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

II. A COMPARISON OF THE INFLUENCE OF VARIATION OF
TEMPERATURE UPON GENERAL SICKNESS IN THE COLDER
AND WARMER SEASONS OF THE YEAR.

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

Received May 13th.—Read June 23rd, 1868.

IN my former communication I pointed out the influence exerted by rises of mean temperature in increasing general sickness, and by falls in decreasing it, and endeavoured to establish the limits within which this operation is exercised. The question now arises, whether this influence is exerted in a similar manner and to an equal extent in the colder and warmer seasons of the year.

I may say here at the outset (for the fact is apparent on the most superficial view of the tables) that, whether we regard the frequency with which sickness occurred with rises of mean temperature and decreases with falls, or whether we regard the clear gain by way of increase as the result of the conditions operating in the weeks of rise or by way of decrease in the weeks of fall, or the amount of increase or

decrease of sickness in each set of weeks, the grand result is that, on the whole, the association of increase of sickness with rises, and of decrease of sickness with falls, is very much more marked in the colder than in the warmer seasons of the year.

I do not think I shall be far wrong in attributing this remarkable result to an essential difference in the signification of the term "mean temperature," when applied to these weeks respectively, and in considering that it is closely connected with the question of the diurnal range of atmospheric temperature. In the colder season of the year the diurnal range is comparatively small; in the warmer it is comparatively great. Hence in the colder season the "mean temperature" represents more closely the real temperature during all the twenty-four hours of each day of which a week consists; in the warmer season it represents it less closely, and, whatever the day temperature may be, its operation would be greatly modified by the lessened temperature of the night.

We may first of all compare the proportion borne by the cases of increase of sickness to those of decrease in the weeks of rise, and the proportion borne by the cases of decrease of sickness to those of increase in the weeks of fall, as exhibited in the Tables I and II, for the colder and warmer seasons respectively. I draw my line at 50° , the average temperature of the colder weeks of rise being $43\cdot2^{\circ}$, and of the warmer $58\cdot9^{\circ}$, and the average temperature of the colder weeks of fall being $40\cdot6^{\circ}$, and of the warmer $57\cdot1^{\circ}$.

1st.—As respects the weeks of rise of mean temperature.

For every 1000 cases of increase of sickness there occurred—

In the course of the 88 *colder* weeks of rise generally 345 cases of decrease of sickness.

"	108 warmer	"	620	"
"	28 colder	slight rise	1083	"
"	42 warmer	"	716	"
"	33 colder	moderate rise	285	"
"	40 warmer	"	1022	"
"	27 colder	considerable rise	123	"
"	26 warmer	"	177	"

Tables showing the relation between fluctuations of mean weekly temperature and weekly fluctuations of general sickness at mean temperatures below and above 50°.

TABLE I.—Rises.

(At temperatures below 50°.)

Rises.	No. of weeks.	Mean temperature.	Sum of rises.	Mean weekly rise.	Clear gain by way of increase (+) or decrease (—) of sickness.		INCREASE OF SICKNESS.						DECREASE OF SICKNESS.						NEITHER INCREASE NOR DECREASE OF SICKNESS.						
							No. of weeks.	Mean temperature.	Sum of rises.	Mean weekly rise.	Frequency of increase per cent. of weeks.	Amount of increased sickness.		No. of weeks.	Mean temperature.	Sum of rises.	Mean weekly rise.	Frequency of decrease per cent. of weeks.	Amount of decreased sickness.		No. of weeks.	Mean temperature.	Sum of rises.	Mean weekly rise.	Frequency per cent. of weeks.
					Sum.	Mean.						Sum.	Mean.												
Generally ...	88	43·2°	366·0°	4·15°	+ 1509	+ 17·1	59	43·2°	271·3°	4·59°	67·04	2306	39·08	29	43·3°	94·7°	3·26°	32·95	797	27·4	—	—	—	—	—
Slight.....	28	42·5°	28·4°	1·01°	— 34	— 1·2	16	42·4°	17·1°	1·06°	57·14	405	25·3	12	42·7°	11·3°	0·94°	42·85	439	36·5	—	—	—	—	—
Moderate ...	33	42·8°	117·2°	3·55°	+ 546	+ 16·5	21	42·0°	74·9°	3·56°	63·63	764	36·3	12	44·2°	42·3°	3·52°	36·36	218	18·1	—	—	—	—	—
Considerable.	27	44·4°	220·4°	8·16°	+ 997	+ 36·9	22	44·9°	179·3°	8·15°	81·48	1137	51·6	5	42·6°	41·1°	8·22°	18·51	140	28·0	—	—	—	—	—
(At temperature of 50° and upwards.)																									
Generally ...	108	58·9°	367·5°	3·40°	+ 737	+ 6·8	62	58·4°	226·2°	3·64°	57·40	1940	31·2	45	59·5°	137·8°	3·06°	41·66	1203	26·7	1	63·5°	3·5°	3·5°	0·92
Slight.....	42	58·2°	42·3°	1·00°	+ 216	+ 5·1	24	57·5°	21·9°	0·91°	57·14	761	31·7	18	59·2°	20·4°	1·13°	42·85	545	30·2	—	—	—	—	—
Moderate ...	40	59·0°	127·8°	3·19°	— 12	— 0·3	19	59·0°	62·9°	3·31°	47·50	531	27·9	20	58·8°	61·4°	3·07°	50·00	543	27·1	1	63·5°	3·5°	3·5°	2·50
Considerable.	26	59·8°	197·4°	7·59°	+ 533	+ 20·5	19	59·1°	141·4°	7·44°	73·07	648	34·1	7	61·9°	56·0°	8·00°	26·92	115	16·4	—	—	—	—	—

TABLE II.—Falls.

(At temperatures below 50°.)

Falls.	No. of weeks.	Mean temperature.	Sum of falls.	Mean weekly fall.	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.	Mean temperature.	Sum of falls.	Mean weekly fall.	Frequency of increase per cent. of weeks.	Amount of in-creased sickness. — Cases.		No. of weeks.	Mean temperature.	Sum of falls.	Mean weekly fall.	Frequency of decrease per cent. of weeks.	Amount of de-creased sickness. — Cases.		No. of weeks.	Mean temperature.	Sum of falls.	Mean weekly fall.	Fre- quency per cent. of weeks.
					Sum.	Mean.						Sum.	Mean.												
Generally ...	103	40·6°	433·3°	4·20°	— 2149	— 20·8	31	41·4°	135·5°	4·37°	30·09	925	29·8	71	40·2°	297·1°	4·18°	68·93	3074	43·2	1	44·1°	0·7°	0·70°	0·97
Slight.....	22	41·2°	23·8°	1·08°	— 247	— 11·2	7	43·1°	7·0°	1·00°	31·81	335	47·8	14	40·0°	16·1°	1·15°	63·63	582	41·5	1	44·1°	0·7°	0·70°	4·54
Moderate ...	49	40·7°	170·8°	3·48°	— 882	— 18·0	14	42·0°	54·3°	3·83°	28·58	407	28·6	35	40·2°	116·5°	3·32°	71·42	1289	36·8	—	—	—	—	—
Considerable.	32	40·1°	238·7°	7·45°	— 1020	— 31·8	10	39·3°	74·2°	7·42°	31·25	183	18·3	22	40·4°	164·5°	7·47°	68·75	1203	54·6	—	—	—	—	—
(At temperatures of 50° and upwards.)																									
Generally ...	90	57·1°	266·8°	2·73°	— 136	— 1·5	45	57·7°	125·2°	2·78°	50·00	1328	29·5	42	56·6°	139·2°	3·31°	46·66	1464	34·8	3	55·8°	2·4°	0·80°	3·33
Slight.....	36	56·9°	36·3°	1·00°	+ 315	+ 8·7	19	57·4°	20·9°	1·10°	52·77	693	36·4	15	56·4°	15·0°	1·00°	41·66	378	25·2	2	55·8°	0·4°	0·2°	5·55
Moderate ...	38	58·0°	119·2°	3·13°	— 86	— 2·2	20	58·6°	63·3°	3·16°	52·63	448	22·4	17	57·3°	53·9°	3·17°	44·73	534	31·4	1	56·0°	2·0°	2·0°	2·63
Considerable.	16	55·6°	111·3°	6·95°	— 365	— 22·8	6	55·3°	41·0°	6·83°	37·50	187	31·1	10	55·7°	70·3°	7·03°	62·50	552	55·2	—	—	—	—	—

2nd.—As respects the weeks of fall of mean temperature.
 For every 1000 cases of decrease of sickness there occurred—

In the course of the 103 *colder* weeks of fall generally 300 cases of increase of sickness.

„	90 <i>warmer</i>	„	907	„
„	22 <i>colder</i>	slight fall	572	„
„	36 <i>warmer</i>	„	1833	„
„	49 <i>colder</i>	moderate fall	315	„
„	38 <i>warmer</i>	„	838	„
„	32 <i>colder</i>	considerable fall	152	„
„	16 <i>warmer</i>	„	338	„

From which it is apparent that in weeks of rise of mean temperature (with the solitary exception of those of slight rise) the tendency to increase of sickness was greater in the colder than in the warmer weeks; and that in the weeks of fall of mean temperature, whatever the extent of the fall, the tendency to decrease of sickness was greater in the colder than the warmer weeks.

RISES OF MEAN TEMPERATURE.

In the colder weeks of the year a rise of mean temperature was associated with increase of sickness more frequently than in the warmer weeks; that is, in 67·04 per cent. of the colder, and in 57·4 per cent. of the warmer weeks. In the following Table III, which relates to the clear gain by way of increase of sickness, I estimate, as in my former paper, 1 degree of rise or fall of mean temperature as equivalent, normally, to 3·16 cases of increase or decrease of sickness.

TABLE III.—*General results of the 88 rises in weeks with a mean temperature below 50°.*

Rises.	Number of rises.	Total extent in degrees.	Estimated clear gain by way of increase of sickness.	Actual clear gain by way of increase of sickness.	Number of cases of increase above or below estimate.	Number of degrees of rise of temperature represented by the difference of estimated and actual increase.	
			Cases.	Cases.	Cases.	Sum.	Weekly mean.
Generally ...	88	366·0°	1156	1509	+ 353	+ 111·70°	+ 1·26°
Slight.....	28	28·4°	89	...	— 123	— 38·92°	— 1·39°
Moderate ...	33	117·2°	370	546	+ 176	+ 55·69°	+ 1·71°
Considerable.	27	220·4°	696	997	+ 301	+ 95·25°	+ 3·52°

General results of the 108 rises in weeks with a mean temperature of 50° and upwards.

Generally ...	108	367·5°	1161	737	— 424	— 134·17°	— 1·24°
Slight.....	42	42·3°	133	216	+ 73	+ 23·10°	+ 0·55°
Moderate ...	40	127·8°	403	...	— 415	— 131·32°	— 3·28°
Considerable.	26	197·4°	623	533	— 90	— 28·48°	— 1·09°

The clear gain by way of increase of sickness in the colder weeks of rise of mean temperature was more than twice as large as in the warmer weeks, although the total sum of rises in each series was nearly the same. In the 88 *colder* weeks the clear gain exceeded considerably that which, according to my tables, might have been anticipated, the excess being such as might have been looked for had the mean weekly extent of the rises been 1·26 degree greater than it was. On the other hand, in the 108 *warmer* weeks it was considerably less than might have been anticipated, the deficiency being equivalent to what might have been looked for had the mean weekly extent of the rises been 1·24 degree less than it was.

Table IV exhibits the extent of operation of the rises, and of supplementary influences co-operating with or antagonising them, in the colder and warmer weeks in which the rises were associated on the one hand with increase, or on the other with decrease of sickness.

TABLE IV.—*Amount of increase of sickness when increase occurred.*
In weeks below 50° mean temperature.

Rise.	Number of weeks of increased sickness.	Extent of rise.		Value in degrees of rise of temperature of supplementary causes of increase in predominant operation.		Value in degrees of rise of temperature of united causes of increase of sickness.		Estimated increase of sickness.		Amount of increase due to supplementary causes.		Joint result of rises of temperature and supplementary causes of increase.	
		Sum.	Mean.	Sum.	Mean.	Sum.	Mean.	Sum.	Mean.	Sum.	Mean.	Sum.	Mean.
Generally ..	59	271·3°	4·59°	458·54°	7·77°	729·84°	12·36°	857	14·5	1449	24·5	2306	39·08
Slight.....	16	17·1°	1·06°	111·07°	6·94°	159·82°	8·00°	54	3·3	351	22·0	405	25·3
Moderate ...	21	74·9°	3·56°	167·08°	7·95°	241·98°	11·51°	236	11·2	528	25·1	764	36·3
Considerable.	22	179·3°	8·15°	180·69°	8·21°	359·99°	16·36°	566	25·7	571	25·9	1137	51·6
<i>In weeks above 50° mean temperature.</i>													
Generally ...	62	226·2°	3·64°	387·97°	6·25°	614·17°	9·89°	714	11·5	1226	19·7	1940	31·2
Slight.....	24	21·9°	0·91°	218·98°	9·12°	240·88°	10·03°	69	2·8	692	28·9	761	31·7
Moderate ...	19	62·9°	3·31°	105·37°	5·54°	168·27°	8·85°	198	10·4	333	17·5	531	27·9
Considerable.	19	141·4°	7·44°	63·92°	3·36°	205·32°	10·80°	446	23·5	202	10·6	648	34·1

*Amount of decrease of sickness when decrease occurred.
In weeks below 50° mean temperature.*

Rises.	Number of weeks of decreased sickness.	Extent of rise.		Value in degrees of fall of temperature of supplementary causes of decrease in predominant operation producing manifest decrease of sickness.		Value in degrees of fall of supplementary causes of decrease nullifying rises and producing manifest decrease of sickness.		Estimated normal increase of sickness nullified.		Manifest decrease of sickness produced.		Virtual decrease of sickness.	
		Sum.	Mean.	Sum.	Mean.	Sum.	Mean.	Sum.	Mean.	Sum.	Mean.	Sum.	Mean.
Generally ...	29	94.7°	3.26°	252.13°	8.69°	346.83°	11.95°	299	10.3	737	27.4	1096	37.7
Slight.....	12	11.3°	0.94°	139.01°	11.58°	150.31°	12.52°	36	3.0	439	36.5	475	39.5
Moderate ...	12	42.3°	3.52°	69.09°	5.75°	111.39°	9.27°	134	11.2	218	18.1	352	29.3
Considerable.	5	41.1°	8.22°	44.02°	8.80°	85.12°	17.02°	129	25.8	140	28.0	269	53.8
<i>In weeks above 50° mean temperature.</i>													
Generally ...	45	137.8°	3.06°	380.55°	8.45°	518.35°	11.51°	435	9.7	1203	26.7	1638	36.4
Slight.....	18	20.4°	1.13°	172.32°	9.57°	192.72°	10.70°	64	3.6	545	30.2	609	33.8
Moderate ...	20	61.4°	3.07°	171.82°	8.59°	233.22°	11.66°	194	9.7	543	27.1	737	36.8
Considerable.	7	56.0°	8.00°	36.08°	5.15°	92.08°	13.15°	177	25.3	115	16.4	292	41.7

FALLS OF MEAN TEMPERATURE.

In the colder weeks of the year a fall of mean temperature was much more frequently associated with decrease of sickness than in the warmer weeks; that is, in 68·93 per cent. of the colder, and in 46·66 per cent. of the warmer weeks.

The following table relates to the clear gain by way of decrease or increase of sickness.

TABLE V.—*General results of the 103 falls in weeks with a mean temperature below 50°.*

Falls.	No. of falls.	Total extent in degrees.	Estimated clear gain by way of decrease of sickness.	Actual clear 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.
Generally ...	103	433·8°	1368	2149	+ 781	+247·15°	+ 2·40°
Slight.....	22	23·8°	75	247	+ 172	+ 54·43°	+ 2·47°
Moderate ...	49	170·8°	540	882	+ 342	+108·22°	+ 2·20°
Considerable.	32	238·7°	754	1020	+ 266	+ 84·17°	+ 2·62°

General results of the 90 falls in weeks with a mean temperature of 50° and upwards.

Generally ...	90	266·8°	843	136	— 707	—223·73°	— 2·48°
Slight.....	36	36·3°	115	...	— 420	—132·91°	— 3·69°
Moderate ...	38	119·2°	377	86	— 291	— 92·08°	— 2·42°
Considerable.	16	111·3°	352	365	+ 13	+ 4·11°	+ 0·25°

The clear gain by way of decrease of sickness in the colder weeks of fall of mean temperature was nearly sixteen times as large as in the warmer weeks. This is not sufficiently accounted for by the difference in the sum of the falls in the

two series of weeks, since the sum of the falls in the colder weeks does not amount to twice that in the warmer weeks. In the 103 colder weeks the clear gain by way of decrease of sickness was such as might have been looked for had the mean weekly extent of the falls been 2·4 degrees greater than it was, and in the 90 warmer weeks such as might have been looked for had it been 2·48 degrees less than it was.

Table VI exhibits the extent of operation of the falls of mean temperature that took place, and of supplementary co-operating and antagonistic influences in weeks in which the falls were associated on the one hand with decrease, on the other with increase of sickness.

TABLE VI.—Amount of decrease of sickness when decrease occurred.
In weeks below 50° mean temperature.

Falls.	Number of weeks of decreased sickness.	Extent of falls.		Value in degrees of fall of temperature of supplementary causes of decrease in predominant operation.		Value in degrees of fall of temperature of united causes of decrease of sickness.		Estimated decrease of sickness.		Amount of decrease due to supplementary causes.		Joint results of falls of temperature and supplementary causes of decrease.	
		Sum.	Mean.	Sum.	Mean.	Sum.	Mean.	Sum.	Mean.	Sum.	Mean.	Sum.	Mean.
Generally ...	71	297.1°	4.18°	675.63°	9.51°	972.73°	13.69°	989	13.2	2135	30.0	3074	43.2
Slight.....	14	16.1°	1.15°	168.03°	12.00°	184.13°	13.15°	51	3.6	531	37.9	582	41.5
Moderate ...	35	116.5°	3.32°	291.45°	8.32°	407.95°	11.64°	368	10.5	921	26.3	1289	36.8
Considerable.	22	164.5°	7.47°	216.13°	9.82°	380.63°	17.29°	520	23.6	683	31.0	1203	54.6
<i>In weeks above 50° mean temperature.</i>													
Generally ...	42	139.2°	3.31°	324.05°	7.71°	463.25°	11.02°	440	10.4	1024	24.4	1464	34.8
Slight.....	15	15.0°	1.00°	104.74°	6.98°	119.74°	7.98°	47	3.1	331	22.1	378	25.2
Moderate ...	17	53.9°	3.17°	115.18°	6.77°	169.08°	9.94°	170	10.0	364	21.4	534	31.4
Considerable.	10	70.3°	7.03°	104.43°	10.44°	174.73°	17.47°	222	22.2	330	33.0	552	55.2

*Amount of increase of sickness when increase occurred.
In weeks below 50° mean temperature.*

Falls.	Number of weeks of increased sickness.	Extent of falls.		Value in degrees of rise of temperature of supplementary causes of increase in predominant operation producing manifest increase of sickness.		Value in degrees of rise of supplementary causes of increase and prolonging falls and producing manifest increase of sickness.		Estimated decrease of normal decrease of sickness nullified.		Manifest decrease of sickness produced.		Virtual increase of sickness.	
		Sum.	Mean.	Sum.	Mean.	Sum.	Mean.	Sum.	Mean.	Sum.	Mean.	Sum.	Mean.
Generally ...	31	135.5°	4.37°	292.40°	9.43°	427.45°	13.80°	428	13.8	925	29.8	1353	43.6
Slight.....	7	7.0°	1.00°	106.01°	15.14°	113.01°	16.14°	22	3.1	335	47.8	357	50.9
Moderate ...	14	54.3°	3.83°	128.79°	9.19°	183.09°	13.02°	171	12.2	407	28.6	578	40.8
Considerable.	10	74.2°	7.42°	57.91°	5.79°	132.11°	13.21°	234	23.4	183	18.3	417	41.7
<i>In weeks above 50° mean temperature.</i>													
Generally ...	45	125.2°	2.78°	420.25°	9.33°	545.45°	12.11°	396	8.7	1328	29.5	1724	38.2
Slight.....	19	20.9°	1.10°	219.30°	11.54°	240.20°	12.64°	66	3.4	693	36.4	759	39.8
Moderate ...	20	63.3°	3.16°	141.45°	7.07°	204.75°	10.23°	200	10.0	448	22.4	648	32.4
Considerable.	6	41.0°	6.83°	59.17°	9.86°	100.17°	16.69°	129	21.5	187	31.1	316	52.6