

Mapping the knowledge base for maritime health: 1 historical perspective

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ABSTRACT

There have been major developments in the understanding of disease and its treatment in the last 150 years. The development of the knowledge base on patterns of disease and injury in seafarers and on the effectiveness of intervention to prevent and treat them indicates the sorts of information that were collected and the settings in which it was possible to collect it. They also show how it has been used, as well as the reactions of those in the maritime sector to the collection and analysis of health information and to its use as a means of reducing harm.

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In the 19th century, case reports and series provided most of the information on acute conditions, supplemented by more detailed studies of outbreaks of infection brought ashore by seafarers in port cities. Information from these was applied to preventative measures but, with few effective treatments available, could do little to reduce the outcomes of illness and injury. Long-term risk received little attention.

The risk of pulmonary tuberculosis among seafarers was the impetus for the first long-term incidence-based mortality studies, which provided important information that aided prevention, mainly by reduction in overcrowded crew quarters and by providing facilities for diagnosis and treatment. However, detailed studies of morbidity, other than case series, were only undertaken when there were pressing needs under wartime conditions.

The good archives and early development of merchant seafaring in the UK make it a suitable location to study. This historical review shows the use of different approaches to data collection and analysis, the settings in which it could be collected, the difficulties in defining the size and makeup of the overall population of seafarers, and the uses to which analyses of the information could be put. The atti-

tudes of employers, seafarers, regulators, and health professionals to the collection and analysis of data and to its use for prevention and treatment are noted.

INTRODUCTION: THE START OF MODERN REGULATION

The 1867 UK Merchant Shipping Act provides a convenient starting point for assessing the development of the knowledge base underpinning maritime health provisions. Evidence on the interactions between the state, ship owners and those concerned for the health of seafarers is well recorded from that time [1]. Previously there had been limited requirements for ships to carry medicines and for doctors to be aboard certain classes of passenger, emigrant, convict, and whale catching ships [2]. The Royal Navy and The East India Company had long had such arrangements in place [3]. Provisions for individual seafarers who needed medical care away from their home-port derived from traditional maritime laws dating back to the Middle Ages [4]. What the 1867 Act did was to specify the medicines to be carried on board in more detail, including their quality; it also made provision for, but did not require, medical examinations of seafarers before embarkation; it in-

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troduced quality standards for citrus juice to prevent scurvy and required ships to carry a guide to medical care at sea (*The Ship Captain's Medical Guide*). It did not, as advocates for improvement had hoped, cover more costly measures to improve health such as better vessel safety, diet beyond antiscorbutics, or standards for crew accommodation [5]. Thus it created a statutory framework for several important aspects of maritime health, but one that was tempered by what was politically and economically acceptable to the powerful interest groups concerned, notably the ship-owners.

The Act's provisions reflected prior concerns and campaigns. There was a continuing debate during the nineteenth century about the toll from loss of life at sea, especially by shipwreck, and whether this was a result of unseaworthy vessels or unseaworthy seamen [6]. Many onshore activists argued that it was the poor vessels, coupled with the existence of an insurance market, that minimized the financial penalties to the owner in the event that a ship was lost. The 'shipping interest', in resisting this allegation, pointed to declining standards of seamanship and in turn blamed the poor condition of British seamen – often shorthand for intemperance and the effects of alcohol, coupled with dissolute behaviour and venereal disease [7]. The ship-owners' resistance to safety-related changes to vessels and to what they saw as state interference in their commercial practices continued, as seen in the further twenty years resistance to introduction of load lines [8]. By contrast, sufficient evidence to provoke action on seafarers' health came from a series of anonymous articles in the *British Medical Journal* that used the admissions data from the Dreadnought Seamen's Hospital in Greenwich to show the pattern of illness in seamen [9]. This made a very clear case that, while alcohol and venereal disease contributed to illness, other aspects such as the poor quality of the citrus juice purchased by owners and masters led to preventable illness in returned seamen, with many suffering from scurvy, long after the Royal Navy had all but eliminated the problems by providing good quality juice [10].

The campaign for better health protection was led by a voluntary self-appointed organization 'The Society for Improving the Conditions of Merchant Seamen', which met for several months in early 1867 and made a range of recommendations, a number of which were taken into the 1867 Act [11]. One of the members of the Society was Dr Harry Leach from the Seamen's Hospital, who emerged as the writer of the *British Medical Journal* articles. He went on to be author of the *Ship Captain's Medical Guide*, also advising the government on the format for the seafarer medical examination and becoming the official Inspector of Lemon Juice! [12]. Dr Leach's published evidence took the form of a case series from the hospital. This did not

enable either the prevalence or the incidence of diseases to be calculated and was limited to those who were ill whilst in the Port of London. It is not clear how much of the recorded illness was in fact a result of risk on shore, including typhus in lodging houses and venereal infections from sex in ports, rather than at sea. It was, however, sufficient to make the case for action, as well as providing a benchmark against which trends, notably the decline in scurvy with quality assured citrus juice, could be followed [13].

ACUTE ILLNESS

Most information on disease in seafarers at this time took the form of case series. Another large one was from the English Hospital in Callau, the main port of Peru, in 1872 and showed a similar pattern of nutritional problems including scurvy [14]. Most ships arriving there had been several months at sea. From 1882 the Marine Department collected information from ships' masters on causes of loss of life at sea, including from illness. British Consuls also provided information on distressed seamen in the ports where they were stationed and on any death of a seaman. A summary was published annually, but using a classification of causes of death that was unique to the Marine Department and which was reliant on the limited diagnostic skills of master and consuls [15]. The annual publications became a routine and little use was made of them as the basis for action to improve health.

The growth in public health in ports both before and after the 1875 UK Public Health Act provided local resources for investigating outbreaks of infectious disease, including the role of seafarers as vectors in its introduction from foreign ports. These investigations used techniques such as geographical spread and trends in cases, case incidence, prevalence, and outcome to monitor the outbreak and its control. This was locally important – leading to preventative action – as well as being of national and international significance [16]. It also fitted with the newly emergent science of bacteriology in showing the importance of contagious transmission [17].

Improvements to health for seamen in the late nineteenth and early twentieth century did take place. These included statutory requirements for food supplies and for the training of ship's cooks. There were some limited improvements in accommodation, while training for officers in first aid and medical care was introduced [18]. In the meantime the requirements for medicines and medical equipment to be carried and the *Ship Captain's Medical Guide* were regularly updated [19]. Empirical observations and changes to onshore practice rather than evidence on patterns of disease at sea were the drivers for such change. One illustrative example was the decision to require ships to carry a clinical thermometer. Yellow fever was a com-

mon cause of death in seafarers and a common clinical view was that deaths from yellow fever could be reduced by resting at an early stage in the disease [20]. An objective measure of infection was a rise in temperature, but without confirmation by thermometer a seaman claiming to be feverish could just be shirking duties. However, introduction was slow because of the concern of officials about the cost to ship-owners and the lack of training in its use by officers; the latter being countered by comparing the simplicity of reading a thermometer to taking sun sights using a sextant!

CHRONIC DISEASE MORTALITY

Information on illness and injury at sea and immediately after arrival in port could be used to provide definitive information on maritime accident risks and a view of the frequency of acute diseases. It could not provide any indication of chronic disease risks associated with seafaring. It was possible to count cases, within the limits of the available diagnostic skills, at sea. It was, and remains, more difficult to collect similar information on diseases in seafarers arising while in port, on leave, between periods of sea service, or after retirement, while linking them to particular types of work aboard is almost impossible. Adding up the cases identified in these different settings to obtain an overview of the pattern of chronic disease in seafarers posed a problem because of differences in diagnosis and recording. Information on the relative frequency of different conditions, of the sort derived from case series, only allowed limited comparisons, for instance between different groups of seafarers or between seafarers and the rest of the working population. Long-term risk could easily be missed or ignored.

Information on the number of people at risk was needed to make more valid comparisons. This has always been a particularly complex statistic to collect because of the pattern of work and leave in seafarers. For many seafarers employment has been casual and so the duration of periods of sea service and time on land are not consistent. No registers of seafarers or social security data were available a century ago. This meant that it was not possible to measure the two main indicators of disease that had already been adopted for public health purposes and by the armed forces: prevalence, that is the percentage of a population that has a disease at any one time, and incidence, that is the number of new cases of a disease that arise in a population of a given size over a given time period [21].

Improving the quality of information on disease has costs. Both the cost of an investigation and the potential cost if the investigation shows that action is needed can be seen as a threat by some and an opportunity by others. It was concern about the frequency of pulmonary tu-

berculosis (PTB) in merchant seamen that brought this to a point where the overall population of seafarers was first estimated to enable prevalence and incidence rates to be derived [22]. Much of the impetus for this was a result of the endeavours of Fleet Surgeon Home. He was a naval surgeon who was used to the good incidence data that was available on naval personnel and knew its importance in monitoring PTB risks and reducing them [23]. In the 1920s he wrote a series of articles in which he used the limited information on the numbers and deaths of merchant seamen to attempt to quantify PTB incidence [24]. In doing so he pointed out the deficiencies of the available information, eventually persuading the Marine Department to align their coding of information on deaths at sea with that used in public health, thus enabling comparisons to be made. He also showed how the at-risk population could be derived from available statistics, and identified the ways in which these could be improved to enable denominators for incidence and prevalence rates to be calculated. He showed that, while PTB was not a cause of excess mortality at sea, deaths were far in excess of the rates for the rest of the population for seafarers in the first year after they ceased to work at sea [25]. Most, he surmised, would have had to stop work because of symptoms and then died soon afterwards. They would very likely have been a source of infection to their shipmates for a while before ceasing to work.

Home's work had a number of consequences: the Marine Department finally acknowledged the need for a formal mortality study on merchant seamen, and this was commissioned and published in 1932 – largely confirming Home's findings but in a more rigorous way [26]. Accommodation standards for seamen on merchant ships were improved, at some cost to ship-owners. X-ray screening for seafarers was initiated, and a number of special sanatoria for treatment of seafarers who fell outside the normal onshore arrangements for treatment were opened [27]. Periodic mortality studies of UK seafarers have been a continuing source of information since then [28]. These have continued to use methods similar to those used in the 1932 study. They have shown a decline in infectious diseases, including PTB and an increase in heart disease to become the major killing disease in seafarers. Fatal accident information is also investigated, showing a declining trend, but with rates that are still well in excess of those in high-risk sectors of onshore employment. In fishing they are even higher and have not shown the same reducing incidence.

TREATMENT AND FITNESS

Mortality is the most extreme measure of disease, but one where recording of the event is almost invariable. There was less progress on the collection and analysis of non-

-fatal disease information, except on the minority of ships that carried a surgeon, and even here the owners were often unenthusiastic about the release of information that could be against their commercial interests [29]. As understanding of disease improved from the 1860s and as more effective treatments were introduced in the twentieth century, disease statistics ashore became both more useful and of greater practical importance, not only for identifying preventative needs but also for assessing the effectiveness of treatment. Chemotherapy for syphilis, introduced from around 1910, was one of the drivers for such data collection in seafarers [30]. The treatment needed to be continued over several months and given in a clinic. Systems of cards carried between port clinics were established, and Norway, with a rapidly growing merchant fleet, took an international lead in proposing a worldwide network of clinics not just for this purpose but also to meet the other health care needs of seafarers, who were poorly looked after by existing arrangements [31]. However, these collaborative efforts yielded little in the way of published health data except on venereal diseases. In the early years of radio-medical advice to ships records of contacts were not analysed and used as a source of information on patterns of illness at sea.

It took the need for fit seafarers to crew merchant ships in the Second World War to secure detailed investigations of health and disease, although sadly wartime constraints meant that most of the results went unpublished and are only to be found in state archives. Malaria was taking its toll on crews on vessels assembling in West Africa to form convoys northwards. Studies were done to identify the ports and anchorages with the highest risk [32]. A 'malaria index' was developed, using case incidence per day in port as a measure. As a consequence targeted onshore mosquito eradication programmes and recommendations about the use of antimalarials were developed – to good effect. Venereal disease was a major contributor to crew disability, and agreed treatment regimes that applied to all allied seamen were introduced together with intensive educational initiatives and supplies of condoms [33]. The evidence of risk for this became available because there was a 'pool' of allied seamen who were medically assessed and the numbers unfit to embark were recorded. Other evidence on morbidity still came from seafarers coming ashore from vessels and from continuing statistical recording of some diseases such as PTB and syphilis [34].

As noted, the concept of 'fitness' and the 'able bodied seaman' underlay thinking on maritime medical matters from the 1860s. This was an area of controversy, not least as seamen's unions developed and were concerned about the coercive nature of medical selection and the denial of employment to some of their members [35]. The failure of

employers and masters to use the state-provided system of fitness assessment created in 1867 resulted in most of the assessment that was done being entirely on the employer's terms and often with little or no redress for an aggrieved seaman [36]. Right back to the original medical examination recommendations for the 1867 Merchant Shipping Act much of the selection was based on diseases that were known from experience to adversely affect work at sea, to be a danger to others aboard, or to be liable to get worse and mean that an ill seaman had to be cared for aboard, with all the limitations on treatment that this implied. Landing a seafarer for treatment at a foreign port was a cost to the employer or, failing that, the state.

Eyesight was one area where decisions on fitness were underpinned by some evidence. Red and green navigation lights came into general use by the 1880s, and colour vision defects were found to be contributing to night-time collisions [37]. Tests performed by the Marine Department were introduced for officers. The fairness of these tests was contested between the emerging officers' unions and the state. Cases where anomalies in test results were found led to experimental field studies of night colour vision in 1911 prior to the introduction of testing lanterns that simulated navigation lights [38].

Since the 1940s there have been a number of studies on particular aspects of seafarer health in the UK and the mortality study referred to above continues to provide information on causes of death. However, the globalization of both the maritime labour market and the registration of ships means that single country studies are likely to become less and less relevant to risk comparisons.

DISCUSSION

Evidence on the health of seafarers has been and continues to be used for a variety of purposes. It can inform about and make the case for legislative action, it can help define policies and practices about who can safely work at sea, it may identify risks arising from living and working at sea, and it can help develop better arrangements for managing illness and injury in seafarers. Three factors can be seen to govern the improvement of the knowledge base and are apparent in this historical review; their relevance to the present will be considered in subsequent articles. They are, first, the motivation to collect data on the health of seafarers; second how the data, once collected, may be used; and underpinning both of these lie the available methods for the analysis of such information.

Most of the early data-sets were put together by doctors, who had seafarers as patients, and they are often based on their own clinical records. Each set of data provided a view on the distribution of different types of illness as diagnosed at the location where the doctor was work-

ing. This distribution could be compared with the distribution at other locations or in non-seafaring populations, but the overall frequency of any form of illness could not be determined. These data sets could usually be compiled at low cost. They were published and sometimes then used, as in the case of Leach's series on scurvy and other diseases seen at the Seaman's Hospital, to make the case for action to improve prevention or treatment.

More informally, the opinion of those with expertise in the diseases of seamen often formed the basis for action. This was not usually codified but played a large part in resolving particular issues such as the need for clinical thermometers aboard and for many other changes to medical stores, and to the advice given in the *Ship Captain's Medical Guide*. The motivation of those providing and interpreting this evidence was similar to that of those who collected case series: to improve protection while enhancing their positions and reputations as experts in maritime health. This was a low-cost approach to improving protection for seafarers but one that could readily become biased by the observations and opportunism of a few practitioners. As such it could be readily challenged by both practitioners with differing views and by those who felt threatened by the consequences of decision taking that was based on such information, whether that be employers who objected to additional costs, unions who saw threats to the employment of their members, or state institutions who had their policies and approaches challenged.

Probably the first moves towards systematic investigation of health aspects of seafaring came from onshore public health authorities who were concerned about the spread of infectious disease brought in through port cities. One of the key features here was the commitment of resources of people and money to the investigation of outbreaks and to preventative measures to avoid introduction of diseases or to limit their spread.

Studies of mortality or morbidity in seafarers based on population estimates enabled better comparisons to be made but had to be based on incidence or prevalence rates. These needed funding and a project structure to ensure that valid results were collected and then analysed in a suitable way that would allow sound and unequivocal conclusions to be drawn whenever it was possible to do so. The germ of this approach can be seen in the campaigning and studies of Home on mortality from PTB and other diseases. He did this, it seems, as a matter of personal commitment. In doing so he made a case that meant that the state had to fund a larger study on seafarers' mortality and, having funded it, consider the implications of its results in detail and support a series of actions, some quite costly, to mitigate the harm from PTB in seafarers. The more recent mortality studies on the health of UK seafarers, which have been fund-

ed by the state, similarly provide a source of evidence for the development of policies and practices that regulators can find hard to ignore.

Most evidence on the effectiveness of interventions has come from time trends, whether in case reports or in population based incidence or prevalence studies. Early success with scurvy was followed by reducing trends in acute infections and later in PTB. Shorter-term measures of effectiveness come from specific studies such as those on malaria risks and prevention or on venereal disease treatment. It seems from accident reports that colour vision testing prevented incidents attributable to confusion over lights but, until test methods were improved, at the price of unnecessarily excluding a number of officers from work.

Good quality morbidity studies on disease in seafarers are rare. The only examples that are apparent are those done during the Second World War on malaria and venereal disease treatment. As they were done in wartime conditions to help reduce pressing manpower shortages their significance, both as a model for future work and as publicly available sources of evidence, was limited. They were, however, an effective means of prioritizing actions and reducing harm, as shown by the prevalence of illness in seafarers at the time.

Two other types of investigation played a part in determining some fitness standards, such as those for colour vision. A case series of incidents, maritime accidents, and near misses that could be attributed to colour impairment was collected to make the case for improvements in test methods. Later when the improved test methods were found to be flawed a series of practical experiments was undertaken to determine the essential colour vision capabilities for lookouts in order to inform about the development of better test methods.

The investigations considered in this article have been initiated either by individuals with a professional interest in maritime health or by the state. Thus there are a number of important gaps in contributors to the knowledge base. Employers have rarely collected and even more rarely published information on health among the crews they employed. Perhaps this is because they implicitly recognised that identification of any new problem is likely to rebound on them: hence in their view 'no news is good news'. Similarly trade unions, while protesting both about the risks to their members and the adverse consequences for employment of medical selection procedures, have done little to produce evidence of harm or loss of opportunity beyond individual case reports. Insurers, despite handling some of the higher-cost medical claims, usually regarded their claims data as commercially confidential and so did not add to the pool of knowledge.

Other underused sources of information become apparent when the historical developments are assessed.

These include the results of medical fitness examinations of seafarers, only analysed in wartime and very recently. Examination results provide a useful but incomplete picture, as those who have serious illness are unlikely to come for an examination that is for a job that they know they will not be able to perform. Records of illness at sea could, in principle, have been gleaned from ships' logs and medical records as well as from the use they make of medical equipment aboard and of radiomedical advice. Illness in those needing treatment in port should be accessible either by cross referencing from ships' logs or by collecting it from those doctors who play a major part in arranging referrals. Port studies provided an important source of information in the nineteenth century that is no longer exploited. Retired seafarers would be widely dispersed, but follow up would have been possible through the records of a small number of pension funds.

Seafarers are only one occupational group, but a distinctive one. For many conditions their pattern of illness has been similar to the rest of the population. For this reason information about other parts of the population can often form the basis for estimating risks to seafarers' health and deciding on the priorities for intervention. In particular the treatment of seafarers who become ill will usually be the same as any other member of the population although it may have to take place in different surroundings. Knowledge from other groups has often been used informally to reach decisions relevant to seafarers, with yellow fever providing a series of examples: the measurement of the temperature to identify those with yellow fever at an early stage then, once the mosquito vector was discovered, to introduce precautions to reduce bites. This was followed, once the virus had been identified, by the development and adoption of immunization.

Information on seafarer's health has been used to initiate a range of interventions, such as training, equipment, and support for medical emergencies at sea and determining what are fair and rational medical fitness standards for work at sea and for the prevention of occupational and lifestyle risks to health in seafarers. All these have long historical roots but remain present day areas of concern. In nearly all cases most decisions on what is needed have been taken on a very limited evidence base. The best form of evidence is often that which enables a well-defined operational question to be answered rather than that which provides a broad comparison of the health of seafarers and of other groups. The present day knowledge base will be the subject of the following articles.

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