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THE CHOLERA MICROBE

AND

HOW TO MEET IT.

ADDRESS

Delivered at Belfast, July 31st, 1884.

BY

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1884.

THE CHOLERA MICROBE, AND HOW TO MEET IT.

HOWEVER disconcerting to us the conviction may be there seems no escaping it, that one of the manifest destinies which man fulfils on this earth is to afford a happy hunting ground for myriads of humble organisms, which find in each of us their little world. This destiny we appear to share with the entire animal kingdom, for if, as Butler rather coarsely puts it,

> "Big fleas have little fleas to bite 'em,
> And these fleas, lesser fleas ad infinitum"

—every mammal, bird, reptile, fish, insect, crustacean, and mollusc amongst us is the dwelling-place of a teeming population of minute beings. If these little creatures can think, each species of them is probably in its own eyes, as we in ours, the great central pivot round which the universe revolves, but to us they seem to belong to the very lowest scale of animated things, so low that, being in doubt as to whether to class them as animal or vegetable, to get rid of the difficulty we have coined for them a non-contentious name and call them microbes, or minute living organisms. The invisible germs of these microscopic organisms swarm in the air we breathe, and in the water we

drink. They are of countless genera and species, contending with and destroying each other in the universal struggle for existence. Some we utilise as slaves to make for us wine and beer, vinegar, nitre, and bread. Others constitute the great scavengers of the world, and ultimately resolve our refuse and ourselves alike into their original elements. Some multiply in our digestive tract, harmlessly to ourselves and probably with results contributing towards the various digestive processes with which they are found associated. Others we know only as our deadly foes — the unmasked causes of tubercle and septicœmia, of small-pox, hydrophobia, and malignant pustule. Others, so to speak, still on their trial, are strongly suspected of being the active agents in typhoid, diphtheria, yellow fever, dysentery, and a longish list of other maladies. And yet another set we know only by results; but, judging by results, we are forced to the belief that in all so-called zymotic diseases the ferment from which the group derives its name will be one day proved to consist of living organisms, and that sooner or later each of them will be dragged forth and identified in that fierce light which of recent years has been focussed on the field of microbe life.

The latest disease-organism which has been introduced to the notice of the public is the cholera microbe, and as a knowledge of the habits and peculiarities of these baneful invaders of mankind is of the first importance in connection with the defence of public health, I have thought that I could not better utilise the opportunity of addressing you, as President of the Public Health Section of the British Medical Association, than by briefly stating what is known concerning our most recent microbe acquaintance; and, considering the lessons which that knowledge to my mind suggests, as to the tactics with which we may most successfully meet the invasion which it is likely in a short time to make upon our shores.

Sooth to say, very little of a definite or satisfactory character is known about it. When over a year ago cholera was raging

in Egypt, the French and German Governments, with an enlightened view of the responsibilities of Governments as guardians of the public health which put to shame the policy of successive British Ministries, sent out each a commission to investigate the question of the causation of the disease. The chief of the German Commission was Dr. Koch, the man who first succeeded in cultivating outside the body the first discovered disease-microbe, the bacillus of cattle-anthrax, and who, later, demonstrated the microbe of tubercle, and proved its connection with the phenomena of tubercular disease. The members of the French commission were nominated by M. Pasteur, comprised two of his most experienced and trusted assistants, M.M. Roux and Thuilier, and was presided over by Dr. Strauss. Before setting out on his mission, Dr. Koch had been supplied from India with preparations of the intestines of persons who had died from cholera, and in their tissues he had observed colonies of a peculiar microbe, which he suspected might be the cause of the disease. Accordingly on his arrival in Egypt, his attention at once took the direction indicated by this clue, and in every one of the cholera corpses which he examined, he found the same organism. It was rod-shaped (microbes of this form are called bacilli, or little rods), in size and general aspect resembling that found in glanders, but curved in a peculiar manner, like a comma. Its habitat was the small intestine, especially its lower portion. In cases where the mucous membrane microscopically showed the smallest change, the bacillus had penetrated into the follicular glands, and had there evidently occasioned considerable irritation. In many instances it had burrowed beneath the epithelium of the glands, and multiplied between it and the glandular surface. Bacilli had copiously settled on the intestinal surface, and in many instances had penetrated into the tissue of the villi. In the more severe cases, where the mucous membrane was infiltrated with blood, these bacilli were found to have penetrated its deeper layers, and even the muscular coat of the intestine. In the dejecta, so long as these remained fœcal,

although they contained numbers of other forms of microbe life, but few of these peculiar comma shaped bacilli were discoverable. As the disease progressed, and the evacuations became of the well-known inodorous rice-water character, these bacilli were found in abundance, and all other forms of microbes disappeared. When death occurred at this stage these bacilli were found in the contents of the intestines in enormous numbers, and almost free from any other living contamination. This stage once past, the peculiar bacillus became less abundant. The coats of the intestine showed signs of serious re-action, being permeated with extravasated blood, and often mortified in the superficial coats. Septic bacteria multiplied themselves again, and the evacuations became fœtid.

For a time the comma-shaped bacillus maintained its hold in the follicular glands, but at length it disappeared from them also; and in cases in which the patient died from the secondary effects of the disease, due apparently to septic infection through the lesions produced by the ravages of the specific bacillus, no specimen of that bacillus could be found. In the blood of cholera patients Dr. Koch could detect no microbe; in their vomit he only found his bacillus in a few cases where the reaction was alkaline, and where the vomit seemed to have found its way upward from the intestines; and in the lungs he found the microbe but rarely, in cases in which it appeared to have been inhaled with vomited matter. Although numerous corpses of persons who had died of other diseases were examined for this bacillus, in none of them was it found.

On the other hand, the French Commission in Egypt, in the intestines of the cholera corpses which they examined, found, like Dr. Koch, a vast variety of microbes, varying according to the portion of the intestine examined and the duration of the disease. One of the most frequent forms was a small bacillus, recalling the bacillus of tubercle. It was most abundantly met with in the lower portion of the small intestine, and formed nests which invaded the sub-mucous tissues without ever

penetrating the muscular coat. This bacillus M. Roux, in a note to his report, states to be without doubt the same on which Dr. Koch had laid so much stress.

The French Commission also proposed to themselves the question whether this microbe was the cause of cholera, but in three cases of the disease, which had carried off the subjects in from ten to twenty hours, they found themselves unable, in spite of the most minute search, to discover any trace of it; and in a fourth similar case the number was extremely small, and it required many sections to find them. As it was precisely in such rapidly fatal cases, if the bacillus and the disease stood to each other in the relation of cause and effect, that the former should have been most numerous, the French Commission came to the conclusion that the variety of microbes which they found in the preparations were due to a secondary invasion of the intestines, and that the special bacillus, which, by its predominance, had attracted their attention, was simply one which found in the intestines of cholera patients a more favourable medium of culture than the others, less numerous, which were seen alongside it. Looking, therefore, elsewhere for some microbe, uniformly present, which might appear to account for the disease, they thought they discovered it in the blood, in the shape of pale particles floating between the blood-corpuscles, of low refraction and difficult to observe unstained, slightly elongated and narrowed at the centre like the figure 8, and much smaller than, but comparable in shape to the lactic ferment. These they found in great numbers in the blood of every one of the cholera subjects which they examined. These particles were difficult to stain, and when stained did not retain their colouring, so that satisfactory preparations of them were not obtained.

In the blood of cholera subjects, collected with every precaution to ensure purity, and maintained for 24 or 48 hours at a temperature of 38° centigrade, these particles multiplied themselves, sometimes forming little chains. The serum of the blood

in which they thus developed in most cases exhibited a slight but distinctly acid reaction, and in one case, where the blood and the serum of the pericardium were examined immediately after death, these liquids were found to be already feebly acid. All attempts to cultivate these particles, in the most varied cultivation fluids, failed, and Koch, when some months later he read the report of his French brethren, declared positively that the particles were not microbes, but the so-called *blut-plättchen*, or blood discs, which exist even in healthy blood, and which in many febrile disorders are greatly augmented in number. These protoplasmic bodies, he said, from their resemblance to micro-organisms had been mistaken for bacteria, as they had often been before, and he added that previous investigators, notably D. D. Cunningham, in 1872, had already described them.

Both commissions made repeated attempts to communicate cholera to the lower animals. Mice, rats, monkeys, pigs, rabbits, guinea pigs, dogs, cats, fowl, chickens, puppies, and other animals were experimented on. They were given choleraic evacuations and tissues, fresh, stale and dried, in their food; fluids containing these substances were injected into their bowels, cholera blood was transfused into their veins; in short, every imaginable device was resorted to, but without success. Except in one case, in which a fowl, submitted by the French Commission to a diet contaminated with rice-water stools, died on the third day of the experiment. The contents of its intestines were found to be liquid, the intestinal mucous was marked with hæmorrhagic spots, and the blood contained the particular body which the French Commissioners considered to be the microbe of the disease. But although the intestines of this fowl were administered to others, and its blood was inoculated into them, no results followed.

On the cessation of the epidemic in Egypt the French Commission returned home, while Dr. Koch and his *confrères* proceeded to India, further to study the disease. His Indian experience coincided with his Egyptian. In every case of cholera he found

the bacillus he had described. In every other disease in which he searched for it he failed to find it. Again all attempts to communicate cholera to the lower animals failed, and Dr. Koch came to the conclusion that they were not susceptible of cholera infection. "Could any species of brute," he wrote, "have con-"tracted cholera, this must have occurred in Bengal, where "choleraic infectional matter is spread throughout the whole "year and the whole country, and it must have been noticed in a "reliable manner." But he could learn of no such observation. Further cultivations of these bacilli gave him a further insight into their habits. When sown in gelatine they formed colourless colonies, which were at first compacted, and looked as if composed of strongly lustrous fragments of glass. Gradually these colonies created currents in the jelly in which they grew, and diffused themselves. Under the microscope they were seen to swim about with great rapidity, affecting the edge of the fluid in which they were placed, and when stained their comma-like form was easily distinguishable. On the linen of cholera patients, befouled with their dejections and kept damp, these bacilli multiplied in an astounding manner, and the same thing occurred when these evacuations, or the contents of the intestines of cholera corpses, were spread upon blotting paper, and most especially upon the damp surface of the earth. "After 24 hours, the thin, out-"spread coat of slimy matter was wholly transformed into a "teeming mass of cholera bacilli."

Numerous specimens of foul water were examined for the microbe without success, until Dr. Koch, hearing that an epidemic had broken out among the dwellers round one of those tanks which so constantly determine the site of village communities in Bengal, and which so frequently constitute the centres of isolated cholera epidemics, proceeded to the spot. These tanks, as he describes them, are small ponds or morasses surrounded by huts. From them the inhabitants derive their entire water supply for all purposes, and

round their margins filth of every description, and especially human ordure, abounds. The inhabitants of the tank village which he visited numbered several hundreds. It had been repeatedly visited by cholera, and in the epidemic which was the occasion of his visit, 17 persons had died. A number of specimens of water were taken from the tank and examined by gelatine cultivations. In several of the earlier specimens the comma-shaped bacillus developed in considerable abundance. In the later specimens, taken when the epidemic was in its decline, it was found in only one, taken from a particularly foul portion of the tank, and then in small numbers.

Dr. Koch endeavoured to find a permanent form of the bacillus, but without success. He could not get it to produce spores. In the sole form in which he was able to obtain it it died after three hours dessication. The only possibility of keeping it alive lay in preserving it in a moist condition. In liquids it would remain for three weeks capable of development. Acids were as fatal to it as drying, and, where bacilli in abundance were introduced into the stomachs of animals, the acid gastric juice appeared to make short work of them, for in such cases Dr. Koch could find no trace of them in the contents of the stomach or intestines. Nevertheless, he says, "Everything goes to show "that they can only be consumed and incorporated into the "human body in an active condition when they are in a moist "state."

I have endeavoured to set forth the results of the two commissions consecutively and without comment, and now let us consider what they amount to. In order to establish the microbic origin of a disease as a scientific fact, four things are necessary. In the first place, something that may be a microbe must be found in the blood or tissues in every case of the disease. In the second, it must be shown by cultivation in artificial media to be a microbe, possessing its vitality apart from the organism of the animal in which it lives. Thirdly, it must be shown, when purified by artificial cultivation, to be

capable if introduced into the systems of animals in which it can develop, of reproducing the particular disease. Finally, before the results can be admitted as established scientific facts, they must be corroborated by independent observers. These are stringent tests; but before the relation of cause and effect was admitted between the maladies and their respective microbes, all four requirements were complied with in the case of cattle-anthrax, fowl-cholera and tubercle. The first three of these conditions have been complied with in the case of malarial fever, glanders, diphtheria and yellow fever, but they require corroboration, and science will not yet accept the facts as established. In the case of cholera, not one of the four requirements has as yet been met, and in the interests of scientific medicine, while admitting the importance of the discoveries, we are bound to reserve our judgment, and to refuse to act upon them as if they were established facts.

For what is the present state of matters? Koch has found a microbe which he asserts to be present in every case of cholera, but which, after the most careful search, experienced investigators like the French Commissioners failed to find in three cases where, if it was the cause of the disease, it should have been most markedly present. The French Commission found a something which they affirm to be invariably present in cholera cases, but which they failed to prove to be a microbe, and which Koch declares to be but an epiphenomenon of the disease. Koch declares that he has never found his peculiar bacillus associated with any malady but cholera, but another experienced and distinguished investigator, Dr. Klein, asserts that he has inspected specimens prepared by Dr. Koch from the rice-water evacuations of cholera patients, but that he possesses preparations of evacuations of patients obtained in an epidemic of diarrhœa in Cornwall, in 1883, and in them, among other microbes, "are undoubtedly "bacteria, which in shape and size, and mode of staining, so "closely resemble the comma-shaped bacilli of cholera, that he is "unable to discover any difference between them." I am glad to

hear that the British Government has at last ordered Dr. Klein to India to follow up the investigation of the disease. There, some differences may be detected in living specimens under cultivation. Meanwhile, Dr. Klein's experience is apparently contradictory to Dr. Koch's.

Even admitting Dr. Koch's facts, however, from a physiological point of view they are far less satisfactory than the facts, put forward years before Dr. Koch's demonstration of the tubercle bacillus, by which Villemin and Toussaint showed that tubercular diseases were communicable by something contained in the expectoration and juices of tuberculous animals. Neither the French nor the German Commissions were able to obtain Theirsch's results in their experiments on mice, but if Theirsch really succeeded in fatally infecting with cholera 30 out of 34 mice fed on the stale rice-water excreta of cholera patients, he more conclusively showed the all-important fact that something in those excreta was a cause of the disease than either of the Commissions have succeeded in accomplishing.

While, therefore, most fully admitting the interest and importance attaching to the observations of one or other of the Commissions, we must absolutely refuse, in the interests of public health, to accept them as established premises on which, unsupported, to found practical conclusions, and especially negative practical conclusions. We must refuse to believe, because Dr. Koch failed to discover any spore or permanent form of his cholera microbe, that it is an exception to the rule according to which all microbes under certain circumstances are propagated by spores endowed with a permanence of vitality and powers of resistance to physical agents far in excess of the parent being. Because Dr. Koch found that his microbe was killed by three hours' dessication, we must not believe that dessication affords a reliable security against cholera contagion, for we know that all microbe spores are proof against dessication, and that Tyndall found some

capable of surviving eight hours' boiling. The very fact that the microbe, as Koch found it, was at once poisoned by acids, and that the acid contents of the healthy stomach immediately destroyed and dissolved it, goes to show that he failed to discover it in the form in which—assuming it to be the cause of the disease—it establishes its hold upon man. Other disease-microbes give rise to the specific maladies of which they are the cause when taken into the system through different channels—the stomach, lungs, or blood—and whether moist or dry, and in the face of the incomplete nature of Dr. Koch's investigations, nothing can justify us in acting on his conclusion that the cholera poison can only harm us when it reaches us moist through the channel of the stomach.

Here are some cases which seem to show that, in point of prolonged vitality and capability of propagation in a dessicated form through the air, the infection of cholera is nowise different from that of anthrax or tubercle. The first I take from a most able paper by Dr. Simmons on Cholera Epidemics in Japan, published in that generally inaccessible repertory of brilliant medical records and discoveries, the *China Customs Gazette*. In that case the origin of the Japanese epidemic of 1879, is thus described. "At Kriushiu, in the beginning of that year, the "graves of soldiers, who died of cholera in 1877, were opened by "the Government, partly it is said for religious purposes, partly "to bury more decently those who had been hastily interred "during the war. The present disease began instantly from that "point, spread slowly in Kriushiu, whence it was brought to "Yokohama and Tokeo by the *Hiroshima Maria*." That epidemic killed 97,000 persons. The second and third cases are *apropos* of the present Toulon epidemic, and I give them as reported in the French journal *Le Soir*, of July 2, in a signed article, the writer of which states that he had the particulars from M. Brouardel's own lips.

The origin of the Toulon outbreak, as you know, is involved in mystery, so much so that one eminent authority is reported

to have said that the disease was most probably introduced by the master of some British vessel, who had concealed the fact that he had cholera on board by falsifying his log. On the appearance of cholera at Toulon a medical commission, consisting of MM. Brouardel, Proust, and Rochard, was appointed by the French Government to investigate its origin. That commission set itself to work systematically, examining all the records of the ships which had sojourned during the month of April in the Roads or in the Port of Toulon. They altogether failed, however, to discover any fissure by which cholera could have entered. "It was then that these gentlemen "conceived the idea of examining the 'Montebello,' a hulk at "the extremity of the port, where the cholera had made its first "two victims. The 'Montebello," built in 1811, was used in 1856 "for the transport of troops which took part in the Crimean "campaign. Since then dismantled, she has served as a magazine "of old stores, and in a corner of the hold the Paris physicians dis-"covered a lot of old cartridge-pouches and shakoes which had "been brought back from Sebastopol, and which had rested there "ever since. Cholera, as everyone knows, decimated the French "troops before Sebastopol. Who were the first two victims? "The very sailors who had charge of these cartridge-pouches and "shakoes. And when were they struck down? A few hours "after having displaced, for the first time since 1856, some of these "old stores."

"M. Brouardel," continues the writer, "had cited these facts "to the Committee of Hygiene without drawing any conclusions "from them. M. Pasteur, who was present, seized upon them. "He recalled a case where, in a foreign ship, cholera had "made its appearance out at sea, twenty days after leaving port, "and the enquiry ordered revealed the fact that seven years "before there had been on board several cases of cholera. The "ship had been thoroughly disinfected at the time, but some "sacks had been left at the bottom of the hold. Seven years "had passed without a single case of cholera. Then by order of

" the captain the old sacks had been cleared out of the hold and " cast into the sea, and the epidemic had burst forth."

For the purposes of public health, while we are bound to take account of the positive discoveries of Dr. Koch, we cannot afford to forego a single precaution, because of his negative conclusions. Our only safe course is to act on analogies based on our knowledge of the habits of other infections. Acting on conclusions derived from those analogies we may unnecessarily multiply our precautions, but we will omit none of those precautions which Dr. Koch recommends. Happily, in our dealings with microbes, innumerable instances present themselves in which we have availed ourselves of their services without even suspecting their existence. Alcohol, vinegar, and leavened bread were made before mankind had any suspicion of the parts which these minute beings played in their manufacture. And so in preventive medicine, two of the greatest discoveries of the age were made, before the existence of microbe-contagion was established, by thinkers, who, working on analogy and correcting their conclusions by accurate and widespread observation, formulated theories which are now accepted as indisputable, and have proved of inestimable value to mankind. I refer to the theories of Dr. William Budd, of Clifton, as to the dissemination of typhoid fever, and that of Sir Joseph Lister as to the septic complications of wounds. Now the similarity between the mode of the propagation of typhoid fever and cholera has struck numberless observers, and among others Dr. Budd, and although he never gave the world such an elaborate and exhaustive demonstration of the truth of the laws he laid down in the case of cholera as he has done in that of typhoid, nevertheless, the application of precautions based on those laws was able to save Bristol from its ravages in the midst of the cholera epidemic of 1866, notwithstanding the repeated importation of the disease into that town. Dr. Budd held that cholera, like typhoid, is spread exclusively

by the discharges from the intestines of cholera patients. He held that from the places of deposition the poison might spread itself by rising into the air with the products of evaporation, by percolation into drinking water, or by atmospheric dispersion after it had passed into the dried state. He held that the contagion infected the ground, that its efficacy might be preserved for months or years like the germs of fungi or infusoria, and that while in unfavourable conditions it might rapidly be destroyed, under favourable circumstances it might, after long intervals, spring into activity, and, multiplying in enormous profusion in the human intestines, afford material for another extensive infection. Now this is a theory which coincides with every positive discovery of Dr. Koch. It is practically identical with what we know regarding typhoid fever, and it fills the gap in Koch's discoveries by the assumption that the cholera microbe, like every other known microbe, under certain circumstances produces spores which may preserve a latent vitality for long periods. If it is at all inadequate we have only to add the hypothesis on which Budd acted, which, since his time, has been repeatedly demonstrated in the case of other microbes, and which can hardly be questioned in the case of typhoid contagion, that at suitable temperatures and under suitable conditions, the contagium may multiply itself outside the human body in sewage, water and other cultivation media, and we have an ample explanation of the phenomena of every choleraic outbreak.

We can at once understand why cholera is endemic in India, where, it is said, 150 millions of our fellow subjects use no latrines, but habitually defecate on the ground; where they wash themselves after defecation in the tanks from which they drink, and in which when they bathe they methodically rinse their mouths; where thousands of infected pilgrims annually carry the disease back to their native villages, polluting the earth and watercourses on their way; where the temperature and climatic conditions favour the production of spores, and

where those spores, in the form of invisible dust, are conveyed far and wide by the winds. We can comprehend why in contiguous China, where the night soil is carefully hoarded for manure in tubs, where there are no mammoth pilgrimages, and where the people, whenever possible, boil their drinking water and drink it as tea, cholera, constantly imported among populations whose habits are filthy in the extreme, has never become endemic. We can see why cholera epidemics are so rare in China that mention of them is conspicuously absent from her literature, and why, even since the country has been opened up, there is no record of the disease having shewn itself in China during the 15 years prior to 1858, or the ten years prior to 1877. We can understand also why in Japan, much more favourably situated for escape, and where the habits of the people are very similar to those of the Chinese, but where excrement is habitually collected in latrines sunk in the ground, and where the use of tea, as a beverage, is not so universal, the ravages of cholera have been much more extensive.

An admirable paper by Surgeon-General De Renzy, read in February last before the Epidemiological Society, corroborates Budd's theory in the most striking manner. Some twelve millions sterling have, within the last 20 years, been spent in improving the sanitary condition of the British troops in India. The cantonments have been spread over immense areas, that of Mianmir covering ten square miles in extent. In them a single regiment may be spread over several miles. They are kept in a state of scrupulous cleanliness. The use of earth closets in them does away with the dangers of sewerage, but their enormous extent making the supply of water by pipes a costly matter, they are supplied by wells. These wells are kept covered, but their covers are so arranged that the water-carriers stand upon them when drawing their supplies, which they do by means of leathern buckets attached to a rope. There is a constant trickling from these buckets, which, washing the water-carriers' dust-covered feet, perco-

lates back into the well through crevices filled with an offensive stuff consisting of moistened dust, epidermis and fibres of cotton-wool. The water is filtered, but the filtering is often very carelessly done, the filter in one case which Dr. De Renzy mentions being filled with sand taken from the bed of a nullah close to the spot where the bazaar drain discharged. In the cantonment of Mianmir, to which I have referred as being spread over ten square miles, the average annual death-rate from cholera for the ten years 1862-71 was 27·6 per 1000 strength. In the ten years 1872-81 it averaged 41·9. On the other hand one of the least improved stations in India is Fort William, Calcutta. The barracks are ill-arranged and crowded together. It is situated on low ground in the vicinity of rice-fields and a vast jungle, and it used to be the most unhealthy station in India. For a long series of years its death-rate was 69 per 1000, and for the ten years ending 1856 it averaged 102 per 1000.] Between 1860 and 1872 some improvement was effected in its water supply, a number of tanks being closed and a supply being laid on in pipes to the barracks from a tank on the glacis. In 1872 the new water supply, which had been brought from a distance to Calcutta, was laid on to the fort. During the ten years 1862-71 the cholera death-rate at Fort William was 18.2 per 1000. In the ten years 1872-81 it was but 9.5. Contrast that with the contemporaneous figures in the magnificent cantonment of Mianmir. In the one case the most elaborate precautions, but a supply of suspicious well-water, and the cholera death-rate doubled. In the other, neglect of other sanitary precautions, but water from an aqueduct, and the cholera death-rate diminished by half. Of course the same agency that cut down cholera diminished other water-borne diseases, and the death-rate of Fort William during the decade 1871-80, from its old standard of 69 and 102 per 1000 was reduced to 10½, as against 8½ amongst troops stationed in England, and 25 in British troops throughout India generally.

Is this result of recourse to a purer water supply an exception in Indian experience? Quite the contrary. Calcutta introduced pure water, and its cholera death-rate at once fell by more than two-thirds of its old figure. Bombay was once a hot-bed of the disease, but pure water was introduced, and for 17 years, according to Surgeon-General De Renzy, the European population of that town has enjoyed almost as much immunity from the disease as the people of London. And again in Nagpore, in the seven years after the introduction of water from the Ambaghiri reservoir, the cholera death-rate fell to one-seventh of its figure during the seven years preceding that event, while in the population in the surrounding district, to which the new water supply did not extend, it rose by close on 50 per cent.

Does not all this prove that the laws which regulate the spread of the disease by water are the same in India as in the United Kingdom, and might not one almost fancy that one heard repeated in these experiences the old story of South London, supplied by two water companies, where in the epidemic of 1849 an equal mortality prevailed in contiguous houses supplied by either undertaking, but where, before the epidemic of 1854, one of them having altered its intake to a purer portion of the Thames, the cholera death-rate among the population supplied by it sank to one-eighth of that among the consumers supplied by its rival?

Now so far as impure water is concerned, I am afraid that in the case of any visitation of cholera we must to a large extent take matters as we find them. You may preach till you are tired about the propriety of boiling water previous to use, but though the few may comply the majority will not adopt any such precaution. Every one has heard of epidemics of typhoid and other diseases propagated by contaminated milk, and most people know that all danger from that source may be avoided by boiling their milk. But how infinitesimally small is the proportion of persons even amongst the most intelligent classes who ever dream of resorting to such a precaution. It is, therefore, by no means

pleasant to think that if any of the cholera refugees who are at present pouring into this country from France find their way into the towns on the upper portion of the Thames and are there attacked, their dejections will infect sewage, which, after diffusion in that river, will be more or less imperfectly filtered and served to Londoners for their drink. If this is not a pleasant outlook for London it is hardly more pleasant for the rest of the country, to which, from London, the contagion will rapidly spread.

But pure water is evidently not everything in the prevention of cholera. Marseilles has now a splendid water supply, but the disease is raging there at this moment. Next to water, bearing in mind the analogy of typhoid, the sanitarian will look to sewerage. Throughout the entire country our sewerage is most defective. However perfect our main drainage may be, our domestic sewerage is almost invariably bad. Houses effectually trapped off from the main drains, with their soil-pipes airtight and properly ventilated, are the rare exception, and although populations living on open sewers like the lower Thames or the Clyde do not seem to suffer appreciably in health from the gases given off, covered sewers—in which vapour and pulverised water, holding all sorts of microbes in suspense, are borne along by strong air-currents and swept into our houses through perforated soilpipes, with a force which at once extinguishes a candle—are in a very different position. No precautions which we can take to prevent cholera dejections finding their way into our sewers are likely to be successful. Were there no other reason, the insidious character of the disease in its earlier stages, when Koch's microbe is already present, would prevent the possibility of keeping our sewage uncontaminated. Budd therefore recognised the primary necessity of disinfecting sewage "by anticipation," and so rendering it fatal to microbe life. With that view, when Bristol was threatened, he flooded the sewers with antiseptics. His precautions cost the town £600, but they enabled it to

dispense with a cholera hospital, and they repeatedly prevented the disease from spreading beyond primary cases. In no one of the numerous sets of precautions against cholera which the present crisis has called forth have I seen this most important and obvious one suggested.

To show how completely Budd's precaution has been lost sight of, the following incident is noteworthy:—In consequence of the loud complaints as to the state of the Lower Thames, according to the *Standard* of July 14th, the Metropolitan Board of Works ordered that the sewage discharged at the two great outfalls in Barking Reach should be deodorised, and sanctioned for the purpose the daily use of 140 tons of chloride of lime, at £9 per ton. By introducing his disinfectants into the sewers themselves, instead of trying to disinfect the sewage after its discharge, Budd, during more than seven months, at a cost of £600, rendered the sewage of 180,000 persons in Bristol so fatal, not only to the microbe of cholera but to those of other sewage-grown diseases, that the total death-rate of the town fell to 12 per 1,000 per annum. London contains about 20 times the then population of Bristol, so that to carry out in London a similar experiment—which would only be less successful because of London's contaminated water supply—would for seven months cost £12,000, or less than the sum authorised to be thrown into the sea in 10 days of this æsthetic but, from a sanitary point of view, perfectly useless extravagance.

The disinfection of the stools of cholera patients is a precaution so clearly necessary that it thrusts itself before everyone. But it is a fact, apparently universally forgotten, that the intestines of every corpse which has died of cholera are filled with the same dangerous fluids, that when the sphincters relax in death these ooze out, that the vast majority of persons dying in our towns are buried in common graves, often within a few feet of the surface, and that our graveyards frequently drain themselves into streams and rivers from whence large populations supply themselves with water. Apart from

theoretical probabilities, the Board of Health Report on Extra-mural Interments, published in 1851, makes special mention of the frequency with which, in the great epidemic then just closed, cholera had burst forth in the neighbourhood of burial grounds. Budd was fully alive to these facts, and in the deaths which occurred in Bristol in 1866 he imbedded the corpses in their coffins in McDougall's powder. In none of the modern cholera precautions which I have read have I noticed one word said about disinfection of the dead.

The necessity for one precaution is so universally recognized that I only refer to it in consequence of the important bearing which, viewed in the light of Koch's discoveries, it has upon the mode of development of the disease. I refer to the necessity of at once checking diarrhœa during cholera epidemics. It has long been a moot point whether that diarrhœa has any real connection with the cholera, or whether it is non-specific, and simply a pre-disposing cause of the graver disease. But the experience of every country has pointed to the advisability of assuming it to be a precursor of the dangerous choleraic phenomena. Where diarrhœa dispensaries have been established, where house to house visitations have been made for the purpose of seeking out and promptly dealing with cases of diarrhœa, and where men congregated in large public works have been systematically attended for a similar object, fatal cases of cholera have been extremely rare. Where anti-diarrhœal treatment has been refused, or where no such precautions have been taken, other circumstances being apparently identical, a vastly greater mortality has occurred. Koch tells us that while the stools are still fœcal, his microbe is to be found in them, though in small numbers, and the French Commissioners, as the result of their observations, propound the theory that the immense predominance of Koch's microbe in the rice-water stage of the disease is due to the fact that they find in the characteristic intestinal contents a medium peculiarly suitable for their multiplication. These facts, viewed in con-

nection with the results of the treatment of the early diarrhœa, seem to prove that, as Budd maintained, this diarrhœa is unquestionably specific, and that, when the quantity of infection received is small, it takes some time for the microbe to develop in sufficient numbers to produce the amount of intestinal irritation required to provoke those watery excretions in which alone it is capable of multiplying with a rapidity defying the resources of medicine. They explain the *rationale* of preventing by anti-diarrhœal medicines the development of a menstruum in which the microbe can flourish, and they enable us to understand how the administration of purgatives, or the ingestion of food of a nature to produce diarrhœa, by creating a menstruum in which the microbe can multiply with unchecked energy, may, in cases where even a single specific germ has found its way into the intestines, provoke the fatal evolution of the disease.

And now let us consider, if it is not already too late, the possibility of preventing the malady from reaching our shores. So long as Europe is free from cholera that is a matter of comparative ease, although the outbreak at Toulon proves that even the elaborate precautions adopted by France are impotent to close every fissure through which the disease may enter. But if the neighbouring shores of Europe once become infected no precautions that man can conceive can guard us against the risk of invasion. St. Kilda is separated by sea from the nearest land to a distance greatly exceeding the breadth of the Channel. It has so little communication with the mainland that the arrival of a vessel is quite an event in its history, and yet cholera found its way to St. Kilda without any trace of a vehicle by which it could have been imported. How came it there? How came the microbes of putrefaction to those high air currents on the Mer de Glace where Pasteur found them, though much less abundantly than in the air of the plains?

But for one germ which may be imported by air, or carried

in letters, merchandise, or clothing, an infected cholera patient will produce millions. How are you to deal with the thousands of persons who daily travel between this country and the continent? You may keep a watch on long sea traffic, but what of the passengers whose voyage is counted by minutes or hours. We don't know exactly how long cholera takes to develop, but from the first symptoms it takes some days. Mr. Goodeve allows two or three days, with a considerably longer time if, as Koch's discoveries seem to show we should, we include choleraic diarrhœa and other preliminary disturbances. In epidemics of typhoid propagated by milk, 14 days have been found to elapse between the consumption of the infecting milk and the patient being stricken down. The first case of cholera which occurred in Bristol in 1866, occurred in a sailor who had sailed from Rotterdam—to which port Budd ascribed the infection—ten days before his malady declared itself. In as many hours hundreds of passengers each day arrive in London from Paris and Brussels. How are you to eliminate the disease from them? Fumigation and baths may purify their skin, but how are you to reach their viscera? An effective quarantine might establish a first line of defence in the Channel Ports, but from them the disease would spread as it is spreading from Toulon. And an effective quarantine would be almost as intolerable as an effective blockade, so intolerable and so impracticable, indeed, that there is no thought of resorting to it.

It is all the more needful, therefore, that effective steps should be organised to prevent the spread of the disease should it be introduced, and it would pay us all the better to take steps for the purpose, inasmuch as if by good fortune we escape an invasion from cholera the measures would be equally effective against typhoid and other diseases which we have always with us. When they were applied in Bristol, as I have already said, not only was cholera defied, but the death rate from all causes fell to the unprecedentedly low figure of 12 per 1000, while Clifton, with its 20,000 inhabitants, passed an entire week with-

out one death. What is wanted to bring about this happy state of things is what one looks for in vain in the vague circulars issued by Government whenever cholera threatens us, but what Dr. Budd never tired of preaching, and what he described as "Sanitation by Anticipation." "To cope successfully with so fatal "a dilemma there is but one possible way—TO BE BEFOREHAND "WITH THE POISON." And how? "Disinfect your closets and "your privies every night and morning, so long as cholera prevails "in England, and you will do more to keep the disease away from "your house and from your city than can be done by any other "means." Such was the proclamation which, acting on Dr. Budd's advice, the authorities at Bristol put forth, and in order to enable it to be acted on they supplied disinfectants gratis. The latrines of great works were disinfected at least one or twice daily, and the sewers were disinfected by placing within them sulphate of iron in bulk. "In these various ways," writes Dr Budd, "a chemical bed was prepared for the poison, by whose action the "population was ensured against harm from any specific germs "that by accident or other cause might find their way into the "drains or sewers of the town. The sulphate of iron in the "drain, thus lying in wait for the poison, may be likened to the "wire gauze of the Davy lamp, always at hand to prevent the "explosion of the fatal fire-damp."

There was a pure water supply in Bristol. In London, unfortunately, the supply is most polluted. But we may do something to "be beforehand with the poison" even there. We can redouble the precautions to be adopted by water companies in filtration—filtering after delivery, from a public health point of view, is utterly unreliable—we can regularly test the physiological purity of our water supplies by gelatine cultivations in the manner suggested by Dr. Angus Smith, and we can proscribe supplies which disclose a superabundance of microbe life. We can "be beforehand with the poison" by compelling the effective disinfection of the contents of cholera corpses, and compelling their burial or destruction in a manner which will not con-

stitute a danger to public health. We can "be beforehand with the poison" by organising our anti-diarrhœal precautions before it arrives. And it seems to me that in the light of the recent demonstrations of the extraordinary tenacity of life exhibited by microbe spores and the impotency of accepted disinfectant processes to destroy them, we can "be beforehand with the poison" by elaborating more effective and certain methods of disinfecting the abodes of the sick than are usually adopted at present.

But can we not strike a little further back, and stamp out the disease in its great breeding place? India is ours, and cannot we free it, and in freeing it go far to free the world, from the cholera poison? It may be too much to say that we shall ever succeed entirely in such an attempt, but of this not a shadow of a doubt can remain in the mind of any one who reads Koch's account of the cholera tanks of Bengal, who studies Hunter's horrible description of the stricken crowds of pilgrims who each year carry cholera seed from the Juggernaut festivals at Orissa, and who winds up with a perusal of Surgeon-General De Renzy's paper, to which I have before referred that much could easily be done in India enormously to cut down the cholera supply of Europe, and free the civilized world from those periodical invasions from which, so long as India remains neglected, no conceivable amount of precaution is likely to ensure our prolonged escape.

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