Abstract
Analysis of brucellosis epidemics in ships of the Mediterranean fleet in the nineteenth century are most easily explained by aerosol transmission in grossly overcrowded, hot and humid confined spaces.

Introduction
Brucellosis may well be the disease most easily acquired in the laboratory. Almost all workers with the bacteria have been infected and almost all veterinarians who have had contact with susceptible animals have high titres of antibodies against the bacteria. The members of the Mediterranean Fever Commission (MFC) in Malta all had episodes of ill-health, but whether this was from the bacterial cultures or from goats’ milk is not clear. Captain Hughes was in Malta from 1890 until he was invalided to Britain with brucellosis in 1896. In the preface to his classic book on the disease, he recorded that his wife and two sisters had also contracted the disease(1). He recommended goats’ milk for army hospital patients with brucellosis. Captain Dudley RN commented that in the navy in the 19th C ‘fresh milk was essentially a wardroom luxury; the men did not get milk on board, and probably rarely drank goats’ milk ashore….. officers were more frequently infected with brucella than men.’(2). This was probably the case for army officers too.

In the 1950s Francois Jacob joined the other members of the Institute on the annual pilgrimage to Pasteur’s crypt. Among the ‘Pastorians … was the one to whom all France sent microbes that were hard to characterize, and who made his diagnosis by smell, sniffing at the culture tubes.’(3). When I worked in a hospital laboratory in 1954, staff opened the petri-dishes to sniff cultures grown on the agar, as some bacteria can be recognised by their distinctive odours. The dangers of this practice are now recognised. In 1931 Captain Dudley RN proposed that brucellosis could be transmitted by droplet infection.

Brucellosis in the Mediterranean Fleet
Surgeon Captain Sheldon F Dudley RN, Professor of Pathology at the RN Medical College at Greenwich, gave the 1931 Milroy lectures which were printed in the Lancet. The third lecture was on brucellosis (Undulant fever) in the 19th century, but this paper has probably been overlooked and forgotten. He traced the outbreaks of brucellosis in ships of the Mediterranean fleet in the later half of the 19th century when they had been at sea for many weeks. In 1882 two ship epidemics accounted for 42 % of the fleet cases. One of these ships was HMS Superb which had 136 cases, 77 of whom were invalided home and one died, ‘typical undulant fever figures’. The Medical Officer gave the spatial distribution of the cases: ‘The ratings in the Superb slept on three decks. The flying deck was a kind of huge shelf

<table>
<thead>
<tr>
<th>Deck</th>
<th>Ventilation</th>
<th>No. ratings</th>
<th>% fever</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flying</td>
<td>worst, lowest cubic space per man</td>
<td>140</td>
<td>29</td>
</tr>
<tr>
<td>Lower</td>
<td></td>
<td>196</td>
<td>17</td>
</tr>
<tr>
<td>Battery</td>
<td>better and relatively spacious</td>
<td>250</td>
<td>10</td>
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Table: Fever on HMS Superb.
cutting part of the lower deck horizontally in two.’

Strange Epidemics
His graph of illnesses in the Mediterranean Fleet showed that peaks of fevers frequently coincided with those of rheumatism. For individual ships, there were also ‘strange epidemics’ where there were coincident peaks of rheumatism and pulmonary disease. He noted that ‘The naval commentator of the 1856 report writes that “the prevalence of fever in the [HMS] Hannibal for a period of two years can only be ascribed to the successive transmission of the disease by infection from one set of men to another”.’ Dudley noted that cases before 1897 (when diagnosis of Mediterranean Fever was first used) were often described as ‘phthisis or inflammation of the lungs’. Phthisis was used to describe the progressive wasting disease, especially of pulmonary tuberculosis: since the use of antibiotics it is no longer used.

HMS St. Jean D’Acre and Cressy both suffered ‘the same peculiar disease’. In the former ship, 416 out of 880 men suffered from the pulmonary illness while the latter had 285 cases with 102 ‘were definitely diagnosed “phthisis” and 117 “cachexia pulmonis”’; 112 of these were invalided home but only six died’. ‘The cases from both ships quickly recovered on their return to England – a characteristic of the pulmonary complications of Malta fever seen in more recent times’. HMS London recorded 54 pulmonary cases, 12 of which were “phthisis” : this epidemic was attributed to bad ventilation between decks. Dudley then reprinted the description of the lower deck in her sister ship the St Jean D’Acre:

‘All the ship’s company amounting to about 930 men…slept on this deck. The hammock hooks were placed ordinarily at only 14 inches apart – less than the average breadth of the mens’ shoulders; consequently while in harbour when no watch was required at night and all hands had turned in, they formed a compact mass close beneath the beams, the only air available for respiration being above them, that beneath the hammocks being almost entirely shut out from the space above. All the ports as well as the small round scuttles were kept closed at night.’ Further details followed.

Dudley concluded ‘that it would seem that in this environment Br melitensis had acquired the power of spreading by droplet infection… this unusual form of pneumonic undulant fever became temporarily able to spread by droplet infection in the relatively spacious wards of the Malta Naval hospital [at Bighi]’.

Aerosol From a Monkey
Aerosol infection had been suggested by an incident in Malta during the researches into transmission of the disease by the MFC. Captain Kennedy RAMC noted that ‘One of the monkeys had become very knowing and learnt to shut his nostrils when the dust was being blown in by means of a rubber bag. One day the attendant [RAMC] instead of using the rubber squirt put his mouth to the tube intending to blow it in himself. Unfortunately for him, the monkey blew first! A fortnight to 3 weeks later he was sent to hospital with an attack of fever. Whether the infection was really contracted by him in this way cannot be absolutely decided, but he himself blames the dust’.[4).

Later Career
Sheldon Dudley (1884 – 1956) became Surgeon Vice Admiral, Medical Director-General of the Royal Naval 1941 - 1945. He was made KCB and OBE and was elected Fellow of the Royal Society in 1941(5). He was given many honours both here and abroad and won many prizes for his researches. ‘Dudley’s work at Greenwich can with justice be claimed to have made possible the success of the national campaign for diphtheria immunization’. In his retirement he wrote two books, The four pillars of wisdom and Our national ill-health service.

Discussion
Dudley wrote three special reports for the Medical Research Council including The spread of droplet infection in semi-isolated communities in 1926. His analysis of the droplet infection of brucellosis was therefore
part of a general study. From the naval health reports of the 19th century he concluded that prior to 1856 there had been little or perhaps no brucellosis in the Mediterranean Fleet. The first recognition of the disease was in the ships carrying invalided soldiers from the Crimea to Malta. He explained that the ship epidemics were caused by droplet infection, quoting broncho-pneumonia and signs in the lungs as a common complication of ordinary brucellosis, which simulates phthisis with remarkable accuracy. He quoted that ‘Br. melitensis had been recovered from the sputum of patients resembling clinical phthisis which was seen in an epidemic of undulant fever at Naples’.

Dudley was a notable Professor of Pathology and a perceptive naval surgeon: his analysis of those far off epidemics was far sighted, but unheeded. These and other arguments make his explanation of droplet infection accurate and convincing. Recent epidemics confirm that inhalation brucellosis happens. For instance, airborne transmission of bacteria caused an outbreak of brucellosis among laboratory workers in Spain in 19826(6).

Droplet infection between humans seems very unlikely in ordinary circumstances, but conditions in detention camps and prisons in many countries make it a real risk even in these times.

References
4. Wyatt HV. Dr. James Crawford Kennedy RAMC and the sexual transmission of brucellosis. JRAMC in press.
5. Obituaries of Sheldon Dudley, BMJ 1956; 1; 1113 and 1177.

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