STUDIES OF PNEUMONIA IN CHILDHOOD.

I. STATISTICAL ANALYSIS OF PNEUMONIA AND BRONCHITIS.

BY

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Introduction.—In a series of papers the subject of pneumonia in childhood will be presented mainly from the standpoint of morbid anatomy and histology, but with reference also to its clinical aspects. Bacteriology will not be dealt with.

In the first place, it will be an advantage to obtain a general view of the subject by means of a statistical analysis of a large series of cases, and the present paper will be devoted to this purpose. The subsequent papers will deal with the so-called lobar type of pneumonia; broncho-pneumonia; bronchiectasis; and empyema. In these studies large thin sections of the entire lung have been used, and illustrations of these will be shown. These large sections give not only an extensive view in one plane of the morbid anatomy, but also permit an accurate microscopic study of the pathological processes over a wide extent of lung.

STATISTICAL ANALYSIS OF PNEUMONIA AND BRONCHITIS.

This analysis includes two distinct series of statistics, 648 cases of pneumonia and 244 autopsies in the same disease. The age period in both was from birth to twelve years.

The 648 cases in the clinical series were admitted to one ward of the Edinburgh Children's Hospital between January, 1921, and October, 1928, a period of almost eight years. Because of the close connection between bronchitis and pneumonia in the early years of childhood, we have placed alongside this series all cases of bronchitis admitted during the same period. A third group, bronchiectasis, includes cases where as the sequel of pneumonia or severe bronchitis there was serious and lasting damage to the bronchial walls, with bronchial dilatation in most cases and with marked fibroid change in the lung in a smaller number.

All these cases have been under one medical charge, (C. McN.). In order to secure full co-operation and exchange of views between clinician and pathologist, we have studied many of them together both in the ward and in the post-mortem room. Moreover, for the purpose of this survey, all the records have been read together by two of us, and the diagnosis and other points carefully reviewed. This revision has resulted in not a few changes;

in some instances the original diagnosis of the type of pneumonia has been modified, and doubtful cases have been excluded from the group. By this selection of a large number of cases from a single medical charge, by co-operation, and by a thorough revision of all the records, we have tried to secure uniform and consistent standards and as much accuracy as possible.

The 244 autopsies have been made and recorded throughout by one of us (A. R. M.). They include 83 examinations from the above series of 648 cases of pneumonia, and 161 examinations in cases from other wards in the hospital. The total (244) represents all cases of pneumonia examined post mortem during a period from 1st July, 1922, to 31st October, 1928.

Main Groups in Clinical Series.—The totals of cases and deaths in the clinical groups are shown in Table I.

TABLE I.
MAIN GROUPS IN CLINICAL SERIES.

Disease.	Cases.	Deaths.	Death-rate.
Bronchitis	231	6	2.5%
Pneumonia (all types and including empyema) ..	648	163	25.0%
Bronchiectasis	33	0	0%
Totals ..	912	169	18.5%

This aggregate of 912 excludes all other respiratory diseases, *e.g.*, asthma and asthmatic bronchitis, pulmonary tuberculosis, tuberculous and rheumatic pleurisy. These figures for bronchitis and pneumonia are compared with those for all other diseases treated in the ward during the same period in Table II.

TABLE II.
PRESENT SERIES COMPARED WITH TOTAL ADMISSIONS.

Disease.	Cases.	Deaths.	Death-rate.
Bronchitis, pneumonia, bronchiectasis	912	169	18.5%
All other cases	1,964	380	19.5%
Totals ..	2,876	549	19%

Thus the bronchitis, pneumonia, bronchiectasis group formed 31.5 per cent. of all cases admitted. The death-rate in the same combined group was slightly lower than in the group of all other cases; while if the pneumonia group be taken alone, its death-rate was somewhat higher than in the 'all other' group.

Twenty years ago Dunlop¹, in the same hospital and ward, collected and analysed 500 cases of pneumonia exclusive of empyema; the total admissions

during the same period were 3,300. A comparison with Dunlop's figures can be made by subtracting the cases of empyema from the pneumonia cases in our series (Table III).

TABLE III.
PRESENT SERIES COMPARED WITH SERIES RECORDED IN 1908.

	PNEUMONIA.			Total Admissions.	Total Deaths.
	Cases.	Deaths.	Death-rate.		
Dunlop (1908) ..	500	104	21%	3,300	?
Present Series ..	559	127	22.5%	2,876	549

This shows that in the present series the incidence and death-rate of pneumonia were slightly higher than in a similar Edinburgh series collected some twenty years ago.

TYPES OF PNEUMONIA.

The types of pneumonia have been studied in two series of cases: a clinical series and a post-mortem series.

Types of Pneumonia: Clinical Series.

Table IV shows the division of the inclusive pneumonia group into its different sub-groups, giving for each the total cases and the numbers of deaths.

TABLE IV.
CLASSIFICATION: INCLUSIVE PNEUMONIA GROUP (CLINICAL SERIES).

Type.	Cases.	Deaths.	Death-rate.
Alveolar (Lobar or Croupous) Pneumonia	386	26	7%
Broncho-pneumonia	144	78	54%
Empyema	89	36	40.5%
Miscellaneous Group	21	21	100%
Acute Pleurisy	8	2	25%
Totals ..	648	163	25%

Table IV is important and requires some explanation and discussion, especially of the clinical and pathological criteria which determined the classification. The death-rates refer to all ages between birth and twelve years and, while they are of some interest, their importance when studied in smaller age periods is much greater.

The term 'alveolar pneumonia' will be used throughout this and succeeding papers instead of 'lobar or croupous pneumonia.' The reasons for this will be given later.

The outstanding feature of the above table is the large preponderance of cases of alveolar (lobar) pneumonia over those of broncho-pneumonia. This is contrary to the majority of collected statistics of pneumonia in children. Crozer Griffith², in a recent paper, has compared a number of statistical analyses on this point and some of these may be quoted. For example, in Dunlop's series of 265 cases of pneumonia under 2 years of age, the ratio between alveolar (lobar) and broncho-pneumonia was 1 to 5; in a similar series by Holt (322 cases) the ratio was 1 to 3. The comparable ratio in the present series (256) is 1.3 to 1. This discrepancy in results from different observers may depend partly upon climatic conditions or the type of case admitted to certain hospitals, but it is probable that a more important factor is a difference in the standards of differential diagnosis between these two types of pneumonia. It is therefore necessary to explain the standards that have been employed in the present analysis.

Differentiation of Alveolar (lobar) and Broncho-pneumonia. The separation of these two types of pneumonia is determined by pathological and clinical data. No bacteriological test is available. The differentiation can be made with certainty only at autopsy: during life it is more difficult and uncertain. Standard text books (*e.g.*, Holt, Thomson) give tables of symptoms and signs by which these two types may be distinguished in life. These criteria are sufficient in many cases, but in a considerable number they fail, and may even mislead, for the reason that the description of lobar pneumonia is based on the adult type, whereas the morbid anatomy of this type of pneumonia in the child often does not conform to that in the adult. In the latter, consolidation usually involves the whole of one lobe, but in children, and especially in young children, it often occupies only a small portion of a lobe. The word 'lobar' is therefore unsuited to many cases of this type in children. The pathological process, however, corresponds in its essential characters to the lobar pneumonia of the adult. The inflammation occurs in the alveoli, producing complete consolidation of a definite area; there is very little involvement of the interstitial tissue; bronchitis, if present, is no more than a trivial and superficial catarrh. We suggest that 'alveolar pneumonia' is a term which accurately describes this type of pneumonia, and that in children it is preferable to the term 'lobar' because in them the inflammation is not necessarily lobar in extent. In broncho-pneumonia, the changes are of an entirely different character. Severe bronchitis is an essential feature, with inflammatory infiltration of the bronchial wall and interstitial framework of the lung; the consolidation occurs in patches, following the distribution of the bronchial tree, with or without confluence over areas of considerable size. The word broncho-pneumonia is thus a correct description of the pathological changes in this type of pneumonia.

Does this real difference of pathological process in these two types of pneumonia manifest itself in different clinical features? The physical signs of auscultation and percussion are essential in the discovery of consolidation, and without evidence of consolidation a diagnosis of pneumonia cannot be made. A 'dry' consolidation localized in one lobe gives physical signs

characteristic of alveolar pneumonia ; scattered patches of consolidation over both lower lobes, accompanied by many moist sounds, are diagnostic of broncho-pneumonia. But in two kinds of case the physical signs may be misleading. First, cases of alveolar pneumonia are met with, in which the area of consolidation is small and there are accompaniments around the pneumonic patch, and occasionally also over both roots and bases, indicating a slight catarrhal process ; in such cases the physical signs closely resemble those of broncho-pneumonia. Secondly, in rapidly confluent and massive broncho-pneumonia the physical signs are very similar to those of an extensive alveolar (lobar) pneumonia. It would therefore be true to state that in the differentiation of the type of pneumonia physical signs in many cases may be of little service and may, indeed, lead to error. The manner of onset in both types may be sudden and immediately grave. It is nearly always so in alveolar pneumonia, while in broncho-pneumonia it is more often progressive ; but this difference is not constant or striking. So also for the type of dyspnoea and the presence of cyanosis ; they may be helpful and corroborative, but they are too inconstant to have a decisive value.

There remain, however, three things, the character of the cough, the duration of high fever and especially the type of decline of fever. These are the most important clinical features by which the two types may be distinguished. In *alveolar pneumonia*, the cough may be absent ; it is, however, generally present, but it is seldom conspicuous ; it is a short single cough, which may be suppressed and painful if pleurisy is present. The duration of the fever does not exceed two weeks in the great majority of cases ; its level is high but not always sustained. The decline of fever is by crisis or occasionally by lysis, and is followed in most cases by equally dramatic improvement in the general condition and by rapid resolution of the exudate. In *broncho-pneumonia*, the cough is generally prominent, occurs in bouts and paroxysms, and is harsh and loud. The fever in all severe cases extends over several, and perhaps many, weeks ; throughout, the temperature is apt to be irregularly remittent, although in the early stages of rapidly confluent pneumonia it may be high and sustained ; in the later stages of severe cases it drops gradually and irregularly to the normal level, about which it may fluctuate for some time. We believe that in this type of pneumonia the fever almost never terminates by crisis, and only rarely by regular lysis.

These three features, the type of decline of fever, the character of the cough, and the duration of the fever, in this order of importance, have been the principal criteria by which, in doubtful cases, we have determined the type of pneumonia. Other signs and symptoms have also been of service, especially the physical signs of auscultation and percussion. The latter are, of course, necessary for the diagnosis of pneumonia, but we wish to repeat that in the differentiation of the type of pneumonia, particularly in children under two years of age, they are not seldom indecisive and misleading. And it is in these first two years, when about half of the cases of alveolar and nearly all the cases of broncho-pneumonia occur, that this separation of the two types has to be made. Whether our main clinical criteria are of the primary importance we

have assigned to them is a matter for discussion. They have been consistently applied to the present series of cases shown in Table IV, and it is probably due to them, and to the secondary place given to physical signs, that the high figures for alveolar pneumonia have been obtained.

One or two other points may be noted here. In Table I a large group of cases of bronchitis (231) is shown; of these, 192 were cases of acute bronchitis, the remainder being chronic bronchitis, laryngitis, and tracheitis. The acute cases were all febrile illnesses with cough and physical signs of bronchitis. The standards of diagnosis, in addition to the above, were the absence of consolidation and a short duration of fever. The presence of rapid and difficult respiration for a few days was not accepted as sufficient evidence of pneumonia. These more severe cases of bronchitis might, however, be regarded by other clinicians as cases of broncho-pneumonia, and in our revision we transferred from the broncho-pneumonia group to the bronchitis group a number of such cases. It must therefore be emphasized that the broncho-pneumonia group in our series has shed off into the alveolar pneumonia group on the one hand, and into the bronchitis group on the other, a number of cases that other observers with different standards would have retained within it.

Cases of Slowly Resolving Pneumonia. Included in the alveolar pneumonia group were 46 cases in which the process of resolution was slow, lasting from two months up to one year, or even longer in one or two instances. It might be argued that these, or some of them, were cases of broncho-pneumonia. They were carefully considered during our revision and have been retained meantime as a sub-group of alveolar pneumonia. In their onset and early course they were of the alveolar type, showing a definite, and sometimes massive, consolidation confined to one lobe or lung, but with little or no cough. In the later stages their course was almost afebrile with a satisfactory general condition. The death-rate was trifling, *viz.*, one case. Nevertheless, it seems likely that the interstitial framework had become the seat of a degree of chronic inflammation. They form an interesting group which deserves further study.

Empyema Group. It is hardly necessary to justify the inclusion of cases of empyema in the general consideration of a large series of cases of pneumonia in childhood, although in some published series this has not been done. In our survey we have taken out of the main groups of alveolar and broncho-pneumonia, and placed in the group of empyema, all cases in which pus or sero-purulent fluid, even in small amount, was found free in the pleural cavity before or after death. Only in this way can an accurate estimate of the frequency of this complication in pneumonia be obtained. Even so, the incidence of empyema will be under-stated by the omission of a few recovered cases in which, undetected, a slight purulent effusion had taken place and had been absorbed, and of a larger number of fatal cases in which no autopsy was made. The frequency of empyema in our aggregate group of pneumonias was 1 in 7 (89 to 648). The attempt was made to determine for all these cases of

empyema whether the original pneumonia had been alveolar or broncho-pneumonia. In 31 cases it was not possible to say; in the remaining 58 cases, the type was presumed to be alveolar in 45 and broncho-pneumonia in 13.

The death-rate in our cases of empyema at all ages was 40·5 per cent. This, however, is not a true estimate. The point will be discussed in a later section when the frequency and the death-rate of empyema over smaller age periods will be given, but the fallacy may be briefly alluded to now. In many cases of fatal empyema in infants the purulent effusion is only incidental, and the death of the child is really due to the predominant and severe pneumonia which accompanies it. For this reason the death-rate for empyema just given is inaccurate, and is too high.

Pleurisy. This was a small group where there was a fibrinous pleurisy without evidence of pneumonia. In several of these, pneumonia was suspected, but no convincing evidence was obtained either clinically or post-mortem. The smallness of the group is interesting, and shows how uncommon is the occurrence of primary pleurisy apart from associated inflammation of the lung.

Miscellaneous Group. All these were fatal cases and included various small sub-groups, terminal pneumonia, early fatal pneumonia, and other indefinite cases. These various sub-groups will be more suitably discussed in the section dealing with the post-mortem series.

Types of Pneumonia : Post-mortem Series.

During the period from 1st July, 1922, to 31st October, 1928, the total number of post-mortem examinations carried out in the hospital was 946. Pneumonia was present in 233 of these, and empyema without recognizable pneumonia in an additional 11 cases. The total number of cases of pneumonia and empyema was therefore 244, almost 26 per cent. of all autopsies.

An attempt has been made to classify the 233 cases of pneumonia according to type. In doing this both macroscopic and microscopic characters have been considered in a large number of the cases. In others, microscopic material not being available, it was necessary to rely upon the gross characters alone; but as few cases of doubtful type were among these and very careful records had been kept, it is perhaps legitimate to claim that even these could be classified with reasonable confidence. In a large series of cases occurring after the end of 1925, in addition to ordinary microscopic material, paraffin sections of whole lungs have been used. The result is shown in Table V.

We do not intend to discuss fully in this paper the pathological grounds on which the types have been distinguished, because that will form an important part of later communications. A brief reference has already been made to the chief pathological features of alveolar and broncho-pneumonia (p. 15).

Broncho-pneumonia. The immense preponderance of broncho-pneumonia over all other forms is a striking illustration of the fatal character of this type. It is not, however, to be regarded as proving that this is the commonest type of pneumonia at any age period. It must not be forgotten that the cases included in any post-mortem series are in a sense selected cases, selected, that

is to say, by the fatality of the disease. The frequency with which any type of pneumonia is seen in the post-mortem room is no measure of its actual incidence. Nevertheless this group must be regarded as the most important, because it is clear from a consideration of the figures presented in Table V, that the pressing problem of pneumonia mortality is in very large measure a problem of broncho-pneumonia.

TABLE V.
CLASSIFICATION : ALL CASES (POST-MORTEM SERIES).

Type.	Number.
Broncho-pneumonia	140
Alveolar (lobar) pneumonia	23
Terminal pneumonia	29
Miscellaneous group	15
Chronic pneumonia	5
Septic (pyæmic) pneumonia	4
Unclassified	17
Empyema without pneumonia	11
Total ..	244

Alveolar (lobar) pneumonia was represented by a small group of 23 cases. This is in striking contrast to the numerical superiority of this type in our clinical series. The relatively low mortality of alveolar pneumonia in children causes it to occupy a subsidiary place in a series of post-mortem cases.

There were several cases in which appearances characteristic both of alveolar and of broncho-pneumonia were present in different parts of the lungs. These have been classed as broncho-pneumonia.

Terminal pneumonia. The cases classed as terminal pneumonia might be regarded as a sub-group of broncho-pneumonia, with which they had certain features in common. They were mostly cases of hypostatic pneumonia in marasmic infants or debilitated children with enteritis or other wasting diseases. In most instances clinical manifestations of pneumonia were not present; consolidation was posterior and basal in distribution, somewhat indefinite in character, and associated with marked passive congestion and oedema.

Miscellaneous Group. Although the great majority of the acute cases fell into one of the above groups, there were a few whose characters did not justify their inclusion under the name of either alveolar or broncho-pneumonia. These are included in Table V in a miscellaneous group which embraces cases of three different types, as follows :—

First, there was a group of four cases, all in infants under one month old, in which the microscopic changes consisted of very intense generalized congestion and rather massive consolidation in both lungs, without much inflammation of the bronchi. The appearance resembled that of the condition which Gaskell³ has called 'miliary pneumonia' and ascribes to an infection reaching the lungs *via* the blood stream. Microscopically, the presence of a copious exudate of polymorphonuclear leucocytes was somewhat at variance with Gaskell's description. Whether or not these cases may be regarded as examples of this blood-spread type of pneumonia, they were certainly not ordinary broncho-pneumonia; nor could they be legitimately classed as alveolar pneumonia.

Secondly, there were five cases which resembled those described by M'Gowan and McNeil⁴ in 1913. In all of these the illness lasted less than twenty-four hours; the symptoms were those of an acute respiratory infection; the lungs showed quite an extraordinary degree of active hyperæmia, some œdema, but no consolidation; and in four of the five cases there was general hyperplasia of lymphoid tissue throughout the body, with or without enlargement of the thymus gland.

Thirdly, six cases showed widespread patches of consolidation in both lungs, not obviously related to the distribution of bronchi, and an absence of generalized bronchitis and of interstitial inflammation of the bronchial walls and pulmonary stroma. The appearance was that of the so-called 'lobular' or 'primary disseminated pneumonia.' Holt⁵, who describes this type fully, states that it is the commonest form of pneumonia in infancy and is attended by a mortality of about sixty per cent. in the first two years of life. In view of this, we have been surprised to find in our series so few cases corresponding to his description. It would seem that either the incidence or the mortality of this type must be much less in this locality than in Holt's experience.

The small group called *chronic pneumonia* includes cases of organising pneumonia, pulmonary fibrosis and bronchiectasis. The *septic or pyæmic pneumonias* were cases of septicæmia and pyæmia in which pneumonia occurred as a secondary manifestation of a general pyogenic infection.

The seventeen *unclassified* cases showed remnants of pneumonia post mortem, but it was impossible to determine with reasonable accuracy of what type the pneumonia had been. Most of them were cases of empyema, or of death from other complications or sequelæ, such as pericarditis, in which the original pneumonia had all but completely resolved.

THE INFLUENCE OF AGE ON THE INCIDENCE AND DEATH-RATE OF PNEUMONIA AND BRONCHITIS.

The factor of age is of great importance and interest. As regards the *clinical series*, its influence is shown graphically in Chart I. In it the numbers of cases of pneumonia and of bronchitis, and also the deaths, are represented for one-yearly periods throughout childhood. All types of pneumonia and empyema, as set out in Table IV, are merged into one inclusive group.

CHART I.

Taking pneumonia, it will be seen that the totals reach their highest peaks in the first two years; they then fall rapidly until the fifth year and more slowly in subsequent years. The deaths from pneumonia are concentrated in the first two years in a remarkable way; indeed, in the first year the number of deaths is almost three times, and in the second year it is quite twice, the total from 2 to 12 years. The cases of bronchitis, numbering 231, show a similar distribution over the yearly age periods, the great mass being found in the first two years. This parallel behaviour of the two diseases, bronchitis and pneumonia, is most significant and interesting.

The influence of age in pneumonia and bronchitis can be emphasized by grouping the twelve one-yearly periods into three larger ones, birth to 2 years, 2 to 5 years, and 5 to 12 years. When this is done, the figures shown in Table VI are obtained.

TABLE VI.
AGE-GROUPS IN CLINICAL SERIES.

Age Group.	PNEUMONIA.			BRONCHITIS.		
	Cases.	Deaths.	Death-rate.	Cases.	Deaths.	Death-rate.
Birth— 2 years ..	310	136	44%	155	5	3%
2— 5 years ..	184	18	10%	55	1	2%
5—12 years ..	154	9	6%	21	0	0%
Birth—12 years ..	648	163	25%	231	6	2.5%

This grouping brings into prominence the period of the first two years, when the remarkable concentration of cases of pneumonia and of deaths therefrom is apparent. One half of all cases of pneumonia and five-sixths of the deaths occur at this time. It is again worth noting that in this grouping the behaviour of bronchitis is closely parallel, two-thirds of the cases and five of the six deaths falling within the first two years. This period therefore stands out as one of special susceptibility to bronchitis and pneumonia, and of high mortality from the latter.

These facts regarding the influence of age on mortality receive striking confirmation from a study of the age incidence in the *post-mortem series*, which comprises a larger number of fatal cases than the clinical series. Chart II represents the number of deaths in the combined group of pneumonia and empyema in one-yearly periods.

In Table VII, the deaths are grouped in the three larger age-periods.

TABLE VII.
AGE-GROUPS: POST-MORTEM SERIES.

Age Group.	Deaths.	Percentage of Total.
Birth to 2 years	196	80.5%
2 to 5 years	36	15%
5 to 12 years	11	4.5%
Birth to 12 years	243	—

CHART II.

AGE INCIDENCE: ALL CASES (POST-MORTEM SERIES).

The high mortality in the first two years and the rapid decrease in the later age periods are very clearly shown. In Chart II it may be noted that almost one half of all the deaths occurred in the first year.

It is worth while tracing in half-yearly periods the death-rates for pneumonia in the *clinical series* through this critical time of the first two years (Table VIII).

TABLE VIII.
INCLUSIVE PNEUMONIA GROUP (CLINICAL SERIES).

Age Group.	Cases.	Deaths.	Death-rate.
Birth to 6 months	45	40	89%
6 to 12 months	89	39	45%
1 to 1½ years	91	34	37.5%
1½ to 2 years	85	23	27%
2 to 3 years	90	9	10%

The numbers of cases in each period are sufficient to allow comparison by a percentage death-rate. The rate shows a regular decline from a very high figure in the first six months. In the third year the rate has dropped to 10 per cent., which is that of the whole period 2 to 5 years.

Table IX shows the number of deaths from pneumonia and empyema in the *post-mortem series* in the first four half-yearly periods.

TABLE IX.					
AGE GROUPS: PNEUMONIA AND EMPYEMA (POST-MORTEM SERIES).					
Age Period.					
Deaths.					
Percentage of Total.					
Birth to 6 months	..	..	..	..	..
6 to 12 months	..	..	..	..	..
1 to 1½ years	..	..	..	..	..
1½ to 2 years	..	..	..	..	..

These figures are in agreement with those of the clinical series. The largest number of fatal cases was in the first half-year and a steady fall occurred thereafter. There was a remarkable decrease in numbers after the age of eighteen months.

Alveolar and Broncho-pneumonia. The influence of age in these separate groups in the *clinical series* is illustrated in Chart III. It should be noted that they do not contain cases of empyema or of the miscellaneous group.

CHART III.

AGE INCIDENCE: COMPARISON OF ALVEOLAR AND BRONCHO-PNEUMONIA (CLINICAL SERIES).

The broncho-pneumonia group may be taken first. Here the broad result is simple and striking: the great majority both of cases and deaths occurred in the first two years—about 80 per cent. of the cases and 84 per cent. of the deaths. There were only three cases after the fifth year, all of them fatal. Thus, in the clinical series the death-rate for this type of pneumonia was high throughout the whole period of childhood.

The results for alveolar pneumonia are different, both in case-incidence and death-rates. Considerably less than half the cases occurred in the first two years (38 per cent.). This type, indeed, was fairly common throughout childhood, although the numbers, measured in yearly periods, fell off after the fourth year. With regard to deaths, although again the great majority (about 80 per cent.) occurred in the first two years, the death-rate for this period was trifling (14·5 per cent.) as compared with that for broncho-pneumonia (61 per cent.); thereafter, it at once fell to a low level, at which it remained throughout childhood.

These broad results can be shown clearly in figures by the use of larger age periods (Table X).

TABLE X.

AGE GROUPS: CLINICAL SERIES.

Age Group.	ALVEOLAR PNEUMONIA.			BRONCHO-PNEUMONIA.		
	Cases.	Deaths.	Death-rate.	Cases.	Deaths.	Death-rate.
Birth to 2 years ..	143	21	14·5%	110	67	61%
2 to 5 years ..	131	2	1·5%	31	8	26%
5 to 12 years ..	112	3	2·5%	3	3	100%
Birth to 12 years ..	386	26	6·5%	144	78	54%

It should be mentioned that the death-rates given above are lower than they should be, especially for broncho-pneumonia, by the omission of cases of empyema and of the miscellaneous group.

Chart IV represents the age incidence in the *post-mortem series* of alveolar and broncho-pneumonia in yearly periods.

It confirms the facts obtained from the clinical series. In the earlier age periods the fatal cases of broncho-pneumonia show a vast preponderance over those of alveolar pneumonia. Nevertheless, the two curves are not materially different in form. Further, in both types of pneumonia, the period of greatest mortality is the first year.

CHART IV.

AGE INCIDENCE: COMPARISON OF ALVEOLAR AND BRONCHO-PNEUMONIA (POST-MORTEM SERIES).

Empyema. The standards of selection for this group have already been explained. The aim was to include all cases in which any pus or sero-purulent fluid, discovered by needle-aspiration during life or by post-mortem examination, had been poured out into the pleural cavity. The total was 89, but as the number for annual periods were small, the influence of age will be better shown by taking the longer periods previously used (Table XI).

TABLE XI.

AGE GROUPS: EMPYEMA (CLINICAL SERIES).

Age Group.	Cases.	Deaths.	Death-rate.
Birth to 2 years	36	27	75%
2 to 5 years	19	6	31.5%
5 to 12 years	34	3	8.5%
Birth to 12 years	89	36	40.5%

The incidence of empyema would appear by Table XI to be fairly equal in the three periods. It must be remembered, however, that empyema is not an independent disease, but a complication of pneumonia. What it is really important to ascertain is the frequency of its occurrence in pneumonia; and to do this, the figures for empyema must be set alongside those for pneumonia in the same age periods. This comparison is made in Table XII.

TABLE XII.
AGE GROUPS: (CLINICAL SERIES).

Age Group.	Pneumonia (all cases including empyema).	Empyema.	Empyema percentage.
Birth to 2 years	310	36	11.5%
2 to 5 years	184	19	10.5%
5 to 12 years	154	34	22%
Birth to 12 years	648	89	13.5%

The result brought out by these figures is definite. The complication of empyema is twice as frequent in pneumonia after five years as before that age. In the present series empyema occurred once in every five cases of pneumonia over five years of age. Some allowance must, however, be made for fatal cases of pneumonia where empyema was undetected during life and where no post-mortem examination was made; but even if this is done, the broad statement is probably true that the complication of empyema is decidedly commoner in pneumonia after five years of age than before it. Over the whole period, the frequency of empyema in pneumonia was about one in seven.

With regard to the death-rates for empyema in these age periods, it must be repeated that empyema is a complication of an acute and death-producing disease, and that in early childhood the death-rate from pneumonia alone is very high. Therefore, the figures for the first two years in Table XI do not accurately express death-rates from empyema. No doubt the occurrence of empyema is an added risk of death, but the risk from the existing pneumonia is already great. In the period 5 to 12 years, when the death-rate from pneumonia is trifling, the death-rate for empyema given above is approximately accurate.

SEX INCIDENCE.

The influence of sex is shown in Tables XII and XIII.

TABLE XII.
SEX INCIDENCE: ALL CASES (CLINICAL SERIES).

Type.	Male.	Female.
Bronchitis	126	105
Alveolar pneumonia	230	156
Broncho-pneumonia	79	65
Miscellaneous group	15	6
Empyema	53	36
Pleurisy	6	2
Bronchiectasis	11	22
Totals ..	520	392

TABLE XIII.

SEX INCIDENCE: ALL CASES (POST-MORTEM SERIES).

Types.	Male.	Female.
Alveolar pneumonia	17	6
Broncho-pneumonia	78	62
Terminal pneumonia	21	8
Miscellaneous group	11	4
Chronic pneumonia	2	3
Septic (pyæmic) pneumonia	3	1
Unclassified	10	7
Empyema (no pneumonia)	7	4
Totals ..	149	95

The noteworthy feature of these figures is the preponderance of males. It is remarkably consistent throughout the different groups. The total for males for both series is 669 as against 487 for females, a ratio of 1·37 to 1. The only exceptions are found in the bronchiectasis group in the clinical series, and in the chronic pneumonia group in the post-mortem series; it is interesting and perhaps significant that these two are the only chronic groups represented in the tables.

SEASONAL INCIDENCE.

Charts V, VI and VII illustrate the influence of season. The figures in Charts V and VI include cases admitted till the end of 1928, thus bringing a period of eight complete years under review and differing slightly from the remainder of the clinical statistics which do not go beyond 31st October, 1928.

Chart V shows the quarterly incidence of pneumonia (all types and including empyema) in each of the eight years. From it the total yearly incidence can be roughly judged and it is seen that there is no very significant difference between the years, the totals ranging from a minimum of 63 in 1921 to a maximum of 105 in 1924. This chart and the succeeding one (Chart VI), which includes bronchitis in addition to pneumonia, also illustrate the relative importance of the seasons. The numbers of cases of both pneumonia and bronchitis were, of course, greater in the autumn and winter months, but it is to be noted that throughout the period of eight years the incidence of these two acute respiratory diseases never became negligible in any one month or quarter of the year.

When the figures are further considered over quarterly periods, it is found that in the case of pneumonia the average is highest in the fourth (October-December) and is only slightly less in the first (January-March) quarter: it is lowest in the third (July-September) quarter. A similar variation is shown in the post-mortem series (Chart VII). It is perhaps worthy of remark that the first quarter of the year, which can be regarded as the second half of the winter, might have been expected to provide the greatest number of cases, and especially of fatal cases, of pneumonia.

CHART V.

QUARTERLY INCIDENCE: PNEUMONIA (CLINICAL SERIES).

CHART VI.

TOTAL MONTHLY INCIDENCE (CLINICAL SERIES).

Chart VI gives the total monthly incidence of pneumonia and bronchitis over the whole period of eight years. Of the individual months in this (clinical) series, November shows the highest, and July and September the lowest incidence of pneumonia. The seasonal occurrence of bronchitis is slightly different: the rate is highest in January and February, with the result that the first quarter (January—March) shows the greatest number of cases.

CHART VII.

TOTAL MONTHLY INCIDENCE (POST-MORTEM SERIES).

Chart VII illustrates the total monthly incidence of fatal cases in the post-mortem series. In order to enable six complete years to be reviewed, the period 1st November, 1922, to 31st October, 1928, has been taken: it differs slightly from that covered by the remainder of the post-mortem statistics (1st July, 1922 to 31st October, 1928). This Chart is more striking than the similar clinical one (Chart VI) and the contrasts are greater. The two correspond, as has already been mentioned, in that in both the fourth (October—December) quarter shows the highest figures. While, however, in the clinical series November had the highest incidence of pneumonia, December was the month in which autopsies were most numerous.

In conclusion we wish to express our thanks to our colleagues, Dr. N. S. Carmichael and Dr. L. H. F. Thatcher, for their courtesy in putting at our disposal a number of their fatal cases of pneumonia. These have been included in the post-mortem series dealt with in this paper. In subsequent papers we shall again be indebted to them for clinical records and post-mortem material in other cases that were under their care.

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APPENDIX.

The three following Tables contain a detailed statement regarding age incidence in both the clinical and post-mortem series: and facts regarding the site of consolidation in the post-mortem series.

TABLE XIV.
AGE INCIDENCE: ALL CASES (CLINICAL SERIES).

Type.	Age in years.	0— $\frac{1}{2}$	$\frac{1}{2}$ —1	1—1 $\frac{1}{2}$	1—2	2—3	3—4	4—5	5—6	6—7	7—8	8—9	9—10	10—11	11—12
Bronchitis ..	Total	56	47	33	19	33	13	9	6	5	5	3	2	—	—
	Deaths	3	—	1	1	1	—	—	—	—	—	—	—	—	—
Alveolar pneumonia	Total	3	40	47	53	45	46	30	30	15	24	11	12	12	8
	Deaths	1	8	6	6	—	1	1	2	1	—	—	—	—	—
Broncho-pneumonia	Total	25	35	31	19	22	7	2	2	—	1	—	—	—	—
	Deaths	22	19	18	8	7	1	—	2	—	1	—	—	—	—
Empyema ..	Total	6	9	9	12	12	4	3	10	7	5	4	5	1	2
	Deaths	6	7	6	8	1	4	1	1	—	1	—	—	1	—
Pleurisy ..	Total	—	1	—	1	—	1	1	1	—	—	1	1	1	—
	Deaths	—	1	—	1	—	—	—	—	—	—	—	—	—	—
Miscellaneous	Total	11	4	4	—	1	—	1	—	—	—	—	—	—	—
	Deaths	11	4	4	—	1	—	1	—	—	—	—	—	—	—
Bronchiectasis	Total	3	5	6	1	6	6	2	2	—	1	1	—	—	—
	Deaths	—	—	—	—	—	—	—	—	—	—	—	—	—	—

TABLE XV.
AGE INCIDENCE: ALL CASES (POST-MORTEM SERIES).

Type.	Age in years.	0— $\frac{1}{2}$	$\frac{1}{2}$ —1	1—1 $\frac{1}{2}$	1 $\frac{1}{2}$ —2	2—3	3—4	4—5	5—6	6—7	7—8	8—9	9—10	10—11	11—12
Broncho-pneumonia		33	37	38	10	13	4	1	2	—	1	—	—	—	—
Alveolar pneumonia		3	9	4	2	2	1	2	—	—	—	—	—	—	—
Terminal pneumonia		19	3	3	2	1	—	1	—	—	—	—	—	—	—
Miscellaneous group		7	4	2	1	1	—	—	—	—	—	—	—	—	—
Chronic pneumonia		—	—	2	—	—	2	—	—	1	—	—	—	—	—
Septic (pyæmic) pneumonia ..		—	—	—	—	—	1	—	—	—	1	—	—	1	1
Unclassified		1	2	4	3	1	1	1	2	1	1	—	—	—	—
Empyema (no pneumonia) ..		1	2	2	2	2	1	1	—	—	—	—	—	—	—
Total ..		64	57	55	20	20	10	6	4	2	3	0	0	1	1

TABLE XVI.
SITE; ALL CASES (POST-MORTEM SERIES).

Type.	Right.	Left.	Both.
Broncho-pneumonia	20	8	112
Alveolar pneumonia	8	8	7
Terminal pneumonia	1	3	25
Miscellaneous group	0	0	15
Chronic pneumonia	0	1	4
Septic (pyæmic) pneumonia ..	0	1	3
Unclassified	5	8	4
Empyema (no pneumonia)	3	4	4
Total ..	37	33	174