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WORK-SITE CASUALTIES AND ENVIRONMENTAL RISK ASSESSMENT ON POLISH VESSELS IN THE YEARS 1960-1999

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ABSTRACT

Objectives: To assess environmental risks of fatal incidents in the maritime work-site and guides for possible prevention.

Methods : All casualties at the work-site in the years 1960-1999 among 25 525 seafarers employed on board Polish vessels were identified according to the ICD-10 classification. The main measure of risk: mean fatality rate per 1000 employees/year was calculated for external and internal causes of death. The impact of the maritime work environment was analysed.

Results : 668 seafarers died on board 405 Polish vessels, and 66 percent of deaths were from external causes. The mean fatality rate 1.17 per 1 000, was five times higher for external (drowning, missing, other accidents) than for internal causes (circulatory system diseases): 412 deaths from accidents and 29 from disease.

Despite modernization of the fleet, the environmental risk factors have strong impact on the mortality. The highest-risk groups were Baltic fishermen, seamen, deck crew, under 40 years of age.

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Conclusions : The risk of casualties in maritime industry exceeds the acceptable level of 1 death per 1000 employees per year. Prevention should concentrate on maritime catastrophes and work-related accidents.
Keywords : maritime environmental hazards, work-related accidents, prevention measures

INTRODUCTION

The hazards of seafaring are well-known (1, 2). The number of accidents and casualties at the work-site differs substantially between fleets and countries, but in general it is higher than in the majority of land occupations (3, 4, 5, 6, 7). Despite modernization of the maritime industry, the environmental risk factors and human losses on board vessels are common (8). What was the main work-related and environmental risk on Polish vessels? Can we identify specific high-risk groups to prevent the fatal incidents?

OBJECTIVES

To analyse the casualties on board Polish vessels, and to find occupational denominators of risk, to evaluate the magnitude of the problem, the environmental hazards and the possible methods of prevention.

METHODS

The death of a seafarer on board was assumed as the basic measure of risk, with the fatality rate per 1000 employees and per year as the main outcome measure. In the cohort of 25 525 seafarers there were: 12 040 seamen, 8 500 deep-sea and 4 985 cutter and boat fishermen, employed yearly between 1960-1999.

668 deaths were reported: 324, 167 and 177, respectively for these three categories of seamen and fishermen. All of the deceased were male, aged between 17 and 67 years, and employed onboard 179 merchant ships, 114 trawlers and 112 cutters and boats. The cause of death was assigned according to the statistical ICD-10 classification and death certificates, in 65% of cases based on autopsies, and in 35% on other data and judiciary inquiries. To meet the criteria of the work-related accident/disease, the circumstances of

deaths and environmental factors were analysed in two main categories of death: related to the external (accidental) or internal (illnesses) causes. The real work time at sea, age, position and rank on board were established. The statistical methods used were the chi-square test, discrimination and correlation analysis and the Kaplan-Meier curves for life-expectancy (9). Deaths on land were excluded from the study to focus solely on the impact of the maritime environment. The material comprises about 92% of all seafarers and fishermen employed on board Polish marine vessels in the period considered.

RESULTS

Of the 324 seamen, 167 deep-sea fishermen and 177 cutter and boat fishermen who died on board, the mean (SD) age was: 40.46 years (11.94), 37.92 years (10.34), and 38.72 years (12.42). The period of employment in years was: 13.98 years (9.67), 14.11 years (12.42), and 15.66 years (11.07) respectively, and time spent at sea in months per year was: 6.9 (1.9), 6.7 (2.0), 7.1 (2,2) respectively. The differences were not significant statistically. The only difference regarding the age and time of employment was found between the subgroup of 140 officers and 528 ratings: 43.71 -18.03 vs 37.51-11.92, respectively, $P < 0.05$, with the identical mean work-time per year at sea. No significant differences were found for the age and time of employment between deck, engine and catering crew.

The relation between the number of employees and number of deaths on vessels is presented in

Figure 1. The numbers were correlated throughout the years in the two groups of fishermen, $P < 0.05$, but not in the group of seamen: irrespective of the decline in employment, the number of deaths increased, mainly due to spectacular sea catastrophes with mass human losses.

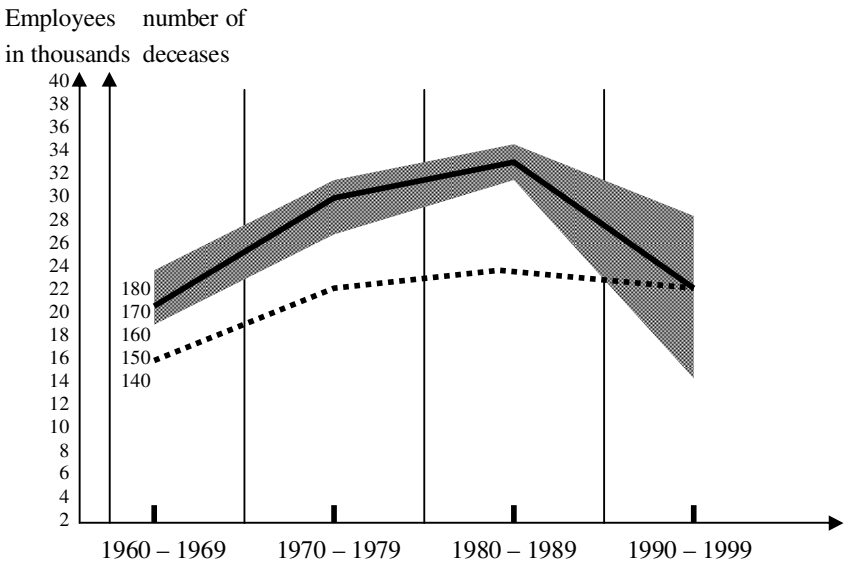


Fig. 1 Employment and number of deceases of crew members on board Polish vessels in the years 1960-1999.

Legend:
- mean number of employed on board vessels
- min. and max.number of employed on board vessels
- number of deceases on board vessels in particular years

Table 1.

Category of death and mean fatality rate among seafarers deceased on board Polish vessels in the years 1960-99

Category	External causes		Internal causes		Total	
Group	Number	Rate	Number	Rate	Number	Rate
Merchant seamen	238	0.85	86	0.31	324	1.16
Deep-sea fishermen	126	0.66	41	0.21	167	0.87
Cutter&boat fishermen	171	1.45	6	0.05	177	1.50
Total	**535**	**0,98**	**133**	**0,19**	**668**	**1,17**

The fatality rate in the groups surveyed and main categories of death are given in Table 1.

The highest fatality rate was noted in small scale fishing industry through the whole period (Table 1). It was also high among seamen, in both groups exceeding the accepted risk rate (1 death at worksite/year/1000 employees) in particular, in some years higher. The decline in the four successive decades was slight, indicating that the safety of work at sea did not improve satisfactorily despite all the technical improvements on ships and the work of health and safety services. The underlying reason was the permanent presence of environmental risk factors: sea catastrophes and collisions, noxious physical, chemical and biological agents. Thus, for external causes the fatality rate decreased insignificantly, 4 times outnumbering the fatality rate observed for internal causes – idiopathic diseases: the difference was significant, $P < 0.01$.

The main categories of death are presented in Table 2. for external and internal causes.

Table 2

Main external and internal causes of deaths on board Polish vessels in the years 1960-99

Category/Cause	External causes				Internal causes		Total
Group	Drowning	Missing	Other accident	Suicide homicide	Ciculatory disease	Other disease	
merchant seamen	126	32	44	36	62	24	324
deep-sea fisherm	56	14	39	17	34	7	167
cutter&boat fish.	87	69	13	2	6	0	177
total	**269**	**115**	**196**	**55**	**102**	**31**	**668**

The data show that in the first category, in the three groups of seafarers, drowning (V 90-92) prevailed over missing (V 93-94) and other accidents (W, X, Y...). Drowning accounted for 40% of fatal events, with mass drowning more frequent among seamen, primarily caused by sea catastrophes with sinking of the ship, while among fishermen mass and individual drowning were less frequently reported, with a smaller number of ships' losses. The direct mechanism of death was associated with drowning and hypothermia in cold water.

Missing at sea (body not found) occured in 17% of the fatal cases, also connected with sea disasters, was the most frequent among cutter and boat fishermen: in this group

both causes accounted for 88% of the fatalities. No clear causes have been stated in 5% cases of missing; the hypothetical reasons might be psychosis, alcohol abuse or a criminal act, with no possibility to specify it in a legal verdict.

Other accidents accounted for 14.4% of fatalities. They were cases of fractures, multi-organ or thermal injuries, electrocutions, caused by mechanical traumas, explosions and fires, intoxication by gases during fires, fumigation or control of dangerous cargoes in holds, where the level of carbon monoxide and tri-bromoethylene was high, or asphyxia in holds with dangerous, oxygen absorbing cargoes.

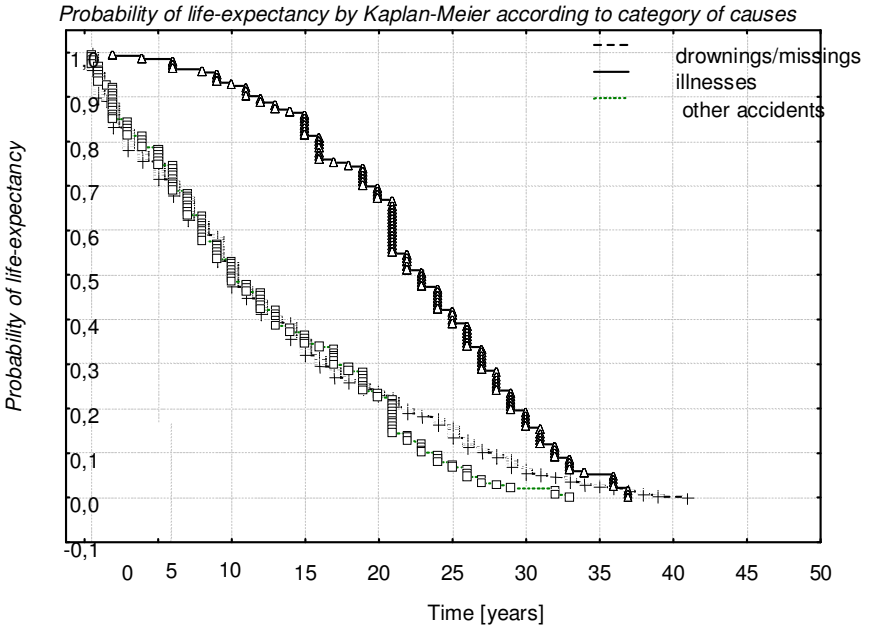
External causes of death affected mainly seafarers up to 39 years of age, ratings, with a period of service shorter than 14 years, limited experience in occupation. The difference between this group and the group aged over 40, or the group of officers was statistically significant, $P < 0.02$.

Among the external causes, about 8.4% were confirmed suicides and homicides (51 and 4 cases), more frequently among seamen, by hanging, strangulation, drowning or poisoning. Some cases of missing in unclear circumstances could also be presumed to be suicides.

The second category, illnesses, accounted for 20% of deceases and was almost entirely dominated by cardiovascular diseases, 15% (I 21-85), with 81 cases of myocardial infarction and, less frequently, cerebral stroke, heart failure, hypertension or myocarditis, with sudden death. They were evenly distributed among seamen and deep-sea fishermen, spending several months at the open sea, while in the group of cutter and boat fishermen, always sailing in the coastal area, they represented only 4% of the events. The difference was significant, $P <0.001$. All other diseases accounted for less than 5% of fatalities. Among them there were 5 cases of tropical diseases: cerebral (Plasmodium falciparum) malaria and amoebic hepatitis. Several cases of neoplasms, pulmonary or gastrointestinal diseases were reported, with deceases due to complications (occlusion, bleeding). The illnesses affected mostly officers and older ratings over 40 years of age, with long time of service at sea. The Kaplan-Meier curves of life expectancy show significant differences in the distribution of deaths on board for external and internal causes, according to categories of death, $P < 0.01$, which is demonstrated in Figure 2.

Figure 2

Kaplan-Meier curves of life-expectancy, according to categories of death



The small share of deaths at sea caused by illnesses may be related to periodic obligatory health examinations of seafarers and fishermen for assessing their fitness for work at sea, and producing the effect of a "healthy worker" in this population. We did not include in the analysis those seafarers who died abroad in hospitals, estimated by available data as 15-20% of all deaths in the Polish merchant marine.

Each death was analysed according to whether it complied with the legal definition of a work-related death. The results are presented in Table 3.

Table 3.

Accidents and diseases considered a work-accident on board Polish vessels in the years 1960-99

Category	External causes		Internal causes		Total	
Group	Number	Percent	Number	Percent	Number	Percent
merchant seamen	182	76,5	19	22,0	201	62,0
deep-sea fishermen	101	80,1	8	19,5	109	65,3
cutter&boat fishermen	129	75,4	2	33,3	131	74,0
total	**412**	**77,0**	**29***	**22,0**	**441**	**66,0**

* 5 cases of occupational diseases included

412 deaths from external causes (62% of all fatalities) met the criteria: 269 drowning, 115 missing and 96 other accidents. They were strictly related with to the type and time of exposure at the work-site, harmful factors, with death resulting immediately or within a few days. 123 deaths in the category of external causes did not satisfy the criteria of a work-related accident. The main reasons were alcohol abuse (over 0.5 per mille of alcohol in blood) and obvious violation of work-safety rules. Thus, 56 cases: 24% of drowning and missing among cutter and boat fishermen, 4% among seamen and 7% among deep-sea fishermen were excluded. Also 67 cases: 46.3% of other external causes were not defined as work-related accidents. This concerned 55 cases of suicide and homicide and 12 cases of ethyl- or methyl alcohol intoxication.

24 cases of circulatory system diseases were classified as work-related accidents in view of the recognized impact of excessive physical effort, thermal shock, or stress exceeding the adaptation potential of the organism. Five cases of tropical diseases were also regarded as work-related.

DISCUSSION

The man-vessel-environment relations in a process of work are very complex, variable and through the unforeseen events or human errors can easily endanger health and life (10).

The construction and equipment, exploitation and organization of work on ships, or fitness of seafarers on board, affect the general safety of the crew and the ship actively, by preventing the sea catastrophe, or passively, by protecting the health and life (10, 11, 12).

High mortality and accident rates in maritime occupations, exceeding those in land branches of industry (4, 5, 6, 7), with 1-2% of all fatal accidents among all are strictly related to the strong impact of maritime environmental factors. The specific structure of mortality in fleets of most of the countries and among all people who work at sea, particularly in the flag of convenience shipping (13), is a real challenge.

General theory of the safety in seafaring (10) applying the ALARP (As Low As Practicably Possible) system to evaluate the acceptable occupational risk, considers more than 1 fatal accident occuring per 1000 employees per year as intolerable situation , and demands preventive interventions to be taken. The crucial issue is to find effective measures, economically justified, that are possible to implement (14, 15).

In this report, high mortality at the work-site and specific risk groups were identified in relation to two categories of deaths: from external and internal causes, differently distributed among three occupational populations: seamen, deep-sea and cutter and boat fishermen over the period of 40 years.

The main external risk factors: sea catastrophes, collisions and other accidents connected with explosions, fires, electrocutions, mechanical injuries or intoxications, were responsible for 80% of the fatal events. Drowning, missing and other accidental deaths most frequentely affect ratings, up to 40 years of age, with short service periods, mainly in deck and engine departments, in small scale fishery and merchant marine.

The internal causes of risk pertained in particular to sudden deaths in the course of heart diseases, mostly among officers and ratings over 40 years of age, with a long time of service, among seamen and deep-sea fishermen.

These findings, similar to reports of other authors (3, 4, 5, 7, 13, 14), seem to identify the high-risk groups, and indicate the goals and means of prevention in seafaring.

As regards the first category of risk, the active prevention depends mainly on technical, organizational and legal measures taken for the improvement of general safety in navigation and fishing, by modernization of the vessel and its equipment, reduction of specific noxious factors on board, education and training of the crew, and implementation of maritime conventions. The responsibility for the task lies with ship owners, maritime administration and trade unions (1, 2, 12, 15, 16). The international network of sea rescue services has to be strengthened world wide (8). Medical actions may only slightly neutralize the effects of sea catastrophes and accidents (10, 11, 12).

Medical prevention should be directed towards the reduction of risk related to the second category: internal causes of death at the work-site. Primary or secondary prevention includes: promotion of the healthy style of life (diet, active physical exercises, eliminating smoking, addictions, obesity), medical training of seafarers, improvement of their treatment and prophylactic medical examination of crew members

on land, aimed at the reduction of the number of circulatory system diseases (14.17). Special attention should be given to subjects affected by neurotic disturbances, with the early recognition of the suicide risk and elimination of alcohol abuse (18, 19, 20). Medical evaluation should not eliminate seafarers from work at sea, if its result is not based on strong evidence (21, 22). The Radio Medical and tele-medicine services might supplement the preventive measures (23).

Although no one should expect the elimination of the entire environmental risk in maritime industry, the principle goal, i.e. the reduction of the mortality and high fatality rate to an acceptable level, seems to be possible to achieve.

CONCLUSIONS

1. The risk assessment in maritime industry shows high risk of casualties at the work-site in the group of cutter and boat fishermen and in merchant seamen.
2. The main causes are related to the environmental risk factors, to sea catastrophes and other maritime accidents particularly in the group of younger seafarers.
3. The circulatory system diseases dominate the internal causes of death on board among officers and older ratings.
4. The complex prevention measures should be directed towards identification of specific high-risk groups of seafarers and elimination of the risk factors from the vessel environment.

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