

Occupation and mortality in the Brazilian Navy

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Keywords

Proportionate Mortality Ratio. Navy. Occupational risk factors. Digestive tract diseases. Genitourinary tract diseases. Nervous system diseases.

Abstract

Objectives

To describe the distribution of mortality due to digestive tract, genitourinary and nervous system diseases according to occupation among Brazilian Navy servicemen.

Methods

This was an exploratory study of proportional mortality among male servicemen in the Brazilian Navy who died between 1991 and 1995. The study population comprises the entire contingent of servicemen during this same time period. Data were obtained from death certificates submitted in order to obtain dependents' pensions, and from the corresponding occupational histories of these individuals. Basic causes of death were coded in accordance with the International Classification of Diseases (9th Revision).

Results

Servicemen presented increased proportional mortality for liver diseases related to alcohol consumption (age-adjusted proportional mortality ratio, $PMR_{adj}=2.03$; 95% confidence interval, CI: 1.26-3.00), pancreatitis ($PMR_{adj}=2.03$; 95% CI: 1.06-3.38), digestive hemorrhage ($PMR_{adj}=1.61$; 95% CI: 1.10-2.23), chronic kidney diseases ($PMR_{adj}=2.82$; 95% CI: 1.98-3.84), Parkinson's disease ($PMR_{adj}=3.00$; 95% CI: 1.27-5.72) and degenerative brain diseases ($PMR_{adj}=2.88$; 95% CI: 1.14-5.70), in relation to the reference population. A statistically non-significant association was observed between radar operators ($PMR=6.50$; 95% CI: 1.43-29.56) and nervous system diseases was observed.

Conclusions

The results indicate the existence of possible occupational risk factors in the working environment of the Brazilian Navy, and the need for studies using quantitative measurement of such exposure.

INTRODUCTION

Within the working environment of the armed forces, extended working days, ergonomic problems and exposure to chemical, physical and biological agents are common. These are well-known occupational risk factors for health.¹⁸ In the Navy, in particular, long periods of exposure to heat or solar radiation during training or shipboard activities,⁷ exposure to dust and

smoke of chemical origin in confined environments,^{7,18} and to asbestos fiber⁵ have been described. Social isolation is another occupational risk described among Navy servicemen, particularly on combat training trips,⁸ which may lead to changes in lifestyle,⁶ for example increased smoking and alcohol consumption.^{3,4} Consequently, high rates of hospitalization due to alcohol-related disturbances,⁸ increased numbers of premature deaths due to digestive tract diseases,^{3,5} vio-

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lent deaths⁵ and, most frequently, high mortality due to cirrhosis of the liver^{5,13} are seen.

Studies carried out in Europe and in the United States have found increased mortality among servicemen due to digestive tract diseases in particular, in comparison with the general population.²⁻⁵ Preliminary findings from the Brazilian Navy, using the same database as in the present study, revealed greater proportional mortality due to digestive tract, genitourinary tract and nervous system diseases than in the reference population.¹⁵ These results motivated the continuation of the analysis, to form the subject of the present study. In this study, the diagnostic subcategories are detailed and also the differences in mortality according to occupations, specifically, for digestive tract, genitourinary tract and nervous system diseases.

METHODS

This was a proportional mortality study of servicemen in the Brazilian Navy who died between January 1, 1991, and December 31, 1995. The deaths that form the study population occurred among active, reserve and retired servicemen who were resident in Brazil and abroad, of male gender and aged over 19 years. Women were excluded from the study because they had only recently been admitted into the navy and only represented 3% of the personnel during the study period. The reference population considered in the study was the total number of deaths among males in the State of Rio de Janeiro that occurred during the same period. This area was chosen because it is the location where the greatest proportion of Navy servicemen are based, and because it presents a similar proportion of deaths recorded as having poorly-defined causes. Further detailing of the procedures is described in the previous publication.¹⁵

Death certificates for the study population were obtained from the Navy's service for retired personnel and dependants' pensions (Serviço de Inativos e Pensionistas da Marinha - SIPM), which is the body responsible for certifying pensions for the families of dead servicemen. Sociodemographic and occupational data on these individuals was also collected from this entity, from the records of the length of service required for, and the calculation of, indemnifications and pensions for eligible family members. Other information, relating to the reference population, was obtained from the mortality information system (Sistema de Informação de Mortalidade - SIM) of the Ministry of Health.

Death certificates do not constitute an official registration of the cause of death. To verify the degree of reliability of the diagnosis of the basic cause of death

between death certificates and declarations, the diagnoses of 106 records selected randomly from among those that made up the study population were compared. Concordance of 89.62% was estimated for groups of causes of death that were defined in accordance with the International Classification of Diseases, 9th Revision (ICD-9), with a weighted Kappa index of 0.61 and 95% confidence interval (CI) of 0.51-0.72, which was considered acceptable.

The causes of death that were of interest in the present study were digestive tract diseases (ICD-9: 520-579), genitourinary tract diseases (ICD-9: 580-629) and nervous system diseases (ICD-9: 320-389), which were found to be associated with working in the navy (Silva et al,¹⁵ 1998). The covariables analysed were: age in years, marital status (single, married, widowed or separated), place of residence (Rio de Janeiro or elsewhere), rank (*enlisted men* – marine, sailor, sergeant, non-commissioned officer; or *commissioned officers* – ensign, lieutenant, lieutenant-captain, lieutenant-commander, commander, commodore and admiral) and occupation. The occupation was assessed by forming occupational groups that were defined according to the similarity of their activities: *combat and arms* – handlers of submarine weapons and artillery, gunners, torpedomen, minemen and infantry; *healthcare* – doctors, dentists, pharmacists, nurses and x-ray technicians; *mechanical and metalworking* – machine and motor operators, aircraft mechanics, craftsmen, metalworkers, boiler operators; *communications and electro-electronics* – ship-to-shore and internal communications, ship signaling, sonar, radar and telegraphy operators, general electronic equipment and aviation electronics operators, and electricians; *naval sciences and administration* – navy staff officers, hydrographers, divers, superintendents, administrators, accountants, secretaries, chaplains, storemen and musicians; *maintenance and repairs* – building and fittings craftsmen, carpenters, damage assessors, deck and aviation equipment handlers and repairers; *general services* – master chefs, occupations related to orderliness and housekeeping, hairdressing and cleaning.

The proportional mortality was calculated in accordance with the covariables and each of the groups of causes of death that were selected: digestive tract, genitourinary tract and nervous system diseases. Within these groups, specific diseases were analyzed, and those that presented sufficient numbers of cases were selected for study in more detail. The proportional mortality was calculated by dividing the number of deaths due to the cause of interest by the total deaths for the same period. Associations were measured as raw proportional mortality ratios and adjusted for age by an indirect

Table 1 - Raw and age-adjusted proportional mortality ratios for digestive tract diseases and specific diseases.

Disease group and specific disease (ICD-9)	N (deaths)			PMR			
	Obs	Exp*	Exp**	Raw PMR	95% CI	Adjusted PMR	95% CI
Digestive tract diseases (520-579)	206	186	192	1.11	(0.96-1.27)	1.08	(0.93-1.23)
Stomach ulcer (531)	11	5	5	2.21	(1.01-4.02)	2.01	(0.90-3.66)
Alcohol-related liver disease (571 (.0, .2))	29	15	14	1.91	(1.18-2.84)	2.03	(1.26-3.00)
Cirrhosis without mention of alcohol (571.5)	59	63	64	0.94	(0.71-1.21)	0.92	(0.76-1.18)
Other liver diseases (571 (.4, .8), 572 (.8), 573 (.1, .3, .9))	17	95	94	0.18	(0.01-0.39)	0.18	(0.01-0.39)
Pancreatitis (577 (.0, .1, .8))	16	9	8	1.70	(0.87-2.85)	2.03	(1.06-3.38)
Digestive hemorrhage (578 (.0, .9))	50	28	31	1.78	(1.23-2.45)	1.61	(1.10-2.23)
Other digestive tract diseases (530, 532, 533, 537.4, 551.8, 555.9, 556, 557.9, 569.5, 570, 574 (.0, .2), 575 (.1, .4))	24	22	23	1.11	(0.61-1.75)	1.03	(0.56-1.63)

Obs: Number of deaths observed among servicemen

*Number of deaths expected, on the basis of the total deaths that occurred between 1991 and 1995 for the male population of the State of Rio de Janeiro, which was utilized as the reference

**Number of deaths expected, on the basis of the age distribution of the deaths that occurred between 1991 and 1995 for the male population of the State of Rio de Janeiro, which was utilized as the reference

PMR: proportional mortality ratio

95% CI: 95% confidence interval calculated in the basis of Poisson's distribution

ICD-9: International Classification of Diseases, 9th Revision

method using the corresponding proportional mortality for the population of the State of Rio de Janeiro. The statistical significance of the proportional mortality ratios was evaluated using 95% confidence intervals that were calculated by means of significance factors for the observed values in relation to the expected values, for variables with Poisson's distribution. Since occupational data were limited to the Navy population, the proportional mortality ratio was utilized for estimating associations with occupation for each of occupational groups, taking all the other groups as the reference. For specific estimates of proportional mortality according to illness and occupational group, the total deaths for each occupational group were taken as the denominator. When applicable, adjustment for age was done via the direct Mantel-Haenszel method, which considers the relative importance of different strata. For the statistical inferences, 95% confidence intervals estimated via the Mantel Haenszel method were utilized.¹⁶

RESULTS

During the study period, 3,882 deaths were recorded. It was not possible to locate 319 death certificates

(8.0%), and seven individuals aged between 17 and 19 years were excluded because of the lack of corresponding strata in the reference population. The study population thus consisted of 3,556 deaths. The majority of these individuals (60%) had died aged more than 59 years, were married (77%), were resident in Rio de Janeiro (70%) and belonged to the ranks of enlisted men (79%).

In Table 1, it can be seen that there was no statistically significant difference between the observed and expected deaths for the group of digestive tract diseases (age-adjusted proportional mortality rate, $PMR_{adj} = 1.08$; 95% CI: 0.93-1.23). Nonetheless, the greatest proportional mortality ratios were found for alcohol-related liver diseases ($PMR_{adj} = 2.03$; 95% CI: 1.26-3.00), pancreatitis ($PMR_{adj} = 2.03$; 95% CI: 1.06-3.38) and digestive hemorrhage ($PMR_{adj} = 1.61$; 95% CI: 1.10-2.23), respectively. Among the genitourinary tract diseases ($PMR_{adj} = 1.45$; 95% CI: 1.16-1.81), it was possible to identify an excess of deaths due to chronic renal diseases ($PMR_{adj} = 2.82$; 95% CI: 1.98-3.84) (Table 2). With regard to nervous system diseases ($PMR_{adj} = 1.36$; 95% CI: 0.83-2.03), larger proportions of deaths among servicemen than

Table 2 - Raw and age-adjusted proportional mortality ratios for genitourinary tract diseases and specific diseases.

Disease group and specific disease (ICD-9)	N (deaths)			PMR			
	Obs	Exp*	Exp**	Raw PMR	95% CI	Adjusted PMR	95% CI
Genitourinary tract diseases (580-629)	81	50	56	1.61	(1.28-2.00)	1.45	(1.16-1.81)
Acute renal disease (584.9)	15	9	9	1.76	(0.89-2.99)	1.59	(0.79-2.71)
Chronic renal disease (585)	48	16	17	3.07	(2.17-4.17)	2.82	(1.98-3.84)
All others (582.9, 588.1, 590.0, 592.0, 595.0, 597.8, 586)	18	11	12	1.70	(0.91-2.78)	1.54	(0.82-2.53)

Obs: number of deaths observed among servicemen

*Number of deaths expected, on the basis of the total deaths that occurred between 1991 and 1995 for the male population of the State of Rio de Janeiro, which was utilized as the reference

**Number of deaths expected, on the basis of the age distribution of the deaths that occurred between 1991 and 1995 for the male population of the State of Rio de Janeiro, which was utilized as the reference

PMR: Proportional mortality ratio

95% C: 95% confidence interval calculated in the basis of Poisson's distribution

ICD-9: International Classification of Diseases, 9th Revision

Table 3 - Raw and age-adjusted proportional mortality ratios for nervous system diseases and specific diseases.

Disease group and specific disease (ICD-9)	N (deaths)			PMR			
	Obs	Exp*	Exp**	Raw PMR	Raw 95% CI	Adjusted PMR	Adjusted 95% CI
Nervous system diseases (320-389)	31	25	23	1.25	(0.75-1.87)	1.36	(0.83-2.03)
Meningitis (320.1(.9), 322.9))	4	4	3	1.02	(0.17-2.62)	1.28	(0.25-3.29)
Cerebral degeneration (331.0 (.7, .9))	8	2	3	3.47	(1.40-6.85)	2.88	(1.14-5.70)
Parkinson's disease (332 (.0, .1))	9	3	3	3.44	(1.47-6.55)	3.00	(1.27-5.72)
All others (323.4 (.9), 326, 335.2, 336.9, 340, 341, 348.5 (.9), 357))	10	5	5	1.90	(0.81-3.57)	2.04	(0.88-3.81)

Obs: number of deaths observed among servicemen

*Number of deaths expected, on the basis of the total deaths that occurred between 1991 and 1995 for the male population of the State of Rio de Janeiro, which was utilized as the reference

**Number of deaths expected, on the basis of the age distribution of the deaths that occurred between 1991 and 1995 for the male population of the State of Rio de Janeiro, which was utilized as the reference

PMR: Proportional mortality ratio

95% CI: 95% confidence interval calculated in the basis of Poisson's distribution

ICD-9: International Classification of Diseases, 9th Revision

expected were observed, caused by Parkinson's disease ($PMR_{adj}=3.00$; 95% CI: 1.27-5.72) and degenerative brain diseases ($PMR_{adj}=2.88$; 95% CI: 1.14-5.70) (Table 3). In general, it could be noted that the raw estimates did not differ significantly from the age-adjusted estimates.

The occupation-related results (Table 4) showed that there were positive associations between the occupations in the communications and electro-electronics group and nervous system diseases ($PMR_{adj}=2.28$; 95% CI: 1.06-4.92), and between the general services group and genitourinary diseases ($PMR_{adj}=1.82$; 95% CI: 1.10-3.03). It should be noted that there was threshold statistical significance for the association between the occupations in the maintenance and repairs group and digestive tract diseases ($PMR_{adj}=1.35$; 95% CI: 0.95-1.91). Detailed analysis of these specific occupational groups (Table 5) showed that the relative excess of deaths due to nervous system diseases was related to greater proportional mortality among radar operators ($PMR_{raw}=6.50$; 95% CI: 1.43-29.56) and telegraphers ($PMR_{raw}=2.94$; 95% CI: 0.80-10.80), which were both in the communications and electro-electronics group. No other associations at a statistically significant level were found.

DISCUSSION

The data from this study indicate that, among the digestive diseases, Brazilian Navy servicemen presented increased proportional death due to alcohol-related liver diseases (ICD-9: 571 (.0, .2)), pancreatitis (ICD-9: 577 (.0, .1, .8)) and digestive hemorrhage (ICD-9: 578 (.0, .9)), in relation to the reference population. For genitourinary tract diseases, they presented greater proportional death due to chronic renal diseases (ICD-9: 585), while among the nervous system diseases there were statistically significant associations only with cerebral degeneration (ICD-9: 331 (.0, .7, .9)) and Parkinson's disease (ICD-9: 332 (.0, .1)), in relation to the reference population.

Studies on servicemen from several armed services have made similar findings regarding mortality due to digestive tract diseases.^{3,5} In particular, increased risk of death due to cirrhosis of the liver has been found,⁴ which is related to abusive consumption of alcohol.^{3,5,13}

However, the greater proportion of deaths due to genitourinary tract and nervous system diseases estimated for Brazilian servicemen differs from the results found by other authors.^{2,5} For example, a higher

Table 4 - Proportional mortality ratios according to disease groups, adjusted for age according to occupational groups in the Brazilian Navy.

Occupational group*	Digestive tract diseases** (ICD-9: 520-579)			Genitourinary tract diseases** (ICD-9: 580-629)			Nervous system diseases** (ICD-9: 320-389)		
	N	PMR	95% CI	N	PMR	95% CI	N	PMR	95% CI
Combat and arms	52	1.27	(0.94-1.73)	16	1.04	(0.60-1.78)	5	0.80	(0.30-2.08)
Mechanical and metalworking	37	1.00	(0.71-1.42)	19	1.38	(0.83-2.28)	4	0.66	(0.23-1.89)
Naval sciences and administration	28	0.76	(0.52-1.13)	10	0.67	(0.35-1.30)	6	1.12	(0.46-2.71)
Communications and electro-electronics	25	0.76	(0.50-1.14)	12	0.97	(0.53-1.78)	9	2.28	(1.06-4.92)
General services	20	0.86	(0.55-1.34)	16	1.83	(1.07-3.14)	3	0.82	(0.25-2.70)
Maintenance and repairs	36	1.35	(0.95-1.91)	7	0.57	(0.26-1.24)	1	0.21	(0.03-1.50)
Healthcare	8	1.01	(0.51-2.01)	1	0.30	(0.04-2.13)	3	2.51	(0.77-8.18)

*Reference category is all the other occupational groups

**Denominator is the total deaths due to all causes

N: number of deaths

PMR: proportional mortality ratio

95% CI: 95% confidence interval calculated via Mantel Haenszel

ICD-9: International Classification of Diseases, 9th Revision

Table 5 - Proportional mortality and raw proportional mortality ratio according to disease group, for occupational specialties with in the Brazilian Navy.

Disease group and occupational specialty*	N	N***	PM**	PMR	95% CI
Digestive tract diseases (N***=36)					
Maintenance and repairs (N=487)					
Maneuvers and deck services	407	30	7.37	0.96	(0.41-2.22)
Carpentry and damage repair	52	5	9.62	1.34	(0.55-3.30)
Construction and installation	11	1	9.09	1.23	(0.18-8.20)
Genitourinary tract diseases (N***=16)					
General services (N=401)					
Orderly	231	11	4.76	1.62	(0.57-4.57)
Hairdresser	45	2	4.44	1.16	(0.28-4.87)
Cook	100	2	2.00	0.43	(0.10-1.86)
Catering Orderlies	25	1	4.00	1.00	(0.14-7.29)
Nervous system diseases (N***=9)					
Communications and electro-electronics (N=546)					
Telegrapher	163	5	3.07	2.94	(0.80-10.80)
Signaler	98	2	2.04	1.31	(0.28-6.19)
Radar operator	23	2	8.70	6.50	(1.43-29.56)

*Reference category is all the other occupations within the same occupational group

**Denominator is the total deaths for the occupation

***Number of deaths per disease of interest (cases)

N: Total number of deaths (all causes)

PM: Proportional mortality

95% CI: 95% confidence interval via Mantel-Haenszel

estimate for the incidence of genitourinary diseases among hospitalized servicemen has only been made in one study, which dealt with the period following the Gulf War.⁹ Greater mortality due to nervous system diseases was observed only in the British army for soldiers who served in desert areas, when compared with the British navy and air force.⁵ Other studies have reported high incidence of sick leave due to nervous system diseases among boiler technicians in the American navy⁹ and premature deaths due to neuromotor diseases among servicemen.¹⁴

It was observed that servicemen who were communications technicians, electricians, technicians or operators of electronic equipment, carpenters, deck and aircraft equipment operators, maintenance personnel in general, cooks, hairdressers, those responsible for cleaning, orderliness and housekeeping services or musicians presented greater proportional death due to nervous system, genitourinary tract and digestive tract diseases than did the respective reference populations. There are only a few studies on occupational factors relating to servicemen's health, but they show that workers in the occupations of healthcare, general operations, naval engineering, maintenance, repairs and services, including those that belong to the marines, are at a greater risk of accidents and violent deaths, and infectious, respiratory and mental diseases, which are common among those working on ships.^{6,7,9,10,17,18} Although some occupations are indicated as presenting greater risk, the causes of death differ from those found for the Brazilian Navy.

In the present study, a strong association between the occupations of the communications and electro-electronics group and deaths due to nervous system diseases was noticeable, especially in relation to the

disease sub-categories of cerebral degeneration and Parkinson's disease. It is plausible that some of these deaths in the navy may be associated with the electromagnetic and microwave fields that are present in these occupations, especially among radar operators. For the latter, nervous system diseases were six times more frequent than in other occupations. Such exposure has, for example, been found to present an association with Alzheimer's disease and other neuromotor diseases among civilian workers who were operating radio and television stations and electric energy plants, and repairing telephone and electrical networks.¹⁴ With regard to the effect of microwaves, studies on American servicemen who served during the period of the Korean War have presented data suggestive of a greater risk of nervous system diseases in the occupations of operating and repairing electrical, electronic and communications equipment.¹² Although there is no evidence regarding specific occupational risk factors among servicemen in relation to nervous system diseases, other types of exposure that are also common in the military working environment are associated with neuropathies, such as exposure to various metallic compounds, organochlorates, solvents and electromagnetic fields.¹

The greater proportional mortality due to genitourinary tract diseases, in which specific analysis of occupations revealed greater risk for general services personnel in the Brazilian Navy, differs from the majority of findings. Servicemen have generally presented low estimates of mortality for this group of diseases.^{2,3,5} The exception to this is a study made among hospitalized Gulf War veterans, which showed a slight increase in the incidence of such diseases.⁸ A review of occupations in relation to genitourinary tract diseases has shown that chronic kidney diseases were the main

causes of death for industrial workers.¹⁰ In addition to these findings, there are records of the occurrence of subclinical nephropathy among workers exposed to nephrotoxic substances such as inorganic lead and mercury, cadmium and solvents, especially halogenated aliphatic hydrocarbons.¹¹ Such occurrences support the hypothesis of an association between the types of occupational exposure that are supposedly more common in the working environment of the navy and renal diseases. Although the estimate for the association between general services occupations and genitourinary diseases did not present great magnitude and statistical significance, possibly due to the instability of the small numbers, some of these deaths may have an occupational implication.

Some methodological limitations must be considered in the present study. This was an exploratory study, and it was only possible to compare occupational groups as approximations for supposedly homogenous groups. Thus, specific exposure was not considered since, within a single occupational group, the individuals could present distinctly varying intensities and duration of exposure. Another limitation relates to the measurement of effect and association: when proportional mortality and proportional mortality ratios are utilized, the risk of death is not measured. The proportional mortality ratio is affected by the pattern of deaths among the population, which includes competing risks between the different causes of deaths and the age and gender composition. Nonetheless, the adjustment for age enabled better comparability with the reference population, especially because the servicemen reached greater ages and presented greater relative excess of deaths due to chronic diseases. It can furthermore be noted that the effect of

healthy workers was minimized in the present study, because all the deaths among servicemen on sick leave or who retired due to health problems or due to length of service were included. In other words, the complete population base and all of the deaths during the period of the study were observed.

Although occupational analysis was only done for occupations in the Navy, this procedure contributed towards minimizing the bias resulting from differences in the quality of diagnosis, measurement of exposure or healthy worker effect. The groups compared had the same origin and therefore were subjected to the same selection and classification criteria. In addition to this, it can be considered that the Navy population forms an excellent database for epidemiological studies. This database contains health and occupational information from the monitoring of servicemen's health from when they join until they leave, as well as the continuation of attendance for retired servicemen within the Navy's own healthcare services throughout Brazil. This allows complete cohorts to be followed, even though much of this information is not computerized.

This study has shown the need for further investigations, with measurement of occupational exposure that enables the identification of specific occupational risk factors in order to prevent damage to health or early death.

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