physical activity, antihypertensive	Wilhelmsen L, Tibblin G, Werkö L. A primary preventive study in Gothenburg, Sweden. Preventive Med. 1972;1:153-60. Wilhelmsen L, Berglund G, Elmfeldt D et al. The multifactor primary prevention trial in Göteborg, Sweden. Eur Heart J. 1986;7:279-88.	The Bank of Sweden Tercentenary Fund and the Swedish Medical Research Council.

	medication, psychological stress, prevalent diabetes mellitus and family history of coronary events).		
MDC	The Malmö Diet and Cancer (MDC) study is a population based prospective cohort study. Baseline examinations were conducted between 1991 and 1996, and eligible participants were men born between 1923 and 1945 and women born between 1923 and 1950, living in the city of Malmö. Swedish reading and writing skills were required. The data collection was done both using questionnaires and interviews, including data on dietary habits, socio-economics, medical history and lifestyle factors. The total number of study subjects were 28,098.	Berglund G, Elmstahl S, Janzon L et al. The Malmö Diet and Cancer study. Design and feasibility. J Intern Med 1993;233:45–51. Manjer J, Carlsson S, Elmstahl S et al. The Malmö Diet and Cancer Study: representativity, cancer incidence and mortality in participants and non-participants. Eur J Cancer Prev, 2001, 10:489–499	Swedish Research Council (VR) Infrastructure grant, Heart-Lung Foundation.
[a]This cohort is part of The Swedish Cardiovascular Effects of Air Pollution and Noise in Stockholm (CEANS) cohort, which consists of four sub-cohorts of persons residing in Stockholm County, Sweden. Harmonisation of covariates has been conducted across the cohorts.			

Table S2. Detailed information on estimation of road traffic noise for all participating cohorts.

Cohort	**Road traffic noise estimation**	**Key references**
DCH	Calculations were conducted for the years 1995, 2000, 2005, 2010, and 2015 using the Nordic prediction method implemented in SoundPLAN (version 8.0). Various input variables were used in the model, most importantly geocode and height (floor) for each address; information on travel speed, light/heavy vehicle distributions, road type, annual average daily traffic for all Danish road links (Jensen et al 2019) and 3D information on all Danish buildings. Screening effects from buildings, terrain, and noise barriers were included. All road traffic sources within 1500 m from the receivers were included. The parameter setting were set to allow 2 reflections.	Thacher JD, Poulsen AH, Raaschou-Nielsen O, et al. High-resolution assessment of road traffic noise exposure in Denmark. Environ Res 2019; 182:109051 Jensen SS, Plejdrup MS, Hillig K. GIS-based National Road and Traffic Database 1960-2020. Aarhus University, Danish Centre for Environment and Energy 2019; Report 151
CEANS (SALT, SNAC-K)	To assess long-term individual transportation noise exposure a noise database for Stockholm County was developed representing the period from 1990 and onwards, with detailed estimation every fifth year. The database includes 3D terrain data as well as information on ground surface, road net, daily traffic flows, speed limits and percentage of heavy vehicles. To calculate noise levels for road traffic a modification of the Nordic prediction method was used, where possible reflection and shielding were taken into account by a Ground Space Index based on building density. The methodology has been developed from the one described by Ögren and Barregard (2016), which was validated against the full Nordic prediction method modelled with SoundPlan and showed coherent estimates.	Ögren M, Barregard L. Road traffic noise exposure in Gothenburg1975-2010. PLoS One. 2016;11:e015532.
PPS	Yearly average road traffic flows, speed and percentage of heavy vehicles were obtained from the environmental office of the municipality of Gothenburg and the traffic office of the municipality of Mölndal. The traffic flow estimations were based on measurements for all major and medium links but used a standard default flow for very small streets. Terrain data and building footprints were obtained from Lantmäteriet and road links from the Swedish National Traffic Administration. Noise barriers of at least 2 m height and 100 m length were also included, and earth berms were included in the terrain model. To save calculation time and reduce demands on detailed input data a simplified methodology was used for multiple reflections in dense urban areas.	Ögren M, Barregard L. Road traffic noise exposure in Gothenburg1975-2010. PLoS One. 2016;11:e015532.
MDC	Estimated for the years 1990, 2000 and 2010, using the Nordic Prediction Method implemented in SoundPLAN (version 8.0, SoundPLAN Nord ApS). Input variables included geocode, information on annual average daily traffic for all road links in Malmö municipality, distribution of light/heavy traffic, signposted travel speed and road type and polygons for all buildings in Malmö. All road traffic sources within 1000m from the receivers were included. Traffic data were retrieved from a regional emission database (Rittner et al. 2020). The screening effects from buildings were included and ground softness considered. The parameter setting in the models were set to allow 2 reflections and receivers placed at 2m height.	Rittner R, Gustafsson S, Spanne M, Malmqvist E. Particle concentrations, dispersion modelling and evaluation in southern Sweden, SN Applied Sciences 2020;2:1013.

Table S3. Distribution of baseline categorical occupational noise exposure.

	Noise category				
Cohort	**<70 dB(A) n/(%)**	**70-74 dB(A) n/(%)**	**75-79 dB(A) n/(%)**	**80-84 dB(A) n/(%)**	**≥85 dB(A) n/(%)**
DCH	28,794 (60.9)	10,419 (22.0)	4,183 (8.8)	1,827 (3.9)	2,087 (4.4)
SNAC-K	916 (79.2)	129 (11.2)	68 (5.9)	39 (3.4)	5 (0.4)
SALT	3,959 (67.2)	831 (14.1)	505 (8.6)	541 (9.2)	55 (0.9)
MDC	13,448 (69.5)	2,733 (14.1)	1617 (8.4)	927 (4.8)	625 (3.2)
PPS	1,928 (41.2)	615 (13.1)	692 (14.8)	811 (17.3)	635 (13.6)
TOTAL	49,045 (62.6)	14,727 (18.7)	7,065 (9.1)	4,145 (5.3)	3,407 (4.4)

Table S4. Association between baseline occupational noise exposure and stroke incidence with additional adjustments.

	Model 3[a]	**Model 3[b] plus road traffic noise**	**Model 3[c] plus BMI**	**Model 3[d] removal of PPS cohort**	**Model 3[d] removal of DCH cohort**
		HR (95% CI)	**HR (95% CI)**	**HR (95% CI)**	**HR (95% CI)**
Occupational noise, all strokes					
<70 dB(A)	Reference	Reference	Reference	Reference	Reference
70-74 dB(A)	1.01 (0.95-1.07)	0.98 (0.92-1.05)	1.00 (0.94-1.06)	0.99 (0.93-1.05)	1.07 (0.96-1.18)
75-79 dB(A)	1.02 (0.94-1.10)	1.00 (0.91-1.09)	1.01 (0.93-1.09)	1.02 (0.94-1.11)	1.02 (0.91-1.15)
80-84 dB(A)	1.00 (0.91-1.10)	0.96 (0.85-1.08)	0.99 (0.90-1.09)	1.00 (0.89-1.12)	0.97 (0.86-1.11)
≥85 dB(A)	1.01 (0.91-1.12)	1.04 (0.92-1.17)	1.00 (0.90-1.10)	1.07 (0.95-1.20)	0.94 (0.80-1.09)
Occupational noise, ischaemic strokes					
<70 dB(A)	Reference	Reference	Reference	Reference	Reference
70-74 dB(A)	1.03 (0.95-1.12)	1.01 (0.92-1.10)	1.02 (0.94-1.11)	1.00 (0.92-1.10)	1.10 (0.98-1.23)
75-79 dB(A)	1.08 (0.98-1.20)	1.08 (0.96-1.21)	1.07 (0.97-1.19)	1.08 (0.96-1.20)	1.11 (0.97-1.27)
80-84 dB(A)	1.09 (0.97-1.24)	1.09 (0.94-1.26)	1.08 (0.95-1.22)	1.10 (0.95-1.27)	1.04 (0.90-1.21)
≥85 dB(A)	1.06 (0.92-1.21)	1.09 (0.92-1.28)	1.04 (0.91-1.19)	1.11 (0.94-1.30)	1.04 (0.87-1.25)

HR: Hazard Ratio; 95% CI: 95% Confidence Interval.

[a] Adjusted for age, sex, and calendar year at baseline (5-year periods), educational level (low, medium, high), marital status (married/cohabiting, single), area-income (quartiles), smoking status (never, former, current), and physical activity (low, medium, high).

[b] Adjusted for age, sex, and calendar year at baseline (5-year periods), educational level (low, medium, high), marital status (married/cohabiting, single), area-income (quartiles), smoking status (never, former, current), physical activity (low, medium, high), and adjustment for road traffic noise (1 year-average) among those with no missing address/exposure history (N=71,628).

[c] Adjusted for age, sex, and calendar year at baseline (5-year periods), educational level (low, medium, high), marital status (married/cohabiting, single), area-income (quartiles), smoking status (never, former, current), physical activity (low, medium, high), and BMI.

[d] Adjusted for age, sex, and calendar year at baseline (5-year periods), educational level (low, medium, high), marital status (married/cohabiting, single), area-income (quartiles), smoking status (never, former, current), and physical activity (low, medium, high).

Table S5. Association between baseline occupational noise exposure and stroke incidence in each cohort.

	DCH		SNAC-K		SALT		MDC		PPS	
	N cases	**Model 3[a] HR (95% CI)**	**N cases**	**Model 3[a] HR (95% CI)**	**N cases**	**Model 3[a] HR (95% CI)**	**N cases**	**Model 3[a] HR (95% CI)**	**N cases**	**Model 3[a] HR (95% CI)**
Occupational noise, all strokes										
<70 dB(A)	2568	Reference	96	Reference	351	Reference	1072	Reference	439	Reference
70-74 dB(A)	936	0.97 (0.89-1.04)	12	0.78 (0.42-1.46)	69	0.91 (0.70-1.19)	272	1.07 (0.93-1.23)	166	1.19 (0.99-1.43)
75-79 dB(A)	437	1.00 (0.90-1.11)	9	1.66 (0.81-3.40)	60	0.92 (0.69-1.22)	153	1.05 (0.88-1.26)	159	1.03 (0.84-1.25)
≥80 dB(A)	434	1.05 (0.94-1.16)	3	0.50 (0.15-1.65)	44	0.68 (0.49-0.95)	175	1.10 (0.92-1.31)	322	0.98 (0.83-1.15)

HR: Hazard Ratio; 95% CI: 95% Confidence Interval.

[a] Adjusted for age, sex, and calendar year at baseline (5-year periods), education level (low, medium, high), marital status (married/cohabiting, single), area-income (quartiles), smoking status (never, former, current), and physical activity (low, medium, high).

Figure S1. Directed acyclic graph on covariates for assessment of the direct effect of occupational noise for development of stroke.

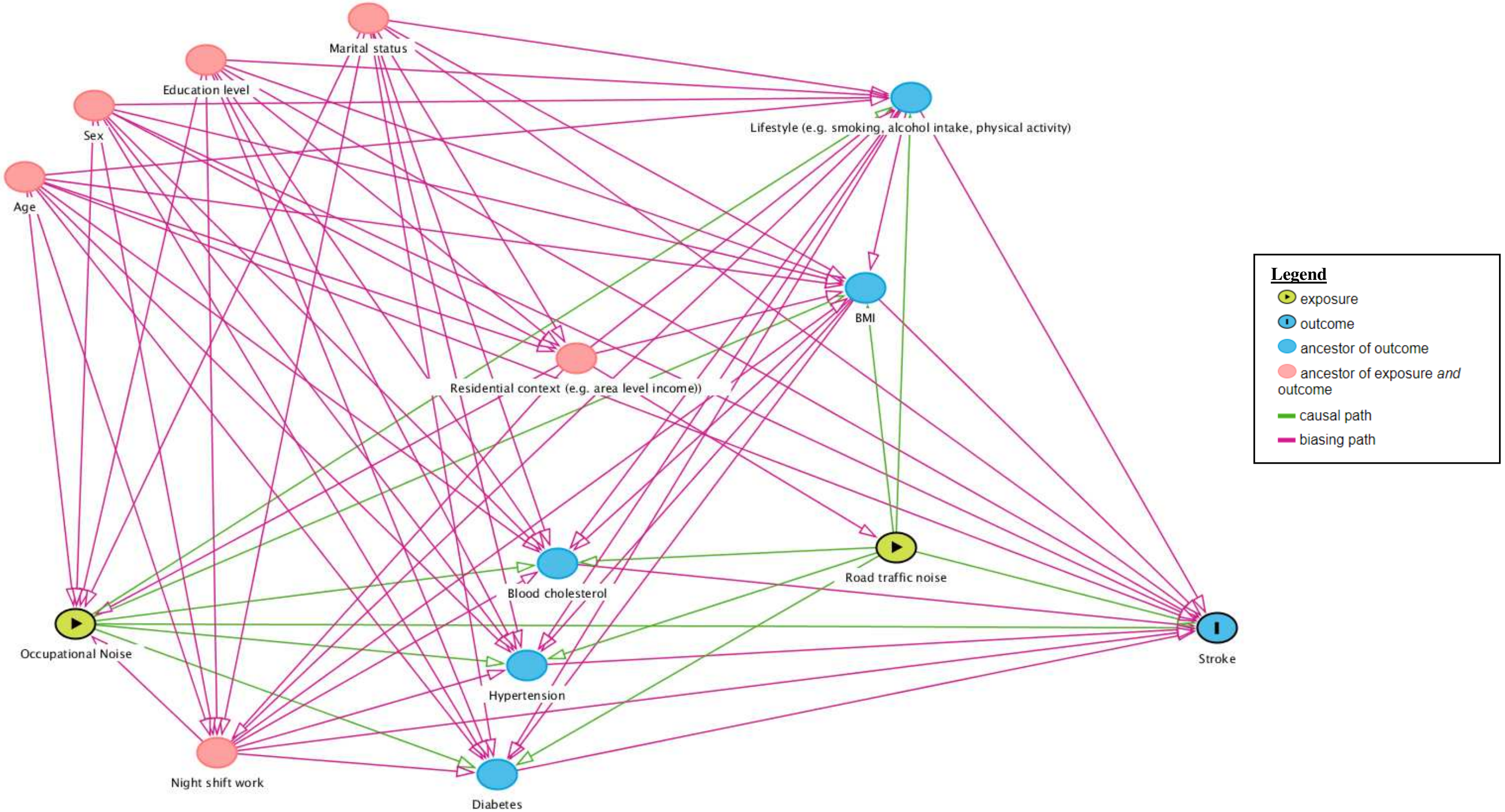

Figure S2. Selection of cohort participants.