

A S T U D Y
OF THE
INFLUENCE OF WEATHER AND SEASON
UPON PUBLIC HEALTH, &c.

III. THE INFLUENCE OF DAILY RANGE OF ATMOSPHERIC
TEMPERATURE.

BY
EDWARD BALLARD, M.D. LOND., M.R.C.P.,
MEDICAL OFFICER OF HEALTH FOR ISLINGTON.

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THE influence of variations of daily range of temperature may be studied by itself on Tables I and II accompanying this paper. The first or *primâ facie* inference that would be drawn from them is that an alteration of range, if slight (under 2 degrees) or moderate (2 and under 5 degrees) is calculated to lessen sickness, and if considerable (to the extent of 5 degrees and upwards) to increase sickness, and that the result is the same, although different in degree, whether the alteration of range be by way of increase or diminution. If, however, we take into our consideration the rise or fall of temperature accompanying these alterations of range, a somewhat different aspect is given to the results. With a view to the condensation of my remarks, however, I shall not enter fully into this part of the question, limiting myself to an inquiry into the modification which simultaneous increase or

decrease of daily range introduces into the results upon sickness of a rise and fall of mean temperature.

In Table III I have tabulated separately the weeks of rise and fall of mean temperature, distinguishing those weeks in which the rises or falls were associated with increase or with diminution of mean daily range.

I. Upon the results of rises.

Among the 196 weeks of rise of mean temperature tabulated in my first communication, there were 108 in which the rise was associated with an increase, and 83 in which it was associated with a diminution, of mean daily range. Generally it may be stated that when rises of mean temperature were accompanied by an increase of daily range, their normal operation was less strongly marked than when they were accompanied by a diminution of range. Thus—

For every 1000 cases of increase of sickness there occurred—

Decrease of sickness.			
In the course of 108 weeks of rise associated with <i>increased</i> range, 514 cases.			
„ 83 „	„	<i>diminished</i> „	444 „

Now, this would be a marked result had the mean weekly extent of the rises been the same in the two series of weeks; but the result becomes more striking still when we observe that the mean extent of the rises in the former set of weeks (4.35 degrees) was greater than it was in the latter set of weeks (2.95 degrees.)

1. As to the frequency of occurrence of increase of sickness in the two groups of weeks.

In the weeks of rise, with increased range, increase of sickness occurred less frequently than when the range of temperature was simultaneously reduced. In the former, increase of sickness was observed in 60.18 per cent. of the weeks, and in the latter in 63.85 per cent. This result be-

TABLE I.

Showing the relation of alterations in daily range of temperature and fluctuations of general sickness.

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Mean daily range.	No. of weeks.	Alteration of range.		Clear gain by way of increase (+) or decrease (—) of sickness. — Cases.		INCREASE OF SICKNESS.						DECREASE OF SICKNESS.						NEITHER INCREASE NOR DECREASE OF SICKNESS.			
						No. of weeks.	Alteration of range.		Frequency per cent. of weeks.	Amount of increased sickness. — Cases.		No. of weeks.	Alteration of range.		Frequency per cent. of weeks.	Amount of decreased sickness. — Cases.		No. of weeks.	Alteration of range.		Frequency per cent. of weeks.
		Sum.	Mean.	Sum.	Mean.																
Altered generally	386	1143·4°	2·9°	— 222	— 0·5	193	611·9°	3·1°	50·00	6335	32·8	188	531·5°	2·8°	48·70	6557	34·8	5	16·9°	3·3°	1·29
Slightly altered.....	171	159·8°	0·9°	— 379	— 2·2	81	73·2°	0·9°	47·36	2483	30·6	87	86·6°	0·9°	50·87	2862	32·8	3	3·8°	1·2°	1·75
Moderately „ ...	138	452·3°	3·2°	— 246	— 1·7	66	222·7°	3·3°	47·82	2386	36·1	71	229·6°	3·2°	51·44	2632	37·0	1	3·2°	3·2°	0·72
Considerably „ ...	77	531·3°	6·9°	+ 403	+ 5·2	46	316·0°	6·8°	59·74	1466	31·8	30	215·3°	7·1°	38·96	1063	35·4	1	9·9°	9·9°	1·29
Unaltered	7	—	—	+ 196	+ 28·0	5	—	—	71·42	213	42·6	2	—	—	28·57	17	8·5	—	—	—	—

TABLE II.

Showing the relation of variations in daily range of temperature, whether by way of increase or diminution, and fluctuations of general sickness.

1. Daily range increased.

Mean daily range.	No. of weeks.	Alteration of range of increase (+) or decrease (—) of sickness.		Clear gain by way of increase (+) or decrease (—) of sickness. — Cases.		INCREASE OF SICKNESS.						DECREASE OF SICKNESS.						NEITHER INCREASE NOR DECREASE OF SICKNESS.			
						No. of weeks.	Alteration of range of increase (+) or decrease (—) of sickness.		Frequency per cent. of weeks.	Amount of increased sickness. — Cases.		No. of weeks.	Alteration of range of increase (+) or decrease (—) of sickness.		Frequency per cent. of weeks.	Amount of decreased sickness. — Cases.		No. of weeks.	Alteration of range of increase (+) or decrease (—) of sickness.		Frequency per cent. of weeks.
		Sum.	Mean.	Sum.	Mean.																
Increased generally ..	197	+ 574·0°	+ 2·9°	+ 259	+ 1·3	99	+ 310·4°	+ 3·1°	50·25	3202	32·3	95	+ 258·4°	+ 2·7°	48·22	2943	30·9	3	+ 5·2°	+ 1·7°	1·52
Slightly increased.....	90	+ 88·6°	+ 0·9°	+ 13	+ 0·1	44	+ 44·2°	+ 1·0°	48·88	1428	32·4	44	+ 42·4°	+ 0·9°	48·88	1415	32·1	2	+ 2·0°	+ 1·0°	2·22
Moderately „ ...	71	+ 235·8°	+ 3·3°	— 13	— 0·1	34	+ 119·4°	+ 3·5°	47·88	1072	31·5	36	+ 113·2°	+ 3·1°	50·70	1085	30·1	1	+ 3·2°	+ 3·2°	1·40
Considerably „ ...	36	+ 249·6°	+ 6·9°	+ 259	+ 7·1	21	+ 146·8°	+ 6·9°	58·33	702	33·4	15	+ 102·8°	+ 6·8°	41·66	443	29·5	—	—	—	—

2. Daily range decreased.

Decreased generally ...	189	— 586·3°	— 3·1°	— 481	— 2·5	94	— 301·5°	— 3·2°	49·73	3133	33·3	93	— 273·1°	— 2·9°	49·20	3614	38·8	2	— 11·7°	— 5·8°	1·05
Slightly decreased ...	81	— 75·0°	— 0·9°	— 392	— 4·8	37	— 29·0°	— 0·7°	45·67	1055	28·5	43	— 44·2°	— 1·0°	53·08	1447	33·6	1	— 1·8°	— 1·8°	1·23
Moderately „ ...	67	— 219·7°	— 3·2°	— 233	— 3·4	32	— 103·3°	— 3·2°	47·76	1314	41·0	35	— 116·4°	— 3·3°	52·23	1547	44·2	—	—	—	—
Considerably „ ...	41	— 291·6°	— 7·1°	+ 144	+ 3·5	25	— 169·2°	— 6·7°	60·97	764	30·5	15	— 112·5°	— 7·5°	36·58	620	41·3	1	— 9·9°	— 9·9°	2·43

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comes the more striking when it is observed that both the mean extent of the rises of temperature and of the alteration of range was greater in the former than in the latter group of weeks.

In the weeks of slight alteration of range, however, the frequency of increase of sickness was greater when it was by way of increase than when it was by way of diminution; in the former it occurred in 59·45 per cent. of the weeks, and in the latter in only 56·09 per cent. But then it is to be observed that extent of the rises was greater in the former than in the latter group of weeks.

In the weeks of moderate and considerable increase of range the frequency of occurrence of increase of sickness was much less than in those weeks when the rises were associated with a lessening of the range; thus—

In the weeks of moderately increased range increase of sickness occurred in 57·44 per cent. of the weeks, and in those of moderately diminished range in 69·23 per cent. Yet the mean extent of the rises in the former group of weeks was 4·29 degrees, and in the latter only 2·92 degrees.

In the weeks of considerably increased range increase of sickness occurred in 66·66 per cent. of the weeks, and in those of considerably diminished range in 75·0 per cent. Yet the mean extent of the rises in the former group of weeks was 5·59 degrees, and in the latter only 4·15 degrees.

2. As to the clear gain by way of increase of sickness in the two groups of weeks.

Deducting the cases of decrease from those of increase of sickness in the two groups of weeks, and taking a mean of the weekly clear gain by way of increase of sickness, we find that, on the whole, in those weeks of rise of mean temperature which were accompanied by an increased daily range the normal operation of the rises was less in amount than in those weeks in which the range was simultaneously lessened; the former gave a clear mean weekly gain of 9·9 cases, while the latter gave a clear gain of 12·7 cases per week.

It was only in the cases of *slight* alteration of range that an opposite result was obtained.

Taking now further into our consideration the mean extent of the rises of temperature in the two groups of weeks, it is worthy of observation that throughout each series the corresponding weeks of increased range presented a greater mean rise than those of diminished range. Normally, this might have been expected to have resulted in a greater clear gain by way of increase of sickness in the former than in the latter group throughout. That the actual result was the reverse of this serves greatly to strengthen the inference drawn on the first view of the Table.

The following Table exhibits more fully the apparent operation of increase or diminution of range in association with the question of the extent of the rise of temperature.

TABLE IV.—*General results where rises of mean temperature were associated with increase or decrease of mean daily range.*

	Number of weeks.	Total extent of rises in degrees.	Esti- mated clear gain by way of increase of sick- ness.	Actual clear gain by way of increase of sick- ness.	Number of cases of in- crease above or below es- timate.	Number of degrees of rise of temperature re- presented by the differ- ence of estimated and actual increase.	
			Cases.	Cases.	Cases.	Sum.	Weekly mean.
Range increased generally.	108	469.8°	1484	1077	— 407	—128.79°	— 1.19°
slightly increased ...	37	133.8°	423	393	— 30	— 9.49°	— 0.25°
moderately „ ...	47	201.8°	638	256	— 382	—120.88°	— 2.57°
considerably „ ...	24	134.2°	424	428	+ 4	+ 1.26°	+ 0.05°
Range decreased generally.	83	246.9°	780	1051	+ 271	+ 85.75°	+ 1.03°
slightly decreased ...	41	104.1°	329	56	— 273	— 86.39°	— 2.10°
moderately „ ...	26	76.1°	230	650	+ 420	+132.91°	+ 5.11°
considerably „ ...	16	66.7°	211	345	+ 134	+ 42.40°	+ 2.65°

3. *As to the amount of increase of sickness, when increase occurred, in the two groups of weeks.*

In the 65 weeks of rise with increased range, in which increase of sickness actually occurred, the mean amount of the increase was 34.1 cases ; while in the 53 weeks accompanied by diminished range the mean amount of the increase of sickness was 35.7 cases. This difference, slight at the first glance, becomes more important when it is observed that in the 65 weeks the mean extent of the rises of temperature was 4.61 degrees, while in the 53 weeks it was less, namely, 3.48 degrees.

4. *As to the amount of decrease of sickness, when decrease occurred, in the two groups of weeks.*

In the 42 weeks of rise with increased range, in which decrease of sickness took place, the mean amount of the decrease was 27.1 cases ; while in the 30 weeks of rise with diminished range it was 28 cases. This is a trifling difference, but it acquires more importance when it is observed that the mean extent of the rises (3.96 degrees) in the former set of weeks was nearly twice as great as in the latter (2.07 degrees). Viewing this difference in the extent of the rises by itself, we should have anticipated a much greater difference in the amount of the decreases of sickness when they occurred. That the difference thus anticipated did not exist must be attributed to the operation of the increased range assisting the other causes of decrease in the 42 weeks of rise, and to the operation of the lessened range antagonising the causes of decrease in the 30 weeks of rise.

II. *Upon the results of falls.*

Among the 193 weeks of fall of mean temperature formerly tabulated there were 87 in which the fall was as-

sociated with an increase, and 104 in which it was associated with a diminution, of mean daily range.

As with rises, so too with falls, it may be stated generally that the normal operation of the falls upon fluctuations of sickness was, on the whole, less strongly marked when they were accompanied by an increase than when they were accompanied by a diminution of daily range. Thus—

For every 1000 cases of decrease of sickness there occurred—

		Increase of sickness.	
In the course of 87 weeks of fall associated with <i>increased</i> range,	555 cases.		
„ 104 „	<i>diminished</i> „	430	„

The mean extent of the falls was not very different in the two groups of weeks, being 3·55 degrees in the one and 3·70 degrees in the other.

1. *As to the frequency of occurrence of decrease of sickness in the two groups of weeks.*

In the weeks of fall with an increased range decrease of sickness occurred rather less frequently than when the range of temperature was diminished. In the former, decrease of sickness was observed to occur in 58·62 per cent. of the weeks, while in the latter it occurred in 59·61 per cent. The difference is trifling. Taking into account the different extent of the alteration of range in the several weeks, it is to be observed that in the 12 weeks of considerably increased range the frequency of occurrence of decrease of sickness was greater, on the whole, than in the 24 weeks of considerably diminished range. On making a further inquiry into this apparent anomaly, however, it is found that it depends upon a difference in the results of considerably altered range when associated with falls in the colder and warmer seasons of the year. In the 7 weeks with a mean temperature below 50°, in which the range was considerably increased, decrease of sickness occurred in 71·42 per cent. of the weeks, while in the 9 corresponding weeks, with considerably diminished

range, decrease of sickness occurred in only 44·44 per cent., notwithstanding that the mean extent of the falls in the latter set of weeks was nearly twice as great as in the former. On the other hand, the result in the warmer season, in weeks with a mean temperature of 50° and upwards, was more normal; in the 5 weeks of considerably increased range decrease of sickness occurred in 40 per cent., and in the 15 weeks of considerably diminished range in 46·66 per cent.

2. As to the clear gain by way of decrease of sickness in the two groups of weeks.

Deducting the cases of increase from those of decrease of sickness in the two groups of weeks, and taking a mean of the weekly clear gain by way of decrease of sickness, we find that, on the whole, in those weeks in which a fall of temperature was accompanied by an increased daily range, the normal operation of the falls was much less in amount than in those weeks in which the range was simultaneously lessened; the former gave a mean clear weekly gain, by way of decrease of sickness, of 9·0 cases, the latter of 15·1 cases. But here again we observe that, while in the weeks of slight and moderate alteration of range the general rule was followed, it was otherwise in the weeks of considerable alteration of range. In these weeks the clear gain was greater where the range was increased than in those where it was diminished. Here also again we find the anomaly is to be referred to a difference of results in the cooler and warmer seasons of the year. In the colder seasons, in those weeks in which the mean temperature was below 50°, the mean clear gain by way of decrease of sickness was 29·8 cases in the weeks of considerably increased range, and only 8·7 cases in those of considerably diminished range, notwithstanding that in the latter weeks the mean extent of the falls was very much greater than in the former weeks. On the other hand, in the warmer season of the year, in the weeks with a mean temperature of 50° and upwards, there was

actually a clear gain of increase of sickness in the weeks where the range was considerably increased to the mean extent of 8 cases; while there was a clear gain, by way of decrease, to the mean extent of 11·4 cases in those weeks in which the daily range was lessened.

The following Table exhibits more fully the apparent operation of increase or diminution of range in association with the question of the extent of the falls of temperature.

TABLE V.—*General results where falls of mean temperature were associated with increase or decrease of mean daily range.*

	Number of weeks.	Total extent of falls in degrees.	Estimated clear gain by way of decrease of sickness.	Actual clear gain by way of decrease of sickness.	Number of cases of decrease above or below estimate.	Number of degrees of fall of temperature represented by the difference of estimated and actual decrease.	
			Cases.	Cases.	Cases.	Sum.	Weekly mean.
Range increased generally .	87	309·2°	977	788	— 189	— 59·81°	— 0·68°
slightly increased ...	53	199·0°	629	380	— 249	— 78·79°	— 1·48°
moderately „ ...	22	83·0°	262	239	— 23	— 7·27°	— 0·33°
considerably „ ...	12	27·2°	86	169	+ 83	+ 26·26°	+ 2·18°
Range decreased generally.	104	385·3°	1218	1575	+ 357	+ 112·97°	+ 1·08°
slightly decreased ...	40	108·9°	344	448	+ 104	+ 32·91°	+ 0·82°
moderately „ ...	40	171·3°	541	877	+ 336	+ 106·32°	+ 2·65°
considerably „ ...	24	105·1°	332	250	— 82	— 25·94°	— 1·08°

3. *As to the amount of decrease of sickness, when decrease occurred, in the two groups of weeks.*

In the 51 weeks of fall with increased range, in which decrease of sickness actually occurred, the mean amount of the decrease was 34·7 cases; while in the 62 weeks accompanied by diminished range the mean amount of the

decrease was 44·6 cases. There was very little difference in the mean extent of the falls in these two groups of weeks. Taking the extent of the falls into consideration, however, in those weeks in which the alteration of range was 5 degrees and upwards, the mean decrease in the weeks of increased range was somewhat larger than in those of diminished range. On further inquiry we find that this depends on a difference in the kind of result in the colder from that observed in the warmer season of the year. In the colder season (mean temperature below 50°) the mean decrease of sickness in the weeks of considerably increased range was 53·2 cases, while it was 51·5 cases in the weeks of considerably lessened range, notwithstanding that the mean extent of the falls was greater. In the warmer season, however, the mean decrease in the weeks of considerably increased range was 29·5 cases, and in those of considerably lessened range 44·7 cases.

4. As to the amount of increase of sickness, when increase occurred, in the two groups of weeks.

In the 34 weeks of fall with increased range, in which increase of sickness occurred, the mean amount of the increase was 28·9 cases; while in the 40 weeks of fall with diminished range it was 29·7 cases. The virtual difference, when the extent of the falls in the two groups of weeks is taken into consideration, is somewhat greater than this. Now if, as appears to be true, a diminished range is opposed to an increase of sickness in weeks of fall of temperature, we must recognise here a concentration of the other supplementary causes of increase of sickness in the 40 weeks of diminished range. This concentration chiefly took place in the weeks in which the range was considerably altered. This does not appear at first sight; but it comes out distinctly on calculating the force of the influence exerted by the falls, varying in extent, in each of the subordinate groups of weeks. Thus, in the 22 weeks of slightly increased range the antagonistic force opposed to the falls equalled that normally exerted by 20 degrees of rise, while in the 14 weeks of slightly

diminished range by 19·1 degrees of rise; in the 7 weeks of moderately increased range it equalled that exerted by 21·9 degrees of rise, and in the 14 weeks of moderately diminished range by 20·7 degrees of rise. On the other hand, in the 5 weeks of considerably increased range the antagonistic force opposed to the falls equalled that normally exerted by only 13·0 degrees of rise, while in the 12 weeks of considerably diminished range it equalled that exerted by 22·4 degrees of rise. Again, it comes out, on pursuing the inquiry, that while the normal influence of the alteration of range was exerted in the warmer season of the year, it was otherwise in the colder season, since with a mean extent of falls of 1·45 degree the mean increase of sickness in 2 weeks was 28·5 cases, in the warmer season with a mean fall of 6·80 degrees it was nearly the same, namely, 25·4 cases.

I may state here that I have found, by pursuing the inquiry into the influence of daily range upon sickness by a totally different method, that its operation in the colder season of the year is very much less than in the warmer season, being quite subordinate to that of the temperature, while in the warmer season the reverse is the case.

The diagrams published with my first communication illustrate both this and the preceding paper.