DIPHTHERIA. THE AGE INCIDENCE DURING EPIDEMIC YEARS IN LONDON

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ALTHOUGH the national statistics of the notifications of infectious diseases are defective with regard to age and sex, it has been established from the returns of London and other large towns that the mean age of attack from diphtheria has been increasing during the present century. The age shift has been from the pre-school to the school age. Several investigators have commented on the change in age incidence, Murphy (1907) reviewed the trend of mortality in London, and Chalmers (1913) the mortality of Scotland. Cheeseman, Martin & Russell (1939), as a result of an analysis of data kindly provided by the Medical Department of the London County Council, concluded that the change might be due to the decrease in size of family, especially in the more crowded districts. This would lead to a decrease of morbidity at early ages and, as a consequence, a lower level of herd immunity at school ages, so that the epidemiological experience of the poorer districts would approximate to those of the middle-class districts. In this paper (pp. 188–9) reference was made to Turner's observation (1923) that both in London and Manchester the mean age of attack in epidemic years of scarlet fever was above the average, and it was shown that if the maximum weekly case rate of diphtheria in London (1897–1930) were correlated with the ratio of the number of cases at ages 0–4 to the number at 5–9, a significant negative value was reached. This finding was consistent with Turner's result, but it seemed of interest to apply a slightly more direct test by comparing years of heavy prevalence with adjacent years in which diphtheria was at a lower level.

DATA

The data were those used in the paper by Cheeseman *et al.* covering the four quinquennial periods 1901–5, 1909–13, 1919–23 and 1929–33, and were compiled from the weekly lists of infectious diseases in London which were kindly loaned to us by the Medical Department of the London County Council. Years of high prevalence during these periods were 1901, 1920, 1921 and 1929. The returns enumerated age, sex and borough. The Metropolitan boroughs were grouped into four classes on the basis of the occupational returns for 1921, class I representing the best and class IV the worst social class.

London generally

The mean age and the ratio of male to female cases, for ages under 15, for the epidemic years and adjacent years in the three quinquennial periods are given in Table 1. The mean age of attack during the epidemic years is larger

Table 1. *Ages under* 15

	1902–5	1901	1919, 1922, 1923	1920	1921	1930–3	1929
Mean age	5·76 ±0·02	5·97 ±0·03	6·41 ±0·02	6·91 ±0·03	6·93 ±0·03	6·22 ±0·02	6·36 ±0·03
Male cases expressed as a percentage of female cases	93	93	97	90	91	98	101

than the average age of attack during the period around the epidemic. The sex incidence does not follow a consistent trend, the ratio for the outbreak of 1901 does not differ from the subsequent years, but the epidemic of 1920 and 1921 appears to have an excessive female incidence whilst that for 1929 had a male excess.

Social class

The means obtained for the four social classes are given in Table 2. The mean age of attack, within the social classes, during an epidemic year is higher than that of the quinquennial period with the exception of class IV in 1929 when the mean was slightly less than for the period. The largest increase

Table 2. *Age and sex distribution by social class for ages under* 15

	Class I		Class II		Class III		Class IV	
	Mean age	% male/ female cases	Mean age	% male/ female cases	Mean age	% male/ female cases	Mean age	% male/ female cases
1902–5	6·16 ±0·05	95	5·92 ±0·04	91	5·65 ±0·04	95	5·43 ±0·04	92
1901	6·26 ±0·08	94	6·13 ±0·06	91	5·72 ±0·07	94	5·81 ±0·08	95
1919, 1922, 1923	6·73 ±0·05	96	6·38 ±0·04	98	6·52 ±0·04	100	6·10 ±0·04	93
1920	7·26 ±0·07	102	7·06 ±0·06	92	6·82 ±0·06	87	6·46 ±0·07	80
1921	7·27 ±0·07	90	6·91 ±0·06	95	7·05 ±0·05	91	6·47 ±0·07	87
1930–3	6·47 ±0·04	99	6·04 ±0·04	102	6·32 ±0·03	99	6·08 ±0·04	93
1929	6·71 ±0·08	108	6·34 ±0·06	102	6·39 ±0·06	101	6·06 ±0·07	93

in the mean age occurred in class II and the smallest in classes III and IV. The sex incidence in 1901 did not differ appreciably from that for 1901–5, although there is a suggestion that the increased incidence during this year affected the males more than the females in class IV. The high incidence of 1920 and 1921 caused a relatively greater increase in attacks among the girls than the boys in classes II, III and IV, and in class I for 1921, but in 1920 the increase in this class was larger for boys. With the exception of class I, where the increased incidence was greater among boys, the epidemic of 1929 did not show any variation of sex incidence from the general trend. The attack rate

during each period reviewed was inversely correlated with social class so that it might be expected that in epidemic years the increase in cases would be greater in the high social classes than in the low, since the latter classes would have proportionally fewer susceptibles. To investigate this point the number of cases in each class was expressed as a percentage for the total for London and the results are shown in Table 3. The trend of the percentages are not

Table 3. *Percentage distribution of cases of diphtheria at ages under* 15, *by social class*

	Class I	Class II	Class III	Class IV	London
1902–5	17	30	30	23	100
1901	16	36	26	22	100
1919, 1922, 1923	16	27	31	26	100
1920	21	29	30	20	100
1921	20	24	34	22	100
1930–3	18	25	33	24	100
1929	18	28	31	23	100

consistent, after the first five-year period the position of classes II and III are interchanged, and there does not appear to be any real relation between the variation in the proportions and social class.

Seasonal trend

To decide whether a particular period during the weeks of prevalence was the cause of the increased mean age found during an epidemic year, the weekly incidence of these years was examined. The maximum weekly notifications occurred in the 43rd week of the year in each of the four epidemics. The ratio of the attack rate under 5 years of age to the attack rate at ages 5–14 for four-week periods was found and it is shown for two periods before and after the maximum in Table 4. Although the percentages fluctuate the general trend

Table 4. *Attack rate at ages under* 5 *expressed as a percentage of the attack rate at* 5–14 *years*

Year	Social class	Four-week period 36–39	40–43	44–47	48–51
1901	I	113	115	130	120
	II	100	133	121	121
	III	177	131	173	127
	IV	145	166	189	233
	All	129	133	150	137
1920	I	63	91	67	75
	II	81	81	62	72
	III	82	92	90	116
	IV	99	127	130	184
	All	82	95	85	106
1921	I	78	70	65	117
	II	91	71	68	100
	III	109	75	81	76
	IV	94	114	114	176
	All	93	83	81	109
1929	I	71	71	67	80
	II	128	82	98	96
	III	97	85	107	137
	IV	116	138	135	175
	All	101	91	102	119

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shows that the proportion of children of school age attacked is larger when the incidence is rising to its maximum than when it is declining. The largest relative changes are displayed in class IV, but a comparison of the social classes reveals no uniform trend.

Discussion

During years of very high prevalence children of school age were subjected to attack in a relatively greater proportion than the pre-school children when compared with the adjacent non-epidemic years. The proportionate sex incidence during an epidemic year does not materially change. When the epidemic was approaching its maximum the proportion of school children to pre-school children attacked was greater than when the incidence was declining. Although the distribution by the four social classes showed fluctuations, there was some evidence that the lowest social class had the greatest relative change during weeks of epidemic prevalence.

The biological interpretation of these statistical results is a matter for conjecture. If the increased prevalence which we characterize by the term epidemic is due to the introduction or emergence of a strain of organism different immunologically from those responsible for cases in adjacent earlier years, the age movement is explicable in terms of the hypothesis put forward by Cheeseman *et al.*, because the relative advantage of past exposure in the more crowded districts at pre-school ages is lost. If, on the other hand, the difference between a normal and an 'epidemic' year is only of degree not of kind, it is not clear why there should be a short-term change of age distribution, unless we assume that the prevalence is so great that there is an exhaustion of susceptibles, which is not a very probable explanation.

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