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**British merchant seafarers 1900-2010:
a history of extreme risks of mortality from infectious disease**

by

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Abstract

Background: This study established trends in major infectious disease mortality in British merchant shipping from 1900 to 2010 as compared with the British male working population and the Royal Navy.

Methods: A population mortality study of six infectious diseases using annual government mortality returns and death inquiry files for British merchant shipping and the Royal Navy, and official mortality statistics for the general male working aged population.

Findings: Relative mortality risks for each disease were increased significantly in British merchant shipping when compared with the general population; malaria by 58.2 fold, yellow fever (6276), typhoid (9.5), cholera (1734), dysentery (20.6) and smallpox (142). For all six diseases combined, relative mortality risks were 21.5 compared with the general population and 3.5 compared with the Royal Navy. Mortality trend patterns varied between diseases, but reductions in mortality in British merchant shipping consistently lagged many years behind those in both the British general population and the Royal Navy.

Conclusions: Merchant seamen were at far higher risk of death than probably any other occupational group of the population. Much of these excess risks came from exposure to infection in unhygienic and tropical ports, although some was a result of neglect of feasible preventative measures.

1. Introduction

Seafarers have long been seen as one of the main routes by which epidemic diseases have reached Britain [1]. In parallel several so called 'sea diseases' have been identified as specific risks of seafarers for at least the last 400 years [2-4]. Some of these, such as ship fever (mainly typhus), ague (malaria) and yellow jack (yellow fever) were subsequently shown to be infections. The historical trends in disease among seafarers and their relationship to those ashore can reveal much about patterns of transmission and the effectiveness of preventative interventions. While these trends have been documented for those serving in the Royal Navy up to the 1960s [5]. Information on trends among merchant seafarers, virtually all male, has not previously been published.

Seafarers were exposed to several categories of infectious disease because of the requirements of their job, particularly docking in ports with exotic disease patterns or as a consequence of their lifestyles at sea and in port. A number of diseases provide good markers for this:

- Infections transmitted by mosquitoes in tropical ports (malaria and yellow fever)
- Diseases caused by poor food and water hygiene in port and on board (cholera, typhoid and dysentery)
- Infections directly transmissible from person to person that are more prevalent outside UK (smallpox)

Reliable mortality data on long duration infections that have been associated with seafaring, such as tuberculosis and syphilis, and more recently HIV/AIDS, cannot be obtained. This is because, in many cases, the early symptoms will have led to cessation of work at sea.

The objectives of this study were:

- (i) to establish long-term trends in mortality from six acute infections among seafarers employed in UK merchant shipping since 1900
- (ii) to compare trends in mortality with those in the corresponding general British population and with those serving in the UK Royal Navy
- (iii) to review the relevance of patterns of transmission and the effects of preventative interventions on the observed trends

2. Methods

Annual returns on mortality among merchant seamen serving in UK merchant shipping have been published from the mid 19th Century to 1988. From the late 1880s these returns included information on illnesses as a cause of death. Prior to this period occasional case series were the sole source of information on disease mortality. These data were collected and analysed by The Registry of Shipping and Seamen (RSS), previously the Registrar General of Shipping and Seamen.

We obtained information on deaths from infectious diseases among seafarers employed in UK merchant shipping from 1900 to 2010 from these annual death returns, published variously by the Board of Trade, the Ministry of Transport, the Department of Trade and Industry, the Department of Industry, the Department of Trade and the Department of Transport up to 1988 [6-10]. Also through examinations of death inquiry files, death registers and death notification files held at the RSS (from 1976) and the Marine Accident Investigation Branch (from 1990). By 1960 most infectious diseases had become very rare causes of death in seafarers, as a result of better prevention and treatment. Deaths from malaria still sometimes occurred, while some new causes identified such as hepatitis B and HIV amounted to only three cases.

The study included all reported deaths from malaria, yellow fever, typhoid, cholera, dysentery and smallpox among seafarers employed on board UK merchant ships of 100 gross tonnes or more that occurred at sea or in foreign ports or following discharge ashore in a foreign country. Deaths that occurred several days after discharge in the UK are usually excluded as they were registered in the same way as the onshore population rather than through the RSS. For the acute conditions studied this gives a valid picture, but it cannot be

used to make an assessment of longer term infectious disease deaths, for instance from tuberculosis or syphilis [11,12].

The populations of seafarers employed annually in UK merchant ships were obtained from the annual deaths returns to 1988, from annual reports published by the Marine Accident Investigation Branch from 1989 to 1995 and through surveys by the Maritime and Coastguard Agency since 1995 [13,14]. Conventionally, the seafarers were counted as if they had been working at sea for the entirety of each year, in order to enable more direct comparisons of mortality with other industries. It should be noted that although seafarers often have longer annual (shore) leave of several months per year, unlike most other occupations, seafarers have much greater occupational workplace exposure when at sea.

Trends in mortality from these infections were compared first with those in the corresponding male working aged population (15-64 years) of England and Wales using death certificate data from the Office for National Statistics (ONS) from 1901 to 2008 [15,16]. Mortality rates for the male working age population were calculated using the annual death counts and residential populations of England and Wales. Secondly, they were compared with deaths among those serving in the UK Royal Navy. Mortality rates for the Royal Navy were calculated using information on causes of death and populations employed from annual Royal Naval death returns [17, 18, 19]. These two reference populations have marginally different inclusion criteria for the population denominators. They also have more rigorous procedures for identifying causes of death than those used for merchant seamen, which are likely to result in better ascertainment of cause and to more delayed deaths being included.

The main outcome measures were mortality rates per 100 000 population at risk and relative mortality risks to compare mortality in British merchant shipping with the two reference populations. Annual trends in mortality rates have been analysed. In addition comparisons of relative mortality risks in merchant shipping, the navy and the male onshore population have been made. Over the 111 year study period from 1900 to 2010, annual details of mortality and populations at risk were obtained for 99 of these years for British merchant shipping (1909-1911, 1913-1914 and from 1919-2010) and for 43 of these years for the Royal Navy (1900-1915, 1921-1936 and 1953-1963). Missing years occurred because the annual death returns - despite exhaustive searches - could not be located or were not released. The Royal Navy did not publish information for the periods of the two world wars and it is also missing for merchant shipping during the first war, when statistical returns were suspended. When comparing mortality in British merchant shipping with the reference populations, only those years when mortality was available for both groups were used.

3. Results

Different infectious diseases in merchant seamen show markedly different patterns, both in the timing of changes in the reported incidence of deaths and as compared to the reference groups (Figure 1; Tables 1 and 2). These can be related to the sources and routes of infection and to the consequences of working at sea, in terms of risks ashore and on board; fitness to work at sea; the timing of changed preventative and treatment options, and possibly to a higher case fatality rate in the absence of medical care at sea.

Those conditions associated with the mosquito borne infections of malaria and yellow fever are only found substantially in the two maritime groups (see Figures 1a and 1b), but rates are lower and fall earlier in the Navy. This is probably due to several factors, including the enforcement of prophylactic use of quinine (which should have been available on both naval and merchant ships throughout the study period) and bite avoidance measures as well as from better treatment as more naval vessels carried medical staff. Above all, merchant ships were likely to spend long periods in tropical anchorages where mosquito control was absent, whereas naval vessels would mainly make shore visits to naval bases or to major port cities. The increased mortality for both conditions around 1920 cannot be explained, but the increase in malaria deaths in merchant seamen during the Second World War is almost certainly the result of changes to shipping patterns with long periods in West African ports, where there was a high incidence of malaria, while convoys were being assembled.

Typhoid was a problem in the early twentieth century in the UK but to a much greater degree at sea (Figure 1c). Reductions in incidence were earlier in the navy than on merchant ships, but the mortality in both naval and merchant seamen prior to 1920 is

probably a reflection of incidence in the UK. Cholera, the epidemic scourge of the nineteenth century, ceased to be a significant cause of death in UK by 1900 and in the navy after 1910, but continued to be important among merchant seamen until the 1950s (Figure 1d). This was probably a consequence of more shore time in unhygienic port areas and a lack of quality control over water and food supplies purchased there. The position of dysentery was complex, notably with an increase in the home population after the first war, presumably from returning servicemen (Figure 1e). Many of the dysentery deaths (43%) were in Lascar (mainly Bengali) seamen who had amoebic dysentery. But a proportion of the cases were almost certainly related to hygiene problems in merchant ports and to contaminated food and water. Larger disparities between merchant seamen and both the navy and general population for cholera and dysentery than for typhoid reflect major differences in exposure patterns.

The excess of smallpox deaths in merchant seamen reflects both exposure to risk and a failure of prevention (Figure 1f). Vaccination was recommended but was never mandatory for merchant seamen and a search of relevant archives indicates an almost total absence of debate on the benefits of compulsion. This is despite the frequency with which merchant seamen were the source for epidemics in port cities in UK in the 19th and early 20th century.[20] Unlike the Navy, much employment in merchant shipping was on a casual basis, where the only contact with a medical system that could have ensured that vaccination was up to date was immediately prior to embarkation. The main barrier to preventative action on this seems to have come from ship owners, who did not want pre-embarkation vaccination, since any complications from the procedure would have arisen at sea. Although not recorded, it is likely that similar attitudes prevailed in relation to other immunisation procedures. There was no formal responsibility for the public health of merchant seamen within UK government, but the Royal Navy had systems in place for

routine vaccination and immunisation for new recruits and regularly thereafter for serving sailors, which would explain some of the differences in mortality witnessed.

Relative mortality risks for each disease were increased significantly in British merchant shipping when compared with the general population (Table 1); malaria by 58.2 fold, yellow fever (6276), typhoid (9.5), cholera (1734), dysentery (20.6) and smallpox (142). Mortality for each infectious disease was also increased significantly in British merchant shipping when compared with the Royal Navy (Table 1); malaria (by 6.5), yellow fever and cholera (no deaths in the Royal Navy), typhoid (1.5), dysentery (8.5) and smallpox (19.6).

For all six diseases combined, relative mortality risks for British merchant shipping were 21.5 (95% CI = 20.6, 22.4) compared with the general population and 3.5 (3.1, 4.0) compared with the Royal Navy. Over time this increased mortality in merchant shipping, compared with the general population, rose from 6.1 in the years before World War 1 to a peak of 30.5 during the late 1940s, it fell to 18.7 by the 1970s and to 4.6 in the last few decades (Table 2).

4. Discussion and conclusion

Despite the limitations and some inconsistencies between the sources of information used, it is apparent that merchant seamen were at far higher risk of death from a range of infectious diseases throughout most of the twentieth century than probably any other group of the population (Table 1). Previous studies have identified large relative risks of accidents and ship disasters as causes of increased mortality in British merchant seamen [21-23]. To this must now be added the far greater excess risks from many of the acute

infectious diseases. Much of this excess risk came from the disease patterns in tropical and unhygienic ports, but some was a result of neglect of feasible preventative measures that could have readily been introduced had the available data been critically reviewed at the time and action taken on the findings. The failure to enforce smallpox vaccination is undoubtedly the most significant shortcoming, and one that led to avoidable infection in seamen and to an increased risk of transmission by seamen to onshore populations. The lack of any formal responsibility for public health measures directed at merchant seamen as well as institutional barriers both in the Marine Department of the Board of Trade and in the maritime industry to such initiatives contributed. These barriers were only briefly set aside under the pressures of the Second World War [24].

- For each of six infectious diseases (malaria, yellow fever, typhoid, cholera, dysentery and smallpox) mortality was much higher in British merchant seafarers than in both the corresponding British general population and the Royal Navy.
- Reductions in mortality over time in British merchant shipping consistently lagged many years behind those in both the general population and the Royal Navy.
- These historical patterns indicate the problems of infectious disease management in the commercial maritime sector.
- Casual patterns of seafarer employment and the attitudes of employers and governments to risks to the health of merchant seamen contributed to avoidable mortality from infectious disease in the past. Although these risks are now better controlled, the same patterns of employment and attitudes to seafarer health persist in what is now a globalised maritime sector. They almost certainly result in avoidable

mortality, if no longer from infectious diseases on a significant scale, very likely from the commoner lifestyle related arterial diseases and cancers of today's seafarers.

Conflicts of interests

The authors state that they have no conflicts of interests.

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Contributors

SER and TC designed the study, collected the study data, reviewed the literature, undertook the analyses, interpreted the study findings, wrote the manuscript and have approved the final version of the manuscript.

Ethical approval

Ethical approval was not required as it is based on anonymised historical death returns and mortality counts, death inquiry files and registers. Study approval was obtained from the Marine Accident Investigation Branch, Registry of Shipping and Seamen, Maritime and Coastguard Agency and from coroners across England and Wales.

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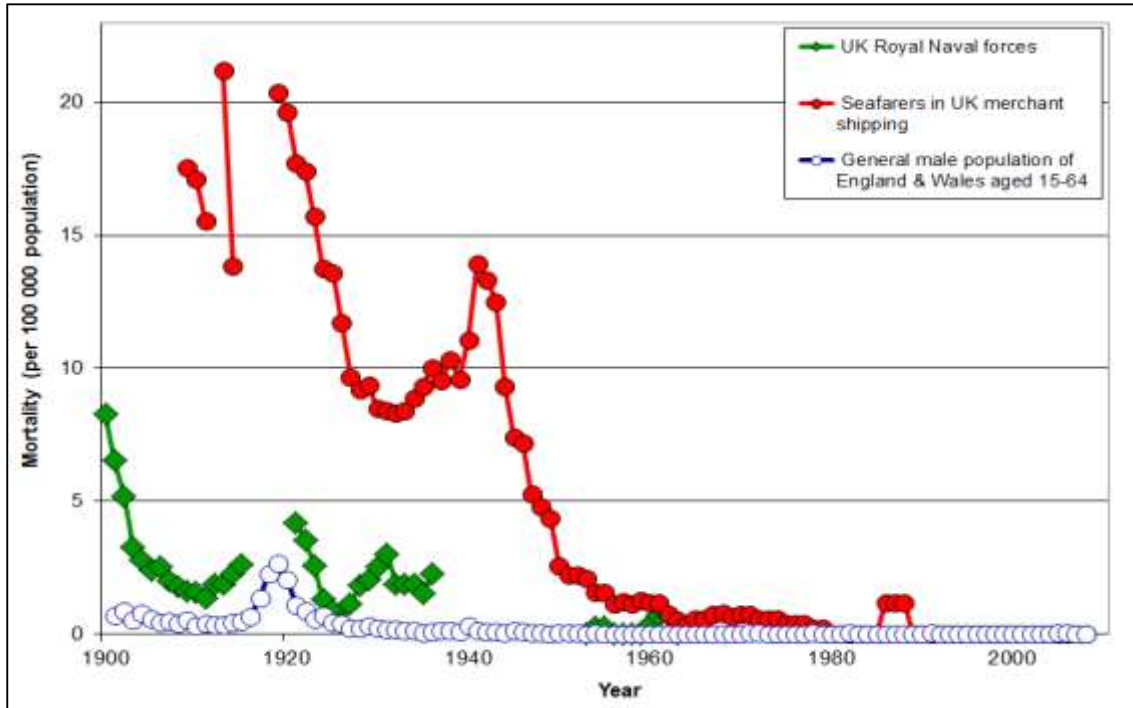
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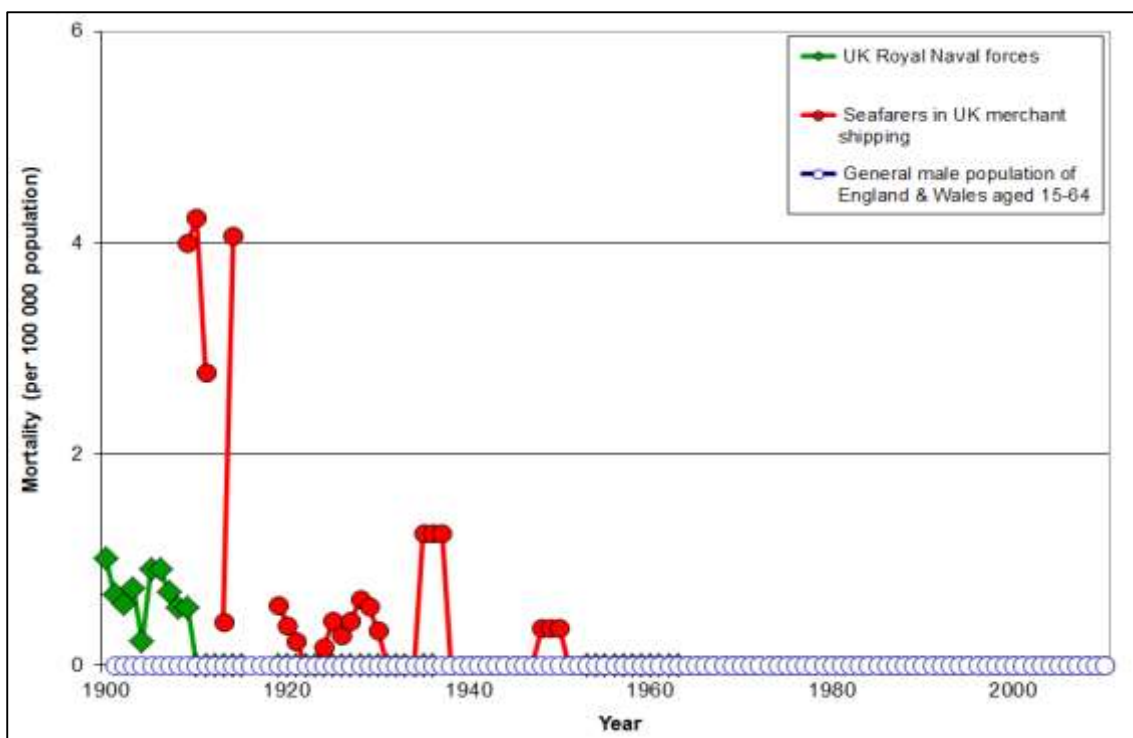
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Figure 1 Mortality rates for malaria, yellow fever, typhoid, cholera, dysentery and smallpox among seafarers employed in UK merchant shipping, among forces in the UK Royal Navy and in the general working age male population of England & Wales, 1900-2010

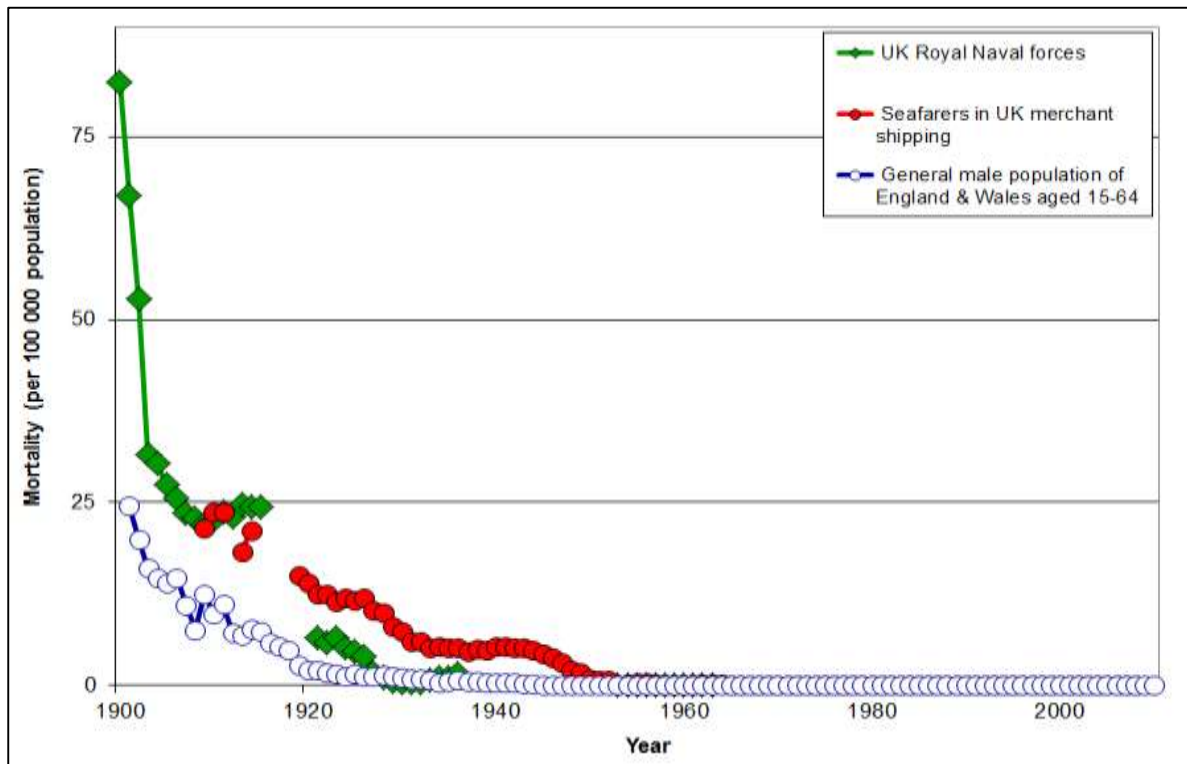
a). Malaria



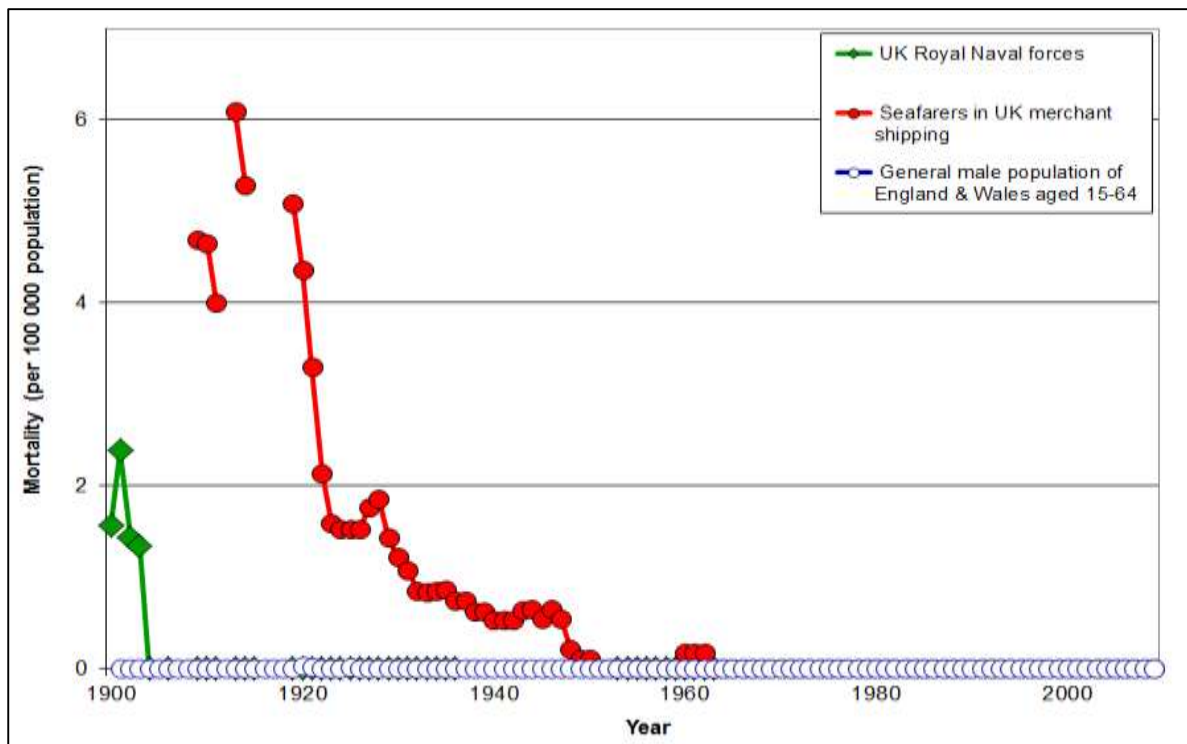
b). Yellow fever



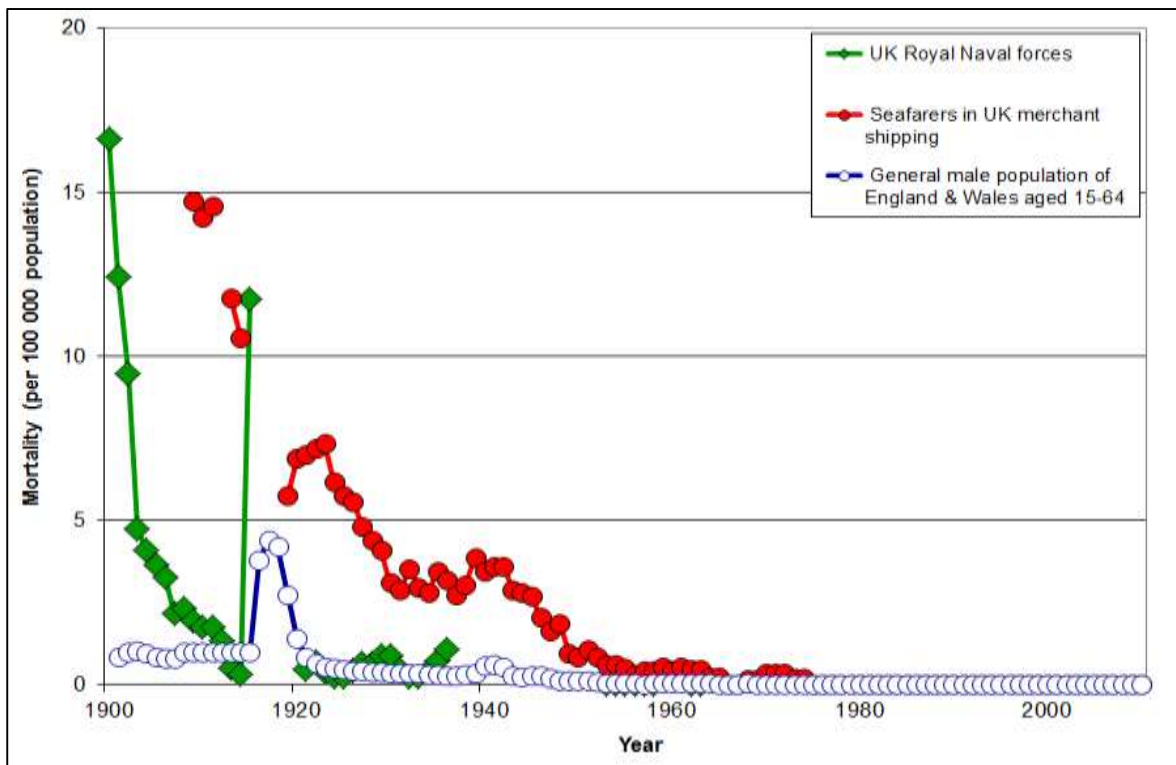
c). Typhoid



d). Cholera



e). Dysentery



f). Smallpox

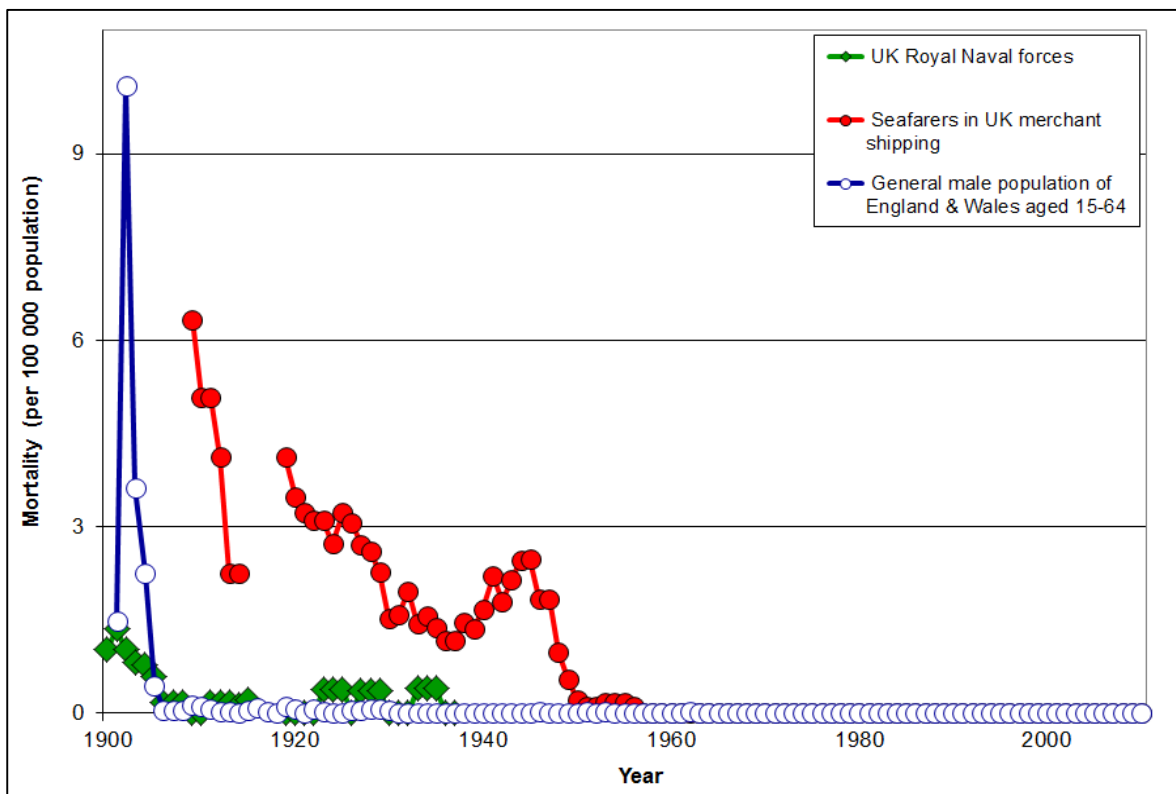


Table 1 Mortality rates for malaria, yellow fever, typhoid, cholera, dysentery and smallpox among seafarers on merchant shipping, compared with the general male working age population of England & Wales and with the Royal Navy

Major infectious Disease	UK merchant shipping		Comparisons of mortality with the general population		Relative risk of mortality for UK merchant shipping compared with the general male working age population (95% CI) ‡	Relative risk of mortality for UK merchant shipping compared with the Royal Navy (95% CI) †
	No. of deaths ‡	Mortality rate (per 100 000 population) ‡	Relative risk of mortality for UK merchant shipping compared with the general male working age population (95% CI) ‡	Relative risk of mortality for UK merchant shipping compared with the Royal Navy (95% CI) †		
Malaria	993	7.5	58.2	(53.9, 62.9)		
Yellow fever	59	0.4	6276	(870, 45 302)		
Typhoid	779	5.9	9.5	(8.8, 10.2)		
Cholera	163	1.2	1734	(916, 3284)		
Dysentery	448	3.4	20.6	(18.6, 22.8)		
Smallpox	186	1.4	142	(114, 177)		
Total	2628	19.8	21.5	(20.6, 22.4)		

Notes

- ‡ Covers the years 1909-1911, 1913-1914 and 1919-2010 - when both merchant shipping and general population mortality data were available.
- † Covers the years 1909-1911, 1913-1914, 1921-1936 and 1953-1963 when both merchant shipping and Royal Navy mortality data were available.
- * Denotes no fatalities in the Royal Navy.

Table 2 Trends over time in relative risks of mortality from malaria, yellow fever, typhoid, cholera, dysentery and smallpox among those employed in UK merchant shipping compared with the general working age male population of England & Wales

Infectious disease	Relative risk of mortality (UK merchant shipping: general working age male population of England & Wales)						
	Time period						
	1909-1914 ‡	1919-1929	1930-1938	1939-1945	1946-1949	1950-1959	1960-1969
Malaria	41.8	17.5	62.3	77.4	80.5	46.6	50.2
Yellow fever	*	391	*	*	*	*	*
Typhoid	2.3	7.1	7.9	16.0	23.7	24.9	10.8
Cholera	3317	397	*	*	*	*	*
Smallpox	57.8	58.3	120	*	72.2	8.3	0.0
Dysentery	16.7	8.6	10.2	7.4	11.3	9.0	10.8
Total §	6.1	11.7	17.5	25.1	30.5	21.8	22.0

Notes

* Denotes no fatalities in the general male working age population of England & Wales.

‡ Excludes 1912.

† Excludes 1912 and 1915-1918.

§ 95% confidence intervals for these relative risks are, respectively, 6.1 (5.6-6.5); 11.7 (10.9-12.5); 17.5 (15.6-19.7); 25.1 (21.9-28.8); 30.5 (23.6-40.9); 4.6 (0.6-32.9) and 21.5 (20.4-22.2).