CHAPTER VIII.

DOMESTIC OVERCROWDING AND INFLUENZA.

In an earlier chapter we affirmed the conclusion that influenza is an infectious disease, and we now pass to discuss the environmental factors which might be supposed to favour

TABLE I.

Manchester Block Census.

District.	No. of Families.	No. of Families Attacked in First Wave.	Percentage.	No. of Families Attacked in Second Wave.	Percentage.	Persons per Family.	Percentage of Males Aged 15—45 to Inhabitants.
Ancoats C.	36	17	47.2	12	35·3	4·8	15·8
,, E.	33	12	36·4	10	30·3	4·1	18·7
,, N.	21	11	52·4	3	14·3	4·6	11·5
,, S.	37	5	13·5	8	21·6	4·7	13·9
,, W.	47	2	4·3	6	12·8	4·8	12·5
Ardwick E.	31	12	38.7	2	6·5	4·4	18·5
,, N.	30	10	33.3	9	30·0	4·4	14·3
,, S.	40	8	20·0	6	15·0	4·5	17·7
Beswick	37	12	32·4	10	27·0	4·6	15·8
Blackley	35	10	28·6	9	25·7	3·5	14·8
Bradford	32	7	21·9	8	25·0	5·4	14·0
,, No. 1	32	9	28·1	10	31·3	4·6	17·1
C./M. E.	42	11	26·2	14	33·3	4·9	12·7
,, S.	35	11	31·4	9	25.7	4·1	16·2
Gorton	36	14	38·9	14	38·9	5·1	19·2
,, S.	33	4	12·1	12	36·4	5·2	20·2
,, W.	38	14	36·8	10	26·3	4·5	18·2
Harpurley	36	15	41·7	9	25·0	3·6	22·3
Hulme C.	37	10	27·0	9	24·3	5·2	13·1
,, E.	22	10	45·5	4	18·2	4·2	10·8
,, N.	38	5	13·2	8	21·1	3·9	23·1
,, S.	35	15	42·9	7	20·0	4·3	15·3
,, W.	36	13	36·1	16	44·4	4·7	14·8
London Road	36	9	25·0	8	22·2	4·9	14·3
Newton	36	18	50·0	11	30·5	4·3	19·4
,, E.	12	6	50·0	1	8·3	5·3	21·9
St. George C.	36	20	55·6	12	33·3	5·8	12·9
,, E.	34	10	29·4	8	23·5	4·4	16·8
,, N.	28	22	78·5	7	38·9	4·8	13·3
St. George Honsell	37	16	43·2	16	43·3	4·6	16·6
Total	1,018	338	33·2	268	26·3	4·6	16·0

the transference of infection from person to person. Of these the one having the strongest *a priori* claim to consideration is domestic overcrowding. It is an old and well authenticated observation that the death rate of pulmonary tuberculosis is highly correlated with the proportion of inhabitants per room in tenements ; a similar remark applies to the distribution of measles. In both instances, one of a chronic, the other of an acute infection, those crowded together in dwellings suffer a relatively heavier incidence than persons better and more amply housed. We had anticipated that the distribution of influenzal infection would exhibit the same phenomenon, and the subject was examined in detail at Manchester, Leicester, Newcastle~on-Tyne, and South Shields.

The salient features of the Manchester inquiry are exposed in Table I. (p. 164). This table has been analysed in various ways. In the first instance the distribution around the mean percentage of infected households was compared with that expected were the density per house a matter of indifference, and the chance of any household becoming infected constant. It was found that the resulting distribution did not agree with the observations, a finding which at once suggested that housing density *was* important. But when account was taken of the number of persons per family the distribution still evaded explanation. For instance, if the number of persons per family is correlated with the proportion of families attacked in each district the resulting co-efficient is nearly zero in value. As a particular instance it may be noted that the number of persons per family in West Ancoats with the lowest attack rate is the same as in North St. George's with the highest attack rate. A larger factor in producing the fluctuations of household attack rates would seem to be the variations of age constitutions. Thus

TABLE II.

MANCHESTER.

Age Distribution of West Ancoats and North St. George (Percentage).

Age Groups.	West Ancoats.	North St. George.	Whole Census.
0–5	15·6	20·7	14·1
5–15	24·1	29·6	27·1
15–25	18·8	11·9	14·0
25–45	22·8	28·2	29·0
45–65	13·8	9·6	13·0
65 and over	4·9	·0	2·8
Total	100·0	100·0	100·0

'the age constitutions of the two last-named districts are different, and significantly so (Table II.), and we have already remarked that in each wave a special age incidence prevailed. To form some notion of the magnitude of this disturbance we correlated the proportion of inhabitants aged 15-25 with the attack rate, and compared the attack rates predicted from the resulting equation with those observed. This led to a better accord than the hypothesis of either independent chance or of dependence upon density, but was still far from satisfactory, hence some source of disturbance not revealed by the figures has operated (the possibility that the proportion of males at ages 15-45, *i.e.*, persons certainly mixing with the outside world, would be correlated with the attack rate was examined, and the correlation found to have no significance). But it seems clear that the number of persons per family has not been an important determining cause.

It is, of course, reasonable to contend that the average number of persons per family is not a good measure of domestic overcrowding, and we pass to evidence concerning the number of persons per room and the attack rate.

In his Leicester census Dr. Arnold found that 2,122 persons were housed in tenements providing one or more persons per room, and amongst these 655 cases occurred, or 30 • 9 per cent. (all waves). The number housed less than one person per room was 2,480. Of these 725 were attacked, 29 • 2 per cent.; the attack rates are sensibly equal. In houses with eight or more persons to the house (627 persons), the attack rate was 27 • 4 per cent. In houses with two or less persons (318 in all) 26 • 7 per

TABLE III.

NEWCASTLE-ON-TYNE.

Households containing Persons per Room.	Total Number of Households Investigated.	Number of Households affected in the whole Epidemic Period.	Number of Households not affected throughout.	Proportion of affected Households to Totals.	Total Number of Cases.	Average Number of Cases per affected Household.	Percentage of Cases to Immediate Contacts in affected Households.
				Per cent.			Per cent.
Less than 1 person -	101	36	65	35·6	49	1·36	47·1
1–2 - - - -	388	166	222	42·8	270	·63	40·6
2–3 - - - -	292	142	150	48·6	322	2·27	41·4
3–4 - - - -	138	77	61	55·8	192	2·50	39·8
4 and over - - -	51	22	29	43·1	60	2·72	37·3
Total - -	970	443	527	45·7	893	1·15	40·8

cent., again a sensible equality of incidence. The data furnished by the assistant medical officer of health, Newcastle-on-Tyne, are shown in Table III, p. 166. No evident association between housing density and attack rate is discernible.

In South Shields information was obtained which is summarised in Table IV. There being some suggestion of a higher

TABLE IV.

SOUTH SHIELDS.

Rooms per Person.	Percentage of Cases.
1·52	15·9
·33	25·0
·49	8·1
1·43	21·4
·49	43·9
·57	4·3
·21	19·6
·95	4·7
1·63	13·5
·46	15·8

attack rate upon the more congested streets, the correlation between rooms per person and attack rate was computed, but although negative, *i.e.,* the attack rate declined as the rooms per person increased—its absolute value did not exceed its probable error and indeed without any calculation it is apparent that the relation is not uniform or striking. Dr. Joseph, M.O.H., Warrington, found that of 777 persons living in infected houses with one or more persons to a room, 327 (42•1 per cent.) contracted influenza. Amongst 112 persons housed at a rate of less than one person per room, 42 or 35•7 per cent were attacked. From these and other tabulations *(see* Table V.), it is seen that the association between density and attack rate is of little importance.

In a valuable report on the epidemic in Paris issued by the Prefecture of the Seine,* it is inferred, from a graph of the death rates from influenza plotted against an index of housing conditions, that " overcrowding and insufficiency of housing are principal factors- of the frequency and gravity of influenza." The writers point out that the particulars of housing and population are inadequate, since they depend upon pre-war enumeration, but we do not think that even *'prima facie* they suggest any causal association between housing and mortality from influenza. From the tables inserted in the report we have extracted:—(1) The proportion of the population who " vivent

* *Receuil de Statistique de la Ville de Paris—Epidemie de Grippe* 30 *Juin* 1918-26 *Avril* 1919. Paris, 1919.

dans des logements defectueux," the death rate from influenza and the death rate from other causes than influenza in each

TABLE V.

Influenza and Housing Conditions at Warrington.

	251 Houses with one or more Persons per Room.	102 Houses with less than one Person per Room.
	Per cent.	Per cent.
Not-infected	123 = 49·0	60 = 58·8
Infected	128 = 51·0	42 = 41·2
No. of occupants in the infected houses.	777	112
No. of persons who contracted influenza.	327 = 42·1	42 = 37·5

Houses with two or more Persons per Room.

There were 66 houses occupied by 467 persons.

The No. of persons affected was 118, or 25 • 2 per cent.

Houses with less than two Persons per Room.

There were 287 houses occupied by 1,159 persons.

The No. of persons affected was 251, or 21 • 6 per cent.

	66 Houses with two or more Persons per Room.	287 Houses with less than two Persons per Room.
	Per cent.	Per cent.
Not-infected	23 = 34·8	160 = 55·7
Infected	43 = 65·1	127 = 44·2
No. of occupants in the infected houses.	314	575
No. of persons who contracted influenza.	118 = 37·6	251 = 43·6

quartier (omitting Salpetriere, the enormous general death rate of which may depend upon the presence of institutions). Tables V.A, V.B, V.C contain these particulars in as fine groupings as the small total number of observations admits. Working out the correlations in the ordinary way, it appears that the correlation between the death rate from all causes except

influenza and the measure of bad housing for a constant influenza rate is • 57 ± • 05; the correlation between the influenzal death rate and bad housing for a constant death rate from other causes is —• 06 ± • 08 and the correlation between the death rates from influenza and from other causes, for housing conditions constant is •19 ± • 07. In other words there is no measurable association between bad housing conditions and the death rate from influenza, the result we have found in our own experience.

TABLE VA.

Death Rate per 10,000, *other Causes than Influenza.*

Death Rate per 10,000, Influenza.	50–75.	75–100.	100–125.	125–150.	150–175.	175–200.	200–225.	225–250.	250–275.	Totals.
15–20	—	—	1	1	1	—	—	—	—	3
20–25	1	4	6	4	2	—	—	—	—	17
25–30	—	7	6	11	3	—	—	—	—	27
30–35	1	2	4	8	3	—	—	—	1	19
35–40	1	—	3	2	2	—	—	—	—	8
40–45	—	—	1	1	1	—	—	—	—	3
45–50	—	—	—	—	—	—	—	—	—	—
50–55	—	—	—	1	1	—	—	—	—	2
Totals	3	13	21	28	13	—	—	—	1	79

TABLE VB.

Death Rate per 10,000, *other Causes than Influenza.*

Proportion per 1,000 Defectively Housed.	50–75.	75–100.	100–125.	125–150.	150–175.	175–200.	200–225.	225–250.	250–275.	Totals.
100–150	1	—	—	—	—	—	—	—	—	1
150–200	1	2	—	—	—	—	—	—	—	3
200–250	1	7	1	—	—	—	—	—	—	9
250–300	—	3	2	—	3	—	—	—	—	8
300–350	—	—	4	1	—	—	—	—	—	5
350–400	—	—	4	4	1	—	—	—	1	10
400–450	—	1	5	2	1	—	—	—	—	9
450–500	—	—	2	9	1	—	—	—	—	12
500–550	—	—	3	4	3	—	—	—	—	10
550–600	—	—	—	5	1	—	—	—	—	6
600–650	—	—	—	3	3	—	—	—	—	6
Totals	3	13	21	28	13	—	—	—	1	79

TABLE VC.

Proportion per 1,000 *Defectively Housed.*

Death Rate per 10,000 Influenza.	100–150.	150–200.	200–250.	250–300.	300–350.	350–400.	400–450.	450–500.	500–550.	550–600.	600–650.	Totals.
15–20	—	—	—	—	—	1	—	—	1	1	—	3
20–25	—	1	4	1	1	2	3	—	1	2	2	17
25–30	—	—	4	3	2	3	4	6	3	—	2	27
30–35	1	1	1	2	—	3	1	4	3	2	1	19
35–40	—	1	—	2	1	—	—	2	1	1	—	8
40–45	—	—	—	—	1	1	—	—	1	—	—	3
45–50	—	—	—	—	—	—	—	—	—	—	—	—
50–55	—	—	—	—	—	—	1	—	—	—	1	2
55–60	—	—	—	—	—	—	—	—	—	—	—	—
Totals	1	3	9	8	5	10	9	12	10	6	6	79

The limitations attaching to these negative results are to be emphasised. To infer from them that the intensity of aggregation in dwellings is without influence upon the spread—*a fortiori* to suppose that it does not affect the fatality—would be unwarrantable. The proper conclusion is that such variations of congestion as occur in an ordinary sample of working class communities or can be gauged by statistics of inhabitants per room or of persons per family are not factors of the first order of importance in the dissemination of the disease. • The most tragic events in the history of the recent influenzas, those witnessed on certain transports bringing great numbers of troops to Europe, happened under conditions of serious overcrowding, probably much more serious than found in any statistically significant proportion of a civil population. But it must be added that even on ships of war, greatly congested and peopled with men at the most susceptible age, the attack rate did not usually exceed what we have found in civilian groupings. Surgeon Commander Sutcliffe estimated the summer attack rate on officers and men of the Grand Fleet at 11•5 per cent, of the average strength, a not excessive figure.

Superficially regarded, the result reached is so irrational that it requires further justification. It will be asked whether the finding is not a *reductio ad absurdum,* since we have admitted and even emphasised the infectious character of the disease ; surely, it may be said, the most favourable conditions for the evolution of an infective disease are afforded by overcrowded dwellings, and if one finds no decisive relation between overcrowding and case incidence, should not this be taken to prove not that no such relationship exists, but that the data are unsuitable.

It is perfectly true that the consequence of errors of observation is to conceal manifestations of a statistical law, and, without doubt, errors inhere in the material discussed. But it has been found that the data still provide evidence of infectivity, that the distribution of cases is not a random one, although density in houses does not seem to be a source of disturbance. Two other tests have been applied. The distribution of houses containing 0, 1, 2, &c. infected persons has proved to be unlike a simple chance distribution, and—what is, perhaps, a more useful criterion—the average interval between successive deaths in the same house or, more generally, the average interval between the members of all possible pairs of deaths, when deaths have occurred in a house, is much shorter than one would expect to find as a matter of chance. If within a period of *m* days, a number of pairs of events have happened at random, the mean interval between members of such pairs would be about *m/3* days. An application of this test to deaths in the C.B. of Blackburn showed that in November and December the average interval was about three days, the defect from the chance expectation being too great to be reasonably attributable to error of sampling. Hence, the conclusion is to be drawn, verified by much non-statistical evidence, that successive deaths or cases are not independent but contingent, and, therefore, that direct infection was probably a factor.

The explanation of the relative unimportance of the house density factor seems to us to be the following:—In the first place, as we have remarked above, the natural infectivity of the germ may be so high that the necessary exposures and contacts of *all* persons living under urban conditions are sufficiently numerous to provide opportunities of transfer so effective that any increase above the average is relatively a factor of negligible order. In the second place, since this will clearly not explain why some districts, or certain houses, suffer much more than others, we must postulate the existence of a variety of strains of infective organism or a considerable variation of resisting power to attack (the latter possibility seems less probable, since we cannot suppose that the inhabitants of a particular district—although we might perhaps predicate it of the inmates of a particular house—all chance to be naturally immune). The former supposition has in its favour other evidence. We saw that the amount of immunity enjoyed during a second exposure to infection by those who had taken the disease before has varied from place to place, even when the circumstances, whether of age or housing conditions, were identical. To explain such discrepancies, we might suppose that the infective properties of the organism have not been uniform, that in some instances the biological type of the second invader has agreed in important particulars with that of the first assailant, that in others this is not so. On this assumption, we could understand why the disease should behave like other

infective diseases in some respects (non-random distribution through houses and districts, short interval between successive cases), and, in others, deviate from the usual course. A thoroughly stable, not highly infective organism, the properties of which vary but little, should certainly cause a greater relative incidence upon overcrowded tenements.

Finally, these results do *not* lead to the conclusion that overcrowding is a matter of indifference from the administrative side. It is, for instance, possible, or even probable, that the incidence of complications and, therefore, the death toll is correlated with density of population. The data used in the present analysis although extensive enough to bear an argument concerned with incidence are much too slender to admit of analysis from the standpoint of mortality in correlation with density. The analysis of the mortality figures of the great towns in chapter 2 suggested that the influenzal death rate was substantially correlated with the death rate from other causes ; the latter is well known to be associated with density (whether through the directly prejudicial effects of overcrowding upon health, or because the poorest and physically least fit are *ab initio* overcrowded, is not here to be discussed); further, the very serious mortality experienced on several of the United States, Transports hurrying men to this country at the crisis of the war is *prima facie* evidence of the importance of this factor when mortality is to be assessed. In ordinary times, we should be able to explore the matter, as did Dr. Farr in 1847, by contrasting the death rates of various quarters of the metropolis which exhibit extreme variations of housing density. But our present inability to assign moderately accurate population totals or criteria of housing density would render such comparison misleading, and it has not been attempted. We conceive that what has been adduced does no more than make it improbable that domestic overcrowding can be deemed a *principal* factor of the spread of epidemic influenza.