Gastrointestinal infections: The British and U.S. Army experiences in World War I

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• Nothing to disclose
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Objectives

• Describe how previous wars determined prevention efforts
• Understand the differences in the British and American Army medical experiences
• Describe lessons learned from the Gastrointestinal infections of World War I
Pre-WWI medical experiences

• In both the British and U.S. Army, much of the medical risk assessment was shaped by the most recent conflicts

• However, there were significant differences in the British and American pre-WWI medical experiences
British Army

- The British Army serving during the South African War 1899-1902 experienced few enteric infections in Great Britain but significant outbreaks in South Africa
  - Typhoid Fever: 57,684 admissions, 8,022 deaths and 19,454 disabled
  - Dysentery: 38,108 admissions, 1,343 deaths and 5,776 disabled

British Army

- Enteric diseases were associated with deployment to endemic areas and ineffective preventive sanitation efforts
- During the South African War, Typhoid vaccination was voluntarily instituted to British troops deploying outside of Europe

### Union Troops: Civil War

<table>
<thead>
<tr>
<th>Disease</th>
<th>Patient reports</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrheal disease</td>
<td>1,739,135</td>
<td>44,558</td>
</tr>
<tr>
<td>Typhoid fever</td>
<td>79,462</td>
<td>29,336</td>
</tr>
</tbody>
</table>


U.S. Army

• An autopsy documented the ileal perforation due to Typhoid fever


U.S. Army

• “That whole damned war business is about 999 parts diarrhea to one part glory”

Walt Whitman
Nurse, Union hospital
Washington D.C.

Schmidgall G, Selections from Walt Whitman’s conversations with Horace Troubel 1888-1892, U Iowa Press, Iowa City, IA, 2001, p 187

U. S. Army

• Unlike the British Army, during the Spanish American war there were massive Typhoid outbreaks in Army bases within the U.S.

• Between June and November, 1898, 20,738 American soldiers were diagnosed with Typhoid fever and 2,192 died


U.S. Army

• As a result of the American experience prior to deployment, routine preventive and sanitation efforts were not considered adequate

• Compulsory Typhoid vaccination for all U.S. soldiers was instituted in 1911

Typhoid Vaccination

• In Great Britain, there was significant civilian resistance to compulsory vaccination. The opposition argued that compulsory Typhoid vaccination would deter recruiting

• The Medical Times wrote that the “supposed benefit of the anti-typhoid serum was a delusion”

Hardy A, Bull Hist Med 2000;74-265-290

In 1914, Osler of the University of Oxford strongly supported Typhoid vaccination of British troops.

Osler warned that without vaccination, any expeditionary force on the continent had more to “fear from the bacillus of Typhoid fever than bullets or bayonets”.

Osler cautioned soldiers not to be misled by the “misguided cranks who are playing into the enemy’s hands”.

Osler W, Br Med J 1914;2(2805):569-70

Typhoid Vaccination

- The Medical Officer journal stated “we cannot find the words strong enough to describe the opponents of vaccination.” They were described as in the same class as those who would arm soldiers with defective weapons or ammunition.

- In 1914, William Leishman told the Royal Sanitary Institute that to send uninoculated men to the front was “little short of murder.”

The British Army continued voluntary Typhoid vaccination. The British Expeditionary Force arrived in France with only 25-30% immunized against Typhoid.

• Between August and December, 1914 in France and Flanders, 466 British and Dominion soldiers were admitted for Typhoid fever resulting in 57 deaths

• During 1915 this increased to 3,462 admissions and 153 deaths

• By the end of 1915, 90% of British troops were vaccinated
• In 1915, triple vaccines for Typhoid, Paratyphoid A and Paratyphoid B were instituted

MacPherson WG (ed), History of the Great War based on Official Documents, Medical Services, Diseases of the War, Volume 1, HM Stationery Office, London, 1921, p 56
The British experience was superior to the French Army which reported over 100,000 soldiers with Typhoid fever and 14,482 deaths in 1914-1915.

Medical Risk of Deployment

• The medical risk and prevalence of enteric diseases were clearly different between the U.S. and British Army

• From 1914-18, the British Army served throughout the Empire and fought in France, Flanders, Africa, Dardanelles, Palestine, Mesopotamia, Italy, Macedonia, North Russia and Siberia.
Medical Risk of Deployment

- From 1917-18 U.S. Army primarily deployed to Great Britain and France with small contingents assigned to North Russia and Siberia.
British Army and Dominion troops: Dysentery

<table>
<thead>
<tr>
<th></th>
<th>Hospitalizations</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>France and Flanders:</td>
<td>26,432</td>
<td>160</td>
</tr>
<tr>
<td>East and Southwest Africa:</td>
<td>26,956</td>
<td>834</td>
</tr>
<tr>
<td>Dardanelles</td>
<td>29,728</td>
<td>811</td>
</tr>
<tr>
<td>Egypt and Palestine</td>
<td>14,844</td>
<td>484</td>
</tr>
</tbody>
</table>

**British Army and Dominion troops: Dysentery**

<table>
<thead>
<tr>
<th></th>
<th>Hospitalizations</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesopotamia</td>
<td>42,995</td>
<td>622</td>
</tr>
<tr>
<td>Italy</td>
<td>901</td>
<td>17</td>
</tr>
<tr>
<td>Macedonia</td>
<td>24,245</td>
<td>480</td>
</tr>
<tr>
<td>North Russia</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>2,049</td>
<td>5</td>
</tr>
<tr>
<td>All theatres</td>
<td>169,164</td>
<td>3,413</td>
</tr>
</tbody>
</table>

Diarrhea at Gallipoli

• “Some battalions were almost 75% ineffective within weeks of landing
• “Virtually no one escaped some form of enteric infection”
• By September, 1915, 800 evacuations per day for diarrhea and dysentery
• Of 110,000 evacuations due to disease, 40,000 were due to diarrhea and dysentery

Dysentery in Mesopotamia

• Major Carter described barges carrying British and Indian casualties at Basra in 1915
• What he thought were ropes on the side of the barges were “dried stalactites of human fæces”
• The stench was “quite definite”
• He described men huddled in a 30 foot square pool of dysentery and generally “covered from head to foot”


Wilcox R, Battles on the Tigris. The Mesopotamian campaign of the First World War, South Yorkshire, UK, Pen and Sword, 2005, pp 69-70
Dysentery treatment

• Bismuth Carbonate
• Intravenous injection of saline
• Oral rehydration, “albumen water” from egg whites, beef tea, chicken tea
• Emetine - antiprotozoal action

Cowan JM, J R Army Med Corps 1918;31:277-95
Hurst AF, Medical Diseases of the War. London: Edward Arnold 1918, pp159-64
Autopsy images of sigmoid colon and rectal ulceration in patients with Shigella

Manson-Bahr P, The correlation of the Pathology and Bacteriology of Bacillary Dysentery: A dissertation on some of the Laboratory problems arising in connexion with this disease in the Eastern Theatres of War, J Royal Army Med Corps 1919;33:117-139
Dysentery ward, Port Said, Egypt, 1917
Imperial War Museum
Amoebic Dysentery

Hurst AF, Medical Diseases of the War. London: Edward Arnold 1918, p 141
Amoebic Dysentery

Role of Amoebic infection as a cause of Dysentery

• France and Flanders 2.8%
• Dardenelles 10
• Egypt and Palestine 7
• Mesopotamia 20-40

MacPherson WG (ed), History of the Great War based on Official Documents, Medical Services, Diseases of the War, Volume 1, HM Stationery Office, London, 1921, pp 92-94
### British Army and Dominion troops: Enteric Fevers/Typhoid

<table>
<thead>
<tr>
<th>Location</th>
<th>Hospitalizations</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>France and Flanders:</td>
<td>8,317</td>
<td>286</td>
</tr>
<tr>
<td>East and Southwest Africa:</td>
<td>565</td>
<td>26</td>
</tr>
<tr>
<td>Dardanelles</td>
<td>9,423</td>
<td>330</td>
</tr>
<tr>
<td>Egypt and Palestine</td>
<td>4,118</td>
<td>148</td>
</tr>
</tbody>
</table>

British Army and Dominion troops: Enteric Fevers/Typhoid

<table>
<thead>
<tr>
<th></th>
<th>Hospitalizations</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesopotamia</td>
<td>5,862</td>
<td>305*</td>
</tr>
<tr>
<td>Italy</td>
<td>142</td>
<td>14</td>
</tr>
<tr>
<td>Macedonia</td>
<td>1,939</td>
<td>60</td>
</tr>
<tr>
<td>North Russia</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>208</td>
<td>26</td>
</tr>
<tr>
<td>All theatres</td>
<td>30,598</td>
<td>1,095</td>
</tr>
</tbody>
</table>

Typhoid Ward, Lamark Hospital, Calais, France

Imperial War Museum
Royal Army Medical Corps,
Salonika, Macedonia
United States Army
342nd Infantry Regiment marching to the docks in Southampton
U.S. Army parasitic infections

- 126,140 soldiers were examined for hookworm
- 19,640 (15.5%) were positive
- Highest rates of infection among Southern soldiers

### U.S. Army

<table>
<thead>
<tr>
<th>State</th>
<th>Examined</th>
<th>Hookworm Ova present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Georgia</td>
<td>3,872</td>
<td>32.6%</td>
</tr>
<tr>
<td>Florida</td>
<td>3,778</td>
<td>31.8</td>
</tr>
<tr>
<td>Alabama</td>
<td>2,223</td>
<td>29.4</td>
</tr>
<tr>
<td>Louisiana</td>
<td>7,348</td>
<td>27.3</td>
</tr>
<tr>
<td>Mississippi</td>
<td>8,684</td>
<td>27.1</td>
</tr>
<tr>
<td>Kentucky</td>
<td>2,301</td>
<td>16.3</td>
</tr>
<tr>
<td>Tennessee</td>
<td>9,722</td>
<td>12.6</td>
</tr>
</tbody>
</table>

U.S. Army Total: 1917-1919

<table>
<thead>
<tr>
<th>Hospitalizations</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrheal disease</td>
<td>92,512</td>
</tr>
<tr>
<td>Typhoid fever</td>
<td>1,529</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Disease</th>
<th>Hospitalizations</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrheal disease</td>
<td>48,202</td>
<td>208</td>
</tr>
<tr>
<td>Typhoid fever</td>
<td>885</td>
<td>148</td>
</tr>
</tbody>
</table>


U.S. Army Disability discharges 1917-1919

- Typhoid Fever 24
- Diarrheal Diseases 198


• Both the British and U.S. Armies had significant reduction in deaths from enteric infections in World War I compared to previous conflicts
How are we still learning from World War I?

• Genetic analysis of bacteria from the Western Front
• Chronic complications of Enteric infections
• Post-infectious Irritable Bowel Syndrome
• Reactive arthritis
• Ophthalmological complications
UK National Collection of Type Cultures (NCTC) 1.

• Private Ernest Cable
• 2nd Battalion, East Surrey Regiment
• Age 28
• Hospitalized for dysentery at the Number 14 Stationary Hospital in Wimereux, France
• A culture was obtained which was called the Cable strain
• Died on 13 March 1915

Mather AE, Lancet 2014;384:1720
No 14 Stationary Hospital, Wimereux, France
Wilmereux Cemetery
9108 PRIVATE
E. CABLE
EAST SURREY REGIMENT
15TH MARCH 1915

[Image of East Surrey Regiment crest]
Private Ernest Cable, vial and memorial plaque
This specimen was subcultured from a stock culture on Dorset egg medium.

The culture was freeze dried since 1951. As part of the research, the bacterium was grown on a 5% blood agar at 37°C.

The bacterium was Shigella flexneri serotype 2a.

Mather AE, Lancet 2014;384:1720
Baker KS, Lancet 2014;384:1691-7
UK National Collection of Type Cultures (NCTC) 1.

- Despite being isolated prior to the discovery of antibiotics, the bacterium was resistant to Penicillin and Erythromycin.
- The bacteria contained antimicrobial resistance genes.
- A century after the war, such specimens continue to provide medical insight into the enteric infections of the Western Front.

Baker KS, Lancet 2014;384:1691-7
Post-infectious Irritable Bowel Syndrome

- After resolution of the acute infection, Hurst described alternating diarrhea and constipation
- He described bloating, mucus discharge and dyspepsia
- Absence of Amoebic infection or Paratyphoid bacteria
- “Post-dysenteric diarrhœa”
- May last months to years after initial infection

Hurst AF, Medical Diseases of the War. London: Edward Arnold 1918, pp 167-170
Post-infectious Irritable Bowel Syndrome

• 63% of troops deployed to Afghanistan or Iraq reported at least one episode of diarrhea in 2004
• Irritable Bowel Syndrome has been described after military deployments
• Incidence of Post-infectious Irritable Bowel Syndrome estimated to be 5.4-10%

Brown JA, Travel Med Infect Dis 2009;7:337-43
Scwille-Kiuntke J, Aliment Pharmacol Ther 2015;41:1029-37
Trivedi KH, Dig Dis Sci 2011;56:3602-9
Thabane M, Aliment Pharmacol Ther 2007;26:535-44
Reactive Arthritis

- First described by Sydenham in 1672
- Reiter’s Syndrome
- Described by British Medical Officers in Egypt, Malta, Salonika, and Mesopotamia
- Graham described 33 patients evacuated to Malta with dysentery and polyarticular arthritis in 1916
- Arthritis began 6-23 days after onset of dysentery
- 13 of 33 patients had Ophthalmological complications

Cowan JM, J R Army Med Corps 1918;31:277-295
Arthritis in Dysentery: Its Causation, Prognosis and Treatment.¹

By George Graham, M.D.
Reactive Arthritis

• 1,753 active duty U.S. military with diarrhea
• Campylobacter 728, Salmonella 624, Shigella 376,
• Yersinia enterocolitica 17
• 6 (0.3%) developed reactive arthritis
• 67% required care > one year

Porter CK, J Rheumatol 2013;40:712-4
Ophthalmological complications

- British Medical Officers described six patients with dysentery, iritis and cyclitis treated in 1916-17

Maxwell EM, Br J Ophthalmol 1918;2:71-79
Disability

• Between 1919 and 1929 there were 20,822 British soldiers on disability for complications of dysentery

Conclusions

• There were significant differences between the British Army and U.S. Army pre-war experiences, resistance to vaccination and deployment to endemic areas

• Modern analysis of stored bacterial specimens from World War I provide new insight on the enteric infections
Conclusions

• Controversies regarding mandatory vaccinations
• Enteric infections during deployment
• Chronic sequelae of gastrointestinal infections remain military medical challenges a century after World War I
In Memory of
Private
E Cable

9108, 2nd Bn., East Surrey Regiment who died on 13 March 1915

Remembered with Honour
Wimereux Communal Cemetery

Commemorated in perpetuity by
the Commonwealth War Graves Commission
9108 PRIVATE E. CABLE
EAST SURREY REGIMENT
13TH MARCH 1915
Wimereux Communal Cemetery