

The Royal Navy's Response to an Epidemic of Cerebrospinal Fever during World War One

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Abstract

Cerebrospinal fever was noted in the Royal Navy from the mid-1860s. Cases tended to occur singly and sporadically but there were occasional outbreaks involving several cases in one ship. In the early 1900s the disease commonly attacked boys on training ships. Before World War One, naval patients diagnosed with the disease were isolated in hospital, subjected to lumbar puncture to allow bacteriological examination and treated with anti-meningococcus serum.

In the first half of 1915 an epidemic of cerebrospinal fever with high mortality took hold in Britain and struck the large naval shore establishments. Since the disease was spread by asymptomatic carriers, the Admiralty introduced a 'test and trace' regimen to limit its transfer from the major depots to the Grand Fleet. Despite testing all recruits and drafts to ships, cases on sea-going ships nonetheless continued to occur throughout the war, affecting all types of naval rating.

Ships' Medical Officers rapidly discharged suspected patients to hospitals or hospital ships, took steps to identify possible contacts and instituted extensive hygiene measures. Speedy diagnosis allowed serum therapy to start early in the course of the disease and favoured a good outcome while undue delay reduced the chances of survival.

Serum therapy worked poorly in 1915 but apparently effective sera, including Flexner serum donated by the Rockefeller Foundation, subsequently helped to reduce case mortality from 60 per cent to 30 per cent. However, the type of serum used, and the frequency and intensity of treatment, varied between different naval hospitals and changed as the war progressed.

Keywords

Royal Navy, cerebrospinal fever, meningitis, epidemic, serum therapy, World War One

Introduction

In early 1915 Britain was gripped by an outbreak of epidemic meningitis of unprecedented scale.¹ Commonly referred to as ‘spotted fever’ – or ‘cerebrospinal fever’ in medical circles – this meningococcal infection also characterised by meningitis had high mortality.² Although cases of cerebrospinal fever caused by the bacterium called *Diplococcus meningitidis intracellularis* (today *Neisseria meningitidis*) were low in number compared with prevalent infections, the spread of such a deadly disease nonetheless threatened the efficiency and morale of the armed forces.

During the war, cases of cerebrospinal fever in the Royal Navy (RN) were diligently tracked by the Consultant in Medicine to the RN Hospital, Haslar, Temporary Surgeon Rear-Admiral (later Sir) Humphry Davy Rolleston (see Figure 1).³ Rolleston published reports after each year of the war,^{4 5 6 7} delivered the Lumleian Lectures in 1919,^{8 9 10} and in the same year wrote an extensive though incomplete review published in 1925.¹¹ The final *Naval Medical History of the War* included an appendix with additional information regarding outbreaks at the main naval barracks, depots and training establishments during the first four years of the war, and subsequent events during the last five months of 1918.¹²

This study builds upon Rolleston’s contemporary overview of events using case reports and other naval records to create a broader understanding of how the Navy responded to the wartime outbreak of cerebrospinal fever. The first aim is to place the experience of 1915-18 in the context of the prior incidence of the disease in the Navy.

¹ Low RB. The prevalence and distribution of cerebro-spinal fever throughout the world during the recent years. In: *Reports to the Local Government Board on Public Health and Medical Subjects, New Series No. 110*. London: HMSO; 1916. p.115-183.

² Cartwright K. Introduction and historical aspects. In: Cartwright K. (ed) *Meningococcal Disease*. Chichester: John Wiley & Sons; 1995. p.1-19.

³ Anon. Obituary. Sir Humphry Davy Rolleston. *Journal of the Royal Naval Medical Service*. 1945; 31: 69.

⁴ Rolleston HD. Report on cerebro-spinal fever in the Royal Navy (August, 1914 – August, 1915). *Journal of the Royal Naval Medical Service*. 1915; 1: 374-407.

⁵ Rolleston HD. Cases of cerebro-spinal fever in the Royal Navy (August 1, 1915 – July 31, 1916). *Journal of the Royal Naval Medical Service*. 1917; 3: 1-18.

⁶ Rolleston HD. Cases of cerebro-spinal fever in the Royal Navy (August 1, 1916 – July 31, 1917). *Journal of the Royal Naval Medical Service*. 1918; 4: 18-40.

⁷ Rolleston H. Cases of cerebro-spinal fever in the Royal Navy (August 1, 1917 – July 31, 1918). *Journal of the Royal Naval Medical Service*. 1919; 5: 131-141.

⁸ Rolleston H. Lumleian lectures on cerebro-spinal fever. Lecture I. Introduction. *Lancet*. 1919; 1(4988): 541-549.

⁹ Rolleston H. Lumleian lectures on cerebro-spinal fever. Lecture II. Clinical picture. *Lancet*. 1919; 1(4989): 593-603.

¹⁰ Rolleston H. Lumleian lectures on cerebro-spinal fever. Lecture III. Mortality and prognosis. *Lancet*. 1919; 1(4990): 645-653.

¹¹ Rolleston H. Naval medical history of the war: cerebro-spinal fever. *Journal of the Royal Naval Medical Service*. 1925; 11: 110-139.

¹² Rolleston H. History of the various outbreaks of cerebro-spinal fever. In: *Naval Medical History of the War*, Admiralty: London; undated (c1926). Appendix.

The second focuses on the efforts of the Admiralty to slow the spread of cerebrospinal fever from shore to ships of the Grand Fleet. A third objective is to examine the nature of fatal cases originating on sea-going ships. Lastly, this paper considers the value of treatment using anti-meningococcus serum.



Figure 1. Temporary Surgeon-General Humphry D Rolleston, RN (1862-1944). Left: Extract from photograph of Medical Staff, RN Hospital, Haslar, taken September 1914. Image from the Historic Collections of the Institute of Naval Medicine, by kind permission of the Commanding Officer. Right: Photograph by J. Russell & Sons, 1916. Wellcome Collection, Attribution 4.0 International, CC BY 4.0.

History of cerebrospinal fever in the Navy

Cerebrospinal fever was first defined as a disease entity in 1805, based on clinical and pathological characteristics.¹³ The first significant outbreak in the British Isles occurred in the workhouses of Belfast, Bray and Dublin in 1846.¹⁴ A purported case at Haslar

¹³ Hirsch A. *Handbook of Geographical and Historical Pathology, Vol. III – Diseases of Organs and Parts*. London: The New Sydenham Society; 1886. p.547-594.

¹⁴ Ormerod JA. Epidemic cerebro-spinal meningitis. In: Allbutt TC. (ed) *A System of Medicine by many writers, Vol. I*. London: Macmillan and Co Ltd; 1896. p.659-679.

Hospital in that year, which was reported as a brief anecdote two decades later,¹⁵ should be treated with caution because the evidence suggests that little was known about the disease in England and Wales before 1865.¹⁶

The disease is first mentioned in the *Statistical Report of the Health of the Navy* for 1865.¹⁷ ¹⁸ John D Macdonald, Staff Surgeon, RN Hospital, Haslar described two cases: a leading seaman from HMS *Excellent* with a relapsing fever thought to simulate epidemic meningitis and a stoker from HMS *Serapis* with a continued fever that was diagnosed as cerebrospinal meningitis though only the head was examined at autopsy. These reports showed both an awareness of meningitis and the challenge of distinguishing cerebrospinal fever from other prevalent fevers using clinical criteria.

In 1876 two cases occurred on 17 and 24 January in the *Implacable*, a training ship for boys at Plymouth. Both boys were sent to Plymouth Hospital and died, the first on the twelfth day and the second on the seventh day of illness. The report of the Medical Officer (MO) in charge, Fleet Surgeon WH Cruice, was included:

I am unable to offer any explanation of the occurrence of these two cases of this fatal disease. None of the conditions, under which it has hitherto been known to occur were present. The two boys who were attacked, were boys of the 1st class, and they belonged to the *Lion*. They did not sleep near each other, and their messes were on opposite sides of the deck.

Lacking any obvious reason, he could only speculate about possible contributing factors:

They were both previously in perfect health and had not been exposed to cold or wet, and were of course well fed. It cannot, I think, be attributable to the unwholesomeness of the bread or other food, as they were the only cases of this disease out of more than 1,200 persons on board; indeed, during the whole of the month of January, when these cases occurred, both the boys and the ship's company were remarkably healthy.¹⁹

Two further fatal cases, one from the *Impregnable* and one from the Plymouth Division Marines, occurred during the first quarter. A fifth case later in the year from the *Impregnable* made a good recovery. Deputy Inspector General J Jenkins described how the patients were cared for at the Plymouth Hospital:

¹⁵ Brown FJ. On an epidemic of cerebro-spinal meningitis at Rochester, with introductory remarks on other epidemics that preceded it. *Transactions of the Epidemiological Society of London*. 1867; 2: 391-398.

¹⁶ Creighton C. *A History of Epidemics in Britain*. Cambridge: CUP; 1894. p.863-864.

¹⁷ Macdonald JD. Observations on a probable case of relapsing fever, simulating epidemic cerebro-spinal meningitis. In: Admiralty. *Statistical Report of the Health of the Navy, for the year 1865*. 1868. Appendix. p.26-29.

¹⁸ Macdonald JD. Fever with cerebro-spinal meningitis. In: Admiralty. *Statistical Report of the Health of the Navy, for the year 1865*. 1868. Appendix. p.42-43.

¹⁹ Admiralty. *Statistical Report of the Health of the Navy, for the year 1876, 1877*. p.7-8.

No specific treatment was followed in any of these cases, except for alleviation of the symptoms, the most prominent being headache and constipation of the bowels. In all the cases, the head was shaved, and an ice-bag was applied to the scalp, an application well borne, and apparently with some relief to the intense vertical headache, which was perhaps the most prominent and distressing symptom in all the cases. Purgatives and enemata were also freely used in all the cases, the bowels being obstinate.

No course of treatment appeared beneficial since

Of the two boys from the *Implacable*, one was treated on the anti-phlogistic plan, leeches being applied locally, and tartrate of antimony freely exhibited; whilst the other was granted a liberal allowance of wine and stimulants generally; but, as seen, with equally unfortunate results. In the last case, morphia in full doses appeared to have a most beneficial effect in relieving the headache, and inducing sleep.²⁰

Further cases, all ending fatally, appeared from time to time: a boy from *Impregnable* in 1878; two boys from *Lion* in 1885; one boy from *Impregnable* in 1886 and a single person from *Lion* in 1893.^{21 22 23 24} The Report for 1899 recorded eleven cases on Home Station, all fatal, yet despite the high number the only comment was: 'The origin of the malady is obscure'.²⁵

In 1900 six cases, five of them fatal, occurred in four ships, all among boys or youths aged less than nineteen.²⁶ In 1901 there were nine cases (seven fatal) on four training ships, including five on the *Northampton* then lying in the basin at Chatham, all in December. The MO, Staff Surgeon Ernest C Lomas, commented on the prevailing weather conditions but was unable to conclude that they played a part:

It did not seem that any particular part of the ship was specially liable to attack, all the five patients being in different messes in separate parts of the ship, but two were in the same class. In favour of the view that the disease is not directly contagious is the fact that the patients were treated in a general ward in hospital

²⁰ Admiralty. *Statistical Report, for the year 1876, 1877* (Note 19). p.8-10.

²¹ Admiralty. *Statistical Report of the Health of the Navy, for the year 1878, 1879*. p.3.

²² Admiralty. *Statistical Report of the Health of the Navy, for the year 1885*. London: Henry Hansard & Son; 1886. p.37.

²³ Admiralty. *Statistical Report of the Health of the Navy, for the year 1886*. London: Henry Hansard & Son; 1887. p.32.

²⁴ Admiralty. *Statistical Report of the Health of the Navy, for the year 1893*. London: HMSO; 1894. p.29.

²⁵ Admiralty. *Statistical Report of the Health of the Navy, for the year 1899*. London: HMSO; 1900. p.5.

²⁶ Admiralty. *Statistical Report of the Health of the Navy, for the year 1900*. London: HMSO; 1901. p.29.

without communicating the disease to others. Invasion was in most cases very sudden and the progress rapid.²⁷

It is notable that the diagnosis of cerebrospinal fever was confirmed in several of the cases by post-mortem and bacteriological examination. The outbreak on the *Northampton* continued in 1902 with another seven cases. Lomas offered the following description:

Sudden onset, severe nervous symptoms, and high fever characterised the disease; muscular twitchings, retraction of the head, the curled-up attitude of cerebral irritation with partial unconsciousness or delirium being present at an early stage. Great confusion of words in attempting to answer questions was noticed in two cases, and rash, something like patches of German measles, in one case; pain in the calves of the legs was also complained of.²⁸

Of the ten patients on Home Station, seven died and three were invalided out of the service.

Pre-war cases of cerebrospinal fever

In the ten years after 1902, one or a few cases of cerebrospinal fever occurred in most years. The next notable rise in incidence occurred in 1913 on Home Station: *Victory* reported four cases and *Pembroke* two, with five of the six involving stokers; two fatal cases occurred on ships of the Home Fleet, *Centurion* and *King George V*. Overall mortality was 50 per cent. Neither the sources of infection in these patients nor potential connections between them could be clearly ascertained.²⁹ The patient from *King George V*, a 25-year-old leading signalman treated at the RN Hospital, Portland, died two days after admission and was only diagnosed following autopsy and bacteriological examination.³⁰

In 1914 thirteen cases, including five deaths, occurred on Home Station from the training establishments *Impregnable* and *Powerful* at Plymouth and each of the three large RN shore establishments *Pembroke*, *Victory* and *Vivid*. In the latter two, the men affected were young stokers under training; some cases appeared connected, and a plausible route of infection proposed. Nine occurred before the start of the war. A further five pre-war cases, two fatal, occurred on different ships of the Home Fleet –

²⁷ Admiralty. *Statistical Report of the Health of the Navy, for the year 1901*. London: HMSO; 1902. p.30.

²⁸ Admiralty. *Statistical Report of the Health of the Navy, for the year 1902*. London: HMSO; 1903. p.29.

²⁹ Admiralty. *Statistical Report of the Health of the Navy, for the year 1913*. London: HMSO; 1914. p.4.

³⁰ Hitch FG. Intracranial disease and glycosuria, notes on two cases. *Journal of the Royal Naval Medical Service*. 1913; 1: 197-200.

Carnarvon, Implacable, Neptune, Queen and Vanguard – including a petty officer, ordinary seaman, stoker, marine and youth.³¹

In his Medical Officers' Journal (MOJ) for HMS *Implacable*, Fifth Battle Squadron, Home Fleet, Fleet Surgeon Adrian A Forrester described a patient taken ill on 22 May 1914 while the ship was at Sheerness. The youth complained of sore throat, headache and vomiting, and looked extremely ill. He was put to bed and treated with calomel, followed by zinc sulphate and sodium salicylate, but his condition worsened overnight:

This morning his whole attitude and symptoms were strongly suggestive of cerebro-spinal meningitis. He was very drowsy, but conscious when roused, he lay on his side with legs drawn up & neck arched back. There was no rash. Kernig's sign was well marked.

The patient was given morphine and immediately taken off the ship:

I accompanied him to the RN Hospital, Chatham. Here a lumbar puncture was made & the *Bacillus meningitidis intracellularis* demonstrated. He made a wonderfully good recovery under treatment by a specific serum.

No other cases occurred among over a hundred youths and boys on board, and it was presumed the youth had contracted the disease while on leave in Margate. He did not return to the ship but Forrester noted that the youth remained quite fit and was still in the service.³²

Having survived this brush with death, Frank Henry Steptoe, Mess Room Boy, RN, would lose his life to enemy action when the ship he was serving on, HMS *Formidable*, was sunk in the English Channel by a submarine on 1 January 1915 just a couple of weeks short of his eighteenth birthday.³³ This tragic example serves to make the point that a key objective of the naval medical service was to reduce the loss of service from sickness to a minimum and to keep as many officers and men as possible in the highest state of fighting efficiency.³⁴ Sadly, Fleet Surgeon Forrester was killed in the bombardment of the Dardanelles on 25 April 1915, a reminder of the risks faced by medical staff on board fighting ships.³⁵

³¹ Admiralty *Statistical Report of the Health of the Navy, for the year 1914*. London: HMSO; 1920. p.4-5.

³² Admiralty and predecessors: Office of the Director General of the Medical Department of the Navy and predecessors. Medical Journals. *Implacable*. 1914. Jan-Dec. ADM 101/317, The National Archives (TNA), Case 50.

³³ Admiralty: Royal Navy Registers of Seamen's Services. Steptoe, Frank Henry. ADM 188/703/28378, TNA.

³⁴ Hewitt DW. The treatment of wounded in naval warfare. *British Medical Journal*. 1914; 2(2799): 357-359.

³⁵ Anon. Obituary. Fleet-Surgeon Adrian Andrew Forrester. *Glasgow Medical Journal*. 1915; 83: 438.

The Royal Navy and Cerebrospinal Fever during World War One (Wawrzynczak)

Period	Plymouth			Portsmouth			C. Palace			Chatham		
	Cases	Fatal	%	Cases	Fatal	%	Cases	Fatal	%	Cases	Fatal	%
1 Aug 14-31 Jul 15	30	11	37	36	19	53	33	21	64	21	16	76
1 Aug 15-31 Jul 16	28	8	29	28	8	29	8	2	25	18	9	50
1 Aug 16-31 Jul 17	36	13	36	46	15	33	18	8	44	10	3	30
1 Aug 17-31 Jul 18	36	11	31	17	7	41	15	7	47	6	2	33
1 Aug 18-31 Dec 18	23	4	17	7	1	14	7	1	14	3	0	0
1 Aug 15-31 Dec 18	123	36	29	98	31	32	48	18	38	37	14	38
1 Aug 14-31 Dec 18	153	47	31	134	50	37	81	39	48	58	30	52

Table 1. Incidence and mortality of cerebrospinal fever cases at major naval depots. Data adapted from Rolleston: Report on cerebrospinal fever, 1915 (Note 4); Naval medical history of the war, 1925 (Note 11).

Controlling the spread of meningococcal infection

The first wartime case of cerebrospinal fever in the Navy was at the RN Barracks, Chatham on 29 October 1914. By 31 July 1915, the end of the first year of the war, 21 cases had been identified there. More than half were recruits, most of whom had joined recently.³⁶ Over the same period, a significant number of cases occurred at all the large naval depots as shown in Table 1. Mortality ranged from 37% at Plymouth to 76% at Chatham. According to Rolleston, the most extensive outbreak occurred at the RN Division, Crystal Palace where there were 33 cases and 21 deaths, a mortality of 64%, mostly among young recruits.³⁷

According to the Admiralty's Register of Deaths, from October to December 1914 there had been only five deaths from all causes at Crystal Palace, including one of meningitis discharged to Croydon General Hospital.³⁸ During 1915, of a total of 30 deaths, 20 were due to cerebrospinal fever. Most were sent to the 'Croydon Fever Hospital', that is the Croydon Borough Hospital for Infectious Diseases, although some died at other local isolation hospitals or at home. These cases all occurred between February and July, which was typical of the disease since the colder months of the year favoured its spread via droplets.³⁹

Bacteriological studies in the first decade of the twentieth century revealed meningococcus in the nasopharynx of a significant proportion of patients with cerebrospinal fever. In most convalescent cases, the coccus disappeared within a few weeks, but some became chronic carriers. Often, the contacts of patients also tested positive, though largely they remained healthy. At the height of an outbreak, the number of healthy carriers in an epidemic could exceed the number of cases of the disease by ten to twenty times. Controlling the disease required that the healthy carriers be identified and isolated to prevent them infecting susceptible individuals.⁴⁰

The Admiralty responded to the threat by issuing Weekly Order 961/15 (M.D. 7365/15) on 18 June 1915, the first of a series of orders that outlined the procedure to be taken in cases of cerebrospinal meningitis (Table 2):

Should a case of Cerebro-spinal meningitis occur in any ship the patient is at once to be discharged to Hospital or to a Hospital Ship. In addition, all close contacts, *i.e.*, the men sleeping on either side of him, the men sitting next to him in his mess or any special personal friend, should also be discharged to Hospital and examined for carriers.

Apart from these contacts, all his messmates should be kept under daily examination by a Medical Officer and their throats swabbed at least once a day for a period of 10 days.

³⁶ Rolleston. Report on cerebro-spinal fever, 1915 (Note 4). p.387.

³⁷ Rolleston. Report on cerebro-spinal fever, 1915 (Note 4). p.393.

³⁸ Admiralty: Service Registers and Registers of Deaths and Injuries. Ships. Register of Deaths. 1910-1918. ADM 104/110, TNA.

³⁹ Low. The prevalence and distribution of cerebro-spinal fever, 1916 (Note 1). p.117.

⁴⁰ Ledingham JCG, Arkwright JA. *The Carrier Problem in Infectious Diseases*. London: Edward Arnold; 1912. p.227-269.

The usual precautions as regards disinfection should be carefully carried out.⁴¹

In addition, all men going from Crystal Palace on draft to other establishments were tested: they were retained if found to be carriers and not released until six consecutive weekly swabs had been declared negative.⁴²

From the beginning of January 1916, contacts were to be quarantined for ten days and were considered fit for drafting when two successive nasopharyngeal examinations were negative. Carriers were kept isolated until they had given two negative tests and then they could return to duty at the depot; if four additional weekly tests proved negative, they were deemed fit for drafting but later this was reduced to two tests and abolished when demobilization began.⁴³ Early in 1917, drafting establishments had been mandated to notify the senior officers of relevant squadrons when a case occurred so that precautions could be taken with men recently drafted to ships under their command. From mid-1917, any carrier still positive after three months was put forward for survey and invalided.

At the Crystal Palace Depot, the average numerical strength during 1915 was 5,100 men. Between 7 August and 31 December 1915, Fleet Surgeon JA Campbell noted ten cases of cerebrospinal fever on the sick list: four had chronic after-effects and were invalided; two returned to duty, but one was later invalided; and four patients ended up in hospital. Case 55, an ordinary seaman admitted on 17 October, was at once taken to Croydon Fever Hospital and the men who had been sleeping and messing with him were sent to RN College, Greenwich for throat examination in accordance with the orders from the Medical Director-General (MDG). A motor transport driver found to be a carrier was discharged to RN Hospital, Chatham.

Two cases involving ordinary seamen provided a stark contrast in outcomes. Case 74, Joseph Hudson, aged eighteen, presented sick on 28 December and was immediately sent to Croydon Fever Hospital, his diagnosis confirmed by lumbar puncture and bacteriological examination. It seems he recovered as there is no record of his death. Case 75, John James Leech, aged nineteen, took leave on 27 December and felt unwell for a few days with headaches and pains in the back. He was attended by the Navy Surgeon and Agent at North Shields on 30 December, diagnosed by lumbar puncture the following day and on 1 January – by which time severe symptoms had developed – he was taken to the Infectious Hospital at Newcastle where he died two days later.⁴⁴

⁴¹ Admiralty: Admiralty Fleet Orders. ADM 182, TNA; ADM 182/6, Admiralty Weekly Orders 1915, and ADM 182/21 to ADM 182/26, Admiralty Monthly Orders from July 1914 to December 1918.

⁴² Bassett-Smith PW. Naval medical history of the war: (e) cerebro-spinal fever; (f) vaccines and sera. *Journal of the Royal Naval Medical Service*. 1921; 7: 37-52.

⁴³ Bassett-Smith. Naval medical history of the war, 1921 (Note 42). p.38.

⁴⁴ Admiralty. Medical Journals. R.N. Division Crystal Palace. 1915. Aug-Dec. ADM 101/373, TNA.

The Royal Navy and Cerebrospinal Fever during World War One (Wawrzynczak)

Number	Date	Title & key content
345/15	Jul 1915	Cases of Cerebro-spinal Meningitis – Procedure. <ul style="list-style-type: none"> • Discharge to hospital, contacts examined for carriers. • Messmates kept under observation and swabbed daily for ten days. • Usual precautions regarding disinfection.
699/15	Dec 1915	Cerebro-spinal Cases – Early Notification. <ul style="list-style-type: none"> • Reporting cases or action regarding contacts by telegram if possible.
38/16	Jan 1916	Cerebro-spinal Meningitis. Drafting of “Contacts” and “Carriers.” <ul style="list-style-type: none"> • Contacts fit for drafting after two successive negative tests in ten days. • Carriers after two negative tests allowed back to duty at depot, tested weekly for a further month; if negative, considered fit for drafting.
3453/16	Jan 1917	Cerebro-Spinal Meningitis Contacts – Notification to the Fleet. <ul style="list-style-type: none"> • Prompt information sent to any ship to which possible carrier drafted. • Notice of case diagnosed at a drafting establishment telegraphed to senior Officers of all Squadrons at home and abroad affected on list. • Senior Officers to inform all ships/establishments under command so necessary precautions can be taken. • Drafting establishments to inform directly if ship on detached service. • List of senior Officers.
111/17	Feb 1917	Cerebro-Spinal Meningitis Contacts – Notification to the Fleet. <ul style="list-style-type: none"> • List of senior Officers updated. <i>(3453/16 cancelled.)</i>
1351/17	May 1917	Cerebro-spinal Meningitis “Carriers” – Disposal. <ul style="list-style-type: none"> • Carriers after three months’ treatment brought for survey and invalided. • Notice of invalided carrier to Medical Officer of Health at site of return.
2753/18	Oct 1918	Cerebro-Spinal Meningitis – Procedure. REPORTS. <p>A. Disposal of cases and contacts [as before].</p> <p>B. Early notification [as before].</p> <p>C. Contacts – Notification to the Fleet [as before but revised lists, A & B].</p> <p>D. Procedure as to drafting from affected Ships or Establishments [new].</p> <p>Action taken when a case discovered, definition of close contacts, room disinfection, swabbing new entries, drafting between ports, medical examination, spraying throats, isolation.</p> <p><i>(345/15, 699/15, 38/16 & 111/17 cancelled.)</i></p>
3106/18	Nov 1918	Cerebro-spinal Meningitis – Procedure. REPORTS. <ul style="list-style-type: none"> • Lists of senior Officers updated. <i>(2753/18 cancelled.)</i>

Table 2. Admiralty Monthly Orders relating to cerebrospinal fever cases, carriers and contacts. Contents summarised from Admiralty Fleet Orders, July 1914 to December 1918, inclusive (Note 41).

In the first half of 1916, examination of all new entries to Crystal Palace was undertaken at the Medical School of RN College, Greenwich under the supervision of Fleet Surgeon (later Surgeon Rear-Admiral Sir) Percy W Bassett-Smith, who had been Professor of Clinical Pathology since 1912 (Figure 2).⁴⁵ Batches of 50 men, and later 100 or more, were sent up each day for testing.⁴⁶ Some 5,000 nasopharyngeal swabs were examined.⁴⁷ In all, Greenwich carried out 43,000 tests during the war and the total number at all naval centres was at least 140,000, based on incomplete data.⁴⁸ Such measures may have helped control spread of the disease, but cases continued to occur at Crystal Palace as shown in Table 1. In all locations, case fatality was lower after the first year, especially at the end of 1918.



Figure 2. Fleet Surgeon Percy W Bassett-Smith, RN (1864-1927). From photograph of Medical Staff, RN Hospital, Haslar, taken August 1910. Image from the Historic Collections of the Institute of Naval Medicine, by kind permission of the Commanding Officer.

⁴⁵ Anon. Obituary. *Journal of the Royal Naval Medical Service*. 1928; 14: 147-148.

⁴⁶ Bassett-Smith. Naval medical history of the war, 1921 (Note 42). p.37.

⁴⁷ Bassett-Smith PW, Rolleston HD. Medicine and the sea affair: medicine and clinical pathology. *British Medical Journal*. 1917; 1(2939): 533-535.

⁴⁸ Bassett-Smith. Naval medical history of the war. (Note 42). p.42.

Cerebrospinal fever on sea-going ships

Despite efforts to control the risk of drafts spreading cerebrospinal fever to the Fleet, cases continued to appear on sea-going ships throughout the war. Cases of the disease usually occurred only once on a ship, but a few ships recorded cases on more than one separate occasion. Rolleston listed 64 cases in total to the end of 1918, about 12% of all naval cases (Table 3).⁴⁹

The number of cases ending fatally in successive annual periods were 8/12 (67%), 5/10 (50%), 6/20 (30%), 8/17 (47%) and 4/5 (80%), giving an overall total of 31/64 (48%). Cross-referencing Rolleston's listings with the Admiralty's Register of Deaths⁵⁰, naval Records and Registers of Service,^{51 52 53 54 55 56} and the Commonwealth War Graves Commission⁵⁷ has permitted 28 of the 31 fatal cases to be identified (Table 4A).

Period	Major Depots	Other centres	Sea-going ships	Total	% of total
1 Aug 14-31 Jul 15	120	38	12	170	30.6
1 Aug 15-31 Jul 16	82	12	10	104	18.7
1 Aug 16-31 Jul 17	110	13	20	143	25.8
1 Aug 17-31 Jul 18	74	1	17	92	16.6
1 Aug 18-31 Dec 18	40	1	5	46	8.3
TOTAL	426	65	64	555	100
% of total cases	76.8	11.7	11.5	100	

Table 3. Total number of cases of cerebrospinal fever. Data compiled from Rolleston: Naval medical history of the war, 1925 (Note 11); History of the various outbreaks, c1926 (Note 12). The four major depots are Plymouth, Portsmouth, Crystal Palace and Chatham; the other centres include Deal and Shotley Barracks.

⁴⁹ Rolleston. History of the various outbreaks, c1926 (Note 12). p.14, 19, 25, 29, 31.

⁵⁰ Admiralty. Ships. Register of Deaths. 1910-1918. (Note 38).

⁵¹ Admiralty. Royal Marines: Registers of Service. ADM 159, TNA.

⁵² Admiralty. Royal Navy Registers of Seamen's Services. ADM 188, TNA.

⁵³ Admiralty. Officers' Service Records (Series III). ADM 196, TNA.

⁵⁴ Admiralty. Royal Naval Volunteer Reserve: Records of Service, First World War. ADM 337, TNA.

⁵⁵ Admiralty and War Office. Royal Naval Division: Records of Service. ADM 339, TNA.

⁵⁶ Registry of Shipping and Seamen. Royal Naval Reserve Ratings' Records of Service. BT 377, TNA.

⁵⁷ Commonwealth War Graves Commission. <https://www.cwgc.org/>

The Royal Navy and Cerebrospinal Fever during World War One (Wawrzynczak)

<u>Ship (Year)</u>	<u>Illness</u>	<u>Death</u>	<u>Days</u>	<u>Surname</u>	<u>Init.</u>	<u>Rating</u>	<u>Service</u>	<u>Number</u>	<u>Age</u>	<u>Place of Death</u>
1915										
Changuinola	20 Jan	14 Mar	53	Taylor	E.F.	Seaman	RNR(N)	1183X	20	Ruchill Fever Hosp, Glasgow
King George V	19 Feb	2 Mar	11	Taylor	C.E.	Cook's Mate 2nd	RN	M10541	19	HS Plassy
Norna [Various]	22 Apr	28 Apr	6	McLeod	K.	Boy Servant	MMR	937445	17	Linlithgow Fever Hosp
New Zealand	25 Apr	28 Apr	3	Edwards	S.J.	Chief Stoker	RN	175834	39	HS China
St. Vincent	9 May	21 Jun	43	Burbidge	H.J.	Bombardier	RMA	9707	32	HS Agadir
Biarritz	19 May	26 May	7	Kinchenton	W.	Fireman	MMR	678350	32	Chatham Hosp
Liverpool	25 May	29 May	4	Thornley	G.	Leading Stoker	RN	225786	28	Linlithgow Fever Hosp
Bairritz	19 Jul	2 Aug	14	Bishop	W.	Fireman	MMR	588849	34	Seamen's Hosp, Greenwich
Campania	6 Aug	22 Aug	16	Chadwick	O.	Fireman	MMR	n/k	27	HS Agadir
St. Elvies MS [Various]	28 Sep	11 Oct	13	German	F.	Seaman	RNR	A7835	19	Ross Mem Hosp, Dingwall
Shannon	13 Oct	15 Oct	2	Simpson	G.	Carp. Crew	RN	343478	40	HS Agadir
Defence	5 Nov	8 Nov	3	McWhirter	J.	Armr. Cr. Wireman	RN	M13662	21	HS Agadir
1916										
Malaya	27 Jul	4 Aug	8	Tindale	W.	Stoker	RNR	S7734	18	HS Agadir
Valiant	18 Nov	25 Nov	7	Lewis	W.	Ordinary Seaman	RN	J58860	19	On board
Mercury MS [Ganges]	19 Dec	29 Dec	10	Paul	R.	Deck Hand	RNR	SD1206	19	Shotley Sick Quarters
1917										
Sandhurst	30 Jan	13 Feb	14	Powell	A.	Ordinary Seaman	RN	J61181	27	HS Agadir
Courageous	6 May	24 May	18	Furssedonn	J.J.	Stoker 1st	RN	K26906	20	HS Agadir
Comus	10 Jul	12 Jul	2	Smith	W.E.	Able Seaman	RN	J34123	19	HS Agadir
ML 62 [Granton NB, ML 65]	26 Dec	2 Jan 18	7	Reed	W.H.	Cook	RNR	TC483	42	City Hosp, Edinburgh
1918										
Centaur	21 Jan	29 Jan	8	Redmond	A.J.	Ordinary Seaman	RN	J74706	31	Shotley Sick Quarters
Erin	27 Jan	28 Jan	1	Edwards	W.A.	Private	RMLI	16153	23	HS Garth Castle
ML? [Granton NB, ML 69]	7 Feb	14 Mar	35	Burgess	J.L.	Motor Mechanic	RNVR	MB2278	18	City Hosp, Edinburgh
Scott	1 Mar	3 Mar	2	Channon	J.G.	Able Seaman	RN	J353	26	[RN Hosp] Haslar
Colossus	6 May	8 May	2	Harding	E.A.	Bugler	RMA	15303	15	City Hosp, Edinburgh
Royalist	12 Jul	27 Jul	15	Turnbull	R.	Stoker	RNR	S4425	24	City Hosp, Edinburgh
Phaeton	30 Aug	18 Sep	19	Lee	J.W.	Able Seaman	RNVR	Z4129	22	City Hosp, Edinburgh
Caradoc	14 Oct	16 Oct	2	Hamilton	J.	Stoker 1st	RN	K50250	21	City Hosp, Edinburgh
Ramillies	29 Nov	4 Dec	5	Greenwood	E.R.	Ordinary Seaman	RN	J57143	18	City Hosp, Edinburgh

Table 4A. Fatal cases ascribed to cerebrospinal fever on sea-going ships. Cases listed by Rolleston. See details below.

The Royal Navy and Cerebrospinal Fever during World War One (Wawrzynczak)

<u>Ship (Year)</u>	<u>Illness</u>	<u>Death</u>	<u>Days</u>	<u>Surname</u>	<u>Init.</u>	<u>Rating</u>	<u>Service</u>	<u>Number</u>	<u>Age</u>	<u>Place of Death</u>
1915										
Otranto	n/k	6 Jun		Robathan	A.K.	Greaser	MMR	n/k	23	Rio de Janeiro Isolation Hosp
Indefatigable	n/k	10 Jun		Warren	H.J.P.	Stoker 1st	RN	K14452	22	[South] Queensferry [RN] Hosp
Hyacinth	n/k	15 Jul		McCrystal	H.	Able Seaman	RNVR(SA)	1118/69	n/k	Govt. Hosp, Mombasa
Hearty	n/k	25 Jul		Knight	R.	Seaman	RNR	A2954	27	Chatham [RN] Hosp
1916										
Granton NB, HMT Quickly	n/k	21 Feb		Tracey	R.J.	Deck Hand	RNR	DA2235	50	Leith Public Health Hosp
Nottingham	n/k	6 Mar		Searle	H.A.	Boy Telegraphist	RN	J36358	16	Linlithgow Hosp
Champion	n/k	28 May		Gardiner	N.J.	Stoker 2nd	RN	K26928	19	Linlithgow Fever Hosp
Doris	6 Jun	20 Jun	14	Cheffers	W.J.	Boy 1st	RN	J33857	16	HS St Margaret of Scotland
Royal Arthur, HMT Staunton	n/k	30 Oct		Windeatt	W.	Leading Seaman	RNR	C3154	32	Infectious Hosp, Inverness
1917										
Calgarian	n/k	18 Jan		Bruce	W.	Ordinary Seaman	RNCVR	VR3198	20	At sea
Phaeton	n/k	2 Mar		Hoy	A.	Ordinary Seaman	RN	J38505	18	HS Agadir
Eagle	n/k	28 Apr		Lyons	W.	Donkeyman	MMR	804991	23	Fazakerley Hosp, Liverpool
Orvieto	n/k	29 Apr		Waters	W.D.	Able Seaman	RNVR	Z8138	18	Fazakerley I.D. Hosp, Liverpool
Dalhousie	27 Jun	19 Jul	22	Mahomed	Y.	Seedie	RIM	n/k	25	Base Isolation Hosp, Basra
Antrim	n/k	3 Aug		Mattin	C.W.	Leading Stoker	RN	K15953	23	Nova Scotia Hosp, Halifax
Donegal	15 Nov	27 Nov	12	Carver	D.G.	Ord. Signalman	RN	J54727	18	Northern Hosp, Liverpool
Gloucester	30 Dec	1 Jan 18	2	Haycock	H.	Gunner	RN	n/k	37	International Hosp, Brindisi
1918										
Eagle, [HMT John Cattling]	n/k	14 May		Cooke	C.A.J.	Signalman	RNVR	Z7753	18	Fleetwood Cottage Hosp
Firefly, HMT Loch Houra	n/k	22 May		Campbell	A.	Second Hand	RNR	DA16747	29	Malta [RN] Hosp
Collingwood	16 May	26 May	10	Allen	A.	Stoker 1st	RN	K38316	30	HS Agadir
Monarch	n/k	6 Jul		King	C.	Ordinary Seaman	RN	J58198	29	Bearpark [at home on leave]
Blake, Watchman	n/k	27 Oct		Adair	W.M.	Able Seaman	RN	J47150	22	City Hosp, Edinburgh

Table 4B. Fatal cases ascribed to cerebrospinal fever on sea-going ships. Additional cases in the Register of Deaths. See details below.

The Royal Navy and Cerebrospinal Fever during World War One (Wawrzynczak)

Table 4. Fatal cases ascribed to cerebrospinal fever on sea-going ships. (A) Cases listed by Rolleston. (B) Additional cases in the Register of Deaths.

Ship. Note that some ratings taken ill aboard ship were discharged and are listed in some records by the naval base where they were officially serving at the time of death. A: ship names given by Rolleston, History of the various outbreaks, c1926 (Note 12), with corrected details; record in Admiralty Register of Deaths, 1910-1918 (Note 38), given in brackets if listed under another ship. B: details in brackets from naval Records and Registers of Service (Notes 51 to 56).

Illness. A: date of illness as given by Rolleston. B: date unknown unless relevant MOJ available.

Death. Date of death as listed in the Register of Deaths, usually exactly or closely corroborated by other naval records.

Days. Length of illness calculated as the time in days between dates recorded of sickness and death.

Surname, Initials, Rating, Service & Number. Obtained primarily from naval Records and Registers of Service, where available, or alternatively from the Commonwealth War Graves Commission (Note 57).

Age. Age of death as stated in the Register of Deaths. Should be considered an approximation (plus or minus up to three years) based on comparison with naval service records. Ages shown in italics are not listed in the Register but taken from other records.

Place of Death. As stated in the Register of Deaths, usually corroborated by naval Records and Registers of Service. Details in brackets not given in the Register but taken from other records.

Abbreviations.

HMT - HM Trawler, HS - Hospital Ship, ML - Motor Launch, MMR - Mercantile Marine Reserve, MS - Mine Sweeper, NB - Naval Base, RIM - Royal Indian Marine, RMA - Royal Marine Artillery, RMLI - Royal Marine Light Infantry, RN - Royal Navy, RNCVR - Royal Naval Canadian Volunteer Reserve, RNR - Royal Naval Reserve, RNR(N) - Royal Naval Reserve (Newfoundland), RNVR - Royal Naval Volunteer Reserve, RNVR(SA) - Royal Naval Volunteer Reserve (South Africa).

Some men died only a day or two after taking ill, half within seven days, and only three lasted more than a month. The average was twelve days. Ages ranged from fifteen to 42, the average being 25 years. Most patients were ratings and, though various branches were affected, nine (32%) were able/ordinary/unrated seamen, and seven (25%) were stokers, 1st/2nd class or unrated, and firemen. Eleven men died aboard a naval Hospital Ship (HS), notably eight in HS *Agadir*. Another eleven died at Scottish fever hospitals, including seven at the City Hospital, Edinburgh during 1918. Four died at RN Hospitals or Sick Quarters. Only one man died on his ship.

An additional 22 deaths primarily ascribed to cerebrospinal fever but not counted by Rolleston can be identified from the Register of Deaths (Table 4B). Among these, the first case from the *Otranto* at Rio de Janeiro was mentioned briefly in the *Statistical Report* for 1915, published after the war.⁵⁸ The patients ranged in age from sixteen to 50, the average being 25 years, and mainly comprised seamen and stokers, comparable with Rolleston's list of cases. They were treated at various RN hospitals and hospital ships, local hospitals at Scottish and English ports, and at hospitals around the world. It should be noted that in four cases, pneumonic, septic or tubercular meningitis was also listed as a cause of death.

For most of the cases in Table 4B, the record date of illness and hence its duration is not known, but there is further evidence from surviving MOJs in five instances. The first, a boy in the *Doris*, was diagnosed with enteric fever; he showed no signs of meningitis, but a post-mortem revealed inflamed membranes in the brain and *Diplococcus intracellularis* in large quantities.⁵⁹ The second, a seedie (native Indian recruit) with the Royal Indian Marine Ship *Dalhousie*, had signs of cerebrospinal fever and lumbar puncture yielded a purulent fluid under pressure apparently heavily infected with meningococci.⁶⁰ The reason these patients were not included in Rolleston's list may have been due, at least in part, to his strict criteria for diagnosis.

Rolleston noted that the 6 May 1918 patient on the *Colossus* was the third on this ship, two non-fatal cases having occurred in 1916 and 1917.⁶¹ However, he did not count a further case on the same ship on 3 August 1918.⁶² This patient was a 22-year-old stoker who had been admitted to the City Hospital, Edinburgh where meningitis was suspected.⁶³ Medical Superintendent Claude B Ker had first-hand experience of cerebrospinal meningitis (CSM) from the major outbreak in Edinburgh in 1906-08.⁶⁴ Observing a skin rash that resembled eruptions only seen in 'very toxic' infectious disease, he immediately undertook lumbar puncture but the fluid was 'crystal clear' and microbes could not be observed or grown in culture:

⁵⁸ Admiralty *Statistical Report of the Health of the Navy, for the year 1915*. London: HMSO; 1922. p.67.

⁵⁹ Admiralty. Medical Journals. *Doris*. 1916. Jan-Dec. ADM 101/410, TNA. Case 33.

⁶⁰ Admiralty. Medical Journals. *Dalhousie*. 1917. Jan-Dec. ADM 101/422, TNA. Case 300.

⁶¹ Rolleston. Naval medical history of the war, 1925 (Note 11). p.112.

⁶² Rolleston. History of the various outbreaks, c.1926 (Note 12). p.31.

⁶³ Admiralty. Medical Journals. *Colossus*. 1918. Jun-Dec. ADM 101/450, TNA. Case 46.

⁶⁴ Ker CB. The treatment of cerebro-spinal meningitis with Flexner's serum. *Edinburgh Medical Journal*. 1908; 1: 306-314.

I suppose we must admit the possibility of mild meningococcaemias without definite meningitis, and abortive forms of this infection as of others. Officially, however, it is difficult to take cognizance of them. They cannot be proved and except in an outbreak have little practical interest.

Rolleston wont [sic] accept a case as C.S.M. without meningococci in the fluid. Therein, of course, as I always tell him, he is absolutely wrong. Some are undoubted. But with a clear fluid as in this case they must always be a matter of speculation.⁶⁵

Rolleston's view was that any clinical manifestation was not by itself pathognomonic of meningococcus infection and so bacteriological examination of the cerebrospinal fluid was necessary for a certain diagnosis of meningococcal meningitis:

No doubt genuine cases of cerebrospinal fever may be ruled out by failure of bacteriological methods. But this error is probably much less than that which would result from the inclusion of cases diagnosed on clinical grounds, and in the latter event it would be difficult to know where to draw the line.⁶⁶

In addition, it may have proved impossible to obtain satisfactory reports on patients admitted to far-flung hospitals, for example the third case from the *Gloucester* who died at Brindisi.⁶⁷ This may also have been true for hospitals outside direct naval supervision: the fourth patient, from the *Donegal*, was diagnosed at the Liverpool Northern Hospital, although the ship's Staff Surgeon thought the diagnosis dubious and was convinced the correct diagnosis was tubercular meningitis.⁶⁸ Finally, the *Collingwood* case had been discharged to HS *Garth Castle*, where he was diagnosed with CSM before transfer to HS *Agadir*.⁶⁹ It is not clear, however, why this patient failed to meet Rolleston's strict diagnostic definition.

Taking all 50 fatal cases identified by this study, those most heavily affected were seamen (able, ordinary and unrated), 16 (32%); and stokers (stokers, 1st/2nd class or unrated, and firemen), 10 (20%). For comparison, Table 5 shows that the average complements of several classes of fighting ships in 1910 comprised 26% seamen and 21% stokers.⁷⁰ In June 1919, among all active service ratings, 35% were seamen and 23% stokers, including all ratings in each branch.⁷¹ Therefore, the number of fatalities among seamen and stokers was in each case roughly in keeping with their relative

⁶⁵ Letter from CB Ker to Dr Woollcombe, 9 August 1918. Admiralty. Medical Journals. *Colossus*. 1918. (Note 63).

⁶⁶ Rolleston. Lumleian lectures on cerebro-spinal fever, 1919 (Note 9). p.601-602.

⁶⁷ Admiralty. Medical Journals. *Gloucester*. 1918. Jan-Jun. ADM 101/457, TNA. Alphabetical Sick List.

⁶⁸ Admiralty. Medical Journals. *Donegal*. 1917. Jun-Dec. ADM 101/424, TNA. Case 17.

⁶⁹ Admiralty. Medical Journals. *Collingwood*. 1918. May-Dec. ADM 101/450. TNA. Case 8.

⁷⁰ Admiralty: Record Office: Cases. Ships Complements – Rules for assessing. 1905-1910. ADM 116/1014, TNA.

⁷¹ Admiralty: Record Office: Cases. Welfare Committee – Lower Deck representation. 1919-1922. ADM 116/1893, TNA.

proportion in the service, while other branches that made up less than 5% of the total strength contributed one or two fatal cases at most.

Ship	Complement (No)	Seamen		Stokers	
		Able & Ordinary (No)	(%)	1 st and 2 nd Class (No)	(%)
Drake	826	207	25.1	187	22.6
Duncan	718	201	28.0	125	17.4
Formidable	707	204	28.9	113	16.0
Indomitable	779	164	21.1	211	27.1
Powerful	799	218	27.3	167	20.9
Warrior	710	174	24.5	157	22.1
Total	4,539	1,168	25.7	960	21.2

Table 5. Complements of RN ships in 1910. Compiled from Admiralty: Ships Complements – Rules for assessing, 1905-1910 (Note 70).

Cerebrospinal fever in the Grand Fleet

The consequences of a case of cerebrospinal fever on board ship are illustrated in the 1915 MOJ of Fleet Surgeon C Marsh Beadnell, Senior MO, HMS *Shannon*, flagship of the Second Cruiser Squadron. He described the case of George Simpson, aged 40, Carpenter's Crew, who was suffering from cachexia and was due treatment to prepare him for artificial dentures on 13 October. That morning, Simpson suffered general malaise, headache, and aches and pains all over, and was discharged to HS *Drina*. On 14 October, he was transferred to HS *Agadir*, which had been specially designed for isolating cases of infectious disease. He died the very next day of cerebrospinal fever.⁷²

Delay communicating the infectious nature of Simpson's illness resulted in a flurry of signals between the Senior MOs of the *Shannon*, *Agadir* and *Iron Duke*, Admiral Jellicoe's flagship, and prompted the MDG to request further information about the case and the consequent actions. Beadnell detailed the steps taken to prevent spread of the disease (Table 6). The isolation of immediate contacts, repeated monitoring and swabbing, and disinfection measures reflected the Admiralty Order of June 1915 and other advice given to MOs.⁷³ It was hard to account for the source of the infection: the deceased had been on ship since spring, there had been no previous cases, and he had not been near any depots where cases had occurred, although he had spent some days on leave in Port Glasgow during September.

⁷² Admiralty. Medical Journals. *Shannon*. 1915. Jan-Dec. ADM 101/374, TNA. Case 95.

⁷³ Colborne WJ. Hints for medical officers of the Royal Navy. Part II. Infectious disease. *Journal of the Royal Naval Medical Service*. 1916; 2: 353-366.

1. Part of ship where this man worked and slept hermetically sealed up and exposed to formalin vapour. Sick bay, ditto, but exposed to fumes of SO₂. Time of exposure to disinfectant, 4 hours.
2. In addition to this, the sick bay, parts of ship where he slept, worked and messed, were scrubbed out, and swabbed out overhead with disinfectant fluid.
3. Hammocks, bedding and kit of all those men who messed, slept, or worked in proximity to deceased, exposed for 4 hours to formalin. The hammocks, bedding and kit of those who were in actual contiguity were sent to hospital ship to be passed through steam disinfectant.
4. All night-clothing of the whole ship's company, as well as all the hammocks and bedding, exposed to fresh air and sunlight. This was also carried out for some of the officers and for all the medical officers.
5. All feeding implements of carpenters' messes disinfected.
6. Fans to parts of ship where he worked kept running extra hours. All scuttles and hatches throughout the ship kept open all day and a considerable portion of latter (light protected) during night.
7. Four immediate contacts isolated in "Agadir". All Carpenter ratings who messed, slept, or worked near deceased mustered for medical inspection twice daily.
8. The bilges have been pumped out and flushed with disinfectant fluid. The latrines and W.C.'s forward also flushed with this fluid.
9. All sick berth staff have had a disinfectant bath.
10. Throats of contacts swabbed daily with disinfectant solution.

Table 6. Actions taken on HMS *Shannon* after a case of cerebrospinal fever in 1915. Extracted from Admiralty, Medical Journals, *Shannon*, 1915 (Note 72).

Similar cases involving immediate discharge of patients to the nearest hospital, quarantine of close contacts, examination of other possible contacts, throat gargles and disinfection were reported by ship's surgeons later in the war.⁷⁴ How a man contracted the disease was often a matter of supposition. In one example, a former carrier on board who had tested negative multiple times was sent to HS *Agadir* for re-examination and proved to be positive.⁷⁵ Both officers and men suspected of having been in contact with cases of cerebrospinal fever either before joining a ship or while on leave were dispatched to hospital.^{76 77 78}

⁷⁴ Admiralty. Medical Journals. *Colossus*. 1918. (Note 63). General Remarks.

⁷⁵ Admiralty. Medical Journals. *Centaur*. 1918. Jan-Dec. ADM 101/449, TNA. Case 4.

⁷⁶ Admiralty. Medical Journals. *Shannon*. 1916. Jan-Dec. ADM 101/395, TNA. Case 88.

⁷⁷ Admiralty. Medical Journals. *Erin*. 1917. Feb-Dec. ADM 101/426, TNA. Case 29.

⁷⁸ Admiralty. Medical Journals. *Emperor of India*. 1918. Jan-Nov. ADM 101/455, TNA. Case 119.

The Grand Fleet's remote northern base at Scapa Flow in Orkney, which lacked the shore facilities available at Cromarty Firth or the Firth of Forth, required the permanent presence of naval hospital ships, working in concert. For example, a rating from the *Collingwood* placed on the sick list on 30 May 1918 for a head injury sustained after falling from a ladder was sent to HS *Garth Castle* three days later. Diagnosed with cerebrospinal fever the same day, he was transferred immediately to HS *Agadir*. He was discharged from *Agadir* to HS *Classic* on 20 July, remaining there until three negative swabs had been obtained, whereupon he was sent to HS *China* to complete his recovery.⁷⁹

Several ratings on ships of the Grand Fleet died on board different naval hospital ships, including *China*, *Garth Castle*, *Plassy* and, most often, *Agadir* (Tables 4A and 4B). Over 20 months or so to the end of 1916, *Agadir* took 570 cases from 110 ships and two shore batteries, the bulk for rubella and mumps, with smaller numbers of measles, scarlet fever, erysipelas, diphtheria, enteric fever and varicella. Nine cases of cerebrospinal fever came from different ships. Five of 54 contacts were positive for meningococcus. Sick berth ratings on board were tested 34 times, and 28 non-contact ratings from other ships were tested too, all proving negative.⁸⁰

Serum treatment of cerebrospinal fever

At the outbreak of war, the RN Medical School, which had been established within RN College, Greenwich in 1912, redirected its laboratory efforts to making vaccines and became the central distribution centre of antitoxins and sera for naval use.⁸¹ The Navy then procured 'anti-meningitic serum' from multiple sources, including US producers Parke Davis and Mulford & Co, as well as Burroughs Wellcome and the Lister Institute of Preventive Medicine in London.⁸² ⁸³ The Pasteur Institute in Paris also sent a consignment of serum, but the major part used was a gift from the Rockefeller Institute for Medical Research, New York.⁸⁴

The treatment, which had been developed at the Rockefeller Institute by Simon Flexner and his collaborators, involved lumbar puncture, drainage of infected cerebrospinal fluid and the intrathecal injection of anti-meningococcus serum. The best results were obtained with treatment begun immediately after diagnosis and repeated daily, regardless of symptomatic improvement.⁸⁵ During the first year of the war,

⁷⁹ Admiralty. Medical Journals. *Colossus*. 1918. (Note 63). Case 7.

⁸⁰ Warren L. Observations on infectious cases treated in R.N. Hospital Ship "Agadir". *Journal of the Royal Naval Medical Service*. 1917; 3: 221-225.

⁸¹ Dickinson HW. *Wisdom and War: the Royal Naval College Greenwich 1873-1998*. Fareham: Ashgate; 2012. p.117-118.

⁸² Royal Naval College, Greenwich. Accounts. Abstracts of receipts and payments, 1912-1916. RNCG/4/52, National Maritime Museum (NMM), Greenwich, London.

⁸³ Royal Naval College, Greenwich. Accounts. Abstracts of receipts and payments, 1916-1920. RNCG/4/53, NMM.

⁸⁴ Bassett-Smith. Naval medical history of the war, 1921 (Note 42). p.50-52.

⁸⁵ Flexner S. The results of the serum treatment in thirteen hundred cases of epidemic meningitis. *Journal of Experimental Medicine*. 1913; 17: 553-576.

however, serum therapy gave poor results, casting doubt on the value of the sera available and driving naval physicians to try various unproven forms and combinations of treatment. Lumbar puncture to draw off cerebrospinal fluid under pressure was relied upon more than any other form of treatment, although it was considered palliative rather than curative.⁸⁶

In 1915 the Rockefeller Institute responded to calls for supplies of anti-meningococcus serum from England and her allies by resuming preparation of the serum, which it stopped making before the war when the responsibility was handed over to commercial producers and health authorities.⁸⁷ ⁸⁸ Supported by the Rockefeller Foundation, Flexner's laboratory developed a rapid method for making the specific serum.⁸⁹ The total number of phials of this type of serum distributed from the RN College was 5,166.⁹⁰ During 1918 alone, the Rockefeller Institute sent 32 litres of serum, equivalent to 1,600 phials of 20 cc.⁹¹



Figure 3. Staff Surgeon Geoffrey P Adshead, RN (1883-1940). From photograph of Medical Staff, RN Hospital, Haslar, August 1917. Image from the Historic Collections of the Institute of Naval Medicine, by kind permission of the Commanding Officer.

⁸⁶ Rolleston. Report on cerebro-spinal fever, 1915 (Note 4). p.403.

⁸⁷ Rockefeller Foundation. *Annual Report 1916*, New York: Rockefeller Foundation. p.333.

⁸⁸ Rockefeller Foundation. *Annual Report 1917*, New York: Rockefeller Foundation. p.269-270.

⁸⁹ Corner GW. *A History of the Rockefeller Institute, 1901-1953, Origins and Growth*. New York: Rockefeller Institute Press; 1964. p.140.

⁹⁰ Bassett-Smith. Naval medical history of the war, 1921 (Note 42). p.51.

⁹¹ Rockefeller Foundation. *Annual Report 1918*, New York: Rockefeller Foundation. p.275-276.

At the RN Hospital, Haslar from January to May 1915, 31 patients – mostly men under the age of 20 – were treated. Diagnosis made provisionally upon clinical examination was confirmed by lumbar puncture and microscopical examination. Routine treatment included repeated lumbar puncture, once a day, during the first four or five days. Up to 30 cc of serum typically was injected intrathecally each day over the first three to four days, then less frequently according to symptoms. Of the first twelve patients treated with serum, eight died. In most treated cases, improvement in symptoms was only temporary, underlining the poor outcomes at the time.⁹²

The most extensive report of cases – from naval and marine establishments and ships in the Portsmouth Command – came from Staff Surgeon (later Surgeon Captain) Geoffrey P Adshead, RN Hospital, Haslar (Figure 3).⁹³ He treated 22 patients between October 1915 and June 1916 with various sera. The ‘Flexner serum’, usually a single dose of 20 cc, was used for the first time in March 1916. A further 49 patients were treated by serum therapy, mostly with Flexner serum, between October 1916 and June 1917. By the end of this series, three or four doses of 20 cc serum on consecutive days was the preferred protocol. Patients receiving such ‘semi-intensified’ treatment experienced rapid convalescence, free from the usual complications of the disease. Of the total of 71 patients, nineteen (27%) died, five (7%) were invalided, and 47 (66%) returned to full duty in HM Fleet.⁹⁴

The practice of serum therapy at RN Hospital, Chatham tended to be more intensive: lumbar puncture and injection of 30-50 cc of serum, repeated in 24 hours or less if the case was a bad one, continued every day as long as the patient had symptoms, typically for at least six days. One patient who recovered had three punctures and three injections of serum within the first 24 hours. Occasionally, a patient recovered dramatically after only one or two doses of serum. Of twelve patients treated with serum between September 1915 and April 1916, eight recovered and four died.⁹⁵ In the final months of the war, two patients received large amounts – 420 cc and 550 cc in total – of Flexner serum intrathecally and survived.⁹⁶

In contrast, during the second year of the war ‘very little serum was given’ at the Croydon Fever Hospital.⁹⁷ In the third year, all patients were treated instead by lumbar puncture, given either soamin (sodium para-aminophenylarsonate) intramuscularly or large doses of quinine by mouth, or the two combined, and some also received a stock vaccine.⁹⁸ At the end of 1918, Flexner serum was used at Croydon but in ‘rather small amounts’ of no more than 60 cc.⁹⁹

⁹² Robson BS, Gould ALP. Epidemic cerebro-spinal meningitis: a report on thirty-one cases. *Journal of the Royal Naval Medical Service*. 1915; 1: 255-269.

⁹³ Anon. Obituary. *Journal of the Royal Naval Medical Service*. 1940; 26: 195-196.

⁹⁴ Adshead GP. The treatment of cerebro-spinal meningitis by anti-meningococcus serum at the Royal Naval Hospital, Haslar, 1915-16-17. In: *National Health Insurance. Medical Research Committee. Special Report Series. No. 17*. London: HMSO; 1917. p.89-154.

⁹⁵ Cheyne WHW. Notes on the treatment of cerebrospinal fever. *Journal of the Royal Naval Medical Service*. 1916; 2: 325-328.

⁹⁶ Rolleston. History of the various outbreaks, c1926 (Note 12). p.31.

⁹⁷ Rolleston. Naval medical history of the war, 1925 (Note 11). p.132.

⁹⁸ Rolleston. Cases of cerebro-spinal fever, 1918 (Note 6). p.38.

⁹⁹ Rolleston. History of the various outbreaks, c1926 (Note 12). p.31.

There were other differences in treatment between centres: at Chatham, more than one brand of serum was intentionally used to begin with but Flexner serum used exclusively later; at Plymouth, multiple sera were used throughout the war and some patients also received serum hypodermically; at Shotley, the spinal canal was washed out with 0.5 per cent carbolic acid in saline before giving serum.¹⁰⁰

Period	<u>Serum-treated</u>			<u>No serum</u>		
	Cases	Deaths	%	Cases	Deaths	%
1 Aug 14-31 Jul 15	109	65	60	54	24	44
1 Aug 15-31 Jul 16	95	30	32	9	7	78
1 Aug 16-31 Jul 17	117	38	33	26	14	54
1 Aug 17-31 Jul 18	81	27	33	11	7	64
1 Aug 18-31 Dec 18	44	8	18	2	2	100
1 Aug 15-31 Dec 18	337	103	31	48	30	63
1 Aug 14-31 Dec 18	446	168	38	102	54	53

Table 7. Mortality of cerebrospinal fever cases treated with anti-meningococcal serum. Data adapted from Rolleston, Naval medical history of the war, 1925 (Note 11).

Rolleston summarised the overall results of serum therapy based on 548 evaluable cases that were bacteriologically proven (Table 7). In the first year, 67% received serum but mortality was high and certainly no better than that of patients not given serum. During the remainder of the war, 88% of patients received serum and the mortality rate was halved from about 60% to 30%. It should be noted that the cohort of patients not treated with serum included some with fulminating disease who died before it was possible to administer the agent.¹⁰¹ Some early reports of treatment success involved patients who failed to show meningococci in the cerebrospinal fluid and would not have been counted by Rolleston.¹⁰²

Serum treatment of individual cases

Detailed information about the serum treatment of specific cases was rarely included in published reports. Table 8 shows an illustrative case of a man 'H.C.', aged eighteen,

¹⁰⁰ Rolleston. Naval medical history of the war, 1925 (Note 11). p.130-134.

¹⁰¹ Rolleston. Naval medical history of the war, 1925 (Note 11). p.129-130.

¹⁰² Halahan TD. Notes on an outbreak of cerebrospinal meningitis. *Lancet*. 1916; 2(4870): 1102-1103.

successfully treated at Chatham in 1916. He was admitted on 13 March with headache and had been vomiting. He looked extremely ill, temperature 104.6° F, pulse 128, and was just conscious. He had a small purpuric rash over flanks and lower abdomen, marked Kernig's Sign, knee-jerks and abdominal reflexes present. He underwent lumbar puncture and was given 20-40 cc injections of serum on each of five successive days. Thereafter he made an uninterrupted recovery, except for a serum rash ten days after admission, and was allowed out of bed after three weeks.¹⁰³

- Day 1. Lumbar puncture (L.P.) Fluid turbid and yellow, 25 c.c. *Burroughs Wellcome's serum*. He became delirious and noisy during the night, but in the morning was conscious with severe headache; he also had marked head retraction and tendency to opisthotonos.
- Day 2. L.P. 25 c.c. *Burroughs Wellcome's serum*. The fluid was rather thicker than the first; both contained numerous pus cells and many meningococci which grew in pure culture.
- Day 3. L.P. 40 c.c. *Flexner*; fluid improved in naked-eye appearance; it still contained many meningococci, but these were degenerated and stained badly; his general condition was a good deal better and his temperature was coming down.
- Day 4. L.P. 40 c.c. *Flexner*.
- Day 5. L.P. 20 c.c. *Flexner*.
- Day 6. L.P. Fluid under very slight pressure and quite clear. No serum given. General condition satisfactory, normal temperature, no pain, taking food well.

Table 8. Case successfully treated with serum at RN Hospital, Chatham. Taken from the report by Cheyne, Notes on the treatment of cerebrospinal fever, 1916 (Note 95).

In the case of sea-going ships, standard practice was to remove men straight to hospital, so their treatment was rarely mentioned in the ship's MOJ. One exception was the case of the seedie from the *Dalhousie* who succumbed to his illness. Recorded in the MOJ as Mahomed Yahia he is remembered with honour at the Bombay 1914-1918 Memorial, Mumbai.¹⁰⁴

Added to the sick list on 27 June 1917, the patient complained of pain in the back and headache and had vomited several times during the previous twelve hours but did not exhibit rigidity of neck or abdomen. Discharged to No 8 Indian General Hospital, Tanooma for observation he entered the Base Isolation Hospital, Basra on the 29 June. By this stage, the patient was restless, had fever, his head was much retracted, neck muscles stiffened and painful, and Kernig's Sign well marked, indicating a severe case,

¹⁰³ Cheyne. Notes on the treatment of cerebrospinal fever 1916 (Note 95). p.327-328.

¹⁰⁴ Yahya Muhammad, Commonwealth War Graves Commission (see Note 57); alternative name spellings in various records include Jahia, Yeheyah and Yoheyah.

confirmed by lumbar puncture. Over the next two weeks, lumbar puncture was repeated eight times; only then did he receive 20 cc serum, and then 25 cc on each of two further occasions (Table 9). He also received stimulation in the form of brandy, strychnine and digitalin, and symptomatic therapy all to no avail as his condition worsened and he died three weeks after treatment began.¹⁰⁵

The delayed use of serum appears out of step with naval practice but, as a native rating, the case likely came under the care of the Indian Medical Service.

- Day 1. Lumbar puncture (L.P.) gave 25 cc of purulent fluid under pressure containing Gram negative meningococci – a heavy infection.
- Day 3. L.P. gave 45 cc of slightly turbid fluid under pressure.
- Day 5. L.P. gave 25 cc of clear fluid.
- Day 7. L.P. gave 31 cc of turbid fluid under pressure.
- Day 9. L.P. gave 35 cc of slightly turbid fluid under pressure.
- Day 11. L.P. gave 25 cc of almost clear fluid under pressure.
- Day 12. L.P. gave 42 cc of slightly turbid fluid.
- Day 13. L.P. gave 50 cc of turbid fluid under pressure.
- Day 14. L.P. gave 45 cc of almost clear fluid under pressure containing numerous meningococci. *20 cc of Anti meningococci serum given intrathecally.*
- Day 15. L.P. gave 35 cc of turbid fluid under pressure. Head retraction much more marked.
- Day 17. L.P. gave 65 cc of slightly turbid yellow fluid. *25 cc of anti-meningococci serum given intrathecally.*
- Day 18. Patient suffering from obstinate constipation.
- Day 19. Nystagmus present and eyes turned upwards. Head retraction much less. Patient drowsy, but tries to answer when spoken to. L.P. gave 65 cc of yellow fluid under pressure. *25 cc of Anti-meningococci serum given intrathecally.*
- Day 20. Vomiting. Pulse weak and rapid.
- Day 21. Condition much worse. Pulse failing. No head retraction, nystagmus more marked. Unable to answer questions. L.P. gave 30 cc of yellow turbid fluid. 10.30 p.m. Patient died.

Table 9. Case treated unsuccessfully at Base Isolation Hospital, Basra. Adapted from Admiralty, Medical Journals, *Dalhousie*, 1917 (Note 60).

Patients also received serum therapy on HS *Agadir* (Table 10). The fatal cases listed can be identified by reference to Table 4A. The first man known to have died on *Agadir*

¹⁰⁵ Admiralty. Medical Journals. *Dalhousie*. 1917. (Note 60).

was a patient from *St Vincent* treated with Parke Davis serum. The third fatal case – ‘under treatment for cachexia from defective teeth’ – is unmistakably George Simpson from *Shannon*, which means the second came from *Campania*. The fourth fatal case, from *Defence*, received serum of unspecified origin. The fifth fatality, probably from *Malaya*, received only Flexner serum. Only one of the four patients given serum therapy survived.¹⁰⁶

Case	Admitted	Serum treatment	Result	Ship	Report	Death
1	3rd day	Parke Davis	Died 6th week	<i>St Vincent</i>	09 May 15	21 Jun 15
2	5th day	Nil	Died	<i>Campania</i>	06 Aug 15	22 Aug 15
3	2nd day	Nil	Died	<i>Shannon</i>	13 Oct 15	15 Oct 15
4	3rd day	Serum	Died	<i>Defence</i>	05 Nov 15	08 Nov 15
5	2nd day	Parke Davis/Flexner	Recovered	<i>Conqueror</i>	05 May 16	n/a
6	2nd day	Nil	Recovered	<i>Royal Oak</i>	23 May 16	n/a
7	4th day	Flexner	Died	<i>Malaya</i>	27 Jul 16	04 Aug 16
8	2nd day	Nil	Recovered	<i>Temeraire?</i>	10 Sep 16	n/a
				<i>Gibraltar?</i>	31 Oct 16	n/a
				<i>Colossus?</i>	28 Nov 16	n/a

Table 10. Cases treated on HS *Agadir*. Based on Rolleston, Naval medical history of the war, 1925 (Note 11); Warren, Observations on infectious cases, 1917 (Note 80).

Naval ships other than hospital ships such as *Agadir* probably did not carry anti-meningococcus serum routinely. However, following the suspected case in November 1917 aboard the *Donegal* while at Liverpool, and in readiness for the possibility that further cases might occur once the ship had put out to sea, the ship’s Staff Surgeon procured a supply of the serum, though lacking time to get it from Plymouth or Greenwich he bought it locally.¹⁰⁷

Conclusion

Naval surgeons appear to have had experience of cerebrospinal fever from the mid-1860s, although it seems likely cases of the disease occurred earlier but were not identified or reported as such. In the following half-century or so, cerebrospinal fever was no stranger to the Navy. Single cases were reported sporadically and there were occasional outbreaks involving several individuals attached to one ship.

At the turn of the century, cerebrospinal fever commonly, though not exclusively, struck boys or youths in training establishments. They usually fell ill suddenly, displayed rashes and neurological disorders, and often died quickly. It was hard to ascribe a definitive cause, make connections between cases, or provide an effective

¹⁰⁶ Warren. Observations on infectious cases, 1917 (Note 80). p.225.

¹⁰⁷ Admiralty. Medical Journals. *Donegal*. 1917. (Note 68).

remedy. Although the bacterial cause of the disease had been established in the late nineteenth century, the risk of infection from patients was low, leaving open the question of how the disease spread during outbreaks.

It is notable that a significant number of cases had occurred in 1913/14, both in training establishments and aboard sea-going ships of the Home Fleet, indicating that cerebrospinal fever had also been endemic in the Navy, as it was in the general population, before the war. By contrast, there had been very few cases reported in the Army before mobilisation.¹⁰⁸ The rapid removal of a naval patient diagnosed with the disease to a suitable hospital, performance of lumbar puncture for the purpose of bacteriological examination, and consequent treatment by anti-meningococcus serum, seems to have been established practice by this time.

Before the war, *Impregnable* was a training establishment, consisting of three old wooden battleships that housed 1,500 recruits. Boys entered at around the age of fifteen, spent nine months in training, and were then drafted to sea-going ships. Hammocks were slung at short distance from the deck above so that exhaled air floated in a layer level with the heads of the sleepers. After the war, Surgeon-Commander Sheldon F Dudley, Professor of Hygiene at the RN Medical College, took a dim view:

It seems scarcely possible to design a more favourable environment than these sleeping arrangements for the dissemination of microbic parasites and the production of high velocities of infection.

During the war, illness due to cerebrospinal fever on *Impregnable* was 53 per 10,000 per annum, six times greater than at RN Barracks, Portsmouth and more than 40 times higher than on sea-going ships. The establishment was subject to high overcrowding and fast turnover, both factors that promoted the continuous import and spread of infection and prevented a lasting rise in herd immunity.¹⁰⁹ By contrast, provided they had undergone a preliminary 'seasoning' in training ships ashore, seamen on sea-going ships were practically immune to the disease despite inhabiting a potentially ideal environment for its spread.¹¹⁰

The increased incidence and high mortality of patients occurring at the large naval shore establishments in 1915 prompted the Admiralty to control the spread of infection through screening and quarantine. It is difficult to evaluate how effective these measures were. The peak of civil cases occurred in 1915, with roughly half as many cases in 1916 and 1917, and a third as many in 1918.¹¹¹ Naval incidence of disease tracked a similar

¹⁰⁸ Wawrzynczak EJ. Treatment of military cases of cerebrospinal fever during WWI; the concerted efforts of the RAMC, MRC and Lister Institute to make serum therapy work. *BMJ Military Health* 2020; 166: 347-351.

¹⁰⁹ Dudley SF. The spread of droplet infection in semi-isolated communities. In: *Medical Research Committee. Special Report Series. No. 111*. London: HMSO; 1926.

¹¹⁰ Dudley SF. Some lessons of the distribution of infectious diseases in the Royal Navy. *Lancet*. 1931; 1(5610): 509-517.

¹¹¹ Reece RJ. Cerebro-Spinal Fever. In: *Forty-Eighth Annual Report of the Local Government Board 1918-1919. Supplement containing the Report of the Medical Department for 1918-1919*. London: HMSO; 1919. p.38-61.

pattern but was proportionately higher in 1916.¹¹² However, the average number of men borne in the Navy increased each year from about 191,000 during Aug-Dec 1914 to 360,000 during Jan-Oct 1918.¹¹³

Despite the best efforts of the Admiralty to identify carriers and track their movements it proved impossible to insulate the Navy from the population at large. Rolleston observed that the proximity of Crystal Palace to London likely favoured introduction of the disease from outside.¹¹⁴ He acknowledged that the screening of all recruits, and of drafts to ships, was unlikely to have had much to do with the incidence of cerebrospinal fever in sea-going ships since this was higher after the start of mass screening in early 1916 than prior to what Dudley termed the 'swabbing mania'.¹¹⁵

Medical Officer's Journals of the time show clearly that naval surgeons appreciated a seaman on shore-leave was at risk of encountering a civilian case or carrier. Most considered the civilian population an unfailing source of infection and re-infection.¹¹⁶ Thus, the Admiralty's attempt to control the spread of cerebrospinal fever through its rigorous 'test and trace' regimen and the quarantine of identified cases and contacts was undermined by the unregulated contacts that inevitably occurred in the wider community.

Fatal cases of cerebrospinal fever occurring on sea-going ships affected all types of rating, on various kinds of ship, in British and foreign waters. Seamen and stokers were most often among the fatal cases, in keeping with their numerical preponderance among ratings, suggesting that no occupation was especially susceptible and that catching the disease was largely a matter of chance. The relatively small complement of commissioned officers even on large battleships may explain why no fatal cases were reported during the war. Also, no MOs or sick-berth staff on board sea-going ships were reported to have died of cerebrospinal fever, although a Surgeon Probationer aboard HMS *Lydiard* did catch the disease in 1916.¹¹⁷

Making an exact count of incidence and fatalities was problematic because not all patients initially diagnosed by clinical criteria were necessarily confirmed by bacteriological tests. Later in the war, it was appreciated that meningococcal infection could manifest in a non-meningitic form involving a purpuric rash, suggesting that meningeal infection was preceded by invasion of the blood or septicaemia.¹¹⁸ In such a pre-meningitic phase, the proper course of action was to inject anti-meningococcus

¹¹² Rolleston. *Naval medical history of the war, 1925* (Note 11). p.110.

¹¹³ War Office. *Statistics of the Military Effort of the British Empire during the Great War. 1914-1920*. London: HMSO; 1922. p.339.

¹¹⁴ Rolleston. *History of the various outbreaks, c1926* (Note 12). p.11.

¹¹⁵ Rolleston. *Naval medical history of the war, 1925* (Note 11). p.113; Dudley. *The spread of droplet infection, 1926* (Note 109). p.50.

¹¹⁶ Whiteside HC. *The bacteriology of cerebro-spinal fever. Journal of the Royal Naval Medical Service*. 1921; 7: 53-65.

¹¹⁷ Rolleston. *Naval medical history of the war, 1925* (Note 11). p.114.

¹¹⁸ Given DHC. *Non-meningitic forms of cerebrospinal fever associated with purpura. Journal of the Royal Naval Medical Service*. 1918; 4: 296-305.

serum intravenously.¹¹⁹ However, the preferred treatment for cerebrospinal fever with typical meningitic involvement remained the intrathecal administration of serum:

The factor in serum treatment that is of essential importance in bringing about a rapid and permanent cure is the early and sufficient use of a serum containing the antibodies specific to the type of infecting meningococci so as to abolish the infection, neutralise the toxæmia, and stop the meningitis before adhesions and blocking of the cerebral ventricles are brought about.¹²⁰

The importance of the rapid disposal of suspected cases on ship and shore to the nearest appropriate hospital was repeatedly evident in MOJs both before and during the war. Speedy diagnosis, allowing serum therapy to start early in the course of the disease, favoured a good outcome, whereas unnecessary delay reduced a man's chances of survival. Cases from ships of the Grand Fleet were treated at the nearest Scottish fever hospital where possible. At Scapa Flow, the specialist hospital ship for infectious diseases, *Agadir*, played a crucial role. However, given the frequently rapid progress of the disease, even prompt medical attention could not guarantee a positive outcome.

Serum therapy of cerebrospinal fever was inadequate during 1915 and naval physicians, like their military counterparts, reported poor results. The supply of an apparently effective 'multivalent' serum like Flexner serum – made against multiple isolates of meningococcus to counter the various strains of the coccus circulating in the population – provided the Navy with relative uniformity of product. The Royal Army Medical College at Millbank, responsible for distributing antitoxins and sera for military use, also developed strain-specific 'monovalent' sera that became available towards the end of the war.¹²¹ Some of these sera were used in a small number of naval patients treated at the City Hospital, Edinburgh in 1918.¹²²

The origin of the serum used, and the intensity of treatment, varied between different naval hospitals and at each hospital over time. The War Office issued Memoranda giving military doctors guidance on serum therapy of the disease in which the urgency, frequency and the volume of doses increased over time.¹²³ It is not clear whether the Admiralty's Medical Department issued such clear guidance on treatment or how far naval physicians were influenced by military practice but it appears that larger quantities of serum were used at naval hospitals towards the war's end.

In conclusion, the chances of surviving cerebrospinal fever depended on a combination of factors. First, *when* a man took ill: being treated with serum, receiving an effective product, and in high amount, was more likely later in the war than earlier. Second, *where* he was at the time: the benefit of prompt medical attention was lost if a man fell ill on the high seas or on leave out of sight of his MO. Last, *who* looked after him: the nature of treatment given depended on the practice adopted by doctors at the hospital where the patient was admitted.

¹¹⁹ Findlay GM. Note on a case of meningococcal infection without meningitis. *Journal of the Royal Naval Medical Service*. 1919; 5: 198-200.

¹²⁰ Rolleston. Lumleian lectures on cerebro-spinal fever, 1919 (Note 10). p.645.

¹²¹ Wawrzynczak. Treatment of military cases, 2020 (Note 108). p.347-349.

¹²² Rolleston. Naval medical history of the war, 1925 (Note 11). p.131.

¹²³ Wawrzynczak. Treatment of military cases, 2020 (Note 108). p.349-350.

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