

# BMJ Open Age and nationality in relation to injuries at sea among officers and non-officers: a study based on contacts from ships to Telemedical Assistance Service in Denmark

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**To cite:** Herttua K, Gerdøe-Kristensen S, Vork JC, *et al*. Age and nationality in relation to injuries at sea among officers and non-officers: a study based on contacts from ships to Telemedical Assistance Service in Denmark. *BMJ Open* 2019;**9**:e034502. doi:10.1136/bmjopen-2019-034502

► Prepublication history for this paper is available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2019-034502>).

Received 23 September 2019  
Revised 25 November 2019  
Accepted 25 November 2019



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## ABSTRACT

**Objectives** Characterisation of worker injuries on board merchant ships is modest. Using telemedical service contacts in Denmark, we describe the worker injuries patterns and factors related to injury incidence.

**Methods** The data for this study were based on contacts (n=1401) from ships to Telemedical Assistance Service (TMAS) in Denmark in 2004–2014, which were supplemented with data on the annual estimation of all seafarers from the Danish Maritime Authority (n=73 336). The final data included information on broad age groups, occupation and nationality. The outcomes were injuries from any cause and six broad categories of injuries characterised by anatomic location or type of injury.

**Results** During the observation period of 11 years, there were 1401 contacts to TMAS due to injuries, of which 36% were in upper limb, 18% in lower limb and 13% in the head. Age-adjusted incidence rates for all injuries varied between 13.6 and 26.8 incidences per 1000 person-years in 2004–2014. In most types of injuries, younger and older seafarers had higher risk for injuries than seafarers aged 30–49 years. Depending on the type of injury, non-officers had threefold to fivefold increased odds of injuries compared with officers, the risk being highest for head injuries with an OR of 5.00 (95% CI 3.19 to 7.83). Non-officers from the European Union (EU) had higher risk in most types of injuries than non-officers from outside the EU, whereas the pattern of this risk was inverse among officers.

**Conclusions** These findings suggest that non-officers and European seafarers have an increased risk for several types of injuries on board Danish-flagged merchant ships. Additionally, age affected risk with the younger (<30 years) and older (>50 years) seafarers having increased risk.

## INTRODUCTION

Injuries are a major cause for years lived with disability<sup>1</sup> and mortality<sup>2</sup> worldwide. For example, in 2017, unintentional injuries were responsible for 36.5 million years lived with disability.<sup>1</sup> In addition to >2.8 million deaths from occupational accidents and work-related diseases, there are annually an estimated

## Strengths and limitations of this study

- Register-based study with very little loss to follow-up.
- The first register-based study to examine the association between sociodemographic characteristics and injuries characterised by anatomic location among seafarers.
- The number of explanatory or confounding variables was limited.

374 million non-fatal work-related injuries.<sup>3</sup> Despite continuous efforts to improve safety on board, seafaring remains a high-risk occupation.<sup>4</sup> In British shipping, for instance, the rate of fatal accidents was almost 5 times higher than in the construction industry in 2003–2012.<sup>5</sup>

Evidence on determinants or risk factors for injuries among seafarers is scarce, partially conflicting and much of it is based on self-reported data.<sup>6–9</sup> Nevertheless, earlier research consistently reports that non-officers have higher risk for injuries than officers.<sup>6–9</sup> There are few studies to date on the association between age and nationality and injuries on board. However, a higher risk for injuries has been found in younger seafarers,<sup>9</sup> and a higher risk for UK seafarers and a lower risk for seafarers from the Philippines have been reported.<sup>9</sup> To our best knowledge, no prior research exists on the association between risk factors and injuries by specific anatomic location among seafarers.

Using data on contacts from ships to the Danish Telemedical Assistance Service (TMAS), we quantified the risk for injuries among officers and non-officers in the Danish-flagged merchant fleet. Moreover, we investigated associations of age and nationality with all-cause injuries and six broad

categories of injuries, characterised by anatomic location or type of injury.

## MATERIALS AND METHODS

### Data sources and study population

In this retrospective cohort study, the cohort was defined as the seafaring population on board merchant ships registered in the Danish Register of Shipping. The registers are annual records administered by the Danish Maritime Authority. We included the years 2004–2014. Another administrative data source, we used in this study, was the TMAS of Denmark, that is, Radio Medical Denmark (RMD). RMD is a 24-hour manned TMAS agency which is staffed by a team of medical specialists from Southwest Jutland Hospital in Esbjerg. RMD can be contacted by seafarers on board Danish trading and fishing vessels and ferries, no matter where in the oceans they may be.<sup>10</sup> The TMAS is responsible for giving medical advice via radio, especially for help in preliminary diagnosis and treatment, making recommendations comprising deviation from planned course to the closest harbour or immediate helicopter transport to shore-based medical facilities depending on the patient's condition.<sup>11 12</sup> Every contact to the TMAS with health-relevant information, such as personal data and diagnosis, is recorded. We obtained information on injuries together with sociodemographic characteristics from these data on all RMD-managed TMAS contacts between 2004 and 2014. In our analysis, we include TMAS contacts from merchant fleet, which means that fishing boats and ferries were excluded. We combined data on annual estimates of seafaring population from the Danish Registers of Shipping with the TMAS data to calculate adjusted incidence rates and to perform analyses on the association between explanatory variables and outcomes.

### Injuries

All reports on TMAS contacts include diagnoses coded according to the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10). The end points used for analyses in this study were defined as TMAS contacts with an ICD-10-registered injury. In case there were two or more contacts to the TMAS on one person within a 2-year period regarding an identical injury category, only the first contact was taken into account. Injuries were defined with a diagnosis code in the interval of injuries, poisoning and certain other consequences of external causes (ICD-10 codes S00-T98), excluding complications of surgical and medical care, not elsewhere classified (T80-T88). Subcategories of injuries determined by a broad anatomic location or type included injuries to the head (S00-09), injuries to the neck, thorax, abdomen, lower back, lumbar spine and pelvis (S10-39 and T08-09), injuries to the upper limb (S40-69 and T10-11), injuries to the lower limb (S70-99 and T12-13), injuries involving multiple body regions and effects of foreign body entering through natural orifice

(T00-07 and T14-19), burns, poisoning and other injuries (T20-79 and T90-98).

### Independent variables

Independent variables were determined by the data obtained from the Danish Maritime Authority. Accordingly, age was grouped into three categories: under 30 years, from 30 to 49 years and 50 years and over. Nationality of seafarers was classified into three categories: Danish, non-Danish European Union (EU) and non-EU citizens. Occupation was classified into deck officers, engine officers and non-officers. Since engine officers were few in number, we used a combined measure of officers in all analyses. Similarly, due to a low number of female seafarers and injuries among them, all analyses included both men and women.

### Statistical analysis

We compared the characteristics of non-cases and cases using  $\chi^2$  tests. We performed logistic regression to account for the associations between sociodemographic factors and outcomes. Logistic regression models were also used to calculate adjusted marginal means and 95% CIs for age-adjusted incidence rates. We examined effect modification by fitting interaction terms for age and occupation, and nationality and occupation, and presented stratified analyses to illustrate any such interaction. Data were analysed using Stata statistical software, V.16.

## RESULTS

Descriptive characteristics of the study population are presented in [table 1](#). In the study population, there were 1401 cases and 71 935 non-cases. Relatively seen, there were more seafarers belonging to the youngest or the oldest among those injured than among non-cases. Those injured were also more often non-officers by occupation than non-cases (82% vs 58%), whereas differences according to nationality were small.

Overall, during the study period from 2004 through 2014, there was an increase in the number of injuries from all causes from 101 cases in 2004 to 219 cases in 2014 (data not shown). [Figure 1](#) presents trends for the age-adjusted incidence rates of injuries from all causes with accompanying 95% CIs in the study period. The trend for the incidence rates was also rising with a variation from 13.6 (95% CI 10.6 to 16.6) per 1000 person-years in 2006 and 15.0 (95% CI 12.0 to 18.0) in 2008 to 26.8 (95% CI 23.3 to 30.3) in 2014.

Out of the 1401 injuries, 36% were upper limb injuries, 18% were lower limb injuries, 13% were head injuries, 12% belonged to the composite injury outcome of burns, poisonings and other types of injuries, 11% were back injuries and 10% included injuries in multiple regions. Unadjusted injury rates in men and women were 19.0 and 21.1 per 1000 person-years, respectively.

### Associations

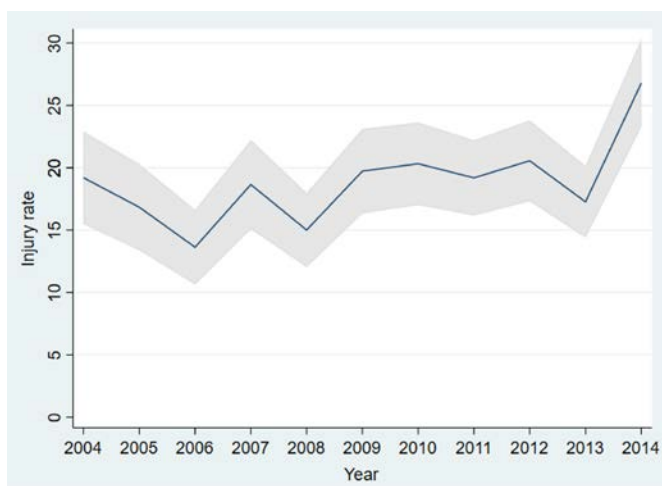
In [table 2](#), we quantify the associations for age groups and nationality with all-cause injuries. Because of a

**Table 1** Characteristics of the seafarers in the Danish Merchant Fleet, non-cases and cases in 2004–2014

	Non-cases (%)	Injuries (%)	P value
	n=71 935	n=1401	
<b>Age group, years</b>			
<30	17 416 (24)	434 (31)	<0.001
30–49	41 449 (58)	650 (46)	
≥50	13 070 (18)	317 (23)	
<b>Sex</b>			
Male	69 892 (97)	1357 (97)	0.503
<b>Occupation</b>			
Engine officer	2062 (3)	55 (4)	<0.001
Deck officer	28 055 (39)	198 (14)	
Non-officer	41 818 (58)	1148 (82)	
<b>Nationality</b>			
Danish	24 913 (35)	493 (35)	0.642
EU, non-Danish	8958 (12)	183 (13)	
Non-EU	38 064 (53)	725 (52)	

EU indicates here the European Union and the member countries of the European Economic Area and Switzerland. Comparisons between non-cases and cases were done with  $\chi^2$  tests.

significant interaction between age and occupation, and nationality and occupation, analyses were stratified by the occupational position. The ORs (95% CIs) for risk of injuries among the youngest and the oldest non-officers compared with those aged 30–49 years were 1.54 (1.34 to 1.76) and 1.95 (1.68 to 2.27), respectively, whereas the OR for the youngest officers was 1.61 (1.20 to 2.15). In the age-adjusted analysis, the OR for risk for injuries among Danish and non-Danish EU non-officers compared with those from non-EU countries were 1.85 (1.61 to 2.11) and 1.35 (1.13 to 1.61), respectively, whereas the OR for



**Figure 1** Age-adjusted incidence rates per 1000 person-years for injuries from all causes and accompanying 95% CIs in the Danish Merchant Fleet in 2004–2014.

non-Danish EU officers was 0.48 (0.29 to 0.79). An unadjusted OR of 0.75 (0.58 to 0.98) for Danish officers was attenuated after adjusting for age.

Analyses on six anatomic location or types of injuries with both officers and non-officers included (table not shown) indicated that non-officers generally had a higher risk for injuries compared with officers, but that the association was most pronounced for head injuries with an OR (95% CI) of 5.00 (3.19 to 7.83), whereas the ORs for back injuries, upper and lower limb injuries, injuries in multiple regions and poisonings and other types of injuries were 3.73 (2.44 to 5.70), 3.34 (2.66 to 4.19), 2.62 (1.94 to 3.53), 3.37 (2.17 to 5.23) and 2.95 (2.01 to 4.33), respectively. Because results were modified by fitting interaction terms for age/occupation and nationality/occupation, we performed analyses on these subgroups of injuries stratified by the occupational position.

Table 3 shows associations for age group and nationality with six anatomic location or type of injuries among non-officers. Compared with those aged 30–49 years, both younger and older age was associated particularly with head injuries, upper and lower limb injuries and the injury group that included burns, poisonings and other types of injuries. Younger age was strongest associated with head injuries with an OR (95% CI) of 1.92 (1.34 to 2.74), while older age was associated markedly with lower limb injuries with an OR of 2.24 (1.58 to 3.17). Older age was also associated with back injuries with an OR of 1.93 (1.28 to 2.91). Age-adjusted analyses showed, with non-officers from non-EU countries as the reference group, that Danish non-officers had an elevated risk especially for back injuries with an OR of 3.08 (2.06 to 4.60) and upper limb injuries with OR of 2.03 (1.64 to 2.52), but also for other injuries with an exception of burns, poisonings and other types of injuries, whereas non-Danish EU non-officers had a higher risk for back and upper limb injuries with ORs of 2.69 (1.69 to 4.29) and 1.37 (1.02 to 1.83), respectively.

Among officers (table not shown), younger age was associated with an increased risk of upper limb injuries and burns, poisonings and other types of injuries with ORs (95% CI) of 1.70 (1.05 to 2.74) and 3.01 (1.35 to 6.71), respectively. Officers from Denmark and non-Danish EU countries had a lower risk for burns, poisonings and other types of injuries than officers from non-European countries with ORs of 0.30 (0.13 to 0.67) and 0.13 (0.02 to 0.95), respectively.

## DISCUSSION

The current study was specifically designed to quantify the risk of injuries among officers and non-officers in the Danish-flagged merchant fleet, and to assess the association between age and nationality and all-cause injuries, and six broad categories of injuries characterised by anatomic location or type of injury using data on contacts from ships to TMAS of Denmark. More than one-third of injuries were in upper limb, followed by injuries in

**Table 2** ORs and accompanying 95% CIs for the association between age and nationality and injuries from all causes among officers and non-officers in 2004–2014

	N (%)	Rate	Model 1		Model 2	
			OR	95% CI	OR	95% CI
<i>Officers</i>						
Age group, years						
30–49	118 (47)	7.1	1.00			
<30	75 (30)	11.4	<b>1.61</b>	1.20 to 2.15		
≥50	60 (24)	8.7	1.23	0.90 to 1.68		
Nationality						
Non-EU	103 (41)	10.0	1.00		1.00	
Danish	132 (52)	8.2	<b>0.75</b>	0.58 to 0.98	0.81	0.61 to 1.08
EU, non-Danish	18 (7)	4.8	<b>0.45</b>	0.27 to 0.75	<b>0.48</b>	0.29 to 0.79
Total	253 (100)	8.3				
<i>Non-officers</i>						
Age group, years						
30–49	532 (46)	21.1	1.00			
<30	359 (31)	32.1	<b>1.54</b>	1.34 to 1.76		
≥50	257 (22)	40.4	<b>1.95</b>	1.68 to 2.27		
Nationality						
Non-EU	622 (54)	22.1	1.00		1.00	
Danish	361 (31)	40.0	<b>2.03</b>	1.78 to 2.31	<b>1.85</b>	1.61 to 2.11
EU, non-Danish	165 (14)	29.5	<b>1.45</b>	1.22 to 1.72	<b>1.35</b>	1.13 to 1.61
Total	1148 (100)	26.7				

Model 1: unadjusted; model 2: adjusted for age. Rates are per 1000 person-years and derived from age-adjusted logistic models for nationality. Statistically significant ORs are highlighted in bold. EU, European Union.

lower limb and in head. Depending on the outcome, non-officers had from a 3 to 5 times higher risk for injuries than officers. We observed a higher risk for most types of injuries in younger (under 30 years) and older ages (50 years or older) compared with those aged 30–49 years, but this pattern was more consistent among non-officers. For example, the risk for head injuries was 1.9 times higher among younger non-officers and the risk for lower limb injuries was 2.2 times higher among older non-officers. We also found that non-officers from EU countries had a higher risk for injuries compared with those outside the EU, the risk being highest for back injuries, whereas the pattern of this risk was mainly inverse among officers.

### Comparison with other studies

We are not aware of any prior studies that have examined the association between age, occupation, nationality or any other determinants and specific types of injuries among seafarers. However, a previous study from the USA, although not addressing specifically these associations, demonstrated a distribution of seafarer injuries by injured body part<sup>8</sup> which is quite similar to the distribution of injuries in the present study: the proportions of the combined category of upper and lower limb injuries,

for instance, in our and the American study were 54% and 60%, respectively.

Our findings agree with previous research, regardless of differences in data sources comprising self-reported data,<sup>9</sup> American telemedicine data<sup>8</sup> and data on hospitalisation,<sup>6</sup> of which all have demonstrated approximately an 1.6 times higher risk for injuries in non-officers than in officers. Higher injury rates in non-officers compared with officers can be accounted for mainly by the fact that non-officers' work simply consists of more manual work, in which they are more exposed to injuries than officers whose work tasks primarily are non-manual. There is some evidence, based on a large-scale study, of which data mainly was comprised land-based occupations, linking information from a survey with outcomes from health registers that night work is a risk factor for accidental injuries.<sup>13</sup> In contrast, no association between long working weeks and this risk was observed.<sup>13</sup> A recent cross-sectional study on seafarers on board container ships under German management found that watchkeepers had 12% shorter sleep periods than day workers and their average efficiency of sleep was 52% lower.<sup>14</sup> Fatigue is also suggested to be an important mediating



**Table 3** ORs and accompanying 95% CIs for the association between age and nationality and different types of injuries among non-officers in 2004–2014

	Head injuries				Back injuries			
	N (%)	Rate	OR	95% CI	N (%)	Rate	OR	95% CI
Age (years)								
30–49	67 (44)	2.6	1.00		70 (55)	2.8	1.00	
<30	57 (37)	5.1	<b>1.92</b>	1.34 to 2.74	24 (19)	2.1	0.77	0.49 to 1.23
>50	30 (19)	4.7	<b>1.78</b>	1.16 to 2.74	34 (27)	5.3	<b>1.93</b>	1.28 to 2.91
Nationality								
Non-EU	87 (56)	3.1	1.00		52 (41)	1.8	1.00	
Danish	46 (30)	5.0	<b>1.61</b>	1.12 to 2.32	48 (38)	5.6	<b>3.08</b>	2.06 to 4.60
EU, non-Danish	21 (14)	3.8	1.24	0.77 to 2.01	28 (22)	4.9	<b>2.69</b>	1.69 to 4.29
Total	154 (100)	3.6			128 (100)	3.0		
	Upper limb injuries				Lower limb injuries			
	N (%)	Rate	OR	95% CI	N (%)	Rate	OR	95% CI
Age (years)								
30–49	187 (45)	7.4	1.00		89 (45)	3.5	1.00	
<30	137 (33)	12.2	<b>1.66</b>	1.33 to 2.07	59 (30)	5.2	<b>1.50</b>	1.08 to 2.08
>50	95 (23)	14.9	<b>2.03</b>	1.58 to 2.60	50 (25)	7.8	<b>2.24</b>	1.58 to 3.17
Nationality								
Non-EU	217 (52)	7.7	1.00		120 (61)	4.3	1.00	
Danish	143 (34)	15.5	<b>2.03</b>	1.64 to 2.52	58 (29)	6.2	<b>1.45</b>	1.05 to 2.00
EU, non-Danish	59 (14)	10.5	<b>1.37</b>	1.02 to 1.83	20 (10)	3.5	0.80	0.50 to 1.29
Total	419 (100)	9.8			198 (100)	4.6		
	Injuries in multiple regions				Burn, poisoning, other injuries			
	N (%)	Rate	OR	95% CI	N (%)	Rate	OR	95% CI
Age (years)								
30–49	62 (53)	2.4	1.00		57 (43)	2.2	1.00	
<30	37 (32)	3.3	1.34	0.89 to 2.02	45 (34)	4.0	<b>1.78</b>	1.20 to 2.63
>50	17 (15)	2.7	1.09	0.64 to 1.86	31 (23)	4.9	<b>2.16</b>	1.40 to 3.35
Nationality								
Non-EU	63 (54)	2.2	1.00		83 (63)	3.0	1.00	
Danish	35 (30)	4.0	<b>1.85</b>	1.21 to 2.82	31 (23)	3.3	1.10	0.73 to 1.68
EU, non-Danish	18 (16)	3.4	1.56	0.92 to 2.65	19 (14)	3.3	1.12	0.68 to 1.86
Total	116 (100)	2.7			133 (100)	3.1		

Models by nationality are age-adjusted. Rates are per 1000 person-years and derived from age-adjusted logistic models for nationality. Statistically significant ORs are highlighted in bold. EU, European Union.

factor between night work and injuries.<sup>15 16</sup> It is, however, unclear whether there are differences in the prevalence of these risk factors between officers and non-officers. Moreover, non-officers may report injuries less frequently than officers due to worries for harmful consequences. This would result in underestimated injury rates among non-officers.

Our finding that non-officers aged under 30 years had from a 1.5 to 1.9 times higher risk for specific types of injuries compared with ratings aged 30–49 years accords with a previous study based on self-reported data, which demonstrated a 2.1 times higher risk for injuries in seafarers aged under 35 years compared with those aged 35 years or over.<sup>9</sup> Another study, although not addressing

directly injuries and using different age categories and reference groups, reported a 3.3 times and a 2.7 times higher risk for accidents causing permanent disability of 5% or over in seafarers aged from 45 to 54 years and those aged 55 year and over compared with those aged under 25 years.<sup>17</sup> However, the risk for accidents not causing disability was highest among seafarers aged 35–44 years.

In accordance with our findings, evidence from land-based industries suggests some explanations that may be applicable to seafaring as well. A recent systematic review of risk factors for agricultural injury indicated, on the one hand, that younger farmers had a higher risk of injury, but on the other hand, that the risk of injury increased slightly with age.<sup>18</sup> One suggested plausible explanation was that younger farmers tend to be less experienced and tend to engage more in risk-taking behaviours compared with older farmers,<sup>18</sup> whereas older farmers may have a higher injury risk because of health ailments and medication use.<sup>18</sup> This may explain the elevated risk for head injuries among younger non-officers and for lower limb injuries among older non-officers.

The observation in the present study that non-officers from the EU had an elevated risk for injuries compared their counterparts from outside the EU is in agreement with earlier studies regardless of differences in the study design and data. An unadjusted analysis of self-reported data showed that, compared with Danish seafarers, those from the UK had a 2.3 times higher risk and those from the Philippines had a 50% lower risk for injuries.<sup>9</sup> However, these associations were attenuated after adjustments for several covariates including occupational position and age. An earlier study reported that foreigners, compared with Danish seamen, had a 50% lower risk for accidents both causing and not causing permanent disability.<sup>17</sup> A previous study showed a 70% lower accident rate for South East Asians compared with Danish seafarers aboard cargo ships,<sup>19</sup> whereas another study indicated a 50% lower accident rate both for South East Asians and East Europeans compared with Western European seafarers.<sup>20</sup> Our finding that non-officers from the EU had approximately a 3 times higher risk for back injuries than those from outside the EU is also in line with a previous study reporting that rates of accidents causing a back injury was approximately 70% lower among Eastern Europeans and 84% lower in South East Asians compared with Danish seafarers.<sup>20</sup>

There is likely not a single explanation for lower rates of injuries among non-officers from outside the EU. Differences in physical performance is among suggested explanations.<sup>19</sup> A recent study based on occupational medicine examinations in Italy reported, for instance, that prevalence of overweight or obesity among Romanian, Italian and Filipinos seafarers was 77%, 52% and 38%, respectively.<sup>21</sup> Overweight is a risk factor for low back pain<sup>22</sup> and it may explain our findings of elevated risk for back injuries among ratings from the EU. Another plausible explanation is under-reporting.<sup>9 19 23</sup> An analysis based on international accident data reported that Filipinos and

other nationalities together reported significantly fewer slips, trips and falls than seafarers from the home state.<sup>23</sup> The foreigners may not have any interest in having an accident reported due to possible negative consequences.<sup>19</sup> In contrast to most Danish seafarers, the foreigners are almost always only employed for one period aboard and reported accidents may diminish the possibilities of a new employment.<sup>19</sup> Other suggested explanations include cultural differences in risk behaviour between different national groups.<sup>9 19</sup> These differences may result from the fact that non-officers are normally trained in their home country with different standards of education regarding safety culture.

### Strengths and limitations

The strengths of this study include the data based on registers with very little loss to follow-up. To our knowledge, this is also the first register-based study to examine the association between sociodemographic characteristics and injuries characterised by anatomic location among seafarers. This study also has limitations. First, the population at risk used in analyses was based on yearly recorded numbers of seafarers in Danish-flagged merchant fleet. We did not have information on their actual number of days onboard. Therefore, incidence rates may be underestimated or overestimated. It is, however, unlikely that this would have affected associations between explanatory variables and outcomes. The type of data on the population at risk was also the reason why the number of explanatory or confounding variables was limited. Second, as many as 23% of the contacts from ships to TMAS had been recorded with a diagnosis code in the interval of 'Symptoms, sign and abnormal clinical and laboratory findings, not elsewhere classified' (ICD-10 codes R00-R99). These diagnosis codes are not reported in this analysis which means that some injuries may have remained unreported. This may lead to an underestimation in the rates of injuries. It is noteworthy that underestimation may also result from ships contacting other TMAS services than RMD in Denmark. Third, we had no description of mechanisms leading to injuries. However, it has been suggested that injuries in seafaring mainly result from the impact of physical hazards including heavy lifting, overexertion, slips, trips and falls, and potential ergonomic hazards.<sup>8</sup> Fourth, we had no information on severity of injuries. It is, however, likely that minor injuries remain unreported regardless of their anatomic location. Fifth, the definition that in case there were two or more contacts to TMAS on one person within a 2-year period, only the first contact was taken into account, may lead an underestimation of occurred injuries. Sixth, our data do not give a comprehensive answer to a remarkable increase in injury rate in the last year of the study period. These data only show that increases have occurred in all injury categories except in head injuries. We are not aware of any changes in safety culture, reporting of injuries to RMD or registration of contacts at RMD. Future analysis with extended data will likely help to find an answer. Seventh, the number

of certain types of injuries among officers was relatively low which affected power to identify associations. Finally, we note that our data are country-specific and safety standards vary across countries. Consequently, these findings do not necessarily reflect the burden of injuries in the international fleet.

The present observations of a higher frequency of some kinds of injury related to upper-limb, lower-limb and head injuries, do, irrespective of limited understanding of their mechanism, point to a potential to feed into a more knowledge-based priority setting in the continued strive to prevent or reduce work-related injuries at sea. Likewise, the observation, that younger seafarers have a higher risk for injuries than older seafarers, may indicate that there could be an unmet educational and training need for the more inexperienced seafarers.

### Conclusions

These register-based data demonstrate that non-officers, older but also younger, and European seafarers have an increased risk for several types of injuries on board Danish-flagged merchant ships. These findings suggest a need for primary prevention of injuries particularly among younger and older seafarers.

**Contributors** KH conceived and designed the study, interpreted the data and drafted the initial manuscript. SG-K, JCV and JBN contributed to the conception of the study, interpretation of the results and assisted with the preparation of the manuscript. All authors approved the final manuscript.

**Funding** The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

**Competing interests** None declared.

**Patient consent for publication** Not required.

**Ethics approval** This study was approved by the Danish Data Protection Agency (10.424).

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** No data are available.

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