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SUGGESTIONS FOR THE LOGICAL USE

OF

HOSPITAL STATISTICS,

WITH EXAMPLES.

BY

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SUGGESTIONS FOR THE LOGICAL USE OF

*HOSPITAL STATISTICS.**

To one engaged in the treatment of Typhus Fever, especially in hospital, the question of how best to compare the statistics of practice in various hospitals possesses a very special interest. The disease, except apparently in the city of Dublin, is so clearly distinct from all other forms of continued fever; and a few hundred cases in Glasgow and in London, or elsewhere, with a certain mortality, seem so much alike, and so comparable, that comparisons are inevitably made. It was in looking over the reports of various hospitals for this purpose that ideas, not, however, new to my mind, on the leading principles to be remembered in such comparisons took shape. I hope to make it apparent that in no disease, more especially in typhus, can the results of treatment be with justice contrasted without attention to certain conditions of logical comparison, of which these are the chief:—(1) The aggregate numbers must be as nearly as possible equal. (2) They must represent cases continuously treated in one place, at one time, and as near as may be over the same space of time. (3) The numbers ought to be classified into similar periods of life, quinquenniads being most

* It having been represented to me that some portions of my report of this Hospital—recently printed by order of the Magistrates' Committee of the Board of Police of Glasgow—would interest a wider circle of the profession than they are likely to reach unless published in a medical journal, I have compiled this paper from it, and I would now merely remind medical readers that these remarks were originally written for non-medical men, and were therefore clothed, as far as possible, in words free from medical technicalities.—J. B. R.

convenient; and any comparison ought to be reduced to the results in patients of the same periods. (4) To give a sound basis to the comparison of the general mortality for all periods, the proportion of those under each quinquenniad to the whole number, must be noted. The reason of this is the obvious fact, that two sets of statistics may run parallel through all the periods, and yet differ greatly in the general mortality. If, for example, one has a much larger number between 10 and 15 at a low percentage, or a much fewer number at a high percentage, or the reverse. This is the most important of all the conditions. Most comparisons between the general percentages of hospitals are fallacious, through what may be called ambiguity of the middle term. We say the mortality in London is 19 per cent., and in Glasgow 11 per cent.; and, the percentage being less, the treatment is more successful in Glasgow. But what is the *centum* of which 19 died, and what the *centum* of which 11 died? Are they the same, or do they not differ in themselves, as well as in the external circumstances we call treatment? When we compare 19 per cent. with 11 per cent. as the interest of two sums of money, the *centum* means pounds of sterling value; but in vital statistics it means men and women, unlike, as only men and women can be unlike, in all properties and circumstances. I confine myself to the point of age, which is the all-important one for us. To institute, *prima facie*, a comparison between the treatment of 1000 patients in London and 1000 in Glasgow, starting simply from the statement that the mortality is 11 per cent. in the one and 19 in the other, is quite as fallacious as to compare interest percentages of francs and dollars. Rather a parallel would be to mix the dollars and francs, and compare two hundreds picked promiscuously from the heap, without regard to the proportion of each. In hospital statistics, the *centum* is not a standard for all hospitals, but each *centum* is peculiar to its own. *It is a hundred patients, the number of whom at each age is in the same relative ratio as in the total number treated.* The Dundee *centum* therefore differs from the London, and the London from the Glasgow *centum*; and if it be that age influences of necessity, and to a degree beyond the reach of treatment, the results of treatment, then surely to compare the general percentages of any two hospitals without expressing somehow the ratio of the ages in each is fallacious. The question is, how can this best be done? I shall first make some remarks arising from a comparison of the mortality at individual periods in four hospitals, and then proceed to discuss this question, using the cases in point as illustrations of various methods which occur to me.

TABLE No. I.

Comparative Table of Mortality of Typhus at Quinquennial Periods of Age, in Four Hospitals.

AGE.	CITY OF GLASGOW FEVER HOSPITAL.			GLASGOW ROYAL INFIRMARY.			LONDON FEVER HOSPITAL.			DUNDEE ROYAL INFIRMARY.		
	Treat.	Died.	per Cent.	Treat.	Died.	per Cent.	Treat.	Died.	per Cent.	Treat.	Died.	per Cent.
0—4,...	48	6	12.5	12	...	...	32	2	6.4	38	1	2.6
5—9,...	172	2	1.16	83	1	1.2	146	5	3.4	123	1	.8
10—14,...	245	3	1.22	150	5	3.33	231	4	1.7	222	5	2.2
15—19,...	204	15	7.3	255	17	6.2	282	13	4.6	184	8	4.2
20—24,...	126	16	12.6	192	27	14.06	242	25	10.4	126	9	7.1
25—29,...	78	11	14.1	116	18	15.51	204	25	12.3	108	7	6.4
30—34,...	80	15	18.7	79	10	12.65	185	38	20.5	60	5	8.3
35—39,...	68	15	22.	82	19	23.17	151	45	29.8	70	12	17.1
40—44,...	55	17	30.9	51	20	39.21	143	52	36.3	94	27	28.7
45—49,...	33	7	21.2	26	15	57.96	126	52	41.2			
50—54,...	17	6	35.2	16	7	43.75	102	53	52.0	43	18	41.7
55—59,...	18	9	50.	15	9	60.	41	22	53.6			
60—64,...	5	3	60.	8	3	37.5	48	30	62.5	16	8	50.
65—69,...	4	2	50.	8	5	62.5	19	14	74.0			
70—74,...	...	...	...				8	6	75.0	...	...	...
75—79,...	1	1	100.0				1	1	100.	...	...	...
All Ages,	1154	128	11.09	1093	156	14.27	1961	387	19.7	1084	101	9.3

TABLE No. II.

Comparison of the General Mortality of Four Hospitals by Marks at each Period of Age.

AGE.								City of Glasgow Fever Hospital.	Glasgow Royal Infirmary.	London Fever Hospital.	Dundee Royal Infirmary.
0—4,	...	...	...	...	...	...	...	4	1	3	2
5—9,	...	...	...	...	...	...	...	2	3	4	1
10—14,	...	...	...	...	...	...	...	1	4	2	3
15—19,	...	...	...	...	...	...	...	4	3	2	1
20—24,	...	...	...	...	...	...	...	3	4	2	1
25—29,	...	...	...	...	...	...	...	3	4	2	1
30—34,	...	...	...	...	...	...	...	3	2	4	1
35—39,	...	...	...	...	...	...	...	2	3	4	1
40—44,	...	...	...	...	...	...	...	2	4	3	1
45—49,	...	...	...	...	...	...	...	2	4	3	1
50—54,	...	...	...	...	...	...	...	2	3	4	1
55—59,	...	...	...	...	...	...	...	2	4	3	1
60—64,	...	...	...	...	...	...	...	3	2	4	1
65—79,	...	...	...	...	...	...	...	2	3	4	1
Total Marks,								35	44	44	17
Average,								2.5	3.1	3.1	1.2

TABLE NO. III.

Comparison of the General Mortality of Three Hospitals, supposing each to have 100 Patients for each Period of Age.

AGE.	City of Glasgow Fever Hospital.	Glasgow Royal Infirmary.	London Fever Hospital.
0—4,	12.5	...	6.4
5—9,	1.1	1.2	3.4
10—14,	1.2	3.33	1.7
15—19,	7.3	6.2	4.6
20—24,	12.6	14.06	10.4
25—29,	14.1	15.57	12.3
30—34,	18.7	12.65	20.5
35—39,	22.0	23.17	29.8
40—44,	30.9	39.21	36.3
45—49,	21.2	57.96	41.2
50—54,	35.2	43.75	52.0
55—59,	50.0	60.00	53.6
60—64,	60.0	37.5	62.5
65—79,	60.0	62.5	75.0
Total Deaths,	346.8	377.04	409.7
Percentage,	24.7	26.0	29.0

Tables showing Various Circumstances affecting the Average Residence in Hospital of Typhus Cases.

No. IV.—MONTHLY VARIATIONS.

MONTH.	TYPHUS.		PERCENTAGE.		AVERAGE RESIDENCE.		
	Recov.	Died	Died.	Stimld.	Recov.	Died.	Over all.
1865.							
April—May, ...	110	16	12.7	31.8	17.4	6.1	16.
June,	105	15	12.5	28.5	18.	7.2	16.9
July,	95	12	11.2	27.3	17.8	6.1	16.4
August,	93	5	5.1	33.3	19.1	5.2	18.3
September, ...	70	9	11.4	32.8	18.7	5.6	18.
October,	79	8	9.6	31.6	17.3	10.6	16.7
November, ...	92	17	15.2	50.0	21.2	7.1	19.
December, ...	89	9	9.2	31.4	19.1	11.2	18.4
1866.							
January,	98	14	12.5	32.6	18.5	7.	17.
February,	84	14	14.2	38.0	19.3	6.8	17.5
March,	64	6	8.5	40.6	19.	5.6	19.
April,	47	3	6.0	38.2	18.7	4.3	17.9
	1026	128	11.	34.3	18.8	7.0	17.5

TABLE No. V.—INFLUENCE OF AGE.

AGE.	TYPHUS.		PERCENTAGE.		AVERAGE RESIDENCE,		
	Recov.	Died.	Died.	Stimld.	Recov.	Died.	Over all.
0—4,	42	6	12·5	4·7	16·4	4·6	14·9
5—9,	170	2	1·16	10·	18·6	6·5	18·5
10—14,	242	3	1·22	16·5	18·5	14·3	18·4
15—19,	189	15	7·3	37·5	20·0	7·8	19·5
20—24,	110	16	12·6	50·	18·7	10·6	17·7
25—29,	67	11	14·1	55·2	17·6	8·3	16·3
30—34,	65	15	18·7	55·3	17·7	7·2	15·7
35—39,	53	15	22·0	58·6	18·3	3·5	15·
40—44,	38	17	30·9	63·	18·2	7·2	14·8
45—49,	26	7	21·2	69·2	18·3	4·8	15·5
50—54,	11	6	35·2	81·8	23·6	2·3	19·
55—59,	9	9	50·0	77·7	22·3	8·3	15·3
60—64,	2	3	60·0	100·	23·5	5·3	12·6
65—69,	2	2	50·0	100·	18·0	8·5	13·2
75—79,	...	1	100·	...	...	4·0	4·0
	1026	128	11·				

TABLE No. VI.

Table showing Proportion above and below Average Residence at various Periods of Age of those who Recovered.

AGE.	Average Residence of those who Recovered	IN 100.		
		Above Av.	Below Av.	At Aver.
0—4,	16·4	14·2	52·3	33·5
5—9,	18·6	28·2	20·5	51·3
10—14,	18·5	28·5	20·5	51·0
15—19,	20·0	40·7	11·6	47·7
20—24,	18·7	29·0	19·0	52·0
25—29,	17·6	20·8	29·8	49·4
30—34,	17·7	26·0	26·0	48·
35—39,	18·3	30·0	22·6	47·4
40—44,	18·2	42·0	18·4	39·6
45—49,	18·3	30·7	26·9	42·4
50—54,	23·6	54·5	9·	36·5
55—59,	22·3	44·0	22·	34·
60—64,	23·5	100·	...	...
65—69,	18·0	...	...	100·

I refer to Table No. I., a "Comparative Table of the Mortality of Typhus at Quinquennial periods of Age, in Four Hospitals," viz.:—the Magistrates' Hospital and the Royal Infirmary, Glasgow; the London Fever Hospital; and the Royal Infirmary, Dundee. The statistics of the two latter are from their last Annual Reports, and those of the Glasgow Royal Infirmary from a paper by Dr. Perry, Physician to the Fever-house, giving the results of his treatment for 1865, published in this *Journal* for January, 1866.

The first three conditions are here all satisfied. The most striking fact is one to the disadvantage of this Hospital, and also a good example of how an analysis of cases, even beyond the quinquennial periods, may prevent a fallacy, and lead to a valuable inference. The fact to which I refer is the excessive mortality of 12·5 per cent. in children below five, which is double that in London at the same age, and nearly five times that in Dundee, while in the Royal Infirmary here there were 12 cases treated without a death. This was quite inexplicable to me for a time, and still is very vexing; but a more minute analysis of my cases proved that the explanation lay in a fact which I had already seen reason to suspect—the fatality of typhus *during the period of suckling* in infants. This is shown by the following subdivision of the 48 cases treated under five years.

9 months and under,	Treated 7; died, 2, or 28·5 per cent.
Above 9 months and under 2 yrs., ..	4; .. 1, or 25·0 ..
From 2 to 4 years,	37; .. 3, or 8·0 ..

The actual ages of the seven cases aged "9 months and under" were:—8 days (*died*), 3 months, 5 months (*died*), 7 months, 8 months, and two 9 months. I have examined carefully the reports of other hospitals, and also written for more minute information, and find that none of them have any experience of patients so young, except Dundee, where they had only three—all of whom, however, recovered. In the Town's Hospital, where also children of this tender age are treated, my results were equally unfavourable. The cause of the mortality is, (1) that up to the time of admission these infants were suckled by mothers far advanced in typhus. They were therefore poisoned by the vitiated milk. (2) The deprivation of their proper food after admission, when conjoined with the constitutional effects of this circumstance, was enough, without the influence of the fever in their own systems, to cause great disturbance, or even to kill them. Indeed, except when the eruption was present, the feverishness might well be explained by gastric derangement alone.

As between the results at other quinquenniads, it will be seen that as a rule the Dundee mortality is uniformly and remarkably less, and our own follows next, but not quite decidedly until we get into the more advanced periods. At all ages above thirty my mortality is less than that of the London Fever Hospital, and, with four exceptions, at all ages whatever less than that of the Royal Infirmary. Above forty my mortality is as much as from 10 to 20 per cent. less than that of London and Glasgow. To put it in the most general way, the treatment of the aged has been more favourable, and of the young less favourable, in this Hospital than in the others I have named.

It is in the comparison of the general mortality that we find the greatest difficulty in satisfying the conditions of accuracy. There are two propositions the remembrance of which will give us considerable aid: (1) That the evil we have to contend against being the including in one category a diversity of ages, minute subdivisions of ages must be the basis of any comparison to be made. (2) That the one permanent element in these statistics is the percentage; and, since the fallacy lies in the *centum*, by operating on it and retaining the percentage we may hope to arrive at what we wish. I speak, of course, of the percentages at the various periods.

To illustrate the necessity of the measure I propose, let me take the *centum* or sample hundred of each hospital, and find what proportion of it is below twenty years of age, and how much each proportion contributes to the general percentage. I have drawn a line across my Table No. I. to indicate the boundary above and below which the greatest contrast of mortality occurs. I have tried to exhibit the result as graphically as possible:—

Mortality.		
G.F.H., 11 $\frac{1}{2}$ 100 patients,	{ of whom 57.9 are below 20, and 3.8 $\frac{1}{2}$ cent. died.	
	and 42.1 are above 20, „ 21.03 „	
G.R.I., 14 „	{ of whom 45.7 are below 20, „ 4.6 „	
	and 54.3 are above 20, „ 22.42 „	
L.F.H., 19 „	{ of whom 35.2 are below 20, „ 3.4 „	
	and 64.8 are above 20, „ 28.58 „	
D.R.I., 9 „	{ of whom 52.3 are below 20, „ 2.6 „	
	and 47.7 are above 20, „ 16.63 „	

No remarks are necessary to point the moral of these figures. Below twenty years of age the mortality must, under all circumstances, be seven or eight times less than above it; and it is impossible to compare general percentages such as those of this and the London Fever Hospital, when out of every hundred of the one only 35, as against 57 of the other, are of such an age that a small mortality is possible. And this is but a

rude way of expressing the disadvantage under which the London Hospital labours; for there is a great stretch of ages above twenty which may exist in all proportions. The question of how best to compare statistics of mortality, so as to give the *minutest* expression to differences of age and of proportions of numbers at various ages, is one to which I have given some consideration. It seems to me that, as between hospitals, the best standard is, *the lowest mortality at all periods of life*; and, therefore, that hospital is most successful which can show *the least mortality at the greatest number of periods*.

1st. This is the first method I would suggest, and it may best be explained by reference to Table No. II., where the method is applied to the four hospitals whose statistics are before us. A comparison is made at each period, and each hospital is credited with its relative position, 1st, 2nd, 3rd, or 4th. The sum of each column is then taken, and this, divided by the number of periods of age, gives the average position of each period in each hospital. Dundee is found to be within a small fraction of the highest standard; the Magistrates' Hospital comes second; and the Glasgow Royal Infirmary and London Fever Hospital are equal.

2nd. Another method is to take from the Table on page 255 the proportions to the 100 above and below twenty in any one hospital, and apply to them the percentages of the others. This partially eliminates the amount of difference in the general mortality which may be supposed to depend simply on the difference in the age of the patients. The difference between the new percentages thus obtained may roughly be credited to other circumstances than age, to treatment among the rest. For example, take the *centum* of this hospital with 57·9 above, and 42·1 below twenty. The result is very interesting:—

Glasgow Fever Hospital,	...	11	per cent.	
Glasgow Royal Infirmary,	...	12	„	instead of 14 per cent.
London Fever Hospital,	...	13·9	„	19 „
Dundee Royal Infirmary,	...	8·5	„	9 „

3d. A third method (illustrated by Table No. III.), and the most easily applied, perhaps, of all, is to take the sum of the percentages at the various periods, and divide by the number of periods. This is, in reality, a more minute application of the second method, and, in plain terms, means this: Supposing each hospital to get 100 patients at each period of age, at their rate of mortality, what would be the comparative death-rate? The sum of the percentages gives the deaths out of the total number of patients, which is in this case 1400. Dividing by 14, of course, gives the general mortality. I have not introduced Dundee, as there can be no question of its superiority in

every way. To my mind, the reflections most plainly suggested by all these attempts to equalize the material, so to speak, on which treatment is practised, are—(1) That the influence of age on the mortality of fever is out of all comparison greater than that of any *internal* circumstance, such as occupation, habits, sex, &c. (2) That, beyond all question, age so affects what at first sight might seem the action of *external* circumstances, such as medical treatment, ventilation, &c., that, when ages are equalized, the results in different hospitals so nearly approach, that the margin is provokingly small, as a rule, which can be justly credited to these external circumstances.

The comparison of the *Average Residence* in hospital of typhus patients, as well as of the mortality, requires certain precautions. In the City of Glasgow Hospital, it was: Of those who recovered, 18·8; of those who died, 7; and over all, 17½ days. In the Town's Hospital, under my own treatment, the average over all cases of typhus was 21 days. In the Royal Infirmary here, and in Dundee, it is rather more. I attribute this, in great part, to the unrestricted use of open air exercise by my convalescents, but I have prosecuted an inquiry, which has led to unexpectedly interesting results, into sundry circumstances affecting average residence, lest there should be any fallacy in my inferences. When we regard the shortness of a patient's residence as a ready index to the resilience of his system after fever, the enquiry becomes more interesting than when viewed as a mere question of finance. In Table IV. the monthly variations of average residence and percentage stimulated are given. Taking the extent of the stimulation as a delicate test of the combined effects of age and severity of attack, it is interesting to note the close agreement between the variations. They are not in the same proportion, but always show a decided sympathy. In Table V. the influence of age is shown. In reference to these Tables I would make the following remarks, as legitimately following from facts which they embrace.

1st. That since, in reckoning the average *over all*, those who died are included, the influence of a greater number of aged patients, and a higher death-rate tends to produce a *shorter general average*. So far, this, as well as the opportunity in a general hospital of shifting fever patients detained by sequelae, as gangrene of limbs, &c., to another department, has been adverse to a favourable contrast between this and other hospitals.

2d. That when only the average residence of *those who recovered* is compared at various ages, there is (1) a remarkable uniformity over all ages. It was, for instance, a surprise to me to find that, up to 50, the average range should differ so little

as 16 and 18 days. (2) It is also worthy of note that below 50, excluding the period 0—4 years, the lowest average should be from 25 to 35 years, and the highest from 15 to 19; while immediately we get above 50, we have an abrupt increase of no less than 5 days. (3) Comparing the length of residence of those who died, it will be seen that, in a general way, it follows a rule the opposite of that of those who recovered. Those who died at the earlier periods seem, on the whole, to have resided longer, that is, to have resisted the disease longer, than those at the later. My general reflection on these facts is:—

3d. That the superior vitality and recuperative power of the system at the earlier periods of life is shown, not by a very decidedly shorter convalescence over all, but by the lower death-rate. The older simply succumb to the force of an attack, against which the younger, even those who ultimately die, bear up for a longer period, as we see from the fact noted above as to the longer residence of those who died young. Consequently, those older persons who do recover, as a rule, rapidly regain strength, while many young persons escape with bare life, and have a tedious convalescence, who at a more advanced age would have died. I find that an analysis of the length of residence of individual cases confirms this explanation. If it be correct, we should expect that in advanced life the duration would be more uniform, none very short and none very long, or, at any rate, a steady preponderance of the longer; while at the earlier ages there would be a wide range—many above, and many below the average, those above representing the tedious cases which have long and successfully resisted the “tendency to death.” So it is. Taking 15 to 20 days as an average residence, I have constructed Table No. VI., showing for different ages the average residence of those who recovered, and the proportion of protracted and rapid recoveries. It is rather curious that, as we may see by subtracting the sum of those above and below average from 100, those at the average do not vary much till we get above 40. The difference is in the proportion going to one side or the other of the average. From 5 to 40, excepting between 15 and 19, the severe and slight cases nearly balance one another, producing, with great variety of case, a result near the general average. Below 5 the mild cases so greatly predominate as to bring down the average by two days. Between 15 and 19 the very opposite condition produces the opposite result, and sends up the average by two days; while above 50 we have the balance between nutrition and decay so nice that the slightest disturbance of it is recovered from with difficulty. Regarding the period of life

between 15 and 19, I would merely record, without at present fully investigating the fact, that in all the relations of age to the phenomena of fever, it is marked by peculiarities. There the mortality shoots up quite out of proportion to the rate of increase either earlier or later in life; there the percentage stimulated is more than doubled, as compared with the period immediately preceding; and there, too, the duration of convalescence is longer than, and the proportion of tedious recoveries almost twice as great as, at any age below fifty. All these facts prove that some disturbing element is here suddenly introduced into the organism, giving to all its derangements a more grave complexion. That element is, in all probability, the attainment of puberty. We see what changes the most normal transition into this period produces in all the physiological processes of the body, more especially in the female sex—how the nutritive functions are modified, the nervous system is made more susceptible, and the mind subjected to new appetites and emotions. It is not, therefore, surprising to find indications that morbid processes also become, at that time of general commotion, unusually active, and productive both of greater mortality and deeper lesions requiring more time to heal.

An enquiry into the influence of sex on the results of fever would be both important and interesting; but such an enquiry must be based on greater numbers than I have yet at command. So far as my present statistics go, the percentage of females stimulated is decidedly greater than of males, while the mortality is as decidedly less. I have remarked this fact previously but in a much greater degree. It would seem that while females have a greater tendency to nervous prostration which induces the exhibition of stimulants, they also, from their previously more temperate habits, or from a constitutional susceptibility of excitement proportioned to this tendency to depression, derive more benefit from them than males. The average residence of those who recovered is about the same in both sexes over all ages, but when we prosecute the enquiry into the quinquennial periods, indications of most interesting facts appear, but, as I have already said, until wider data are obtained they can only be regarded as guides for future investigation. Puberty is marked alike in both sexes by a sudden aggravation of all the phenomena of fever, but in the male immediately that climacteric age is passed, the severity of these phenomena tends to subside or rather to increase with the age in a lesser ratio, but not so in the female. The child-bearing period seems to bring with it certain penalties to which the male is not exposed. Certainly, since it is this which is the chief characteristic of the sex between 15 and

45, it is not unreasonable to trace to it more or less directly the peculiarities of typhus in the female between these extremes.

The diagram prefixed to this paper is a graphic representation of the variation on each side of the average of the slight and severe cases which I have explained above verbally. If one will take the trouble of looking at the relations between the two sets of lines, many interesting reflections will be suggested, and especially this, which may be taken as the moral of this paper—*the danger in reasoning founded on vital statistics, of losing sight of the units of the numbers from which we reason.*

DIAGRAM ILLUSTRATIVE OF TABLE N^o 6







