Health of Danish seafarers and fishermen 1970-2010: What have register-based studies found?
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Background
Monitoring of health by the use of registers and register linkage

Monitoring seafarers’ and fishermen’s health has both public and occupational health perspectives. Knowledge about the frequency and the severity of diseases and accidents, as well as of vulnerable subgroups are relevant issues from a public health point of view. The occupational health angle focuses on health consequences of work and life on board including the role of lifestyle and the extent to which it links to working conditions. Both perspectives have preventive implications.

During the last decades, Danish register studies have linked occupation to health-related outcomes (mortality [1,2], cancer [3], medication [4], sickness absence [5], disability pension [6], voluntary early retirement pension [7]). In addition, specific work exposures have been linked to death [8], hospitalization [2] and medication [4]. Danish register studies are feasible due to legislation that facilitates...
researchers’ access to administrative data. In addition, the personal identification number (CPR number) allows linking data from administrative registers on, e.g., residence, vital status or occupation with registers covering health indicators of the entire Danish population.

**Danish merchant seafaring and fishery**

The Danish maritime sector has changed considerably during the last decades. While the number of merchant vessels dropped from 948 in 1970/71 to 483 in 2013, the gross tonnage more than doubled from 3,194,000 to 11,083,000 [9]. Simultaneously, the crew-size fell from 16,626 to 9,611. Renewal during the last three decades has resulted in a significantly younger Danish merchant fleet than the global fleet (11 vs. 21 years in 2009). In 2009, Danish registered and owned merchant ships contributed 1% and 2.6% of the world tonnage, respectively, and foreign seafarers constituted 30% of officers and 65% of ratings [9]. The Danish fishing fleet has also undergone a significant transition over recent years with pronounced decline in the number of vessels and active fishermen [10].

This study aims to review the accumulated results of Danish research based on register-linking of seafarers’ and fishermen’s occupational data with health indicators.

**Methods**

We searched bibliographic databases (Pubmed and Web of Science) to identify relevant studies. By a snowballing technique we examined the reference list of the identified studies to detect further studies to include in the review. Studies were initially identified based on title and abstract and subsequently by full-text evaluation. By applying this procedure, we believe to have identified all relevant studies linking register data about the health of Danish seafarers and fishermen.

Outcomes were reviewed in terms of mortality and maritime death, hospitalizations, occupational accidents and certain specific health conditions.

**Mortality and deaths (Table I)**

Since 1970, occupational mortality studies have linked information from Statistics Denmark to the Danish Mortality Register (DMR), reviewed by Lynge in 1979 [11] and in 2011 [12]. Four of the included studies concerned seafarers [13–16] and two studies dealt with fishermen [17,18].

Two studies using data from the 1970 census compared the mortality of maritime workers with that of all other employed Danes [13,17]. Two of four studies between 1986 and 1993 were based on the Danish Seafarers Registry (DSR) and compared seafarers’ mortality with that of all Danish males [14] and females [16]. Two studies [15,19] of maritime deaths among seafarers on Danish merchant vessels compared the rate of fatal occupational accidents on board with the corresponding rates for the land-based occupations in the same observation periods. DMR does not cover deaths of foreign seafarers during employment on a Danish ship and could not inform about causes and modes of deaths. These data were consequently collected by a trained physician and based on more than 2,000 documents from 27 different countries (death certificates, maritime inquiries, notifications to authorities police reports, ships’ log books, captains’ reports, telex communications, medical records, necropsy reports, bills and newspaper articles). The latest study [19] followed the trend of deaths in three 8-year periods until 2009.

**Hospitalization (Table II)**

Four articles (two studies) addressed hospitalizations of seafarers and fishermen [20–23]. One study concerned the general hospitalization pattern of seafarers [20] and another seafarers and fishermen recorded in DSR [21–23]. A cohort study with 5-year follow-up investigated chronic conditions, i.e. respiratory and circulatory diseases [21], musculoskeletal disorders and injuries [22], and hearing impairment [23] in fishermen and seafarers, respectively.

**Occupational accidents (Table III)**

Non-fatal occupational accidents aboard fishing vessels were studied in 1996 [24]. Data from two registers in the Danish Maritime Authority (DMA) and one occupational insurance registry permitted a historical follow-up study in 1993–97 of accidents among merchant seafarers [25]. Two register-linking studies investigated and compared rates of occupational injuries in different nationalities [26,27].

**Specific diagnoses and conditions (Table IV)**

Two of the three cancer studies represented an extensive follow-up of a relatively small population of Danish seafarers from the 1970 census [28,29]. A third study addressed a larger population of seafarers recorded in DSR [30]. The seafarers’ cancer risk was compared with that of Danes engaged in land-based occupations [28,29] and all Danes [30].
<table>
<thead>
<tr>
<th>Authors</th>
<th>Details</th>
<th>Baseline year(s)*</th>
<th>Type/occupational group</th>
<th>Study population</th>
<th>Outcome of interest</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reference group: men aged 20–64 and economically active</td>
<td></td>
<td></td>
<td></td>
<td>Suicide</td>
<td>1.87 (1.42–2.47)</td>
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<td></td>
<td>Follow-up: 15 years</td>
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<td></td>
<td>Accidents</td>
<td>2.79 (2.25–3.46)</td>
</tr>
<tr>
<td></td>
<td>Machine officers</td>
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<td></td>
<td>3442</td>
<td>Cancer of respiratory organs</td>
<td>1.90 (1.39–2.60)</td>
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<td></td>
<td>Machine crew</td>
<td></td>
<td></td>
<td>977</td>
<td>Ischemic heart disease</td>
<td>2.47 (1.59–3.82)</td>
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<td></td>
<td>Cirrhosis of the liver</td>
<td>1.43 (1.02–2.00)</td>
</tr>
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<td></td>
<td>Accidents</td>
<td>4.85 (2.55–8.98)</td>
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<td></td>
<td></td>
<td>SMR (95%CI)</td>
<td>2.58 (1.43–4.50)</td>
</tr>
<tr>
<td>Jensen [17]</td>
<td>Data origin: 1970 Census, DMR, CPR</td>
<td>1970</td>
<td>Skippers</td>
<td>5792</td>
<td>All causes</td>
<td>SMR (95%CI)</td>
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<tr>
<td></td>
<td>Reference group: men aged 20–64 and economically active</td>
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<td></td>
<td>Accidents</td>
<td>1.12 (1.03–1.20)</td>
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<td>Follow-up: ≤ 14 years</td>
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<td></td>
<td>SMR (95%CI)</td>
<td>4.10 (3.09–5.35)</td>
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<td></td>
<td>Crew</td>
<td></td>
<td></td>
<td>4457</td>
<td>All causes</td>
<td>1.49 (1.34–1.65)</td>
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<td>Accidents</td>
<td>5.76 (4.36–7.46)</td>
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<td></td>
<td>Ischemic disease</td>
<td>1.27 (1.01–1.57)</td>
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<td></td>
<td></td>
<td></td>
<td>Unknown causes</td>
<td>6.44 (4.31–9.27)</td>
</tr>
<tr>
<td>Hansen &amp; Pedersen [14]</td>
<td>Data origin: DMA, DMR, CPR</td>
<td>1986–1993</td>
<td>All male seafarers</td>
<td>24,132</td>
<td>All causes of death</td>
<td>SMR (95% CI) 1.43 (1.33–1.54)</td>
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<tr>
<td></td>
<td>Reference group: all Danish men</td>
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<td></td>
<td>All causes of death</td>
<td>1.24 (1.06–1.45)</td>
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<td>Follow-up: ≤ 7 years and 9 months</td>
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<td></td>
<td>Respiratory diseases</td>
<td>1.47 (1.13–1.89)</td>
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<td>Gastrointestinal diseases incl. cirrhosis of the liver</td>
<td>1.52 (1.09–2.06)</td>
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<td>Alcoholism</td>
<td>2.82 (1.77–4.26)</td>
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<td></td>
<td>Accidents</td>
<td>3.05 (2.62–3.52)</td>
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<td>Suicides</td>
<td>1.77 (1.41–2.20)</td>
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<td></td>
<td>Deck and engine room crew</td>
<td></td>
<td></td>
<td>9994</td>
<td>All causes of death</td>
<td>2.03 (1.82–2.26)</td>
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<td>Galley and catering crew</td>
<td></td>
<td></td>
<td>6171</td>
<td>All causes of death</td>
<td>1.56 (1.30–1.87)</td>
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<td>Officers</td>
<td></td>
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<td>7967</td>
<td>All causes of death</td>
<td>1.01 (0.89–1.14)</td>
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<td></td>
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<td>SMR (95%)</td>
<td>1.20 (0.89–1.58)</td>
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<td></td>
<td></td>
<td>SMR (95% CI)</td>
<td>2.82 (1.41–5.05)</td>
</tr>
<tr>
<td>Hansen &amp; Jensen [16]</td>
<td>Data origin: DMA, CPR, DMR</td>
<td>1986–1993</td>
<td>All female seafarers</td>
<td>6788</td>
<td>All causes of death</td>
<td>SMR (95%)</td>
</tr>
<tr>
<td></td>
<td>Reference group: All economically active women.</td>
<td></td>
<td></td>
<td></td>
<td>All causes of death</td>
<td>1.20 (0.89–1.58)</td>
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<td></td>
<td>Follow-up: ≤ 7 years and 9 months</td>
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<td></td>
<td></td>
<td>SMR (95% CI)</td>
<td>2.82 (1.41–5.05)</td>
</tr>
<tr>
<td></td>
<td>Female seafarers in traditional male occupations</td>
<td></td>
<td></td>
<td>696</td>
<td>All causes of death</td>
<td>1.20 (0.89–1.58)</td>
</tr>
<tr>
<td>Hansen [15]</td>
<td>Data origin: RS, CPR.</td>
<td>1986</td>
<td>Seafarers in Danish</td>
<td>147 cases of death</td>
<td>Accidents directly related to work</td>
<td>RR (95% CI) 3.72 (2.3–6.0)</td>
</tr>
<tr>
<td></td>
<td>Reference group: Danish men in all occupations ashore</td>
<td></td>
<td>merchant fleet</td>
<td></td>
<td>Accidents directly related to work plus maritime casualties</td>
<td>8.48 (6.2–11.6)</td>
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<td></td>
<td>Follow-up: n/a</td>
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<td>All accidents except self-inflicted intoxications and traffic accidents ashore</td>
<td>11.37 (8.6–15.0)</td>
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</tbody>
</table>

(Continued)
Table I. (Continued)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Details</th>
<th>Baseline year(s)*</th>
<th>Type/occupational group</th>
<th>Study population</th>
<th>Outcomes of interest</th>
<th>Outcomes of interest</th>
<th>Results</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laursen et al. [18]</td>
<td>Data origin: DDF, DIMA and DMA.</td>
<td>1989</td>
<td>Fishermen</td>
<td>6992</td>
<td>Fatal occupational accidents / IR per 10,000 fishermen per year</td>
<td>Fatal occupational accidents</td>
<td>10</td>
<td>9.91</td>
</tr>
<tr>
<td>Borch et al. [19]</td>
<td>Data origin: DMA, DSAIS. Reference group: Danish men in all occupations ashore</td>
<td>1986–1993</td>
<td>Seafarers in Danish merchant fleet</td>
<td>Person-years at risk</td>
<td>Occupational accidents</td>
<td>Person-years at risk</td>
<td>111,152</td>
<td>9.63</td>
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<td></td>
<td></td>
<td>11,515</td>
<td>6.41</td>
</tr>
</tbody>
</table>

* One year denotes a closed cohort, a range of years denotes an open cohort.


One out of two studies on tuberculosis [31,32] additionally addressed the risk of hepatitis A and B [31]. The DNA patterns of tuberculosis strains indicated the source of transmission [32]. Both studies compared the risk of seafarers with that of the general population.

Two studies of overweight were based on information from the DMA’s register of the outcomes of statutory health examinations of seafarers and fishermen [33,34].

Results

Mortality (Table I)

The first mortality study from 1970–1985 demonstrated an increased mortality of Danish seafarers. The rate in the later study from 1996–2005 was still significantly increased [12].

In the 1970 cohort, male seafarers’ mortality exceeded that of other working Danes with the highest mortality in engine crew followed by deck crew and engine officers. Cirrhosis of the liver and accidents contributed to the high mortality of ratings, ischemic heart disease and lung cancer of machine crew, and suicides among deck crew [13].

The fishermen’s all-cause mortality in the 1970 cohort was significantly increased for both skippers and crew. The 20–34 year olds were in particular risk, and the excess mortality was mainly related to accidents, cardiovascular diseases and unknown causes [17].

In the study of deaths among seafarers employed in the Danish merchant fleet from 1986 to 1993, fatal occupational accidents were almost four times that of male Danes working ashore [15]. With inclusion of fatalities related to maritime disasters, the excess was more than eight-fold. Out of 51 natural deaths, 29 were associated with a cardiovascular condition. In 11 of these the seafarer was found dead on board without previous signs of disease [15]. There was a large general reduction (54%) across all strata of modes of death in a more recent follow-up of deaths among seafarers in service [19]. The risk of fatal accidents was, however, still more than three-fold increased and with inclusion of maritime disasters more than six-fold.

In the study of fatal occupational accidents in fishery (1995–2005), the yearly incidence approached 10/10,000 full-time fishermen. Most fatalities happened on trawlers and gillnets and more than half were related to a maritime disaster [18].

Hospitalizations (Table II)

Follow-up of the 1994 and 1999 cohorts [21,22] has shown that compared to officers, merchant
Table II. Studies on hospitalization.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Details</th>
<th>Baseline year(s)*</th>
<th>Occupational group</th>
<th>Study population</th>
<th>Outcome of interest</th>
<th>Results</th>
</tr>
</thead>
</table>
| Hansen et al. [20] | Data origin: DMA, CPR, NIPR  
Reference group: all men and women recorded in ECM  
Follow-up: 5 years | 1995              | Male seafarers         | 7401 male seafarers   | Neoplasms  
Endocrine and nutritional diseases incl. cirrhosis of the liver  
Cervical disc disorders  
Gastro intestinal diseases  
Injuries and poisoning | SHR (CI 95%)  
133 (114–155)  
278 (199–387)  
217 (112–379)  
112 (101–125)  
115 (105–126) |
|                  |                                                                        |                   | Female seafarers       | 926              | Neoplasms  
Diseases of the circulatory system  
Gastritis and duodenitis  
Diseases of the genitourinary system  
Injury and poisoning | SHCR (CI 95%)  
159 (113–217)  
181 (121–262)  
369 (101–946)  
181 (138–234) |
|                  |                                                                        |                   | Fishermen              | 6003             | Neoplasms  
Diseases of the circulatory system  
Diseases of the digestive system  
Diseases of the musculoskeletal system and connective system  
Injury and poisoning | SHCR (95% CI)  
125 (107–146)  
118 (106–131)  
129 (117–142)  
144 (129–160) |
| Kaerlev et al. [21] | Data origin: DMA, OHR  
Reference group: entire Danish workforce  
Follow up: 5 years | 1994              | Officers               | 5061             | Neoplasms  
Respiratory diseases  
Circulatory diseases  
Neoplasms  
Alcohol-related liver disease  
Endocrine and nutritional diseases | SHCR (CI 95%)  
135 (116–156)  
118 (103–136)  
129 (115–145)  
147 (126–172)  
124 (107–167) |
|                  |                                                                        |                   | Non-officers           | 5170             | Respiratory diseases  
Circulatory diseases  
Neoplasms  
Alcohol-related liver disease  
Endocrine and nutritional diseases | SHCR (95% CI)  
204 (133–299)  
120 (100–144)  
126 (152–383)  
135 (107–167) |
|                  |                                                                        |                   | Fishermen              | 4570             | Bronchitis, emphysema  
Neoplasms  
Raynaud’s syndrome  
Raynaud’s syndrome | SHCR (95% CI)  
204 (133–299)  
120 (100–144)  
261 (112–514)  
285 (147–499) |
|                  |                                                                        |                   | Officers               | 5375             | Lung cancer  
Diabetes  
Diabetes  
Diabetes | SHCR (CI 95%)  
194 (117–302)  
134 (103–172)  
143 (105–193)  
264 (121–524) |
|                  |                                                                        |                   | Non-officers           | 5867             | Respiratory diseases  
Circulatory diseases  
Lung cancer  
Endocrine and nutritional diseases  
Bronchitis, emphysema  
Diseases in veins  
Alcohol-related liver disease | SHCR (CI 95%)  
114 (100–130)  
115 (103–127)  
236 (142–369)  
124 (102–150)  
163 (109–234)  
163 (128–203)  
217 (129–343)  
285 (147–499) |
|                  |                                                                        |                   | Fishermen              | 3470             | Raynaud’s syndrome | SHCR (CI 95%)  
285 (147–499) |
(Continued)
<table>
<thead>
<tr>
<th>Authors</th>
<th>Details</th>
<th>Baseline year(s)*</th>
<th>Occupational group</th>
<th>Study population</th>
<th>Outcome of interest</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaerlev et al.</td>
<td>Data origin: DSR, DMA, OHR, ATP Reference group: economically active Danish population Follow-up 5 years</td>
<td>1994</td>
<td>Seaferers (non-officers)</td>
<td>5170</td>
<td>Injury and poisoning and certain other consequences of external causes (1 body region)</td>
<td>SIR (CI95%) 110 (105–115)</td>
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<td></td>
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<td></td>
<td></td>
<td>Injury and poisoning and certain other consequences of external causes (+1 body region)</td>
<td>125 (115–1136)</td>
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<td></td>
<td>Carpal tunnel syndrome</td>
<td>168 (109–246) SIR (95%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1999</td>
<td>5867</td>
<td></td>
<td>Injury and poisoning and certain other consequences of external causes (1 body region)</td>
<td>112 (108–117)</td>
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<td></td>
<td>Injury and poisoning and certain other consequences of external causes (+1 body region)</td>
<td>120 (111–129)</td>
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<td></td>
<td></td>
<td>Carpal tunnel syndrome</td>
<td>172 (124–233) SIR (CI95%)</td>
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<tr>
<td></td>
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<td>1994</td>
<td>Fishermen</td>
<td>4570</td>
<td>Diseases of the musculoskeletal system and connective tissue</td>
<td>SIR (CI95%) 122 (113–133)</td>
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<td></td>
<td>Thoraco-lumbar disc disorders</td>
<td>224 (189–266)</td>
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<td>Shoulder lesions</td>
<td>162 (115–221)</td>
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<td></td>
<td>Rotar cuff syndrome</td>
<td>225 (138–348)</td>
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<td></td>
<td>Injury and poisoning and certain other consequences of external causes (1 body region)</td>
<td>112 (107–118)</td>
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<td>Carpal tunnel syndrome</td>
<td>315 (233–418) SIR (CI95%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1999</td>
<td></td>
<td>3470</td>
<td>Diseases of the musculoskeletal system and connective tissue</td>
<td>118 (108–129)</td>
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<td>Gonarthrosis</td>
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<td>Thoraco-lumbar disc disorders</td>
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<td>Shoulder lesions</td>
<td>137 (102–181)</td>
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<td>Rotar cuff syndrome</td>
<td>205 (127–313)</td>
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<td>Injury and poisoning and certain other consequences of external causes (1 body region)</td>
<td>120 (114–126)</td>
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<td></td>
<td></td>
<td></td>
<td>Injury and poisoning and certain other consequences of external causes (+1 body region)</td>
<td>118 (106–130)</td>
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<td></td>
<td></td>
<td></td>
<td>Carpal tunnel syndrome</td>
<td>292 (214–389) SHCR (95% CI)</td>
</tr>
<tr>
<td>Kaerlev et al.</td>
<td>Data origin: DSR, ATP, OHR Reference group: economically active Danish population Follow-up 10 years</td>
<td>1994</td>
<td>Seafarers and fishermen</td>
<td>4372</td>
<td>Noise induced hearing loss, tinnitus and conductive and sensorineural hearing loss</td>
<td>142 (118–171)</td>
</tr>
</tbody>
</table>

*One year denotes a closed cohort, a range of years denotes an open cohort.

Health of Danish seafarers and fishermen

7

fleet ratings and fishermen were consistently more hospitalized due to injuries and poisoning [22], respiratory and circulatory diseases, and cancer [21]. Fishermen and merchant fleet ratings were also more frequently hospitalized with musculoskeletal diseases, particularly for rotator cuff and carpal tunnel syndrome [22]. Officers had significantly more hospital contacts from noise-induced hearing loss than deck crew but less than engine room ratings [23].

Cancer hospitalizations were significantly reduced from the first to the second follow-up [21]. For ratings, the trend was similar for circulatory diseases [21]. However, male seafarers’ hospitalizations for locomotor diseases, injuries and poisoning were comparable in the two follow-up periods [22].

The follow-up of female seafarers in the 1995 cohort demonstrated increased hospitalization rates for cancer, circulatory diseases, genital urinary diseases, and injuries and poisoning [20].

Specific diagnoses (Table IV)

The higher rate of cancer notifications, particularly of lung cancer, in seafarers than in workers ashore demonstrated in the follow-up of the 1970 cohort [29] remained significant in the follow-up of seafarers in 1986–1999 [30]. In one study, prostatic cancer notifications were increased for seamen but not for fishermen [29]. Ratings on deck, engine room and catering, galley and maintenance crew had higher cancer risk. Ratings on tankers had the highest risk, especially of pulmonary cancer [30].

In 1986–1999, the cancer incidence of female seafarers was similar to that of females ashore but higher for cervical, pulmonary and rectal cancer [30]. The two studies of cancer in the Nordic countries showed a significantly increased standardized incidence rates for all malignant neoplasms for male seafarers and fishermen followed up for 20 [28] as well as 33 years [29] but also for specific locations (lip, tongue, oral cavity, pharynx, esophagus, stomach, liver, pancreas, lung, mesothelioma, penis, kidney and urinary tract). Non-melanoma skin malignancies were significantly increased in seafarers and fishermen in the first [28] but not in the second study [29].

Table III. Studies on accidents.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Details</th>
<th>Baseline year(s)*</th>
<th>Type/occupational group</th>
<th>Study population</th>
<th>Outcome of interest</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jensen [24]</td>
<td>Data origin: DMA; Reference group: n/a; Follow-up: n/a</td>
<td>1993</td>
<td>Fishermen</td>
<td>625</td>
<td>Over-all rate of injury per year</td>
<td>Prevalence (95%CI) 20.4% (17.5–23.8)</td>
</tr>
<tr>
<td>Hansen [25]</td>
<td>Data origin: DMA, DMAIB, DSAIA; Reference group: n/a; Follow-up: n/a</td>
<td>1993–1997</td>
<td>Seafarers</td>
<td>5598–6094</td>
<td>Incidence of accidents/10,000 days</td>
<td>IR</td>
</tr>
<tr>
<td>Hansen et al. [26]</td>
<td>Data origin: DMA, DSAIA, DRMS; Reference group: West European seafarers; Follow-up: n/a</td>
<td>2003</td>
<td>East European seafarers</td>
<td>11786</td>
<td>All identified accidents</td>
<td>IRR(95%CI) 0.84 (0.65–1.09)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>South East Asian seafarers</td>
<td></td>
<td>All identified accidents</td>
<td>IRR (95%CI) 0.39 (0.30–0.50)</td>
</tr>
<tr>
<td>Adam [27]</td>
<td>Data origin: DMA; Reference group: Danish seafarers; Follow up: n/a</td>
<td>2010–2012</td>
<td>EU seafarers</td>
<td>7289</td>
<td>Occupational injuries</td>
<td>OR (95%CI) 0.256 (0.169–0.388)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Non-EU seafarers</td>
<td></td>
<td>Occupational injuries</td>
<td>0.536 (0.473–0.608)</td>
</tr>
</tbody>
</table>

* One year denotes a closed cohort, a range of years denotes an open cohort.

DMA: Danish Maritime Authority; DMAIB: Danish Maritime Accident Investigation Board; DSAIA: Danish Ship owners’ Accident Insurance Association; DRMS: Danish Radio Medical Service; OR: Odds Ratio; IR: Incidence Rate; IRR: Incidence Rate Ratio.

A study of occupational accidents among fishermen that linked questionnaire data to hospital registers and accident notifications from the DMA estimated the annual accident rate to 20.4% in 1993 [24].

In a historical follow-up of accidents in the merchant fleet 236 accidents were identified from 1993 to 1997. 209 of these accidents caused permanent disability exceeding 5% and 27 were fatal. The major risks for occupational accidents were young age, recent change of ship, first period on the particular ship, and moving from one place to another on board the vessel [25]. Most accidents happened on deck. A lower risk in foreign than Danish crew [25] was confirmed in later studies [26,27].

Occupational accidents (Table III)

A study of occupational accidents among fishermen that linked questionnaire data to hospital registers and accident notifications from the DMA estimated the annual accident rate to 20.4% in 1993 [24].
### Table IV. Studies on specific diagnoses and conditions.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Details</th>
<th>Baseline year(s)*</th>
<th>Type/occupational group</th>
<th>Study population</th>
<th>Outcome of interest</th>
<th>Results</th>
</tr>
</thead>
</table>
| Hansen et al. [31] | Data origin: CPR, DMA, DSOAIA and NRNID Reference group: whole Danish population Follow-up ≤ 8 years | 1986–1993         | Seafarers                | 24,132           | SIR (95%CI)          | Hepatitis A 1.77 (0.91–3.10)  
                |                                                                         |                   |                          |                  |                     | Hepatitis B 3.02 (1.79–4.78)  
                |                                                                         |                   |                          |                  |                     | Tuberculosis 1.23 (0.56–2.35)  |
| Andersen et al. [28] | Data origin: 1970 Census Reference group: entire Danish study population Follow-up 20 years | 1970              | Fishermen                | 8604             | SIR**               | All site cancers 110  
                |                                                                         |                   |                          |                  |                     | Lip 323                
                |                                                                         |                   |                          |                  |                     | Larynx 163             
                |                                                                         |                   |                          |                  |                     | Other skin 122          
                |                                                                         |                   |                          |                  |                     | Seafarers 11,331        
                |                                                                         |                   |                          |                  |                     | SIR** All site cancers 121  
                |                                                                         |                   |                          |                  |                     | Tongue 263             
                |                                                                         |                   |                          |                  |                     | Mouth 220              
                |                                                                         |                   |                          |                  |                     | Liver 226              
                |                                                                         |                   |                          |                  |                     | Lung 148               
                |                                                                         |                   |                          |                  |                     | Other skin 132          
| Kaerlev et al. [30] | Data origin: DSR, DCR Reference group: Total Danish population Follow-up: 3 years -15 years and 9 months | 1986–1999         | Male seafarers           | 33,340           | SIR (95%CI)          | All site cancers 1.26 (1.19 - 1.32)  
                |                                                                         |                   |                          |                  |                     | Tongue 1.87 (1.02–3.13)  
                |                                                                         |                   |                          |                  |                     | Mouth 2.69 (1.90–3.71)   
                |                                                                         |                   |                          |                  |                     | Pharynx 2.47 (1.80–3.30)  
                |                                                                         |                   |                          |                  |                     | Oesophagus 1.61 (1.11–2.26) 
                |                                                                         |                   |                          |                  |                     | Colon 1.24 (1.00–1.52)    
                |                                                                         |                   |                          |                  |                     | Pancreas 1.72 (1.25–2.30)  
                |                                                                         |                   |                          |                  |                     | Larynx 2.14 (1.56–2.87)   
                |                                                                         |                   |                          |                  |                     | Lung 1.61 (1.42–1.82)     
                |                                                                         |                   |                          |                  |                     | Kidney 1.37 (1.01–1.81)   
                |                                                                         |                   |                          |                  |                     | Urinary bladder 1.26 (1.03–1.52)  
                |                                                                         |                   |                          |                  |                     | Bone 2.55 (1.02–5.25)     
                |                                                                         |                   |                          |                  |                     | Female seafarers 11,291  
                |                                                                         |                   |                          |                  |                     | Rectum 2.37 (1.18–4.24)   
                |                                                                         |                   |                          |                  |                     | Lung 1.70 (1.14–2.44)     
                |                                                                         |                   |                          |                  |                     | Cervix uteri 1.59 (1.09–2.23) 

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### Table IV. (Continued)

<table>
<thead>
<tr>
<th>Authors</th>
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<th>Baseline year(s)*</th>
<th>Type/occupational group</th>
<th>Study population</th>
<th>Outcome of interest</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoeyer &amp; Hansen [33]</td>
<td>Data origin: DMA&lt;br&gt;Reference group: non-seafarer data from the National Institute of Public Health SUSY&lt;br&gt;Follow-up n/a</td>
<td>2001/2</td>
<td>16–24 years</td>
<td>106</td>
<td>BMI ≥ 25</td>
<td>RR (95% CI) 1.76 (1.36–2.28)</td>
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<td></td>
<td></td>
<td>25–44</td>
<td>613</td>
<td>BMI ≥ 25</td>
<td>1.26 (1.16–1.37)</td>
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<tr>
<td></td>
<td></td>
<td>45–66 years</td>
<td>538</td>
<td>BMI ≥ 25</td>
<td>1.57 (1.48–1.67)</td>
<td></td>
</tr>
<tr>
<td>Hansen et al. [32]</td>
<td>Data origin: DMA, DoE&lt;br&gt;Reference group: Whole Danish population&lt;br&gt;Follow-up ≤ 11 and 10 months</td>
<td>1992–2003</td>
<td>Seafarers</td>
<td>53,302</td>
<td>Tuberculosis</td>
<td>SIR (95% CI) 1.51 (1.102.01)</td>
</tr>
<tr>
<td>Pukkala et al. [29]</td>
<td>Data origin: PR, NIPR, 1970 Census, DCR, CPR&lt;br&gt;Reference group: entire Danish study population&lt;br&gt;Follow-up 33 years</td>
<td>1961</td>
<td>Seafarers</td>
<td>8,936</td>
<td>Cancer in:</td>
<td>SIR**</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Lip</td>
<td>1.58</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tongue</td>
<td>2.33</td>
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<td></td>
<td></td>
<td>Oral cavity</td>
<td>2.75</td>
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<td></td>
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<td></td>
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<td></td>
<td>Pharynx</td>
<td>1.87</td>
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<td></td>
<td></td>
<td></td>
<td>Oesophagus</td>
<td>1.42</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Stomach</td>
<td>1.34</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Colon</td>
<td>1.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Liver</td>
<td>2.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pancreas</td>
<td>1.45</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Laryngeal</td>
<td>1.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lung</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mesotheloma</td>
<td>2.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Penis</td>
<td>2.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bladder</td>
<td>1.26</td>
</tr>
<tr>
<td>Hansen et al. [34]</td>
<td>Data origin: DMA&lt;br&gt;Reference group: shore-based reference group&lt;br&gt;Follow-up n/a</td>
<td>2010</td>
<td>Male officers</td>
<td>677</td>
<td>BMI ≥ 25</td>
<td>RR (95% CI) 1.33 (1.26–1.39)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male ratings</td>
<td>632</td>
<td>BMI ≥ 25</td>
<td>RR (95% CI) 1.30 (1.22–1.38)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fishermen</td>
<td>217</td>
<td>BMI ≥ 25</td>
<td>RR (95% CI) 1.45 (1.35–1.57)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maritime students</td>
<td>228</td>
<td>BMI ≥ 25</td>
<td>RR (95% CI) 1.44 (1.25–1.66)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Female seafarers</td>
<td>207</td>
<td>BMI ≥ 25</td>
<td>RR (95% CI) 1.41 (1.22–1.65)</td>
</tr>
</tbody>
</table>

* One year denotes a closed cohort, a range of years denotes an open cohort.
** Lower limit of the confidence interval is above 100.

Two studies found tuberculosis to be more common among seafarers than in the general population [31,32]. DNA typing of the mycobacterial strains in the most recent study indicated that tuberculosis was acquired ashore rather than at sea [32]. While 77% of seafarers between 45 and 66 years were overweight and 31% obese in 2001/2002 [33], 71% of all male seafarers and 73% of fishermen were overweight in 2010. Compared to the outcome of surveys of non-maritime workers, there was an significant increased relative risk of overweight for male officers and ratings in the merchant fleet, as well as for fishermen and maritime students [34].

Discussion

The reviewed studies demonstrate significant health and safety challenges for Danish seafarers and fishermen. Some of the studies suggest improvement over time, but compared to employees in land-based occupations, the health of both maritime populations remains poor. This is reflected by elevated rates of mortality, hospitalizations, cancers, certain infections, accidents and overweight. These health characteristics were unevenly distributed in between sexes and various groups of maritime workers. Young male seafarers and ratings in the engine were in particular risk. Except for more overweight and poorer health of females in male-dominated seafaring occupations, female seafarers were generally no worse off than females ashore.

Obvious adverse health outcomes related to occupation include the impact of maritime disasters and specific malignancies such as mesothelioma related to asbestos exposure. Occupational exposures such as asbestos, polyaromatic hydrocarbons and oil mist may also explain other malignancies, e.g. the increased occurrence of lung cancer among seafarers working in the engine. The pattern of location for other cancers, however, strongly indicates the role of exposure to tobacco smoke.

Other frequent diseases in seafarers such as cirrhosis and primary liver cancer may appear non-occupational and rather related to alcohol consumption and to non-alcoholic steatohepatitis. An interesting observation for both seafarers and in particular fishermen is the excess rates of lip cancer, which may be due to occupational exposure to ultraviolet radiation or pipe smoking. The mycobacterial DNA pattern suggesting seafarers’ tuberculosis to be mainly acquired ashore in Denmark may reflect social circumstances related to the trade and a tendency to marginalization of some seafarers.

Provided a correct content of registers, linking studies are favoured by allowing valid estimation of the differential distribution of health indicators between various strata of the covered population. An excess of a certain health event therefore suggests causal relations, and may consequently identify opportunities for preventive action. This may be supported if several studies display comparable risks for the same occupational strata. However, poor preconditions for register linking studies limit the opportunities for comparative international studies of maritime health, which have been only possible for a few conditions, e.g. the elevated risk of ischaemic heart disease in naval officers and fishermen [35].

There are several limitations of register-based research when the study group is small as it is the case for Danish maritime workers and particularly specific strata of maritime workers. With a short follow-up time, elevated rates of less frequent diseases may not reach significance, despite a highly increased risk. Consequently, it is only feasible to monitor the most frequent conditions. The 5-year hospitalization follow-up studies illustrate this challenge [20–22]. If frequent health events are also the most important ones in terms of severity, this limitation may at times be acceptable, but there will always be a loss of information. This constraint may be reduced by increasing the follow-up time. Doing so, however, challenges the preventive value of a register linking study because identified cause–effect relations may reflect historical rather than current exposures, and consequently cannot justify preventive intervention.

Historical data have demonstrated the severe health impact of seafarers’ alcohol consumption [13,20], but cultural and legislative changes have led to a minimal alcohol intake during work on board Danish ships. Consequently, the most recent information from Statistics Denmark demonstrates that death of seafarers from alcohol-related disorder such as cirrhosis of the liver has almost disappeared [36].

To overcome the challenges of register-linking studies of limited populations, a compromise may be the execution of a series of follow-up studies with assessment of the trends of incident data such as in the studies with two 5-year follow-up periods [21,22]. An increasing trend of a certain condition indicates a need for prevention while a decline suggests that improvement has taken place. The demonstration of significant trends, however, requires a follow-up of sufficient duration to yield a sufficient number of years in risk.

Although the presented data linkage studies do suggest interesting associations between occupational factors and health outcomes they must be interpreted with caution. In particular, selection bias
and misclassification of exposure and/or outcome variables may occur in administrative databases created for purposes other than the association of interest in a particular epidemiologic study. The interpretation of the results from cohort studies of maritime workers is further complicated by their high turnover in terms of occupational stability. Consequently, a studied cohort of seafarers may eventually consist of a major fraction of previous seafarers, some of which may have developed a marginal labour market relation and be characterized by poor health and high rates of accidents [37]. The current educational requirements in the seafaring industry are likely to reduce the previously substantial selection out of the trade. Another constraint that may limit the validity of our findings is the fact that none of the quoted studies were stratified by social class. As a consequence, the results cannot exclusively be interpreted as work related because the studied effects potentially are related to social class.

Dramatic changes have influenced the composition of the Danish merchant and fishing fleet, its technology and work environments, the living conditions and lifestyle of maritime workers. In addition, the composition of seafarers has changed. While seafarers of the Danish merchant fleet in the seventies were almost exclusively Danish citizens, foreign crews dominate today. The register studies quoted in this review except the studies of maritime deaths [15,19] do not represent the whole seafaring population because Danish registers of health-related issues cover Danish nationals only.

The increased fraction of foreign seafarers in the Danish merchant fleet challenges register linking as a future way to monitor maritime health and safety. It is therefore increasingly essential to seek other ways to study seafarers’ health such as by collection of health data in labour-supplying countries (Philippines, India, Eastern Europe); in particular, data that reflect early signs of adverse health among these seafarers. Such early identification of deviations in health among migrant workers is challenging because the pre-employment health examinations are not always based on validated and comparable methods. One exception is simple but important health indicators such as body mass index [34] that are already collected internationally during health examination of seafarers. However, such international data are not easily accessible for research purposes. Data collection in the migrant workers’ home counties, where registers comparable to those in Denmark are scarce, requires employment of new methods, e.g. collection of health data from questionnaires or extensive international collaboration with colleagues and authorities.

Surveillance of seafarers’ health continues to be important for two main reasons. Firstly, in spite of significant improvements, the maritime industries still expose their employees to harmful occupational exposures and accident risks. In addition, their health care opportunities are poorer than those ashore [38]. Secondly, the reduction of crew on board modern vessels influences the workloads and sleep patterns of the remaining crew. Consequently, fatigue is becoming an increasingly important risk factor in the maritime occupations, not only for accidents and maritime disasters. The adverse metabolic consequences of fatigue compete with those related to overweight [39] and contribute to morbidity related to the seafarers’ lifestyle.

Conclusion

Register-linking studies of deaths, hospitalizations, accidents and statutory health examinations have demonstrated a number of negative health effects related to the work and life of seafarers and fishermen and additionally indicated adverse health outcomes of non-occupational nature. The studies in this review clearly demonstrate an excess risk in terms of mortality, poor health and occupational accidents among maritime workers compared to other Danes. The excess risk justifies a continuing monitoring of health indicators of seafarers and fishermen. Such monitoring does, however, require additional information than the existing Danish registers currently provides.

Conflict of interest

None declared.

Funding

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References


[34] Hansen HL, Hjarnoe L and Jepsen JR. Obesity continues to be a major health risk for Danish seafarers and fishermen. Int Marit Health 2011;62:98–103.


