

Occupational Noise Exposure and the Risk of Stroke

Zara A. Stokholm, MD; Jens Peter Bonde, DMSc; Kent L. Christensen, MD;
Åse M. Hansen, PhD; Henrik A. Kolstad, MD

Background and Purpose—Traffic noise <60 dB(A) has been associated with an increased risk of stroke. We investigated this relationship for 80 to 86 dB(A) occupational noise.

Methods—We followed 116 568 industrial and 47 679 financial workers by linkage to Danish registries 2001 through 2007. Full-shift noise levels were estimated from subsets of workers at baseline and end of follow-up.

Results—We identified 981 stroke patients and observed a 27% increased confounder-adjusted risk of stroke for industrial compared with financial workers. However, longer duration or higher noise level within the industrial workers were unrelated to the risk of stroke.

Conclusions—Our study did not support an association between occupational noise exposure and stroke, and the higher risk among industrial workers may reflect lifestyle differences. (*Stroke*. 2013;44:3214-3216.)

Key Words: cohort studies ■ epidemiology ■ noise, occupational ■ stroke

Recently, Sørensen et al¹ reported an exposure–response relationship for traffic noise and stroke. A 2-fold increased stroke incidence² and intracerebral hemorrhage mortality³ has been suggested for workers reporting severe noise exposure. However, 2 cohort studies showed no association with traffic noise at the residence.^{4,5} Occupational noise levels are orders of magnitude higher than traffic noise levels, and studies of occupational populations are thus more likely to detect an effect, if it exists. We report the incidence of stroke in a large noise-exposed occupational cohort.

Methods

Study Population

In 2001, we identified 625 companies from 10 industrial trades with high levels of compensation claims for occupational hearing loss and 100 reference financial companies.⁶ In the national pension fund, we identified all employees (2001–2007) and their employment histories since 1964, which were complete since 1980.

During 2001 to 2003 and 2009 to 2010, we recorded mean, full-shift noise exposure levels (L_{Aeq} values in dB(A)) by personal dosimeters (Brüel & Kjær, 4443 and 4445) for 1077 workers (1268 personal measurements) from 168 randomly selected companies.⁷ We assumed a linear relationship with calendar year and predicted exposure levels by linear regression for trade since 1964.

Cases were defined by first diagnosis of stroke in the Danish National Patient Register, ICD-10 codes (DI61 [intracerebral hemorrhage], DI63 [cerebral infarction], and DI64 [stroke, unspecified]) between January 1, 2001, and December 31, 2007. Information on occupation, socioeconomic status, redemption of antihypertensive and statin medication, and vital status were obtained from national registers.

In total, 219 550 workers were used from 2001 to 2007. We excluded white-collar workers from industrial trades and blue-collar

workers from financial companies (n=56 467), participants living outside Denmark (n=164), and participants diagnosed with stroke (n=467) before baseline. The study population then consisted of 164 247 subjects.

We classified participants from the predicted noise exposure levels (L_{Aeq}) for each exposed year (T) by the following: (1) cumulated noise exposure, $10 \times \log[\sum (10 \text{ dB(A)}^{10} \times T)]$ resulting in “dB(A)-year”; (2) duration of exposure >80 and >85 dB(A), respectively; and (3) recent noise level. Additionally, we restricted analyses to industrial workers, analyzed stroke ICD-10 subcategories, first year of exposure, and average exposure level (cumulated exposure/duration of exposure) and duration of exposure in the same model, and excluded workers exposed before start of follow-up.

Statistical Analyses

Rate ratios (RRs) and 95% confidence intervals (CIs) of stroke were estimated by logistic regression using STATA 12. We adjusted for age, sex, socioeconomic status, calendar year, employment status, and antihypertensives and statins in a sensitivity analysis.

Results

We identified 981 incident cases of stroke. At baseline, industrial workers were younger, more often men, had lower socioeconomic status, and slightly lower redemption rates of antihypertensives and statins than the reference group. Industrial workers showed higher risk of stroke than financial workers (adjusted RR, 1.27; 95% CI, 1.04–1.54). Sex and occupation showed no significant interaction ($P=0.67$), and we did not stratify by sex.

Crude analyses showed an 8-fold increased risk of stroke for the highest exposed (≥ 100 dB(A)-years), and the trend RR was 1.04 (95% CI, 1.03–1.05; Table 1). Adjusted analyses

Received July 15, 2013; accepted July 22, 2013.

From the Department of Occupational Medicine, Danish Ramazzini Centre, Aarhus University Hospital, Denmark (Z.A.S., H.A.K.); Department of Occupational and Environmental Medicine, Bispebjerg Hospital, Denmark (J.P.B.); Department of Internal Medicine and Cardiology A, Aarhus University Hospital, Denmark (K.L.C.); and Department of Public Health, University of Copenhagen, Denmark (Å.M.H.).

Correspondence to Zara A. Stokholm, MD, Department of Occupational Medicine, Danish Ramazzini Centre, Aarhus University Hospital, Nørrebrogade 44, 8000 Aarhus C, Denmark. E-mail: zarastok@rm.dk

© 2013 American Heart Association, Inc.

Stroke is available at <http://stroke.ahajournals.org>

DOI: 10.1161/STROKEAHA.113.002798

Table 1. Association of Stroke With Cumulative Noise Exposure for Industrial and Financial Workers

Cumulative Noise Exposure (dB(A)-year)	Person-Years	Cases	Crude RR (95% CI)	P Value	Adjusted RR (95% CI)	P Value
<75	93 424	47*	1.00		1.00	
75–79	139 819	90	1.16 (0.81–1.65)	0.420	0.80 (0.56–1.15)	0.223
80–84	192 520	206	1.95 (1.42–2.68)	<0.001	1.04 (0.75–1.44)	0.834
85–89	182 837	199	1.97 (1.44–2.72)	<0.001	1.11 (0.79–1.55)	0.559
90–94	240 630	300	2.09 (1.53–2.86)	<0.001	1.08 (0.77–1.51)	0.673
95–99	69 334	124	3.01 (2.14–4.23)	<0.001	0.99 (0.68–1.42)	0.939
≥100	3235	15	7.88 (4.39–14.15)	<0.001	1.49 (0.82–2.73)	0.193
Trend RR†	921 799	981	1.04 (1.03–1.05)	<0.001	1.01 (0.99–1.02)	0.129
Trend RR excluding financial workers†	644 813	746	1.05 (1.03–1.06)	<0.001	1.00 (0.98–1.01)	0.915

Adjusted for age, sex, socioeconomic status, calendar year, and employment status.

*Reference group of workers used <100% of a year and financial workers.

†RR by 1-unit dB(A)-year increase.

showed an RR of 1.49 (95% CI, 0.82–2.73) for the highest exposed and a trend RR of 1.01 (95% CI, 0.99–1.02). Similar results were seen for industrial workers only.

Increased adjusted RRs between 1.07 and 1.49 were seen for different exposure durations >80 dB(A) and >85 dB(A), but no positive trends (Table 2), neither for industrial workers only, were seen.

Recent noise exposure level >80 dB(A) indicated an increased risk of stroke (adjusted trend RR, 1.01; 95% CI, 0.99–1.03), which vanished for industrial workers only (adjusted trend RR, 0.96; 95% CI, 0.90–1.03).

Analyses by stroke subcategories, adjusted for antihypertensives or statins, by first year of exposure, including average exposure level and duration of noise exposure in

the same models, or by cumulative exposure among first-exposed ≥2001 showed no risk trends, but a trend RR of 1.35 (95% CI, 0.81–2.26) by duration of exposure >85 dB(A) among industrial workers first exposed between 2001 and 2007.

Discussion

Industrial workers showed a 27% higher risk of stroke than financial workers, but not significantly related with noise levels.

The lack of an exposure-response relationship could be explained by nondifferential misclassification at the trade and calendar year level. But a higher variability is assumed within rather than between workers, and our exposure measure should

Table 2. Association of Stroke With Duration of Exposure >80 dB(A) and >85 dB(A) for Industrial and Financial Workers

Duration of Exposure	Person-Years	Cases	Crude RR (95% CI)	P Value	Adjusted RR (95% CI)	P Value
<70 dB(A)	276 986	235	1.00		1.00	
>80 dB(A)						
<3 yr	278 388	256	1.19 (0.99–1.43)	0.052	1.38 (1.10–1.73)	0.006
3–9 yr	271 825	316	1.31 (1.11–1.55)	0.002	1.22 (0.99–1.51)	0.066
10–19 yr	74 952	127	1.87 (1.50–2.32)	<0.001	1.28 (0.99–1.64)	0.057
≥20 yr	19 648	47	2.66 (1.94–3.64)	<0.001	1.13 (0.80–1.59)	0.481
Trend RR*	921 799	981	1.04 (1.03–1.05)	<0.001	1.01 (0.99–1.02)	0.232
Trend RR excluding financial workers*	644 813	746	1.04 (1.03–1.05)	<0.001	1.00 (0.99–1.01)	0.975
>85 dB(A)						
<3 yr	152 437	200	1.55 (1.29–1.88)	<0.001	1.30 (1.01–1.68)	0.025
3–9 yr	69 195	88	1.47 (1.15–1.87)	0.002	1.07 (0.80–1.44)	0.541
10–19 yr	14 809	38	2.90 (2.06–4.09)	<0.001	1.49 (1.02–2.19)	0.030
≥20 yr	2967	11	4.20 (2.29–7.69)	<0.001	1.39 (0.74–2.61)	0.282
Trend RR*	516 394	572	1.06 (1.05–1.08)	<0.001	1.01 (0.99–1.03)	0.139
Trend RR excluding financial workers*	239 408	337	1.05 (1.03–1.07)	<0.001	1.01 (0.99–1.03)	0.503

Adjusted for age, sex, socioeconomic status, calendar year, and employment status.

*RR by 1-year increase.

reduce nondifferential misclassification.⁸ A healthy-worker survivor effect is an alternative explanation, had analyses not been adjusted for employment status, that accounts for early termination of employment.⁹

The inconsistency of our findings compared with previous traffic studies could also be attributable to lower stress levels because noise annoyance is much lower in this population than similar level traffic noise.¹⁰

We adjusted for socioeconomic status,¹¹ but information on other potential confounders was missing. Adjustment for antihypertensives and statins only changed point estimates minimally. We previously observed in a subsample that industrial workers smoked more often than financial workers,⁷ which indicates that the overall higher risk of stroke among industrial workers may be attributable to lifestyle differences.

Two occupational^{2,3} and 1 traffic study¹ have indicated an association with stroke at noise levels from <60 to >80 dB(A).¹⁻³ The occupational studies were limited by small numbers and self-reported exposure and outcomes.

We assessed long-term noise exposure, and cases were obtained from registries, neither influenced by individual recall. Selection bias is unlikely because all Danes have free access to health care. Information on hearing protection would have been useful, although analyses by first year of exposure, a proxy of noise level at the ear, did not reflect an increased risk.

To conclude, we do not confirm an association between long-term occupational noise exposure between 80 and 86 dB(A) and stroke. Thus, we could not extend recent findings for low-level traffic noise to high-level occupational noise. Although our data suggest an increased risk of stroke for industrial workers, this does not seem preventable by reducing noise levels.

Sources of Funding

This work was supported by the Danish Working Environment Research Fund and the Danish Working Environment Authority.

Disclosures

None.

References

1. Sørensen M, Hvidberg M, Andersen ZJ, Nordsborg RB, Lillilund KG, Jakobsen J, et al. Road traffic noise and stroke: a prospective cohort study. *Eur Heart J*. 2011;32:737–744.
2. Gopinath B, Thiagalingam A, Teber E, Mitchell P. Exposure to workplace noise and the risk of cardiovascular disease events and mortality among older adults. *Prev Med*. 2011;53:390–394.
3. Fujino Y, Iso H, Tamakoshi A; JACC study group. A prospective cohort study of perceived noise exposure at work and cerebrovascular diseases among male workers in Japan. *J Occup Health*. 2007;49:382–388.
4. Beelen R, Hoek G, Houthuijs D, van den Brandt PA, Goldbohm RA, Fischer P, et al. The joint association of air pollution and noise from road traffic with cardiovascular mortality in a cohort study. *Occup Environ Med*. 2009;66:243–250.
5. Huss A, Spoerri A, Egger M, Röösli M; Swiss National Cohort Study Group. Aircraft noise, air pollution, and mortality from myocardial infarction. *Epidemiology*. 2010;21:829–836.
6. Stokholm ZA, Bonde JP, Christensen KL, Hansen AM, Kolstad HA. Occupational noise exposure and the risk of hypertension. *Epidemiology*. 2013;24:135–142.
7. Rubak T, Kock SA, Koefoed-Nielsen B, Bonde JP, Kolstad HA. The risk of noise-induced hearing loss in the Danish workforce. *Noise Health*. 2006;8:80–87.
8. Kromhout H, Symanski E, Rappaport SM. A comprehensive evaluation of within- and between-worker components of occupational exposure to chemical agents. *Ann Occup Hyg*. 1993;37:253–270.
9. Richardson D, Wing S, Steenland K, McKelvey W. Time-related aspects of the healthy worker survivor effect. *Ann Epidemiol*. 2004;14:633–639.
10. Miedema HM, Oudshoorn CG. Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals. *Environ Health Perspect*. 2001;109:409–416.
11. Addo J, Ayerbe L, Mohan KM, Crichton S, Sheldenkar A, Chen R, et al. Socioeconomic status and stroke: an updated review. *Stroke*. 2012;43:1186–1191.

Occupational Noise Exposure and the Risk of Stroke

Zara A. Stokholm, Jens Peter Bonde, Kent L. Christensen, Åse M. Hansen and Henrik A. Kolstad

Stroke. 2013;44:3214-3216; originally published online August 29, 2013;
doi: 10.1161/STROKEAHA.113.002798

Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2013 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the
World Wide Web at:

<http://stroke.ahajournals.org/content/44/11/3214>

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in *Stroke* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the [Permissions and Rights Question and Answer](#) document.

Reprints: Information about reprints can be found online at:
<http://www.lww.com/reprints>

Subscriptions: Information about subscribing to *Stroke* is online at:
<http://stroke.ahajournals.org/subscriptions/>