Influence of Occupational Accidents and Deaths Related to Lifestyle on Mortality among Merchant Seafarers

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Objectives. The aim of the present historical cohort study was to enhance the understanding of the unusual mortality pattern seen among seafarers. The main object was to describe the mortality pattern of Danish seafarers in recent years with special reference to the influence of accidents in the maritime workplace and ashore and the influence of diseases related to lifestyle.

Subjects. A cohort of 24,132 male seafarers of all job categories employed on a Danish merchant ship between 1986 and 1993, was followed up. Mortality among those who left the occupation before the end of the follow-up period was analysed separately.

Results. The standardized mortality ratio was 1.43 (95% CI : 1.33–1.54) from all causes and 3.05 (95% CI : 2.62–3.52) from accidents. An excess mortality from natural causes was attributable mostly to an excess among deck and engine room crew and was mainly caused by diseases related to lifestyle. While active as seafarers, the SMR for accidents was 2.62 (95% CI : 2.12–3.20), accidents at the workplace explaining almost half the deaths. Among those who left shipping, the risk of fatal accidents increased. All categories of seafarers continued to have a high risk of fatal accidents into older age.

Conclusion. Merchant seafarers were shown to have a higher mortality than the general population. Despite a very high risk of fatal accidents in the workplace, these accidents could only explain a proportion of the observed excess mortality. Accidents ashore and diseases related to lifestyle factors such as drinking and smoking made a major contribution to the observed excess mortality. The results indicate that people in occupations with a high risk of fatal accidents at the workplace also seem to have a high risk of accidents away from the workplace after leaving the occupation. The high risk lifestyle seems to be linked to lifestyle in general and hence the related diseases and high risk of death.

Keywords: maritime medicine, occupational accidents, mortality, merchant seafarers

Seafaring is known to be a dangerous occupation with a high risk of fatal accidents at work. In Scandinavian follow-up studies, seafaring has also been identified as an occupation with a high mortality, especially among unskilled and semi-skilled ratings on deck and in the engine room. Certain diseases such as lung cancer and cirrhosis of the liver, both related to lifestyle, could explain some of the excess mortality, but accidents were also an important contribution to the elevated mortality. None of these studies have been able to distinguish between accidents at work and other accidents and are thus unable to estimate the impact of occupational accidents on mortality of workers in a dangerous occupation. At sea there may be no direct access to qualified medical assistance for cases of serious illness which may result in loss of life.

The aim of this study was to enhance the understanding of the unusual mortality pattern among seafarers. Furthermore, it was to describe the mortality pattern of Danish seafarers in recent years with special reference to the influence of accidents in the maritime workplace and ashore and the influence of diseases related to lifestyle. It was also an objective to study the impact of deaths at sea caused by diseases on mortality rates. Finally, the aim was to study the mortality pattern among a group of former seafarers to see whether the risk of fatal accidents decreased after leaving the dangerous occupation.

MATERIAL AND METHODS
This study is a historical cohort study. Data were obtained from a register at the Danish Maritime Authority in which seafarers have been recorded on a computerized database since 1 April 1986. The information recorded is based on copies of employment contracts. It

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is mandatory for the shipping companies to complete one each time a seafarer is signed on or off a ship under the Danish flag. Seafarers signed on ships owned by the government or on small vessels in domestic trade are not included on the database. Only seafarers who lived in Denmark at the time of registration are included, as it was only possible to trace the vital status of this group via registers. New seafarers were included until the end of the follow-up on 31 December 1993. The seafarers were classified in occupational groups based on their recorded occupation on entry into the cohort. The study only includes males.

In order to establish the place of residence at the time of entry into the database, to identify seafarers who had taken up residence abroad, disappeared or died during the follow-up period, the personal identification number of each seafarer was record-linked with the Central Population Register kept by the Ministry of the Interior. Time of observation for each seafarer was calculated from day of first employment until 31 December 1993 or date of death, date of taking up residence abroad, or recorded date of disappearance prior to 31 December 1993. A seafarer with no recorded active employment aboard ship reporting to the register for 6 months, was counted as a former seafarer from day 181 after the date of cessation of the latest employment period. Some men counted as former seafarers have been working in ships not obliged to report to the register, though the exact number is unknown.

Causes of death were primarily obtained from the Register of Causes of Death at the Danish National Board of Health. The underlying cause of death was coded using the 8th Revision of the International Classification of Diseases throughout the study period. The Danish National Board of Health only accepts Danish death certificates for coding. Seafarers or other citizens who die at sea or in a foreign port or on foreign soil are not given a Danish death certificate. In this study, no cause of death was available in 104 cases, despite all being recorded as having died. As part of another study of causes of deaths aboard ship it was possible to obtain information on diagnosis in 83 of these cases. Manner and causes of death were subsequently determined in cooperation with a specialist in forensic medicine from the Department of Forensic Medicine, University of Aarhus, Denmark. Causes of death were subsequently coded independently by the staff at the Register of Causes of Death to ensure homogeneous coding. Some basic information existed about almost all the remaining 21 cases, but the available medical data were judged insufficient to determine cause of death with certainty. None of them died aboard Danish ships, but several had died aboard ships under flags of convenience. In such cases, Danish authorities are unlikely to receive detailed information on the cause of death.

The number of expected deaths was calculated on the basis of the total number of person-years for each 5-year age category multiplied by the cause and age-specific mortality rate for Danish men during the same period. The standardized mortality ratio (SMR), the ratio between the observed and the expected numbers, was calculated with 95% confidence intervals (95% CI) assuming a Poisson distribution. For observed numbers above 100 normal distribution was assumed.

RESULTS
The entire cohort consisted of 24 132 male seafarers with an accumulated total of 133 233 person-years and a total of 724 deaths occurred during the follow-up period (Table 1). Of these, 9767 were active from entrance into the cohort to the end of the follow-up period or until deleted because they had died, were recorded as disappeared, or had taken up residence abroad. The remaining 14 365 seafarers stopped active service in

### Table 1: Number of seafarers, deaths and person-years of observation divided into employment status and main job categories

<table>
<thead>
<tr>
<th>Category</th>
<th>No. of seafarers</th>
<th>Active seafarers</th>
<th>Former seafarers</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Person-years</td>
<td>Person-years</td>
<td>Person-years</td>
</tr>
<tr>
<td>Officers, deck and engine room</td>
<td>7967</td>
<td>35 721</td>
<td>13 409</td>
<td>49 130</td>
</tr>
<tr>
<td>Deck and engine room crew</td>
<td>9994</td>
<td>32 005</td>
<td>20 200</td>
<td>52 205</td>
</tr>
<tr>
<td>Galley and catering crew</td>
<td>6171</td>
<td>14 515</td>
<td>17 383</td>
<td>31 898</td>
</tr>
<tr>
<td>Total</td>
<td>24 132</td>
<td>82 241</td>
<td>50 992</td>
<td>133 233</td>
</tr>
</tbody>
</table>
the two remaining occupational groups. The SMR for categories, although the mortality rate for natural deaths than doubled. The same trend was seen in the other job officers having a mortality close to that of the general non-natural death, especially from accidents, was more was below average for diseases, whereas the risk of causes of death together was close to normal for symptoms and ill-defined conditions. The SMR for all cirrhosis of the liver, alcoholism and to some extent diagnoses related to alcohol consumption include malignant neoplasms in the respiratory system, heart diseases and cerebrovascular diseases. Diagnoses related to alcohol consumption include cirrhosis of the liver, alcoholism and to some extent symptoms and ill-defined conditions. The SMR for all causes of death together was close to normal for officers, but significantly elevated for deck and engine room crew and for galley and catering crew. Despite officers having a mortality close to that of the general male population, detailed calculations show that SMR was below average for diseases, whereas the risk of non-natural death, especially from accidents, was more than doubled. The same trend was seen in the other job categories, although the mortality rate for natural deaths was above the level for the whole male population in the two remaining occupational groups. The SMR for endocrine diseases including diabetes (ICD 240–279), including all job categories, was reduced to 0.55 (0.22–1.13). A major contribution to the elevated mortality from natural causes was cancer, cancer of the respiratory system being quantitatively most important. In 15 (45%) of the cases where symptom diagnoses and ill-defined conditions (ICD 780–796) were the main cause of death, the contributory cause of death was either alcoholism (ICD 303) or alcoholic liver cirrhosis (ICD 571.0).

During the period of active service, SMR for all diagnoses was 0.98 (0.87–1.10) and for accidents 2.62 (2.12–3.20). During the period following active service, the SMR increased to 2.09 (1.90–2.30) for all causes and to 3.71 (2.97–4.58) for accidents. Table 3 shows the observed numbers of deaths and SMR values for different diagnostic groups and job categories, divided between the period while the seafarers were active and that after cessation of active service. While active seafarers, all job categories had an SMR for all diseases below one. For all job categories, there was a steep increase in mortality after leaving active service at sea. This could mainly be explained by a steep increase in deaths caused by disease, whereas the SMR for

### Table 2: Observed number of deaths, standardized mortality ratio (SMR) and 95% confidence limits for 24,132 male seafarers. The seafarers are divided into main job categories and cause of death by main diagnostic group

<table>
<thead>
<tr>
<th>Category</th>
<th>Obs.</th>
<th>SMR</th>
<th>CI</th>
<th>Obs.</th>
<th>SMR</th>
<th>CI</th>
<th>Obs.</th>
<th>SMR</th>
<th>CI</th>
<th>Obs.</th>
<th>SMR</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>All causes (001–E999)</td>
<td>264</td>
<td>1.01</td>
<td>0.89–1.14</td>
<td>339</td>
<td>2.03</td>
<td>1.82–2.26</td>
<td>121</td>
<td>1.56</td>
<td>1.30–1.87</td>
<td>724</td>
<td>1.43</td>
<td>1.33–1.54</td>
</tr>
<tr>
<td>Natural deaths (001–799)</td>
<td>188</td>
<td>0.88</td>
<td>0.76–1.01</td>
<td>197</td>
<td>1.60</td>
<td>1.39–1.84</td>
<td>54</td>
<td>1.05</td>
<td>0.79–1.37</td>
<td>439</td>
<td>1.13</td>
<td>1.03–1.24</td>
</tr>
<tr>
<td>Malignant neoplasms (140–209)</td>
<td>72</td>
<td>1.02</td>
<td>0.80–1.29</td>
<td>69</td>
<td>1.72</td>
<td>1.34–2.18</td>
<td>17</td>
<td>1.03</td>
<td>0.60–1.66</td>
<td>158</td>
<td>1.24</td>
<td>1.06–1.45</td>
</tr>
<tr>
<td>Respiratory system (160–163)</td>
<td>28</td>
<td>1.18</td>
<td>0.78–1.70</td>
<td>22</td>
<td>1.72</td>
<td>1.08–2.61</td>
<td>11</td>
<td>2.26</td>
<td>1.13–4.05</td>
<td>61</td>
<td>1.47</td>
<td>1.13–1.89</td>
</tr>
<tr>
<td>Heart diseases (390–429)</td>
<td>61</td>
<td>0.97</td>
<td>0.74–1.25</td>
<td>37</td>
<td>1.09</td>
<td>0.77–1.50</td>
<td>10</td>
<td>0.75</td>
<td>0.36–1.39</td>
<td>108</td>
<td>0.98</td>
<td>0.81–1.19</td>
</tr>
<tr>
<td>Gastroinest. diseases (520–577)</td>
<td>11</td>
<td>0.76</td>
<td>0.38–1.35</td>
<td>20</td>
<td>2.29</td>
<td>1.40–3.54</td>
<td>10</td>
<td>2.65</td>
<td>1.27–4.88</td>
<td>41</td>
<td>1.52</td>
<td>1.09–2.06</td>
</tr>
<tr>
<td>Cirrhosis, liver (571)</td>
<td>7</td>
<td>0.64</td>
<td>0.26–1.32</td>
<td>15</td>
<td>2.26</td>
<td>1.26–3.73</td>
<td>7</td>
<td>2.44</td>
<td>0.98–5.03</td>
<td>29</td>
<td>1.42</td>
<td>0.95–2.04</td>
</tr>
<tr>
<td>Cerebrovascular diseases (430–438)</td>
<td>6</td>
<td>0.56</td>
<td>0.19–1.21</td>
<td>12</td>
<td>2.01</td>
<td>1.04–3.51</td>
<td>3</td>
<td>1.20</td>
<td>0.25–3.49</td>
<td>21</td>
<td>1.09</td>
<td>0.67–1.67</td>
</tr>
<tr>
<td>Alcoholism (303)</td>
<td>7</td>
<td>1.69</td>
<td>0.68–3.48</td>
<td>13</td>
<td>5.08</td>
<td>2.70–8.68</td>
<td>2</td>
<td>1.85</td>
<td>0.22–6.69</td>
<td>22</td>
<td>2.82</td>
<td>1.77–4.26</td>
</tr>
<tr>
<td>Symptoms and ill-defined conditions (780–796)</td>
<td>11</td>
<td>0.75</td>
<td>0.37–1.33</td>
<td>19</td>
<td>2.14</td>
<td>1.29–3.35</td>
<td>3</td>
<td>0.78</td>
<td>0.16–2.28</td>
<td>33</td>
<td>1.20</td>
<td>0.83–1.69</td>
</tr>
<tr>
<td>Other diseases (remaining &lt;800)</td>
<td>20</td>
<td>0.35</td>
<td>0.33–0.84</td>
<td>27</td>
<td>1.18</td>
<td>0.78–1.71</td>
<td>9</td>
<td>0.84</td>
<td>0.39–1.60</td>
<td>56</td>
<td>0.80</td>
<td>0.60–1.04</td>
</tr>
<tr>
<td>Non-natural deaths (E800–999)</td>
<td>67</td>
<td>1.60</td>
<td>1.24–2.03</td>
<td>133</td>
<td>3.31</td>
<td>2.77–3.92</td>
<td>64</td>
<td>2.70</td>
<td>2.08–3.44</td>
<td>264</td>
<td>2.49</td>
<td>2.20–2.81</td>
</tr>
<tr>
<td>Accidents (E800–E949, E960–E999)</td>
<td>46</td>
<td>2.10</td>
<td>1.54–2.80</td>
<td>96</td>
<td>4.07</td>
<td>3.30–4.97</td>
<td>41</td>
<td>2.83</td>
<td>2.03–3.84</td>
<td>183</td>
<td>3.05</td>
<td>2.62–3.52</td>
</tr>
<tr>
<td>Suicide (E950–959)</td>
<td>21</td>
<td>1.05</td>
<td>0.65–1.61</td>
<td>37</td>
<td>2.23</td>
<td>1.57–3.07</td>
<td>23</td>
<td>2.49</td>
<td>1.58–3.73</td>
<td>81</td>
<td>1.77</td>
<td>1.41–2.20</td>
</tr>
<tr>
<td>No information*</td>
<td>9</td>
<td>1.98</td>
<td>0.91–3.76</td>
<td>9</td>
<td>2.43</td>
<td>1.11–4.61</td>
<td>3</td>
<td>1.53</td>
<td>0.32–4.47</td>
<td>21</td>
<td>2.05</td>
<td>1.27–3.13</td>
</tr>
</tbody>
</table>

* No information on cause of death in the Register of Causes of Death or from other sources.
accidents decreased slightly for officers and galley and catering staff, but increased for deck and engine room crew. Among the 96 fatal accidents occurring among active seafarers (Table 3), 46 were among men signed on a ship at the time of the accident (47.9%). The remaining fatal accidents among active seafarers took place ashore during holidays, time off in lieu of wages, or unemployment periods. Among the 46 fatal accidents, 14 were caused by occupational accidents directly related to the work of the seafarer, and 14 were caused by maritime disasters (shipwreck, capsizing). The remaining 18 accidents took place during off-duty hours, the majority being caused by drowning in harbour areas in an inebriated condition. To estimate the impact of accidents aboard on the SMR for accidents and on all causes of death, the SMR can be recalculated after subtracting all accidents aboard. During active service, accidents aboard comprised 46 of 292 deaths (15.8%) and the corresponding SMR for all accidents during active service would be reduced from 2.62 to 1.36 (1.01–1.80), and for all causes of death from 0.98 to 0.83 (0.73–0.94). Correspondingly, during the entire follow-up period, the SMR for accidents was reduced from 3.05 to 2.28 (1.91–2.70) and for all causes of death from 0.98 to 0.83 (0.73–0.94).
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TABLE 4  Standardized mortality ratios and 95% confidence limits for all accidents (E800–E949, E960–E999) for different occupational and age groups during the whole follow-up period.

<table>
<thead>
<tr>
<th>Age groups</th>
<th>15–29</th>
<th>30–44</th>
<th>45–59</th>
<th>60–79</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational group</td>
<td>SMR 95% CI</td>
<td>SMR 95% CI</td>
<td>SMR 95% CI</td>
<td>SMR 95% CI</td>
<td>SMR 95% CI</td>
</tr>
<tr>
<td>Officers</td>
<td>0.89 0.24–2.28</td>
<td>2.43 1.52–3.68</td>
<td>2.13 1.16–3.58</td>
<td>3.31 1.22–7.21</td>
<td>2.10 1.54–2.80</td>
</tr>
<tr>
<td>Deck and engine room crew</td>
<td>4.41 3.31–5.75</td>
<td>3.54 2.24–5.31</td>
<td>4.00 2.29–6.50</td>
<td>3.57 0.74–10.44</td>
<td>4.07 3.30–4.97</td>
</tr>
<tr>
<td>Galley and catering staff</td>
<td>2.95 1.93–4.32</td>
<td>2.37 1.08–4.50</td>
<td>2.60 0.71–6.66</td>
<td>6.06 0.73–21.89</td>
<td>2.83 2.03–3.84</td>
</tr>
</tbody>
</table>

Deaths and 21.0% of the excess deaths in the cohort. Among the 87 fatal accidents occurring after cessation of active service at sea, two were recorded as occupational accidents in the register of causes of death. Three cases of homicide are included in the figures for accidents giving an SMR of 1.47 (0.30–4.30) for this specific diagnosis.

The SMR increased for suicide for all job categories after cessation of active service at sea. The suicide rate among galley and catering staff was strongly influenced by the many suicides among seafarers from Greenland. If these suicides are subtracted, the SMR for suicide among galley and catering staff drops to 1.62 (0.91–2.68).

Deaths at sea or shortly after evacuation from a ship for natural causes totalled 31, but 12 were found dead; thus 19 died aboard of diseases known to other crew members. If all had hypothetically survived as a result of being brought under optimum medical treatment from the time of discovery of the disease, the SMR for all causes of death would have gone down from 1.43 to 1.40 (1.30–1.50).

DISCUSSION

The results of this study, using recent data, show that Danish seafarers still have a high mortality compared to the general population. In this study, the population for comparison was the whole male population, not only the economically active portion as in earlier mortality studies of seafarers from Scandinavia, which tends to lower the observed standardized mortality ratios found in the present study. The short follow-up period in this study may have influenced some of the results. Induction and latency time do not need to be taken into account when discussing fatal accidents, whereas diseases such as lung cancer and mesothelioma have very long induction and latency times. In a cohort of seafarers with a high turnover, people dying from the latter diseases are less likely to be included. In this study, people dying from diseases like ischaemic heart diseases, which is often preceded by a long period of disease before death, are also less likely to be included because they are less likely to be in active service during the last years of their lives. The design thus tends to underestimate mortality due to natural causes.

The differences in mortality from natural causes between officers and ratings correspond to what has been seen between different social classes in Denmark and elsewhere. A mortality pattern similar in some aspects called the 'unhealthy worker effect' has been described among Danish workers on an Arctic air base, although the seafarers in the present study were also shown to have a high mortality when young, and a much higher risk of violent death. During active service, all job categories had an SMR for death from natural causes below that in the population in general, which reflects a healthy worker effect. Danish seafarers have to pass a health examination every second year and only reasonably healthy individuals can be active seafarers. Not surprisingly, death due to natural causes increased after cessation of active service at sea. Many of the seafarers probably stopped active service at sea because of disease. For some conditions such as endocrine diseases (mainly diabetes), mortality for the whole cohort was low. This shows that despite a generally high mortality, a strong healthy worker effect was present for certain causes of death. Although diabetes is not an absolute contraindication for active service, seafarers with this condition will tend to leave the occupation.

The high risk of death from intoxication, mainly with alcohol and drugs, is also reflected in the diagnoses of natural deaths. There was a greater risk of death from gastrointestinal diseases, mainly cirrhosis of the liver, particularly for ratings. Analysis of contributory causes of death among those classified as symptom diagnoses and ill-defined conditions (ICD 780–796) revealed that alcohol was a contributory factor in almost half the cases.
Smoking has been and still is very common among Scandinavian seafarers\textsuperscript{16,17} and is likely to be the most important explanatory factor for the observed excess risk of lung cancer. Asbestos was used extensively in ship construction in Scandinavia until the mid-1970s.\textsuperscript{18} Seafarers in general and ship’s engineers in particular have been shown to have radiological abnormalities consistent with asbestos exposure,\textsuperscript{19,20} but other occupational exposures may be present in the engine room.\textsuperscript{3} No relevant conclusions can be drawn from the present study because of lack of exposure data.

In some cases, death at sea from natural causes was caused by lack of direct access to professional medical care,\textsuperscript{1} but the calculation shows that even if all those who died at sea, or shortly after evacuation, had survived—which is hypothetical—this would have had little influence on the observed mortality in this cohort. Lack of access to professional medical care is obviously crucial in some cases, but it is not an important explanatory factor for the high mortality observed.

Fatal accidents aboard have been shown to be common, with a rate of 5.3 per 10 000 years of active service, which is more than 10 times the mean in other occupations in Denmark.\textsuperscript{1} However, this could only to some extent explain the high mortality found in this cohort. Less than one-sixth of all deaths among active seafarers were caused by accidents on board and less than a quarter of the excess deaths in the whole cohort could be attributed to accidents at sea. Even if all deaths in the workplace were subtracted, the SMR for accidents was still higher than one during the period of active service. The SMR for all accidents decreased slightly for galley and catering crew, but increased for deck and engine room ratings. It seems as if seafarers involve themselves in other high risk activities after leaving the risks related to a life at sea: not only did the population studied have a high accident mortality in the workplace, but they also seem to have involved themselves in other high-risk activities in other settings. These other accidents included a broad spectrum of different occurrences, including traffic accidents and intoxication. Only two occupational accidents were reported after cessation of active service at sea although this may be an underestimate because the register of causes of death may not record some deaths as occupational accidents.

The risk of fatal accidents was shown to be highest for ratings and lowest for officers, but for all categories it was well above the figure for the population in general. The differences in accident mortality between officers and unskilled ratings correspond well with studies of differences between white-collar workers and unskilled workers in Denmark.\textsuperscript{4} It is noteworthy that even the officers had an SMR more than double the expected, whereas white collar workers in Denmark have been shown to have a risk of fatal accidents well below the mean for males in all age categories.\textsuperscript{4} An elevated SMR for accidents, see again also in higher age groups, is also found among unskilled workers in Denmark, and the same observation has been made among Icelandic fishermen.\textsuperscript{21} Seafarers are probably drawn by their occupation towards hazardous behaviour and a high risk lifestyle,\textsuperscript{22} but people with a high risk lifestyle may also be attracted by or pushed into high risk occupations such as seafaring and fishing. The very high mortality found among the youngest could suggest this, as they only had a short time to be influenced by their occupation.

We conclude that seafaring is a high risk occupation with a high mortality. Prevention should be directed towards the hazardous working conditions causing occupational accidents and the high risk lifestyle in general, causing many accidents at sea and ashore. Excess mortality caused by diseases related to tobacco and alcohol consumption also reflects a high risk lifestyle and indicates another field of prevention although an improved working environment at sea may be of benefit as well.

ACKNOWLEDGEMENTS
We would like to thank Annie Vesterby, of the Department of Forensic Medicine, University of Aarhus, for assistance with the classification of manner and causes of death, and Hedda Bille and the staff of the National Board of Health for coding the data on cause of death. This study was supported by the Danish Maritime Occupational Health Service.

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