

Hospital contacts for noise-related hearing loss among Danish seafarers and fishermen: A population-based cohort study

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ABSTRACT

Aims: Noise-induced hearing loss (NIHL) is a leading occupational disease and some seafarers and fishermen may be at high risk. We present here standardized hospital contact ratios (SHCRs) for hearing loss among Danish seafarers and fishermen. **Materials and Methods:** Cohorts of all Danish seafarers registered by the Danish Maritime Authority (DMA) and fishermen retrieved from a 1989-1998 pension registry were linked to the nationwide Occupational Hospitalisation Registry (OHR) with follow-up for NIHL from 1994 to 2003, using rates specific for age and calendar time for the entire Danish workforce as a reference. **Results:** We found high SHCRs for NIHL: 165 [95% confidence interval (CI) 131-206] among officers, 113 (79-157) for nonofficers and 119 (85-162) for fishermen. The increased SHCR for hearing impairment among seafarers was solely found in engine room personnel (SHCR = 222; 95% CI 178-277). Compared to other seafarers, the engine room personnel had a relative risk ratio of 2.39 (95% CI: 1.74-3.26). Short-term employment is common in many trades. No duration response pattern was observed which may suggest a secondary healthy worker effect. **Conclusions:** These findings indicate that hearing problems are frequent among men who work in the engine rooms on ships. Long-term cumulative effects of employment were not shown.

Keywords: Occupational NIHL profile, risk factors, surveillance system

Introduction

Noise-induced hearing loss (NIHL) is a leading occupational disease in Europe^[1,2] and seafarers and fishermen are exposed to potentially harmful engine noise although measures have been taken to reduce the exposure.^[3-15] NIHL in the range of 3000-6000 Hz, particularly, 4000 Hz can affect a worker's safety and work performance and can reduce the quality of life for most affected individuals.^[16-17] Existing studies of NIHL in these occupational groups are few and reflect exposures in the past. A Croatian study from 1996 shows a correlation between age, length of sea service and the average hearing loss at 4000 Hz.^[9]

Efforts to improve the working environment for seafarers and fishermen have included compulsory work place inspections, noise measurements and mandatory training in safety and health. Hearing protection has improved worldwide, but protection is not used consistently.^[4,6,18] It is not currently possible to reduce engine room noise levels below 85 dB(A)

although ships have become larger with more modern engine room isolation.^[19] Noise levels have therefore declined mainly outside the engine room. We provide updated standardized hospital contact ratios (SHCRs) for hearing loss among Danish seafarers and fishermen, calculated SHCRs for engine room personnel and estimated relative risks for hospital contacts as a function of the length of employment.

Materials and Methods

The study has already been described in detail.^[20-21] A ten-year follow-up study, starting on 1 January 1994, was conducted to examine SHCRs of different types of hearing disorder among male seafarers and fishermen in Denmark. The study also examined SHCRs during 1994-2003 as a function of the length of service during 1964-1993. SHCRs were obtained by linking data from the Occupational Hospitalization Register (OHR) to occupational cohorts extracted from the Danish Seafarer Registry (seamen) and from the fishing boat yearbooks, fishery yearbooks, the

Danish Maritime Authority (DMA) files, tax and pension registries (fishermen).^[21-24]

Occupational cohorts

The cohort of Danish seafarers was based upon individual data files kept in the Danish Seafarer Register. This data source is administered by the DMA and is regarded as almost complete and suitable for research purposes.^[23] It is compulsory for shipping companies to send a copy of the employment contract to the DMA each time a seafarer signs on and off a Danish ship. Such information is also kept for retired or deceased seafarers. The registry has been computerized since 1986 and it includes the name, birthday, job title, name and call signal of the ship and dates of the start and end of each employment period. All ships were classified by a code in the registry according to their main use in the periods, *e.g.*, passenger ship, gas tanker or product/chemical tanker.

The fishermen cohort was established by using different data sources covering all professional native fishermen. Information was extracted from fishing boat yearbooks, fishery yearbooks, the DMA files as well as tax and pension registries with a view to identifying all fishing boats in the Danish fishing industry operating during 1989-1998 and their company identification code. This code was used to extract employee data from the ATP Registry, the largest national pension scheme. The Arbejdsmarkedets tillægspension (ATP) holds data on the occupational history of each person on board all registered fishing boats. It is compulsory for all companies in Denmark with employees working for nine or more hours per week to participate in a noncontributory pension scheme. Seafarers and fishermen with a permanent address in Denmark also have a unique ten-digit Personal Identification Number (PIN), which has been assigned to each Danish resident since 1968. The number includes the birth date and sex of the individual and is used by all authorities for registration purposes. We used the PIN to link the occupational data with each fisherman's or seafarer's hospital contacts as an inpatient or outpatient as recorded by the nationwide OHR.^[25]

Occupational hospitalization registry

The OHR consists of information on each individual obtained through record linkage among three Danish national registers: the Danish civil registration system (CRS), the national hospital patient register and the employment classification module. The national hospital patient register has existed since 1977 and contains data from all national public hospitals. During 1977-94, the register only included inpatients but since 1995, it has also included outpatients and emergency ward visits.^[22] The diagnoses have been coded according to the International Classification of Diseases, 10th revision (ICD-10) since 1994. The civil registration system contains information on gender, addresses and dates of birth, death and migration for every person who is or has been a Danish resident at any time between 1968 and the present. A person's

employment status is registered annually in the employment classification module.^[22]

In Denmark, hospital services are free of charge and the national health system is tax-financed. For most of the population, a hospital is within a driving distance of 30 minutes or less.

Inclusion criteria

A total of 36,113 officers and nonofficers of either gender (persons with and without residence in Denmark) and 11,755 male fishermen with a PIN, were initially retrieved from the DMA and the pension registry. Due to a high cohort turnover, we restricted the study to those employed since 1 January 1994. Short-term employment is common: 30.6% of the seafarers and 41.9% of the fishermen had a total service length in 1989-1998 of less than six months.

Inclusion criteria for follow-up of hospital contacts during 1994-2003 were ages between 20 and 59 years on 1 January 1994, Danish residency according to the civil registration system, employment according to the employment classification module, employment as a seaman or fisherman some time during 1993 (the year preceding the start of follow-up) and at least three months of service during 1964-1993 according to the occupational registers. For the study on SHCRs during 1994-2003 as a function of service duration during 1964-1993, we added the criterion that a person had to be at least 30 years old at baseline.

A total of 8,487 seafarers (4,372 officers and 4,115 nonofficers) and 3,702 fishermen were included at start of follow-up in 1994. Thus, 5,994 seafarers and 2,740 fishermen were at least 30 years old at the start of follow-up.

Follow-up of diagnoses in the occupational hospitalization register

Each person was linked to the files of the nationwide OHR using the PIN. Observation began on 1 January 1994. The follow-up ended on the date of the diagnosis under study, date of death, date of emigration or at the end of the study (31 December 2003), whichever came first. Person-years (PY) at risk were calculated for each individual.

The following diagnoses were chosen for follow-up because previous studies of seafarers and fishermen as well as a recent pilot interview study among Danish fishermen have shown that they may be associated with these occupations. The codes were selected before the study started and included the ICD-10 codes: H83.3 (NIHL), H93.1 (tinnitus), H90.0-H90.8 (conductive and sensorineural hearing loss) and all three groups together.

Statistical analyses

Each study participant was assigned to the type of ship on board which he worked during his latest known employment

before the start of the follow-up. Evaluations also took into account the job title of the most recent employment before the start of the follow-up, which was expected to reflect the seafarer's social class membership.

SHCR = 100 × (total number of observed cases with a specific hospital diagnosis)/(total number of expected cases).

Total number of expected cases = (PY at risk during the follow-up period in each five-year age and calendar-year group) × (corresponding sex-specific rates of hospital contacts among economically active people in the total Danish population).

Their corresponding 95% confidence intervals (95% CI) were estimated assuming a Poisson distribution for the observed number of cases with a specific diagnosis. For the SHCRs, we calculated exact intervals when the observed number of cases was <100. Otherwise, we used the propagation of error formula and normal approximation to form a 95% CI around the logarithm of risk ratio, which we then transformed into a 95% CI around the risk ratio.

To evaluate the possible effect of working in the engine room where noise levels are the highest, we performed subanalysis for seafarers by job title (separating engine officers and engine room crew from other seafarers).

To evaluate SHCRs by duration of employment for each job, we divided service duration into three categories approximately corresponding to tertiles. For fishermen, we used the categories: 3-71 months, 72-143 months and ≥144 months based on income data from the pension registry and the corresponding cut-offs for seafarers when estimating SHCRs as a function of the length of employment. Seafarers' data were based on actual days at sea with six months at sea corresponding to a full income year. For each occupation, we estimated adjusted relative risks for hospital contacts

according to service duration by means of a multiplicative Poisson regression model with no interaction, using SAS software version 8.1. We controlled for age and county at the start of the follow-up and also for the type of the ship (passenger ship vs other) for seafarers. We used a likelihood ratio test to test for significance of service duration.

Results

Among all employees on Danish ships regardless of nationality, the percentage of male seafarers with permanent residence in Denmark (as a percentage of all Danish and nonDanish seafarers on Danish ships) on each type of ship was 75% for tankers, 90% for passenger ships and 80% for other types of ships. The percentages by job types were 88% for officers, 90% for engineers, 77% for deck crew, 77% for engine crew, 75% for galley and catering crew and 64% for others.

We found high SHCRs for NIHL among male seafarers employed as officers [Table 1].

The SHCRs for tinnitus and conductive and sensorineural hearing loss had not increased.

Subanalyses of the data with separate analyses for persons employed in 1994 and 1999 with five years of follow-up for NIHL for each group from the starting date 1.1.94 and 1.1.99, respectively, revealed that fishermen and seafarers had the highest rates of hospital contacts for NIHL in 1999: SHCR for fishermen = 182 (115-273), officers = 233 (175-303) and nonofficers = 142 (94-205).

Subanalysis by job title revealed an increased risk of hearing impairment only for engine room personnel. The risk for seafarers not working in the engine room did not differ from that of the economically active population on shore [Table 2].

Table 1: Standardized hospital contact ratios for selected diseases among male fishermen and seamen in Denmark during 1994-2003 by job type

SHCR by job type				SHCR adjusted for county of living ²	
ICD-10 ¹	Diagnosis	Job type	Cases	SHCR	95% CI ³
H83.3	Noise induced hearing loss (NIHL)	Fishermen	40	119	85-162
H83.3		Officers	81	165	131-206
H83.3		Non-officers	35	113	79-157
H93.1	Tinnitus	Fishermen	4	69	19-176
H93.1		Officers	15	146	82-240
H93.1		Non-officers	8	91	39-179
H90	Conductive and sensorineural hearing loss	Fishermen	9	71	32-135
H90		Officers	21	95	59-146
H90		Nonofficers	16	92	53-150
H83.3, H93.1, H90	All 3 groups together	Fishermen	53	104	78-136
H83.3, H93.1, H90		Officers	113	142	118-171
H83.3, H93.1, H90		Nonofficers	58	103	78-134

¹International Classification of Diseases (ICD) version 10; ²In the calculation of the SHCR, we included people who were ≥20 years (3702 fishermen, 4372 officers, 4115 nonofficers); ³Confidence interval

Table 2: Standardized hospital contact ratios during 1994-2003 for hearing disorders¹ among male seafarers in Denmark, by job title

Job title	Persons	Cases	SHCR	95% CI ²
Engine room personnel	2344	78	222	178-277
Other seafarers	6143	93	93	76-114

¹International Classification of Diseases (ICD-10) [H83.3, H93.1, H90]; ²Confidence interval

Compared to other seafarers, engine room personnel had a relative risk ratio of 2.39 (95% CI: 1.74-3.26).

We evaluated SHCRs by the duration of employment for each job by dividing the individuals into three groups based on years of employment in tertiles: less than six years, 7-12 years and more than 12 years. No duration-response pattern was observed for NIHL and the length of employment (Data not shown).

Discussion

This follow-up study of seafarers and fishermen reports high SHCRs for NIHL among engine room personnel. Only a fraction of NIHL is expected to cause hospitalization and it is expected that this fraction will change over time as a function of the available treatment options. We therefore compared the cohorts' SHCRs for NIHL with those of all economically active members of the Danish public. We studied relative changes, *e.g.*, if NIHL goes down in the working population in general but remains unchanged among the studied occupational groups, the SHR will also increase. Fishermen and seafarers had a slightly higher rate of hospital contacts over time perhaps because they are now more aware of the problem or are more attentive to it than before.

The main strength of the present study is that it rests on population-based cohorts with detailed register data. This made it possible to establish a complete cohort of fishermen and seafarers and to obtain almost complete follow-up. Thus, we avoided the methodological differences encountered by several previous studies in defining or tracing the population at risk.^[15]

The disadvantage of this study is the lack of data on noise exposure at an individual's level. Referral bias may be a problem in studies considering hospital admission because hearing loss is commonly treated outside hospitals.^[21-22,25-27] Minor differences in referral pattern between rural areas and larger cities may also exist. We do not expect this to be a major problem because we calculated SHCRs in the two time cohorts, using the background population as a reference while adjusting for age and area of living. A former Danish study has shown that referral bias in hospital register studies of geographical and industrial differences in health can be nearly fully adjusted for by standardizing for county.^[26] Furthermore, the engine room personnel had a relative risk

ratio of 2.39 (95% CI: 1.74-3.26) for NIHL when using other seafarers as a reference.

Even if the 'healthy worker effect' (HWE) is less pronounced in NIHL studies than for many other more serious diseases, using the entire employed Danish population as reference group does not provide an estimate of the full effect of noise exposure as the reference cohort is also exposed. We are only able to estimate a deviation from this average. Still, we found increased NIHL estimates among officers. If the lack of an employment duration effect reflects a selection bias due to the mandatory health check every second year, then our study is only able to monitor recently diagnosed hearing impairments.

As age-induced hearing loss produces a lag time between exposure and diagnosis and short-term employment is common in these seafaring trades, it is possible that the exposure could be a result of previous working conditions. Noise exposure from various sources is commonly expressed as the average sound pressure level over a specific time period, such as eight or 12 hours. The DMA stipulates that the eight-hour daily personal noise exposure $L_{EX,8h}$ must not exceed 85 dB(A), which is equivalent to a maximum energy equivalent noise level, $L_{Aeq,12}$ of 83 dB(A).^[28] Anyone regularly exposed to a noise level exceeding 80 dB(A) should be supplied with ear protectors and such protectors must be used above 85 dB(A). The instantaneous sound pressure (impulse noise) must not exceed 130 dB(A) and efforts should be made to keep the noise level, including infrasound (<20 Hz) and ultrasound levels (>18 kHz) at a reasonable minimum. Ear protectors must be used in engine rooms (main and auxiliary engine room), where experience shows noise cannot be reduced to a level <85 dB.

The NIHL diagnosis rests on a 3-6000-HZ dip in audiometric recordings. Former studies establish that NIHL may result either from traumatic impulse noise > 140 DB, resulting in acute permanent hearing loss or from exposure to lower noise levels of longer duration.^[16] Noise levels vary considerably in various areas of vessels and are highest in the engine rooms.^[17,29] A1993 report from the DMA of noise on 152 different Danish merchant fleet ships showed an average sound level on 103 dB ± 4.4 dB in the main engine room and 75 dB ± 8.7 dB in the control rooms.^[29] Similar levels have been reported in engine rooms in a Norwegian study.^[30] The engine officers and engine room crew are thus more heavily exposed to noise than other seafarers, which is in line with our findings. Noise levels on Danish fishing vessels commonly reach 102-110 dB in the engine room and 75-85 dB in the working and living areas.^[31]

Early hearing loss can be detected by audiometric screening. In light of this fact, it would seem relevant to initiate intervention initiatives to prevent further progression of hearing loss among those with early signs of hearing loss.

Such screening could consist in including audiometric screening at the mandatory health examination every 2nd year. It should be recognized that noise is an exposure that not only causes hearing loss, but also acts as a stressor.^[6,17]

In conclusion, Danish male fishermen and seafarers employed in the engine room have increased risk rates for NIHL compared with other seafarers and with the general population and these rates have not declined over time. Long-term cumulative effects of employment have not been shown.

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