ENTERIC FEVER: A WATER-BORNE DISEASE.

By Major Norman Faichnie.
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In a recent letter to the Times, under date October 17th, 1905, by Surgeon-General Sir Thomas Gallwey, it was stated that the following, in order, were considered the chief factors in the causation of enteric fever: personal contact, ambulatory cases, latrines, dust, flies, milk, fruit and raw vegetables, bazaar products, especially sweets and aerated waters; and that the steps now being taken for its prevention in India are: (1) isolation, (2) disinfection, (3) evacuation of barracks, (4) segregation of drafts. The views which I held on the subject until recently were, that though water was the chief cause, the factors enumerated above were of considerable importance, especially in India. After fifteen months’ duty, however, as Sanitary Officer of the Home Northern Command, I have completely altered my opinion, and now firmly believe that, compared with water, others are of very little importance in its causation. I include under the head of water all such things as can be polluted by it, e.g., milk, raw vegetables and bazaar aerated waters, but I consider of quite inappreciable importance infection from personal contact, ambulatory cases, latrines, dust and flies. As there can be no subject of greater importance to the officers of the Royal Army Medical Corps, I venture to bring forward my reasons for holding these views.

Barracks.—On going round barracks in England one is struck by the fact that, in many ways, they are not in such a good sanitary state as those in India. Take Manchester, for instance, where the barracks are situated in the heart of the slums of a densely populated city. The men’s rooms are above the stables, quite close to manure and stable drains; latrines are damp and dark, and are flushed about four times a day. Kitchens, stables and latrines are quite close to each other, and flies abound in the summer. In the married quarters, till within a few months ago, six families shared one kitchen sink between them; the latrines are situated outside, so that in winter other arrangements are probably made at night. Or, again, take Warrington. The drains are constructed with practically no fall, so that the surface water and the urine lie often in a state of stagnation; the latrines are on the pail system, and are emptied four or five times a week by the Corporation, who...
will not allow the use of earth, as it increases the work of the Borough destructor. In addition, tubs are used as night urinals almost entirely throughout the Command. These two towns alone seem like places where typhoid fever ought to flourish, and yet no cases occurred in either, nor in any station in the Command, except at Beverley, the only place that has a bad water supply.

Except the water supply, in my opinion there is no essential difference between barracks in England and those in India, to account for the variation in the admission rates.

<table>
<thead>
<tr>
<th>British troops</th>
<th>Strength</th>
<th>Admissions</th>
<th>Rate per 1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1903</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>...</td>
<td>69,613</td>
<td>1,366</td>
</tr>
<tr>
<td>England</td>
<td>...</td>
<td>100,246</td>
<td>66</td>
</tr>
</tbody>
</table>

Camps.—During the past year I have inspected camps of Regulars, Militia and Volunteers throughout the Command. Thousands of young men, most of them of the most likely age to get enteric fever, and ignorant of, or thoughtless about sanitation, have been out for various periods without a single case having been notified as being contracted in camp. This goes on year after year here in the North with the same result. Some of the camps are occupied for only a few days, but others for three and four months continually at a time. Latrines are sometimes trenches, but generally on the pail system. It is extremely unlikely that urinals are used at night, so that in course of time the soil is soaked with hundreds of gallons of urine. Flies and dust abound in some of the camps, and it is very probable that some of the men suffer from typhoid bacilluria. Some crowded camps that are partly permanent, and that have been occupied several years in succession, have latrines and kitchens as close as fifty yards to each other. In all these camps there was no advantage, that I could see, over those in India, with one exception, that every camp, even if it were occupied for only a week in the year, was supplied with water brought in pipes, sometimes at great expense, from a recognised pure source. The last cases that occurred in camp were in 1899, at Strensall. At that time the water supply was a local one, liable to pollution from surface manure; since York water was laid on in 1900 no case has occurred. In the early summer of last year, when I thought dust and flies were important in spreading the disease, I lived in dread of cases occurring in at least two camps,
Enteric Fever: a Water-borne Disease

but nothing happened, nor has it, under similar conditions, for years, so that the conclusion is forced on me that, given a good water supply for drinking and all washing purposes, it is almost impossible to get enteric fever.

Infection by Dust and Flies.—Milk is admittedly a perfect bacteriological medium, many times more so than water, so that if two flies infected with typhoid microbes settle on a tumbler of milk and a tumbler of water respectively, in a few hours it would be much more dangerous to drink the milk than to drink the water. Consider the conditions under which milk is supplied to a city like Leeds. It comes from numerous farms which are notoriously in an insanitary state. Dung-plastered cows are milked by unwashed hands, in badly drained cow-sheds, in the dark hours of the early morning, and the milk sent from various parts of the country by train, with all the microbes growing by millions. The milk is often then left unprotected in town dairies or cheap grocery shops, and after it is delivered, kept uncovered in the homes of the poor, and seldom, if ever, boiled before use. This occurs in a densely populated city like Leeds, which rejoices still in nearly 5,000 privy middens, abominations in sanitation, that are cleaned once a month. Then take any month when it is hot, and dust and flies are at their worst, and, I think, we get ideal conditions for dust and fly-borne disease. Yet, on turning to the notifications for Leeds, with a population of 450,000, in September, 1904, we find: Enteric fever, from all causes 26, or 0.05 per 1,000 for the month. Where does dust or fly-borne infection of milk come in here, and if milk is infected so little, what fraction of cases is due to dust-infected water, which is not nearly so favourable a medium? Some measure of the actual amount of enteric fever due to flies and dust may, I think, be gauged by comparing the admissions for this disease of a city like Manchester, population 558,000, for the year 1903 with other years. In that year the summer was very wet and cold, therefore flies were scarce, dust was absent, filth was washed away instead of lying about, and fly-borne disease would be at its minimum; and yet there is very little difference between this and other years. So that a large town like Manchester, which is crowded and generally insanitary, and very well suited from the conditions of its milk supply for the spread of fly-borne disease, gives no positive indication of any having occurred, and therefore, if the infection of milk is small, that of water is very much less; and yet, in India, where the dangers of milk are so well guarded against that, as a cause of disease, it can be ignored, epidemics are
attributed to water being infected in this way. It seems to me, then, that although infection by these media has been proved to be possible, the positive evidence that it ever does occur to any great extent is very slight.

**Nature of Incidence when Caused by Polluted Water.**—One of the greatest difficulties to me in accepting the idea that enteric fever is solely a water-borne disease was the nature of its incidence in India, where various people using the same water supply were affected in different degrees, and some, not all, without any semblance of reason, while it is generally considered that the incidence should be uniform among those using the same water. As this is a difficulty which appears to trouble others, as well as myself, I may be excused for explaining at some length why I now think that there is nothing in its incidence in India to exclude water as a cause. Some of my reasons are drawn from observations made during the analysis of water in the laboratory, others from the study of epidemics.

The bacteriological water-carrier supplied in the Army consists of a small bottle with a capacity of about half a pint. The bottle having been first shaken up, portions of the water are mixed with corresponding amounts of bile salt broth and put in the incubator. After twenty-four hours, one tube may have become acid, another acid with the formation of gas, a third may have remained alkaline. That is to say, the composition of samples of a small volume of water like half a pint may entirely vary in character. The deduction from this is that if the composition of a small amount varies, that of a large volume may also vary so much that different people with the same water supply may be using water of entirely different characteristics. Again, in collecting a sample for analysis, directions are given that an examination shall be made as soon as possible, and experience teaches that a sample arriving in twenty-four hours has a different character from a sample of the same water that takes forty-eight or seventy-two hours to come. Therefore, water stored in "chatties," even if it be fairly uniform at first, may entirely vary according to the time it is stored, and a draught that is drunk at once is purer than another stored for some days, owing to the development of the microbes contained therein from the beginning. This may sound like a laboratory theory, but on turning to Dr. Thresh's book on "Water and Water Supplies," we read: "Water engineers now avoid 'dead ends' as far as possible. Near 'dead ends' there is always a tendency for sedimentary matter to be deposited, and for
bacterial and fungoid growths to develop." These, then, are some reasons why water does vary in character, and why, considering the very small quantity of water examined, a bacteriological analysis giving a negative result does not by any means prove that the water is necessarily pure.

A third reason why water may vary in composition in India is that it is so often stored in vessels, even when there is a piped supply. The microbes fall to the bottom and to the sides, and very soon a slime is formed containing vast quantities of bacteria. It is evident, then, that the quality of the water subsequently put in or taken out of uncleanse "chatties" does vary according to the bacterial quality of the slime in the different vessels, and that one of several vessels may contain polluted water, while the others may contain wholesome water. Moreover, a storage vessel once polluted may give out polluted water in gradually diminishing strength till all the harmful bacteria are washed away.

Other facts may be learnt by the study of an explosive typhoid epidemic like that of Lincoln in January, 1905. The water supply of this city was a sewage-polluted river purified by sand filtration, which, for six weeks, was working unsatisfactorily, and impure water (Bacillus typhosus was not found) was supplied, and nearly one thousand cases of typhoid resulted. The cases fall into two divisions:

<table>
<thead>
<tr>
<th>Division</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary cases in the six weeks before any correction of the sand filter was made</td>
<td>747</td>
</tr>
<tr>
<td>Secondary cases—first month</td>
<td>164</td>
</tr>
<tr>
<td>&quot; second month</td>
<td>71</td>
</tr>
<tr>
<td>&quot; third month</td>
<td>11</td>
</tr>
<tr>
<td>&quot; fourth month</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>249</td>
</tr>
</tbody>
</table>

The secondary cases all occurred after the filter had been purified, so that according to the experts "no germs could have remained in the waterworks unless some reinfection took place from the 'dead ends' and cisterns." Thus, secondary cases occurred while water, pure at its source, was flowing through the system of polluted pipes. It was proved that the whole of the water of the city of Lincoln was polluted with sewage, and the incidence was 1,000 cases, or 2 per cent. of the population. In the barracks using the same water no women or children, and only four men, contracted the disease, and yet this was an undoubted water epidemic lasting about five months, as the result of a pollution that lasted six weeks. One cannot help wondering what would
have happened if the pollution had lasted a few days and only a few cases had occurred, spreading over a month or two. What would it have been put down to? Probably anything but water, because the incidence would have still less resembled that of a water epidemic.

With regard to the secondary cases, viz., those occurring after pure water is again running, though the pipes are still fouled, in some reports it is stated that very little is known as to their cause, and they are attributed to personal infection, to drainage, and to ambulant cases. I think it is more reasonable to attribute them to the poison which remains in "dead ends" and cisterns, and which is present in the bacterial slime lining the water-pipes, being gradually washed off by the pure water as the secondary cases get less and less each month, and disappear altogether when the pipes are completely cleansed. That this must be so is shown by studying typhoid epidemics due to milk, which are noted for their non-contagiousness. Thus, while the water epidemics at Lincoln and Worthing lasted five months, and that at Maidstone four months, the milk epidemics at Glasgow (508 cases) lasted one month, at Dundee (118 cases) one month, at Marylebone (244 cases) two months, and others for similar short periods. If the secondary cases are due to ambulant attacks, personal infection, or to drains infected by the primary patients, and not to the poison remaining in the uncleansed water-pipes, why does a milk epidemic stop dead when the infecting cause is removed? And why are there no secondary cases in a milk epidemic where personal infection should have as much influence, and where the drains are as much infected? It must be remembered that in the Maidstone epidemic the suspected water was cut off, and a pure supply was run through the foul pipes, with the result that cases continued till the poison was gradually washed away. One more point of special interest and great importance is that about a month after the Lincoln epidemic began the people either imported water or boiled it, and yet the epidemic went on for four months longer. But even though water was "boiled," I think it is quite possible that infection by it may have occurred in several different ways, of which I give two:—

1. To kill the \textit{B. typhosus} it requires a temperature of 60° C. for thirty minutes, or 100° C. for two or three minutes (Muir and Ritchie). In a great many of the houses in Lincoln it would undoubtedly be taken for granted that water coming out fairly hot from the boiler would have been boiled and would be safe. Most boilers are so constructed that as hot water is drawn off, cold water flows in automatically. It follows, therefore, that polluted water
is always mixing with what is sterile, and as soon as the tempera­
ture gets near 60°, the water would be anything but sterile. These
facts are entirely borne out by experiments made by me both in
my laboratory and in my kitchen. In the laboratory I can boil
about one and a half gallons in one and a half minutes, and yet
when water was drawn off, in a very few minutes the temperature
fell to 60° C., with the gas on full, and to 30° C. with the gas half
on. In the kitchen, with the fire burning all day, the tap-water
varies between 40° and 65° C., and to get really hot water the fire
has to be kept banked up. With the small boilers supplied in
cottages there can be no doubt that contamination was possible
in this way. In my own house it would be impossible to get
a continuous supply of sterile water from the boiler unless very
special trouble was taken.

(2) Water at 60° C. is too hot for the hands, and would need
cold, and therefore polluted, water to be added to make it possible
to use it, so that milk stored in a vessel washed in such water
would at once become contaminated.

The application of the above facts will explain the statements
that epidemics have continued after boiled water has been used.
Thus, in the Dongola Expedition of 1896, cholera, almost certainly
a water-borne disease and enteric fever continued, although all
water was boiled and put into vessels to cool; but it is not stated
whether those vessels were also sterile first. I must confess I have
never seen vessels for storing water sterilised first either in Burma,
India, or South Africa. Again, in Munson’s “Hygiene,” it is
stated that troops at Jacksonville, Lexington and Knoxville used
the same water supply as the civil population, and yet the military
had typhoid while the civilians had none. At once one asks, was
the water piped to the military camp or was it carried in infected
water-carts? What was the water stored in in camp? Unless
these questions are answered satisfactorily, there is no proof that
water was not the cause.

This theory also accounts for the varied incidence of the disease
in India. Even when a piped supply is used the water must be
stored to cool, and if there are 200 storing vessels in a cantonment
there are 200 different kinds of water supply, according to the state
of the lining wall of each vessel, and a vessel once polluted may
remain so for some time. That storage vessels may remain foul is
demonstrated by the following provisional experiments made in my
laboratory:—

Water was obtained from the Ouse below the city of York, and
placed in a regulation water-bottle and a Burmese earthenware
"chatty," both having been previously sterilised. After twenty-four hours 2 cc. of water were taken from each, and mixed with corresponding portions of bile salt broth. The original was then poured out, and the bottle and "chatty" filled with sterilised water, shaken up, and 10 cc. from each mixed with 10 cc. of bile salt broth. The remaining water was then poured away and fresh sterilised water put in, and samples (10 cc.) were taken after the second and third washings in like manner.

After twenty-four hours' incubation, both the original water and each of the three washings had become acid with the formation of gas; that is to say, a sterilised bottle and "chatty" polluted with organisms producing acid and gas still retained them after three washings with sterile water.

These experiments I consider a severe test, for various reasons, one of which is that the chief source of pollution of a water-bottle or "chatty" is the slime that collects on the walls in course of time. In twenty-four hours this slime had formed to only a slight extent in the sterilised bottle and new "chatty," and yet three washings of each still remained impure.

Enteric Fever in Large Towns.—The small amount of enteric fever in the large towns of England is very significant.

<table>
<thead>
<tr>
<th>Town</th>
<th>Population</th>
<th>Rate per 1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1904</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manchester</td>
<td>558,000</td>
<td>0·58</td>
</tr>
<tr>
<td>Leeds</td>
<td>450,000</td>
<td>0·79</td>
</tr>
<tr>
<td>Halifax</td>
<td>108,000</td>
<td>0·45</td>
</tr>
<tr>
<td>Warrington</td>
<td>68,000</td>
<td>0·29</td>
</tr>
<tr>
<td>York</td>
<td>80,000</td>
<td>1·1</td>
</tr>
<tr>
<td>1903 British troops in India</td>
<td>69,000</td>
<td>19·6</td>
</tr>
</tbody>
</table>

Some of these towns are densely populated. Halifax has the Goux closet system, Leeds has 5,000 privy middens, Warrington is almost entirely a pail-closet town, York has its share of privy middens and slums. It is impossible to compare the sanitation of an Indian barrack with that of a slum of a large English town to the advantage of the latter, so that the great fact stands out once more that, given a good water supply, insanitation is of little importance as a causation of enteric fever. It is interesting to compare Warrington with York as regards their typhoid fever and water supply.

<table>
<thead>
<tr>
<th>Town</th>
<th>Population</th>
<th>1900</th>
<th>1901</th>
<th>1902</th>
<th>1903</th>
<th>1904</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warrington</td>
<td>68,000</td>
<td>62</td>
<td>32</td>
<td>32</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>York</td>
<td>80,000</td>
<td>244</td>
<td>121</td>
<td>56</td>
<td>47</td>
<td>89</td>
</tr>
</tbody>
</table>
Warrington was once noted for the prevalence of enteric fever, but with a change in water supply the disease at once diminished. York draws its water from the River Ouse, which receives the sewage of Northallerton and Thirsk among other impurities, and it is filtered on the Jewell system. Typhoid in York is not put down to water, but it is curious that a few days ago I found B. coli in 10 cc. of water from a tap in my laboratory, and a short time afterwards the blood of one or two cases of diarrhoea clumped slightly (sic) with a culture of B. typhosus.

Personal Infection.—In all the Asylums Board hospitals in London 127 nurses were infected in eight years, an average of about sixteen a year. Considering how enteric cases are mixed with others owing to the difficulty of diagnosis and other reasons, and how very seldom another patient contracts the disease, it is hard to believe that personal infection has any importance in the spread of it, except, of course, for nurses. In military hospitals in England infection from patients to nurses counts for 2·6 per cent. of all enteric admissions, which works out at 1 in 50,000 for the Home Army per year.

Presidency Towns in India.—The three Presidency towns in India have all got piped water supplies, presumably of good quality. If the slums of a large city in England are insanitary, how much more so are those of a large Indian town. Yet Fort William, Bombay and Madras are not noted for typhoid. As a matter of fact, the figures for the Presidency districts are about 15 per 1,000, lower than the average for India. Concerning Agra, in the Army Medical Department Reports for 1902, it was noted that while in 1897 there were 181 cases of enteric fever, in 1902 there were only four, great improvements having been made in sanitary matters, chiefly in connection with the water supply.

Ashanti Campaign of December, 1896, to February, 1897.—No recent campaign has given better results than the above under Sir W. Taylor as Principal Medical Officer, although it occurred in so unhealthy a part of the world as the West Coast of Africa.

Ashanti, December, 1896, to February, 1897.

<table>
<thead>
<tr>
<th>Per 1,000</th>
<th>Admissions for disease</th>
<th>49-27</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deaths from disease</td>
<td>0-56</td>
</tr>
</tbody>
</table>

Compare this with the worst results obtained in late years.

Dongola, 1896.

<table>
<thead>
<tr>
<th>Per 1,000</th>
<th>Admissions for disease</th>
<th>976</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deaths from disease</td>
<td>81-7</td>
</tr>
</tbody>
</table>
Several precautions were taken in the Ashanti campaign, but amongst others may be noted:

(1) "The first principle impressed upon all was to avoid doubtful water.

(2) "Not only companies and sections, but individuals, were looked after by officers personally, who saw that each man drank no water that had not been boiled."

It is significant that in Sir W. Taylor's Report the words "cholera," and "enteric fever," are not even mentioned.

The Nile Barrage Works.—At Assouan, these works were occupied by an average of 923 Europeans and 5,463 natives for twenty months, and special care was taken to supply pure water. The camp was said to be swarming with flies, and dust-storms were frequent. Nine cases of enteric fever, all imported, occurred, but no death. In the Army Medical Department Report, 1896, on the Dongola Expedition, it is stated: "Considering that enteric fever is always present everywhere in the Soudan, and that the natives themselves suffer from it, and, I believe, die to a greater extent than Europeans, and foul their water supply, it is not to be wondered at that enteric fever is so common among British troops." Under these circumstances the freedom of such a large camp of Europeans and natives as at Assouan is truly remarkable.

Enteric Fever in Foreign Stations.—Can water be excluded?

South Africa.—In the report on the prevalence of this disease in Pietermaritzburg it is stated: "One is then justified in saying that the surroundings of the water supply warrant the gravest suspicions as to its purity."

During the South African War the water was notoriously bad, and attempts at sterilisation admittedly incomplete.

India.—In the last Army Medical Department Report (1903), the following general statement is made: "The drinking water in Indian cantonments will probably always require to be boiled unless some form of mechanical filtration is introduced." In the Army Medical Department Report for 1902, a description of the "so-called prophylaxis" by boiling of water in the various stations in India is given. I regret to say it quite tallies with my experience, and there is no doubt that the system is not thorough enough to be an absolute preventive. A little further on it is said that the water, at, amongst other places, Mhow, Ahmednagar and Umballa,
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all noted for the frequent recurrence of enteric fever, is liable to contamination.

In 1903 Umballa had 107 admissions. "All water was boiled, but utensils for distribution were not sterilised."

At Meerut, with 100 admissions, boiled water was stored in "gurrahs," but whether these were sterilised is not stated.

The station where there is the greatest difficulty in excluding water as the cause is Quetta, where the water comes from a dam in an uninhabited region and is distributed in pipes.

In 1898, 232 cases were attributed to fecal filth from filth-pits, but in 1899, when the site of these trenches was sown over and cropped, 26 cases occurred. In 1900 there were 129 admissions. The barracks are noted as models of tidiness and cleanliness, but the epidemic is attributed to native latrines. In 1901 there were 30 cases; in 1902, 77, and in 1903, 44 admissions. That native latrines should give rise to such virulent outbreaks at Quetta and yet have no harmful effects in many other places seems to be very improbable. Considering the perfect sanitation that appears to prevail there and the virulence and recurring nature of the epidemics, I think water must be the cause, although this is against that of so great an authority as Lieutenant-Colonel Davies. The recurrence of the disease, after the offending filth-pits were covered over, shows that they were not the cause.

I have made inquiries about Quetta, from an officer who was there in 1902, and from him I learn that the source of the water is isolated, and that the pipes lead direct to the different barracks and kitchens; on the other hand, water running in open channels through the cantonment is liable to pollution; also that in the barrack-rooms water is stored in small earthenware vessels.

Dr. Thresh, in his book already quoted, states: "To inspect a stream for pollution, every tributary, drain, and ditch should be noted carefully, as well as the extent and character of the area liable to flood." Can Quetta stand that test, considering the habits of the natives? Or is it possible that the earthenware storage vessels, for the sterilisation of which, I understand, there was no general order, had become polluted, either by the tap-water, or by the water in the cantonment channels? If enteric fever in Quetta is not due to water, I think sanitation may be given up as useless as a preventive of that disease.

Turning to Ceylon, can water be excluded as the cause in the camp of the Boer prisoners at Dyatalawa (Army Medical Department Report, 1900)? Six hundred cases occurred amongst a group of 5,028 prisoners. The epidemic started and subsided with the
Norman Faichnie

rains, and it is stated to have been imported from South Africa, where the disease had been rife amongst the Boer forces, and in the ports where the transports put in. If this is so, it seems curious that the fever did not start among the prisoners of the first three ships. The first case was admitted fourteen days after the arrival of a man from the fourth ship in camp, and the stage of the illness was "probably of ten or more days' duration." The minimum periods of incubation laid down are—five days by Davies, four or five days by Fagge and Pye-Smith, a few days by Notter and Firth; it is not impossible, then, that the disease was contracted in Ceylon. As the water was piped from an isolated spot three miles distant, could it have been the cause? I think, from the Report as it stands, that it is not impossible. Having known that part of the country, on reading the Report two things at once struck me:

(1) A stream in the hills, that in one place appeared to be an isolated mountain torrent, came out at another close to the high road on a plateau, and was likely to be polluted both by natives and by flooding of the surrounding area.

(2) This part of Ceylon is partially covered by tea estates, on which hundreds of coolies work.

If, then, remembering the rules for inspecting water supplies, the stream, or any of its tributaries, that supplied the Boer camp, was ever liable to pollution in either of these two ways (and it must be remembered that the epidemic began with the rains), water cannot be excluded as a cause of the outbreak. As regards the cases in the military camp, the water used was the same, except that it was put through Pasteur and Berkefeld filters. If the supply was impure, as I have suggested, it only bears out the fact that the order given in South Africa for the candles of the Berkefeld filters to be boiled twice a week as a very necessary one.

To sum up, the positive evidence that we have as regards the spread of enteric fever is that the infection may be due to milk polluted by water, to polluted water, and, to a slight extent, by those nursing or in intimate contact with the sick. It is theoretically possible that infection may be by dust and flies and by direct transmission from ambulant cases, but in large towns with good water supplies, where ideal conditions exist for infection in this manner, experiences teaches that their effect is slight. Moreover, in milk epidemics where the infection can be definitely checked in these ways, it is practically nil. In England, we have good, though not by any means necessarily perfect, water supplies,
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the attack rate averages 1.3 per 1,000; in India it is admitted that no water can be trusted, and the average attack rate is 22.6 per 1,000. That cholera has been stamped out, while enteric increases, only proves, I think, that the poison of the latter is more diffused. In Quetta, where it has been taken for granted that the water supply is pure, measures taken on other lines have had little effect. The study of water epidemics shows that water-pipes or storage vessels once polluted may remain so for months, and that the incidence may be very varied, depending probably on the strength of the pollution of the water and on the number of storage vessels poisoned; and also that the measures taken for boiling must be very complete before success can be expected, and must include the sterilisation of storage vessels. Admissions due to infection while nursing, amount to about 1 in 50,000 British troops per year, and the dangers of milk are so well known that infection by its means must be quite inappreciable. The great fact then remains that water must be the chief and almost sole source of infection. If this be so, methods, other than those in respect of supplying pure water, now being employed in India, can have but a remote effect in prevention. Possibly they hamper, and if they do it is a curious anomaly that they should be due to the result of good work done by three of the best sanitarians in the Army. Moreover, if water be the sole cause of enteric fever, lecturing to officers and men on hygiene becomes quite simple. The four great diseases of the Army and the methods for their prevention on active service can be put in very few words. Thus, for malaria mosquito nets, for cholera and enteric fever pure water, and for dysentery pure water and the avoidance of chill. Remembering that it is a safe rule to trust no water in South Africa or India, to organise a system to supply pure water to the troops seems to me to be the most urgent want we have. Difficulties there may be, but it is not for the medical officer to make them; let those who refuse to follow our recommendations take the responsibility. Finally, no system for supplying pure water is complete that does not include arrangements for sterilising water-bottles. Once filled with impure water, those of the present pattern remain polluted, and sterile water added would soon be worse than ordinary water. The remedy is a metal water-bottle which can be put on the fire without being injured, and this would make small detachments quite independent of transport, as fuel, even in South Africa, is somehow found by the men. Water to replace water is the physiological necessity, its temperature being quite immaterial.