A comprehensive body of evidence associates certain occupations with a high risk of coronary heart disease. Less attention has been paid to the identification of occupational groups with an increased risk of stroke. Several cohort studies have reported low or average standardized mortality ratios due to stroke for occupations primarily investigated for other diseases. A high risk of stroke was found among pot emission exposed workers in a Norwegian study of aluminium smelter workers. Drivers are known to have an increased risk of coronary heart disease but no reports on the risk of stroke were found in the scientific literature. It is possible to study such associations in Denmark because all hospital admissions are recorded in the National In-patient Register and the occupation of all adults is recorded annually in an independent register.

The purpose of the present study was to estimate the risk of developing stroke among various groups of professional drivers.

MATERIALS

All gainfully employed people in Denmark aged 20–59 years in 1981 were classified according to their most important occupation in 1980. We restricted the analysis to those aged below 59 years in 1981 as only half the population above this age had a known occupation. This cohort and a sub-cohort of stable drivers, having the same occupation in 1985 as they had in 1980 or having an early pension, were followed up for first hospital admission with stroke from 1981 to 1990.

METHODS

Anyone aged 20–59 on 1 January 1981, and registered in the Central Population Register of Denmark, was included in the follow-up until 31 December 1990. All hospitalizations and all deaths during the 10 years were recorded by linkage of the population census of Denmark to the National In-patient Register and the National Death Register. Coding of occupations was done by means of the Employment Classification Module.

Employment Classification Module

Annually every Dane from the age of 16 is classified according to occupation in the Employment Classification Module (ECM). The ECM holds information on economic activity, occupational classification and industry. The occupational code is an extended classification of the International Standard Classification of Occupations (ISCO) 1958 version, including the self-employed. The industrial code is a national extension...

In the past tram and bus drivers were civil servants. In 1980 a considerable part of the city bus drivers were still salaried employees. They could thus be identified as city bus drivers. Others are wage earners and are listed with other unskilled bus drivers.

National In-patient Register and the Death Register
The National In-patient Register combines information from all 16 county registers in Denmark, and contains data for all admissions to Danish public hospitals (more than 99% of all admissions). The National In-patient Register is updated every year. First hospitalizations with stroke as the primary diagnosis (the main cause of treatment) in all Danish people treated in Danish hospitals between 1981 and 1990 are included in this study. The Personal Identification Number (PIN) from the National In-patient Register was used in the cross-linking procedure.


Central Population Register
From the Central Population Register information on gender, date and year of birth was abstracted. The Central Population Register was used to identify all persons, living in Denmark on 1 January 1981. The analysis was restricted to age groups with the highest percentage of the economically active (20–59 years).

Validity of the Basic Information
Age and gender are part of the PIN and are recorded practically without error. The completeness and accuracy of these data are shown by the fact that the matching of different registers on PIN was 100% complete. Data on occupation are not routinely checked by the primary data producers but information from various sources is compared and pooled in the ECM. A recent thesis showed that 90–96% of the bus drivers occupied in Greater Copenhagen for more than 6 months in 1980 were, according to company personnel files, also classified as working in the bus service industry. However, the occupation was not stated correctly for 23% of bus drivers. No difference in risk estimates for acute myocardial infarction was found between the correctly and the incorrectly classified bus drivers.

Analysis
Standardized Hospitalization Ratios (SHR) were calculated by dividing the observed number of deaths or hospitalizations in 1981–1990 in a given occupation by the expected number. The expected number was based on age-specific incidence rates for all gainfully employed people in Denmark on 1 January 1981. Cohort members were no longer at risk of being admitted to a hospital in Denmark (censored) from the date of first emigration or from date of death, whichever came first. Hospitalization is often an earlier endpoint than death, and therefore less susceptible to the secondary healthy-worker effect. It is a proxy measure with certain problems but with satisfactory power.

It is debatable if the group ‘all gainfully employed’ is the best standard. There are considerable differentials in risk between social groups. We adjusted for these differences by using the relevant occupational status groups as the standard instead of all gainfully employed. These groups were ‘self-employed in sales and service’ (SHR = 115 for men and 114 for women), ‘other salaried employees’ (SHR = 96 for men and 100 for women), ‘unskilled workers’ (SHR = 115 for men and 113 for women). The standardization may adjust well for lifestyle factors, but they may overadjust because occupational risk factors common for all groups in an employment status category are also adjusted for. This paper therefore presents estimates based on all economically active people as well as estimates based on the relevant employment group.

In order to estimate the risk among stable drivers we also analysed a sub-cohort of drivers in 1980 who were still drivers or who were compensated in 1985.

A relative risk ratio (RRR) was calculated by dividing one SHR by another and 95% confidence intervals (CI) for SHR and RRR were calculated assuming a binomial distribution estimated by a Poisson distribution.

RESULTS
The group ‘all drivers’ numbering 82 991 men and 5302 women was found to have an increased risk of stroke, SHR = 130 for men (95% CI : 123.6–137.5) and SHR = 148 for women (95% CI : 113.9–191.4). Standardization for employment status reduced the risk but we still found a statistically significant increased risk: SHR = 114 for men (95% CI : 108.2–120.3) and SHR = 130 for women (95% CI : 100.0–168.0). A subgroup of 50 995 male drivers had the same occupation in 1985 as in 1980, or they had become pensioners. This stable
FIGURE 1 Age-standardized (a) and age- and employment status-standardized (b) hospitalization ratios (SHR) and 95% confidence intervals for first admissions with stroke in all and in stable male drivers 1981–1990.

<table>
<thead>
<tr>
<th>Occupation</th>
<th>All: N = 8321</th>
<th>Stable: N = 5378</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-employed hauliers</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Taxi-cab owners, transport activity not elsewhere classified</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>City bus drivers</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Drivers, food industry</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Drivers, alcohol, beer and soft drinks</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Drivers, petrol, oil and asphalt</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Drivers with railway company</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Bus drivers</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Taxi-cab drivers</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Drivers, shipping company, harbour, etc.</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Drivers with haulage contractor, freight forwarder, etc.</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Removal men</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Drivers in cleansing and garbage disposal, and drivers not elsewhere classified</td>
<td>a</td>
<td>b</td>
</tr>
</tbody>
</table>

0 100 200 300 SHR
subgroup of male drivers also had an SHR of 130 (95% CI: 122.2–138.8) compared to all gainfully employed men and an SHR of 114 (95% CI: 107.0–121.6) after standardization for employment status. There were 3335 stable female drivers. Their SHR was 143 compared to all gainfully employed women; (95% CI: 105.6–194.7) and 123 after standardization for employment status (95% CI: 90.4–166.7).

Only one of the specific groups of drivers, ‘removal men’, had an SHR below average. A higher risk among the stable workers in an occupational group than among all workers often indicates that the risk may be due to occupational exposures. Such a pattern was found for male as well as for female city bus drivers.

We also found an increased relative risk ratio (RRR = 2.65; 95% CI: 1.02–5.76) for stable male city bus drivers compared to other bus drivers.

DISCUSSION

Our data suggest that professional drivers in most industries may be at increased risk of stroke. How can we explain these results? Are they due to occupational hazards or do they arise from residual confounding from lifestyle factors?

Known traditional risk factors for stroke are: age, male gender, high blood pressure, high body mass index, smoking, low social status and oral contraceptive use.5,6

Our design may control for age, gender and socio-economic status. Since smoking and social support is only weakly associated with stroke (RR = 1.25 for men and RR = 1.4 for women according to the above-mentioned study from Copenhagen,6 it is unlikely that an unequal distribution of these confounders could account for our finding across various employment strata and industries. Chance is always a possible explanation for individual results but an unlikely explanation for the consistent pattern found in this study.

The ‘primary healthy worker’ effect is difficult to estimate. It is not very likely that prevalence of stroke or hypertension should encourage people to become professional drivers, but we cannot exclude the possibility that bus drivers with early cardiovascular symptoms may prefer to become taxi drivers or that removal men with early ischaemia may prefer more sedentary driver jobs. Professional drivers need to pass a health examination to obtain their professional drivers’ licence. Many may not try to obtain this licence because they are aware of former or prevalent health problems, especially cardiovascular disease. Some are also rejected by the police after consulting the National Board of Health. For the group as a whole, selection of diseased people into the profession is hardly an explanation for the excess risk of stroke.

The ‘secondary healthy worker’ effect is a well-known problem in studies of health risks in occupations. In the present study we have either used all economically active as standard or the relevant employment status group. These standardizations may compensate for the ‘secondary healthy worker’ problem.

Hospitalization due to first stroke in the follow-up period is a proxy measure of the true incidence of stroke.
Referral bias may be suspected for health workers, especially those employed in hospitals, while no such bias is identified for the occupational groups included in the present study.4

The interaction between way of life and occupation may complicate the interpretation of the results. Differences in lifestyle between occupational status groups are increasing. Standardization may solve this problem, but it is likely that it may overadjust for important differences common for several occupations belonging to the same status group.7

Little is known about associations between occupational exposure and stroke. We expect, however, that at least those stroke cases which are due to thrombosis may partly have the same aetiology as coronary heart disease. If so, what accounts for these findings?

We have found no previous studies showing an increased risk of stroke in drivers. It has been known for some time, however, that city bus drivers have a high prevalence of hypertension8 and hypertension is the most important risk factor for stroke. Since hypertension is associated with stress as may be present in jobs with high psychological demands and low control, stroke in drivers may be caused by occupational work strain. Bus drivers are exposed to high and conflicting demands such as keeping to tight time tables, providing services to the passengers and driving safely. And there is very little they can do to control the situation when they are caught in a traffic jam.

It has also been known for four decades that bus drivers have an excess risk of coronary heart disease and the aetiology of ischaemic heart disease (IHD) and stroke is partly the same.

Causes of the high risk of IHD among bus drivers are not understood in detail and there is more controversy about its aetiology than before. Five hypotheses have dominated the discussion: most drivers have an unhealthy lifestyle;9 absence of vigorous physical exercise was suggested to be one of the key factors in a pioneer study;10 while psychosocial stress;11,12 and working abnormal hours13 were suggested recently: a common aetiology for cancer and coronary heart disease was suggested by Benditt and Benditt more than 20 years ago14 and has been supported by many studies since then. If the hypothesis that exposure to mutagens like polycyclic aromatic hydrocarbons causes arteriosclerosis is correct it may be that traffic related air pollution leads to stroke. City bus drivers are exposed to high levels of traffic generated air pollution.15

In a recent study a disproportionately high DNA adduct level was found in city bus drivers who were exposed to diesel exhaust and other traffic related combustion products.16,17 None, one, two, three or all these possible risk factors may contribute to the increased risk level since IHD is a multifactorial disease. Occupational groups with excess risk may be exposed to more than one risk factor. Only quantitative studies, like a recent study of risk factors of IHD among male professional drivers in the northernmost part of Sweden,9 can attribute aetologic fractions to each of the possible hypotheses. In this Swedish study drivers smoked more than the referents drawn from the general population, and their leisure time physical activity was less. The drivers did more heavy lifting and dragging in working hours than the referents. Social support at work was lower, and they were more often in high strain situations. Multivariate analysis also showed that shift work influenced the score on a risk factor index including overweight, smoking, blood pressure, serum lipid level and serum cholesterol.

Stroke may partly have the same aetiology. If so, the excess risk of stroke in drivers found in this study may well be prevented by manipulation of parameters like shift work, job strain, air pollution, smoking habits, physical exercise and diet.

The increased risk found in stable city bus drivers compared to the risk of their unskilled colleagues may either be attributed to psychological strain or to air pollution, and to more evening, early morning and night work.

The risk pattern found in the stable drivers is very much the same as the pattern found in all drivers albeit a little blurred because of the wider confidence intervals. We have consequently no reason to believe that the often found high risk among workers who change jobs frequently can account for our findings. The higher risk estimates for stable city bus drivers compared to all city bus drivers support the hypothesis that this job may be associated with an increased occupational risk of stroke.

In conclusion, professional driving may be associated with an increased risk of developing stroke. This conclusion should be regarded as a hypothesis until it has been confirmed by other studies.

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REFERENCES


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