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VOLCANIC ACTION AS A CAUSE OF OUTBREAKS
OF EPIDEMIC DISEASE.

By NOEL BARDSWELL, M.D., M.R.C.P. Edin. and Lond.

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VOLCANIC ACTION AS A CAUSE OF OUTBREAKS OF EPIDEMIC DISEASE.¹

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THE subject of the following essay is in accordance with the terms of the bequest of the late Dr. John Parkin, Fellow of the Royal College of Physicians, Edinburgh, the founder of the Parkin Prize for essays on certain subjects connected with medicine. Judging from his published works on this subject, Dr. Parkin included under the head of Volcanic Action all the natural phenomena associated with the molten interior of the earth, namely, volcanic eruption, earthquakes, etc., and it is chiefly the relation of the latter to epidemic outbreaks that I have considered in this essay. Before going further, I will very briefly review what literature I have been able to find bearing on the subject.

The first instance which I can find of any author definitely attributing outbreaks of epidemic disease to volcanic activity is an article written by Mr. Webster.² In 1843 a work was published in Paris by Dutrouleau and Gounet, in which they described various ailments and lesions which were due to an earthquake.³

In 1851, John Parkin, the physician already referred to, published a large work,⁴ in which he strongly advocated the claim of volcanic action to be regarded as the cause of cholera and other epidemic diseases. He advanced as his arguments the following characteristics which volcanic action and cholera epidemics have in common:—(1) Progression along particular lines; (2) more marked towards the sea and near large expanse of water; (3) limited duration—periodical return, with total cessation in a particular locality after certain definite periods. His views were very ably attacked, as not being in accordance with facts, by the then Registrar-General in his Report on the Cholera Epidemic in India, published shortly after the appearance of Parkin's work. Dr. Parkin wrote a reply in support of his theory, illustrating it with several maps designed to show the coincidence of cholera tracks with lines of volcanic action. That Dr. Parkin's theory had a fairly wide acceptance, is shown by the fact that his work was reproduced in a Spanish journal.⁵

GEOGRAPHICAL DISTRIBUTION OF VOLCANIC ACTION AND DISEASE.—In a map illustrating Geikie's "Physical Geography," and showing the geographical distribution of volcanic activity throughout the world, the countries most subject to earthquakes are

¹ Awarded Parkin Prize, 1900.

² "On the Connection of Earthquakes with Epidemic Disease," Medical Report, New York, 1801.

³ "Relation medico-chirurgicale de tremblement de terre."

⁴ "The Remote Cause of Epidemic Diseases," 1851.

⁵ *Boletín de med. y cirug.*, Madrid, 1855.

seen to be Portugal, Italy, Beloochistan, Afghanistan, the Bengal Presidency of India, Japan, Mexico, and the Pacific Coast of South America. All the areas marked light blue by Professor Geikie are, he says, liable to occasional earthquake shocks of varying degrees of intensity. Volcanic vents, both active and dormant, are chiefly to be found in the following regions:—Iceland, the Canary Isles, South Italy, and Sicily, the islands encircling the Pacific Ocean, including especially Japan, Philippine Islands, and Sandwich Islands, the Islands of the Malay Archipelago, including Java and Sumatra, the West Indian Islands, Mexico, and the Pacific Coast of South America.

DISEASES MOST PREVALENT IN VARIOUS VOLCANIC DISTRICTS.—The following table is designed to illustrate the above, the death-rate being added where obtainable:—

Name of Country.	Most Prevalent Diseases.
Iceland	{ Enteric fever. Endemic pneumonia.
Italy	{ Malaria . Deaths—5·0 per 10,000. Enteric fever „ 9·6 „ Enteritis } „ 29·4 „ Diarrhœa }
Portugal	{ Malaria. Enteric fever.
Canary Islands	{ Diarrhœal diseases. Leprosy and phthisis are common.
Japan	Cholera.
India (Bengal Presidency)	Enteric and cholera.
Beloochistan	{ Enteric and dysentery.
Afghanistan	
Java	{ Malaria and dysentery.
Sumatra	
Mexico	

This next table shows the total death-rates per 1000 in several countries, volcanic and non-volcanic:—

Death-Rate per 1000, calculated from Average of Ten Years.

Great Britain	19·2
France	22·0
Germany	25·7
Switzerland	21·0
Sweden	17·6
Italy	28·1
Portugal	23·4
Sandwich Islands	26·0
Jamaica	23·0

The bare statistics of these tables at first sight seem to support the theory of earlier writers, namely, that there is a higher death-rate in volcanic than in non-volcanic countries, but almost certainly local conditions of soil, climate, latitude, etc., are the chief deter-

mining factors. Nor does there appear to be any especially fatal disease common to volcanic countries in different parts of the globe. Cholera, enteric fever, and dysentery, as Parkin observed, are certainly very deadly in many volcanic countries situated in the tropics, yet the same diseases are comparatively rare in equally volcanic countries situated in a more temperate zone, and are replaced, as chief cause of death, by some other malady, *e.g.* malaria in Italy and Portugal. It seems, therefore, that the presence of volcanic activity in a country as a whole has no obvious effect on the death-rate or incidence of epidemic disease. However, it is well in this respect to compare the statistics of two parts of one same country, subject and not subject to volcanic disturbance respectively. On referring to Geikie's map of the geographical distribution of volcanic activity, it may be seen that in the United States the Southern States on the Atlantic seaboard (in fact, south of New York) are subject to earthquakes (the earthquakes at Charleston being perhaps the best known of recent years), while the rest of the States on the same seaboard are quite free from such visitations. The volcanic area includes the following States:— Virginia, Kentucky, North and South Carolina, Alabama, Georgia, Tennessee, and Florida.

The following table gives the vital statistics of the States included in the volcanic area and of the States adjoining:—

State.	Total Death-rate.	Malaria.	Enteric.	Phthisis.
VOLCANIC AREA.	Virginia . . .	16.3	23.7	Average for the four States. 30.1 141.7
	North Carolina . .	15.8	44.6	
	South Carolina . .	15.4	46.4	
	Kentucky . . .	14.3	31.3	
	Tennessee . . .	16.8	35.2	22.3 111.6
	Alabama . . .	14.2	73.4	
	Georgia . . .	13.9	49.1	
	Florida . . .	11.7	95.2	
Average . . .		14.8	49.8	26.2 126.6
NON-VOLCANIC AREA.	Maine . . .	14.6	2.8	Average for the eight States. 18.0 147.0
	New York . . .	17.3	11.4	
	Pennsylvania . .	14.9	6.3	
	Michigan . . .	12.1	16.2	
	New Hampshire .	16.1	3.0	
	Vermont . . .	15.1	5.9	
	Massachusetts .	18.6	2.3	
	Rhode Island . .	17.0	0.8	
Average . . .		15.0	6.0	18.0 147.0

In the statistics just quoted, the total death-rate is that per 1000 from all causes; and that from malaria, enteric, and phthisis, the number of deaths from each of these diseases per 1000 deaths from all causes.

On comparing the figures, it will be noticed that, while the total death-rate is practically the same in the two areas, the death-rates from malaria and enteric are very much higher in the area subject to volcanic activity than in the other. The death-rate from phthisis is, however, somewhat smaller in the former than in the latter part of the country. Turning now to the statistics of another volcanic country, namely, Italy, we see that there is an area of maximum volcanic disturbance made up of South Italy, Sicily, and the Lipari Islands, which includes the famous vents of Vesuvius, Stromboli, and Etna.

The next table gives the vital statistics for this area of Italy, and for the adjoining part of the country:—

Number of Deaths in 10,000 of the Population.

Mortality by the Population.						
Department.	Malaria.	Enteric.	Dysentery.	Diarrhœa.	Phthisis.	
VOLCANIC.	{ Sicily	8.4	14.3	6.0	40.0	Average considerably below that for the whole of Italy.
	{ Calabria	20.4	10.7	5.0	35.0	
	{ Basilicata	27.5	9.4	8.0	56.0	
	{ Apulia	14.6	18.7	2.40	44.6	
	{ Campania	2.5	7.2	2.63	28.6	
Average	14.6	12.0	4.8	40.8	...	
NON-VOLCANIC.	{ Abruzzio }	8.4	9.6	0.60	38.5	...
	{ Molise }
	{ Latium	13.2	3.2	0.60	22.5	...
	{ Marches	0.8	6.2	0.96	28.9	...
	{ Umbria	1.5	6.6	4.0	22.0	...
	{ Tuscany	1.4	11.2	1.9	19.2	...
Average	5.0	7.7	1.6	26.2	...	

It will be seen from the above tables that the death-rates from malaria, enteric, dysentery, and diarrhœal diseases are all considerably higher in the area most disturbed by volcanic phenomena, than in the adjoining part of the country farther removed from the chief centres of such activity. According to Davidson,¹ the average death-rate from phthisis for the whole of Italy is 23.9 per 10,000, but that the Departments of Sicily, Basilicata, Calabria, and Apulia all show death-rates from this disease considerably below the mean.

¹ "Geographical Pathology," vol. i. p. 233.

Comparing the American and Italian statistics, it is seen that they show somewhat similar results, namely, an increased death-rate from malaria, enteric, etc., with a lessened death-rate from phthisis, in the areas associated with volcanic activity as compared with the non-volcanic regions. That these figures are not mere coincidences, and that the increased death-rate in the districts described is really due to their liability to volcanic phenomena, rather than to other local conditions, are deductions which I feel that I should be very cautious in drawing. It does not, however, seem to me to be unlikely that volcanic action may be one of various determining factors of the high mortality, especially in towns possessing anything like modern water supply and drainage systems.

THE EFFECT OF EARTHQUAKES IN THE PRODUCTION OF EPIDEMIC DISEASE.—Taking volcanic phenomena *seriatim*, I will first consider the effects of earthquakes. When we consider that even in England earth vibrations are now and again sufficiently severe to cause leakages from drain and water pipes,¹ it is not surprising to learn that in towns situated on lines of volcanic activity such a state of things has not unfrequently been found to exist in a very marked degree, by medical committees appointed to investigate the cause of outbreaks of epidemics, *e.g.* in Naples and Yokohama. That towns thus situated should be of all towns particularly subject to epidemics of disorders associated with faulty drainage, is exactly what one would expect. To give statistical proofs of this fact is, however, a matter of some difficulty, owing to the impossibility in many cases of getting access to reliable figures. However, the evidence which I have been able to collect bearing on this subject has convinced me that volcanic action in the shape of earthquakes is responsible for outbreaks of epidemic disease, especially of cholera and typhoid, occurring in towns such as I have just described, and that these outbreaks are directly due to the rapid dissemination of the causes of these diseases from an infected locality by means of the water supply, which has become contaminated with sewage owing to the leaking condition of the pipes, cesspools, etc. In answer to my request for some information as to the attitude of Japanese sanitary authorities in this respect, Mr. J. Milne, late Professor of Seismology at the University of Tokio, tells me that "of course wells, water, and drain pipes are interfered with by earthquakes," and it is clear that the making of these structures proof against danger from earth vibrations is a matter of great importance for Japan, since, as at Tokio at the present moment, modern systems of underground water and drainage are rapidly replacing more primitive methods in that country.

EXPERIENCE OF THE TOWN OF YOKOHAMA.—The history of the town of Yokohama is one of very great interest, as affording

¹ *Trans. Inst. Civil Engineers.*

evidence of the close relationship, as cause and effect, existing between damaged water and drainage systems and epidemics of disease. This town is notoriously subject to constant shocks of earthquake, often of a very severe nature; in fact, it is situated on one of the chief lines of volcanic activity in Japan.

Turner, writing on the construction of the Yokohama water-works in 1887,¹ says: "The attention of the municipal authorities of this town was forcibly directed to the insanitary state of affairs, by recurrent epidemics of cholera during the past twenty years, and an official investigation by the late Dr. Geerts proved the close relationship existing between the use of water from polluted sources and the virulent development of choleraic disease." I am indebted to the Asiatic Society of London for permission to read and make the following abstract from the original report.² Dr. Geerts gives the following statistics of the cholera epidemic of 1877:—

Persons.	Attacked.	Died.
Inhabitants	731	404
Travellers	21	12
Total	752	416

He then reports the result of "systematic investigation into the nature of the water supply of Yokohama," which appears to have been both well water and water brought by pipes to the town from a distant reservoir, the latter of which was found to be quite pure at its source. The result of an analysis of 2324 samples of water taken from various parts of the town, was that 14·5 per cent. of them were found to be contaminated by sewage. He then goes on to describe the drains, which he found to "consist of narrow leaky drains connected with underground cylinders of pottery." Turner, in the paper already referred to, gives us another account of the drains. He says: "The main drains had flat wooden floors and covers and stone sides, and some were built of brick, and all that were opened were surrounded by earth saturated with sewage." Geerts also stated that "many houses were connected with cesspools of various sizes, many of which were damaged and cracked, thus constituting sources of danger. The descriptions just quoted were not those of the results of a severe recent earthquake, but rather the natural sequence of an almost constant

¹ *Trans. Inst. Civil Engineers*, vol. c.

² "On the Drinking Water of Yokohama, and the Necessity for its Improvement, in relation to Continual Outbreaks of Cholera," by Geerts, *Trans. Asiatic Soc. of Japan*, 1878, vol. vii.

succession of shocks of varying intensity continued over a prolonged period. The investigation convinced Geerts that "the defective condition of the drains was the cause of the bad condition of the drinking water, and the propagation of epidemic diseases, such as cholera, typhoid fever, etc." The result of this report being sent to the Japanese Government was that it was decided to introduce into Yokohama a new high pressure water supply, and to reconstruct the drainage system; and it is evident that it was fully realised that ordinary methods of such construction would have to be largely modified in view of the local conditions, if the new schemes were to permanently save the town from the danger of leaking pipes and the consequent ravages of epidemics, to which it had for long been subject. In Mr. Turner's paper is an interesting account of the modifications adopted, and it may be taken as an expert opinion on the question of how best to prevent damage to underground water carriage systems by earthquakes; and since the satisfactory solution of this problem must do much to improve the health of towns in volcanic countries, I do not think it is irrelevant to briefly notice the plan adopted. Turner says that personal observation convinced him that it would be imprudent to rely upon obtaining watertight structures by brick, masonry, or concrete alone. He therefore encased the service reservoirs and other water receptacles in puddle freely used, and prepared and laid with the greatest care, and used lead joints for the pipes. "Selection and manipulation of the puddle clay, upon which it was felt that the water tightness entirely depended, was directed with the greatest care. The clay was thoroughly aerated and disintegrated by frost during the winter before it was used. It was then cut, watered, and trodden four times *in situ*." 18-in. main pipes were used, jointed with yarn and lead, depth of lead being 2 in., and average thickness of joints $\frac{3}{8}$ in. When laid in gravel soil, brick-in-cement lining was resorted to. Distribution was by lead service pipes. With regard to the new drainage scheme, Dr. Geerts evidently distrusted any form of underground system, for he recommended in his report "the replacement of drains by watertight open conduits, with free water flushing." The drainage of the town was thoroughly reorganised and reconstructed, but whether or not Dr. Geerts' suggestions were adopted I have been unable to find out. The carrying out of these two schemes of improvement has proved very satisfactory for Yokohama. Turner says that the "absence of leakage from any part of the water-work system, notwithstanding several severe earthquakes and multitudes of smaller shocks, demonstrates the efficacy of puddle properly worked in earthquake countries. The health of the town, as regards epidemic disease, has greatly improved since the improvements, the mortality from enteric fever especially having notably diminished, as reported by Davidson.¹

¹ "Geographical Pathology," 1892.

The history of Yokohama, summed up briefly, is as follows:—

A town situated in a district constantly disturbed by volcanic activity, had an appalling death-rate from epidemic diseases, especially cholera and typhoid fever. An investigation proved conclusively that the contamination of drinking water by sewage was the cause of the epidemics, and that the cracked and leaking condition of the drainage and water systems was the cause of the contamination. New systems of water supply and sewage removal were then constructed, special precautions being taken to guard against injury to the pipes, etc., by earth vibrations, and, as a result, the epidemics to which Yokohama had grown accustomed are now a thing of the past, and the death-rate from enteric, instead of being enormous, compares very favourably with that of most European towns.

In view of the light thrown by the history of Yokohama upon the relationship of volcanic action to the causation of epidemic disease, it seems to be not at all improbable that a state of affairs similar to what was found in Yokohama might arise in many towns, which are fairly often visited by slight earth shocks, though perhaps they may but rarely amount to what would be popularly called an earthquake.

The city of Naples is a town of this description, its proximity to Vesuvius rendering it liable to frequent earth oscillations, (now and again amounting to definite earthquakes), phenomena inseparable from that of eruption. The following extract from a report on the sanitation of Naples is therefore of much interest: ¹—

“The imperfections of the drainage and water pipes culminated in a severe cholera epidemic in 1884, during which the total mortality rose to 6971 persons, out of a population of 504,700, or a death-rate of 13·8 per 1000. The drainage works consisted of some fifty principal sewers, emptying into the Bay of Naples, but owing to numerous leakages they had led to all kinds of insanitary dangers.”

The fact that very free communication existed between the drainage and the water supply was demonstrated in the following interesting way, for an account of which I have to thank an English doctor living in Naples. On the outbreak of cholera, the sanitary authorities flushed the drains very freely with carbolic acid. As a result, the drinking water became so strongly leavened with carbolic, that the people refused to drink it, imagining that the unwonted taste was due to some poison which had got into the water supply, and was causing the epidemic.

Since that date, new drainage and water-supply works have been constructed, and the health of the town has improved.

THE EFFECT OF THE RIVIERA EARTHQUAKE OF 1887 ON THE MORTALITY FROM EPIDEMIC DISEASE.—It may be remembered that a fairly severe shock of earthquake travelled through the

¹ *Deutsche Vrtljschr. f. öff. Gsndhtspf.*, Braunschweig, 1894.

Riviera in 1887, and did a great deal of damage. The destruction of houses, etc., naturally attracted most general attention, but, as one would expect, bearing in mind the experience of Yokohama and Naples, the drainage and water systems also suffered severely. I hear from residents in several of the towns visited by the earthquake, that great cracks were made in the cesspools, and that the drainage pipes were rendered leaky. For some time after the earthquake, the well-known Riviera towns had an unenviable reputation for being unhealthy, and were avoided by visitors in consequence. Hoping that figures might support the statement that the earthquake was followed by epidemics of disease, I have endeavoured to get statistics of the towns in question, namely, Alassio, Porto Maurizio, San Remo, Mentone, Nice, and Cannes. I have only been able to get the figures for Nice, Cannes, and Mentone, and for the following table of the mortality in those towns from enteric fever I am indebted to the courtesy of Dr. Bertillon. Unfortunately, to quote Dr. Bertillon's letter, "Je n'ai pu vous donner les renseignements que depuis 1886. Avant cette époque, ils n'existent pas." The table thus gives the statistics for the year before the shock, the year of the shock, and for the four following years:—

Death-Rate from Enteric Fever: 1886 to 1891.

Town.	1886.	1887.	1888.	1889.	1890.	1891.
Nice	35	49	90	80	35	20
Cannes	3	8	13	2	6	2
Mentone	3	9	12	2	1	3
Total	41	66	115	84	42	25

The figures show that a serious epidemic of enteric fever broke out in Nice after the earthquake, and that for the two following years the death-rate from this form of epidemic disease was considerably more than twice as high as the average for that town. In both Cannes and Mentone the deaths from enteric were four times as many during the year after the earthquake as in the previous year.

Taking the statistics for the three towns together, it will be noticed that, as compared with the mortality from enteric in 1886, there was a marked increase in 1887, the year of the earthquake, in the following year the number of deaths had nearly trebled, after which the death-rate (though still above the average) gradually declined. I hear also from resident medical men that for some time after the earthquake there was quite an epidemic of septic sore throats. The data afforded us by Yokohama,

Naples, and the Riviera towns prove very conclusively that earthquakes may be the cause of outbreaks of epidemics of disease, and since they are due to the damage done to drainage and water supply, it is perhaps as well to briefly refer to various precautionary measures which should be taken by towns liable to volcanic disturbance.

Milne, speaking on the subject, says that the best sites for cities, waterworks, etc., and the best course in which to lay main pipes, may with advantage be determined by a seismic survey, which will indicate the lines of least movement. Low ground, ground that is marshy, also deep sloping ground, or that situated over geological faults, should be avoided.¹ These principles are enforced by the building laws of Manila and Ischia, which were drawn up after their destruction by earthquakes. It would seem that the plan of encasing in puddle clay, which has proved so satisfactory in Yokohama, might also be adopted with advantage.

THE INFLUENCE OF THE EARTHQUAKE AT CHARLESTON, U.S.A., IN 1885, ON EPIDEMIC DISEASE.—I have already briefly referred to the city of Charleston as being situated in the part of the United States subject to volcanic disturbance. A severe earthquake shock visited Charleston in 1885, and several interesting papers were written in the course of the next year upon the influence of the earthquake upon the public health. Two of the most important articles, written by Guiteras and Porcher, I fortunately have for reference. For this advantage I am much indebted to Surgeon-Major Menill, Librarian of the U.S. Army Medical Library, Washington, who kindly sent me copies of both publications.

Guiteras divides the pathological effects produced by the earthquakes under three heads, namely—(1) Mechanical, (2) Nervous, and (3) Epidemic.

The first heading does not come within the scope of this essay, and the epidemics of neurosis I will refer to later. Writing on the subject included under the third heading, he says: "Certain it is that a mild fever prevailed during the months of September and October, and that it went by the name of earthquake fever. It was characterised by catarrh of the air passages, irregular pains, some fever, and occasionally gastro-intestinal disturbances and jaundice. Some suspicion of dengue was at first aroused, but they were soon dissipated. The epidemic of this disease persisted throughout the winter, the pulmonary complications being quite severe. Two facts militate against the view that the epidemic was due to exposure, namely, the frequent presence of symptoms that were not exclusively catarrhal, and the warm and dry weather that prevailed during the seismic period. I may add that the recrudescency of the catarrhal epidemic is culminating at present in an epidemic of pneumonia of low type."

¹ *Trans. Inst. Civil Engineers*, and Appendix by F. Milne to "Construction of Waterworks" by Burton.

Further on in his paper he notices the great increase in the death-rate from malaria which followed the earthquake, namely, thirty-seven deaths in one quarter as compared with seventeen during the same quarter of the previous year; and this fact is of interest, in view of the much higher death-rate from malaria that we find in the volcanic areas of the States and in Italy, as compared with the non-volcanic.¹ Guiteras and others, whilst observing the fact, do not attempt to explain it, so I may perhaps be pardoned in offering, as a suggestion, the possibility that the mechanical disturbance of the marshy ground may be the cause. It is one of the most generally accepted axioms of the West African Coaster, that the digging or otherwise disturbing virgin soil is of all pursuits the one most liable to be followed by a bad attack of malarial fever. A few years ago, when visiting the railway being built from Lagos into the interior, I was much struck by the fear Europeans had of engaging on this work. They had good grounds, however, since in the preceding twelve months, so I was told, 50 per cent. of the Europeans working on the line had died of malaria, a bad record even for West Africa.

I do not know whether the observed connection between disturbances of virgin soil and incidence of malaria is accounted for by modern theories of malarial etiology, but if the West Coaster's observations are correct, it is only to be expected that malaria should be unusually prevalent in malarious districts after an earthquake. That the malarious district near Charleston were much disturbed by the earthquake, is shown by the fact that "smells like that of gas or sulphur were noticed by passengers travelling to Charleston by the N.E. Railway, which were probably caused by the emanations from the extensive marshes of this region" (Porcher).

In addition to that for malaria, it is to be noticed that, as at Naples and Yokohama, the mortality from enteric fever and choleraic diseases also increased after the earthquake.

Statistics of Death-Rate in Charleston for the corresponding Quarters of the Years 1885 and 1886.

Disease.	Number of Deaths.	
	1885. ¹	1886.
Malaria	17	37
Typhoid fever	7	10
Dysentery	0	7
Choleraic diseases	22	38

¹ *Vide* "Statistics," pp. 8-10.

Unfortunately I cannot obtain statistics of mortality from the so-called "earthquake fever"; presumably it was not a very fatal, although a widely distributed epidemic.

EARTHQUAKES AS A CAUSE OF EPIDEMICS OF NEUROSIS.—*Hysterical symptoms, etc.*—Instances of epidemic hysteria due to various causes are now and again reported in the Medical Journals, and it causes me but little surprise to find that quite a number of travellers and writers in volcanic countries have described epidemics of neurosis which have followed the occurrence of volcanic phenomena. The following types of cases seem to be the most familiar:—

TYPES OF CASES WHICH MAY BE MET WITH IN EPIDEMICS OF NEUROSIS AFTER EARTHQUAKES, ETC.—1. *Various functional disturbances*, namely—(1) Nausea; (2) vomiting; (3) headache; (4) vertigo (5) diarrhoea; (6) frequent micturition; (7) hysterio-epilepsy (8) disordered sensation, namely tingling, pins and needles, etc.

2. *Various abnormal mental conditions*, namely—(1) Condition of nervous apprehension; (2) depression and prostration; (3) moral instability—loss of control; (4) mania; (5) insanity.

3. *Functional paralysis*, namely—(1) Paralysis of limbs; (2) railway spine.

Lastly, it appears that some of these symptoms already mentioned may develop into organic lesions, or organic lesions may directly follow the shock; *e.g.* multiple neuritis (two cases recorded by Guiteras), paraplegia, and other forms of paralysis, sometimes ending in a fatal result.

1. *Functional disturbances—Nausea, etc.*—Milne has written some very interesting notes on this subject, from the point of view of a lay observer.¹ He says that a whole community, by repetition of small earthquakes, may be gradually worked up into a state of mental nervousness, and that many are often seized with feelings of nausea and sickness. In one instance, all the pupils of a large school were thus affected. Mr. Milne also quotes from Temple's description of the earthquake at Naples in 1732.² Temple says that "the second shock, which was the least terrifying, had a great effect upon the nerves. Almost every one was seized with a shaking just as if they had the palsy, the teeth chattering in their heads to such a degree that they could hardly speak. Even people who did not feel the shock were seized in the same way. They all complained of headache for some time after." Similar manifestations are recorded as having been noticed after the earthquake in London,³ and that of Yokohama in 1880. Numerous instances of this nervous vomiting, etc., were noticed by Porcher and Guiteras during the epidemic of neurosis which followed the Charleston earthquake in 1885.⁴ Porcher

¹ "Earthquake Effects, Emotional and Moral, *Trans. Seismol. Soc. of Japan*, Yokohama, 1887, vol. xi.

² *Phil. Trans.*, London, vol. xlv.

³ *Ibid.*

⁴ *Med. News*, Phila., 1886.

says that "after the earthquake some persons were attacked with nausea, accompanied by vomiting, which recurred or persisted in some cases for days." Mr. S. and Mr. H. also had nausea, accompanied by colic and diarrhoea. Guiteras in his paper already referred to, when writing on the nervous effects produced by the earthquake, says "that the majority of symptoms were evidently hysterical. The functional disturbances may be classified as vertigo, nausea, vomiting, diarrhoea, and frequent micturition." *A propos* of the same subject, Stuart of Beaufort wrote as follows:¹—"It was curious to note the number of persons, both male and female, particularly female, who suffered from nausea after the earthquake. This I attributed to fear, but many disclaimed any feelings of fear, and yet continued to suffer from the symptoms of nausea. In some cases the nervous symptoms were more serious. In one patient, that of a young lady, hysterical convulsions developed.

2. *Abnormal mental conditions*.—Dr. Porcher of Charleston recorded several cases of severe mental disturbance amongst the numerous list of neurosis which followed the 1885 earthquake. He attributed them to anxiety and prolonged loss of rest. In an article in the *Medical News* he says that two such persons will require to be sent to an asylum, and that another case under his observation had not (at the time of writing) recovered sanity. To Dr. Sturge of Nice I am indebted for some interesting personal reminiscences of the Riviera earthquake in 1887 bearing on this subject. He tells me that in quite a number of cases real nerve-shock was produced, which there can be no doubt in several instances resulted in death. Of equal clinical interest are the cases of what Sturge calls "late nerve shock," "consisting of a state of nervous apprehension, most difficult to deal with, which developed insidiously a month or six weeks after the shock, in people of good nerves, who suffered no fright at the time, and whom one looked upon as quite strong-minded, and out of reach of nervous disturbances of the kind." A similar type of case is described by Porcher, which "occurred in an active, strong, hard-working man, who was not unnerved by the shock, but who had finally to succumb, with his nerves completely shattered." Another observation on the curious mental effect which may be produced by earthquakes is made by Sekiza of Tokio University.² He records "that many persons became mad, and many more, though not going so far, became sick, or wasted away their property."

I was interested to receive from Prof. Milne the following advice in connection with this subject: "When treating of nervous effects of earthquakes, you should carefully distinguish between the effect on different nationalities: Europeans are

¹ "Medical Notes," U.S.A.

² "Letters on the Great Earthquake in Japan," 1891.

hysterical, especially the women; the Japanese are most distinctly less so." Cases of nervous prostration appear to be met with after earthquakes; *e.g.* Dr. Moore (U.S.A.), in his report to the State Board of Health after the earthquake in 1885, said that it "had undoubtedly produced a very deleterious effect upon feeble persons, being followed by much nervous prostration and other unpleasant symptoms. Even upon well and robust people, their effects have been striking in some instances."

3. *Functional paralysis*.—Functional paralysis appears to be one of the rarer forms of neurosis which may be met with. Dr. Porcher of Charleston records one case, that of a boy whose leg became stiff and contracted after the earthquake.¹ I hear also that numerous cases of spinal troubles, paralysis, etc., were treated in the University Hospital of Tokio after the great earthquake in 1891, but it is not clear whether they were considered organic lesions, or functional. In Dr. Sturge's opinion (from his experience after the Riviera earthquake in 1887), there is a relationship between earthquake shock effects and the so-called "railway spine," the condition being far more due to the mental state produced than to the physical shaking, in his opinion.

EPIDEMIC OUTBREAKS OF OTHER DISEASES FOLLOWING EARTHQUAKES.—1. *Conjunctivitis and keratitis*.—Guiteras records² that a severe form of conjunctivitis and keratitis became epidemic after the Charleston earthquake, the inflammation frequently being accompanied with superficial and painful ulceration of the cornea. He attributes this to irritation set up by particles of lime and other débris.

2. *Tetanus and erysipelas*.—After the great earthquake in Japan of 1891, both erysipelas and tetanus were extremely common complications among the injured, in fact, sufficiently so to attract the attention of lay historians of that event. Dutrouleau and Gounet, in their work on the earthquake in Guadeloupe (1843), also remark on the number of cases of tetanus which were observed after that shock.

THE EFFECTS OF VOLCANIC GASES AND VAPOURS.—Apart from fairly numerous instances of death having been caused by inhalation of volcanic gases escaping from fissures in the earth (*e.g.* in Java), I can only find two instances of volcanic gases causing disease. The first is recorded by Daubney in his famous work on "Volcanoes." Describing his tour through the volcanic province of Basilicata in South Italy, he writes *à propos* of the town of Maina, "that since the cutting down of a wood between this town and the mephitic lake, a disease has broken out amongst the inhabitants due to the inhalations of deleterious gases which were now much more noticeable in the town." He then describes the disease as being one of the liver, and characterised clinically by marked pallor of the complexion. Volcanic gases usually consist

¹ *Med. News*, Phila.

² *Ibid.*

chiefly of hydrochloric and sulphurous acids and sulphuretted hydrogen. The second instance is recorded by De Corogna in his work on the "Eruption of Santorin."¹ He says that there were many cases of bronchitis and of other troubles, due to irritation of the air passages, which arose from the presence in the air of sulphuretted hydrogen and other irritating gases.

In conclusion, I wish to express my thanks to the following gentlemen, who have personally given me information:—Prof. Milne, Prof. Geikie, Dr. Bertillon (Paris), Dr. Tatham (Superintendent of Statistics, Somerset House), Dr. Sturge (Nice), Dr. Gairdner (Naples), Dr. Michael Foster (San Remo), and Dr. Harris (Teneriffe).

¹ "De l'influence des emanations volcaniques sur les êtres organisés, particulièrement étudiée à Santorin pendant eruption de 1866."









