GEOGRAPHICAL AND SOCIAL VARIATIONS IN THE INCIDENCE OF NOTIFIED POLIOMYELITIS

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The natural history of poliomyelitis is not yet completely written. Although the clinical features of this disease have been recognized for more than a century, problems of management still give rise to controversy, and in spite of recurring outbreaks of widespread and dramatic character many enigmatic features of epidemiology remain to be explained. The outbreaks come without presage, reaching dimensions which cannot be forecast, and burning themselves out almost completely uncontrolled. While in the laboratory the search for prophylactic measures continues, there remains in the field a need for that combination of observation and hypothesis which may add to the accumulated epidemiological knowledge and consequently may add if even slightly to the state of preparedness of local health services. To this pattern, and in succession to an earlier review (Logan, 1952), the present study belongs.

If it were found that poliomyelitis reached epidemic prevalence invariably after a particular series of movements of attack rates or that the disease selected particular sections of the community or parts of the country, this would enable us to predict the commencement and spread of outbreaks, thus enabling clinical services to be mobilized on an adequate scale.

UNEVEN PREVALENCE IN DIFFERENT AREAS

It is known that in individual outbreaks, even in urban areas, some localities may escape epidemic prevalence, for reasons which are not apparent, and also that areas which suffer high incidence in one epidemic may have a lower than average incidence in the next, perhaps by some carry-over of the herd immunity gained in the earlier outbreak (Breen and Benjamin, 1950). These two effects, independent

geographical variation and correlation between one local outbreak and the next, operate together; jointly they produce in any one outbreak considerable unevenness in geographical spread. In order to remove this second effect, carry-over of a higher level of immunity from the close of one epidemic to the onset of the next, it is necessary to average the prevalence over several epidemics. The question then remains whether the residual geographical variation in epidemicity is a matter of chance and a feature which will also disappear over a further period as individual localities experience their proportionate share of the total prevalence in due course.

Table I (overleaf) shows the result of averaging the years 1947-50: three years of severe epidemic prevalence and one year (1948) with comparatively few cases. In this Table the actual uncorrected* notifications are compared with those "expected" if the England and Wales total notifications were distributed in proportion to the local population, *i.e.* if every area suffered the same attack rate. Looking first at each region as a whole, we find that prevalence was significantly† *below* average in the Northern, North Western, and Eastern Regions, and in Wales, and that it was significantly *above* average in the Midland, London and South Eastern, Southern, and South Western Regions.

In the remaining regions the differences between actual and expected notifications were not statistically significant. The significant differences are too large to be accounted for by the fact that (to be consistent with Table V) uncorrected notifications

*Uncorrected notifications are the *original* notifications made to local Medical Officers of Health and transmitted to the General Register Office weekly; corrected notifications are the *final* notifications returned by the Medical Officer of Health quarterly, after taking account of corrections of diagnoses during the period.

†The criterion has been twice the standard error of the "expected".

TABLE I

COMPARISON OF ACTUAL AND EXPECTED* ORIGINAL NOTIFICATIONS OF POLIOMYELITIS IN COUNTY BOROUGH
AND ADMINISTRATIVE COUNTIES, 1947-50

Region	County Borough	Actual	Expected	Sig.	Actual % Expected	Administrative County	Actual	Expected	Sig.	Actual % Expected
Northern	Carlisle	26	42	-	62	Cumberland	146	134		109
	Darlington	14	54	-	26	Durham	525	568		92
	Gateshead	50	73	-	68	Northumberland	258	276		93
	Middlesbrough	59	92	-	64	Westmorland	51	43		119
	Newcastle-on-Tyne	235	187	+	126	Yorkshire (North Riding)	201	224		90
	South Shields	60	68		88					
	Sunderland	108	115		94					
	Tynemouth	31	42		74					
	West Hartlepool	22	46	-	48					
	Total—County Boroughs and Administrative Counties						1,786	1,964	-	91
East and West Ridings of Yorkshire	Barnsley	83	48	+	173	Yorkshire (East Riding) ..	117	133		88
	Bradford	177	184		96	Yorkshire (West Riding) ..	1,054	1,000		105
	Dewsbury	39	33		118					
	Doncaster	40	51		78					
	Halifax	20	61	-	33					
	Huddersfield	67	81		83					
	Kingston-on-Hull	152	189	-	80					
	Leeds	330	320		103					
	Rotherham	37	52	-	71					
	Sheffield	342	325		105					
	Wakefield	35	37		95					
	York	121	66	+	183					
	Total—County Boroughs and Administrative Counties						2,614	2,580		101
North Western	Barrow-in-Furness	38	43	-	88	Cheshire	414	508	-	81
	Birkenhead	62	89	-	70	Lancashire	956	1,278	-	75
	Blackburn	20	71	-	28					
	Blackpool	37	95	-	39					
	Bolton	64	107	-	60					
	Bootle	26	44	-	59					
	Burnley	12	54	-	22					
	Bury	18	37	-	49					
	Chester	25	30		83					
	Liverpool	442	505	-	88					
	Manchester	506	443	+	114					
	Oldham	33	77	-	43					
	Preston	32	75	-	43					
	Rochdale	35	56	-	63					
	St. Helens	26	70	-	37					
	Salford	181	114	+	159					
	Southport	15	54	-	28					
	Stockport	44	90	-	49					
	Wallasey	31	64	-	48					
	Warrington	36	50		72					
	Wigan	33	54	-	61					
	Total—County Boroughs and Administrative Counties						3,086	4,008	-	77
North Midland	Derby	57	90	-	63	Derby	249	429	-	58
	Grimsby	92	58	+	159	Leicester	192	217		88
	Leicester	295	179	+	165	Holland	99	64	+	155
	Lincoln	44	44		100	Lincoln } Kesteven	168	77	+	218
	Northampton	58	66		88	Lindsey	237	190	+	125
	Nottingham	141	190	-	74	Northampton	186	159	+	117
						Nottingham	269	330		82
						Peterborough	37	40	-	93
						Rutland	18	13		138
	Total—County Boroughs and Administrative Counties						2,142	2,146		100

*On the basis of the England and Wales notification rate applied to the local population.

TABLE I (continued)

Region	County Borough	Actual	Expected	Sig.	Actual % Expected	Administrative County	Actual	Expected	Sig.	Actual % Expected
Midland	Birmingham	1,060	702	+	151	Hereford	117	79	+	148
	Burton-on-Trent ..	19	31	—	61	Salop	126	172	—	73
	Coventry	148	160		93	Stafford	496	530		94
	Dudley	81	40	+	203	Warwick	369	303	+	122
	Smethwick	50	49		102	Worcester	272	248		110
	Stoke-on-Trent ..	87	175	—	50					
	Walsall	60	72		83					
	West Bromwich ..	24	55	—	44					
	Wolverhampton ..	107	102		105					
	Worcester	43	39		110					
Total—County Boroughs and Administrative Counties							3,059	2,757	+	111
Eastern	Great Yarmouth ..	31	33		94	Bedford	242	191	+	127
	Ipswich	18	66	—	27	Cambridge	54	104	—	52
	Norwich	96	75	+	128	Ely	21	57	—	37
	Southend-on-Sea ..	76	94		81	Hertford	381	377		101
						Huntingdon	33	41		80
						Norfolk	258	223	+	116
						Suffolk (East) ..	108	135		80
						Suffolk (West) ..	52	71	—	73
Total—County Boroughs and Administrative Counties							1,370	1,467	—	93
London and South Eastern	Brighton	93	99		94	Essex	973	983		99
	Canterbury	13	16		81	Kent	1,061	945	+	112
	Croydon	146	158		92	London	2,743	2,147	+	128
	Eastbourne	13	36	—	36	Middlesex	1,433	1,445		99
	East Ham	44	77	—	57	Surrey	861	847		102
	Hastings	37	42		88	Sussex (East) ..	199	213		93
	West Ham	56	110	—	51	Sussex (West) ..	175	197		89
Total—County Boroughs and Administrative Counties							7,847	7,315	+	107
Southern	Bournemouth	86	88		98	Berkshire	191	176		109
	Oxford	60	67		90	Buckingham	203	238	—	85
	Portsmouth	92	139	—	66	Dorset	300	174	+	172
	Reading	64	73		88	Oxford	87	103		84
	Southampton	139	114	+	122	Southampton ..	382	366		104
						Isle of Wight ..	141	59	+	239
Total—County Boroughs and Administrative Counties							1,745	1,597	+	109
South Western	Bath	58	49		118	Cornwall	279	211	+	132
	Bristol	636	279	+	228	Devon	376	317	+	119
	Exeter	52	48		108	Gloucester	284	267		106
	Gloucester	24	41	—	59	Somerset	344	295	+	117
	Plymouth	71	120	—	59	Wiltshire	269	222	+	121
Total—County Boroughs and Administrative Counties							2,393	1,849	+	129
Wales	Cardiff	158	154		103	Anglesey	8	31	—	26
	Merthyr Tydfil ..	22	38	—	58	Brecknock	27	34		79
	Newport	26	67	—	39	Caernarvon	49	78	—	63
	Swansea	114	101		113	Cardigan	15	34		44
						Carmarthen	114	108	—	106
						Denbigh	93	107		87
						Flint	88	88		100
						Glamorgan	347	462	—	75
						Merioneth	19	25		76
						Monmouth	98	202	—	49
England and Wales						Montgomery	43	29	+	148
						Pembroke	26	55	—	47
						Radnor	20	13	+	154
	Total—County Boroughs and Administrative Counties						1,267	1,626	—	78
	TOTAL—County Boroughs ..	8,355	8,624		97	TOTAL—Administrative Counties	18,954	18,685		101
TOTAL—all County Boroughs and Administrative Counties combined ..							27,309	27,309		100

have been used. The ratios of corrected (final) to uncorrected (original) notifications in each region are shown in Table II.

TABLE II
ACUTE POLIOMYELITIS
Corrected Notifications per 100 Original Notifications at All Ages.
Standard Regions, 1947-50 (average)

Region*	Corrected Notifications per 100 Original
Northern	87
East and West Ridings of Yorkshire ..	87
North Western	77
North Midland	89
Midland	86
Eastern	89
London and South Eastern	83
Southern	94
South Western	87
Wales	87
Total (England and Wales) ..	85

*As defined in publications of the Registrar-General

Looking now at individual towns and counties, the following contrasts may be noted:

Significance Excesses	Significant Deficiencies
Newcastle, Barnsley, York, Manchester, Salford	Most other towns and outlying areas of north of England.
Grimsby, Leicester, and most of Northamptonshire and Lincolnshire	Derby, Nottingham, and surrounding county areas.
Birmingham, Dudley, and parts of Warwickshire and Herefordshire	Burton-on-Trent, Stoke-on-Trent, West Bromwich, and county of Shropshire
Norwich, and counties of Bedford and Norfolk	Ipswich and county districts of Suffolk, Cambridge, and Ely.
London and the county of Kent. (Prevalence in the other Home Counties—Surrey, Middlesex, Essex—was close to expectation)	East Ham, West Ham, Eastbourne.
Southampton, Bristol, and county districts of Dorset, Isle of Wight, Cornwall, Devon, Somerset, and Wiltshire	Gloucester, Portsmouth, Plymouth, Buckinghamshire.
Montgomery and Radnor	Rest of Wales.

No obvious explanation suggests itself why the two similar towns of Ipswich and Norwich or the similar counties of Suffolk and Norfolk should experience widely different levels of prevalence, or why differences should exist between Portsmouth and Southampton, between Bristol and Nottingham, between Hereford and Shropshire, between Leicester and Derby, between inner London and the contiguous dense urban areas of West Ham and East Ham, or between Manchester and the almost indistinguishable urban area of Stockport. Even the apparently common factor of high prevalence in the major towns of London, Manchester, Birmingham, Newcastle, Bristol, Leicester, and Southampton,

and (to a non-statistically significant extent) in Sheffield and Leeds, is invalidated by the exclusion of Liverpool, Bootle, Kingston-on-Hull, Nottingham, Stoke-on-Trent, and Portsmouth, and many other towns which approach them in size.

SOCIAL CONDITIONS

The question arises whether the differential incidence of poliomyelitis in towns and counties is associated with social factors such as standards of living and hygiene or housing density. No correlation has yet been established between social class and poliomyelitis incidence when indirect indices are used, such as the proportions of local populations engaged in certain occupational groups (Daley and Benjamin, 1948) or infant mortality (Hill and Martin, 1949), but there has been a suggestion that overt (as distinct from subclinical) cases of poliomyelitis tend to 'appear relatively less frequently in more crowded housing conditions (Daley and Benjamin, 1948).

An examination of the variability of poliomyelitis incidence was made by extracting, for each County Borough and Administrative County, the corrected (final) notification rate at all ages for the years 1947-50 inclusive, the average number of persons per dwelling (this is both a measure of crowding though not necessarily overcrowding, and a measure of the equally important number at risk in households), and the percentage of the male population over the age of 15 with occupations in Social Classes IV and V (Census 1951, 1 per cent. Sample Tables), i.e. persons in unskilled occupations.

The coefficients of correlation between the notification rate and both the housing density index and the proportion in the lower social classes were then calculated. In making these calculations the County Boroughs were zoned (Northern, Midland, Southern, etc.) to permit of the emergence of any differential association for parts of the country. The results coefficients is significantly different from zero. If (Table III, opposite) indicate that poliomyelitis incidence (as measured by notification) is not sensibly associated with the proportion of the population in occupations of low social status. None of the socio-economic environment is measured by the adopted index, viz. proportion in Social Classes IV and V, then it appears unlikely that this is a factor influencing the transmission of or the susceptibility to poliomyelitis in different areas.

The findings are equally negative in relation to housing density. None of the correlation coefficients is significantly different from zero. There is thus no evidence that the different notification rates in

TABLE III

CORRELATION BETWEEN POLIOMYELITIS INCIDENCE AND SOCIAL FACTORS IN COUNTY BOROUGHES AND ADMINISTRATIVE COUNTIES OF ENGLAND AND WALES, 1947-50

Areas		Number of Areas	Mean Notification Rate of Poliomyelitis at All Ages per 100,000 (1947-50)	Mean Proportion of Male Population aged 15+, in Social Classes IV and V, per cent. (1951, 1 per cent. Sample Table)	Number of Persons per Dwelling	Correlation Coefficients between Poliomyelitis Notifications and	
						Social Class	Housing Density
County Boroughs in Groups of Standard Regions*	Northern East and West Ridings of Yorkshire North Western	42	10.0	32.2	3.21	+0.176	+0.139
	North Midland Midland Eastern	20	15.9	28.1	3.27	-0.105	-0.054
	Greater London South Eastern Southern South Western Wales	21	12.6	26.6	3.15	-0.167	-0.124
All County Boroughs		83	12.7	29.6	3.21	-0.118	+0.061
All Administrative Counties		62	13.9	28.7	3.18	-0.146	-0.033
All Areas		145	13.5	29.0	3.19	-0.114	+0.040

*Standard Regions as defined in publications of the Registrar-General.

different areas of the country are associated with different levels of housing density as measured by the adopted index of persons per dwelling.

Urbanization as such, apart from housing density, does not seem to be a factor. In a general review of the years 1947-50 Martin (1951) found no evidence that the towns had a greater liability than the rural districts.

DIFFERENTIAL EXPOSURE

One might approach the problem by considering the exposure of individual families. More often than not poliomyelitis spreads rapidly and diffusely (Daley and Benjamin, 1948), defying attempts to identify foci or to trace spread from infector to infected, except in some of the more localized outbreaks (as for example in the Isle of Wight in 1950—Ministry of Health, 1952). Nevertheless a virus which moves so disconcertingly quickly must still require the assistance of a vector, human or otherwise, and must emanate from some source of supply. If differential attack rates in families could be established in conditions comparable in all aspects except degree and type of contact with specific sections of the community, then an examination of the variability of such contact might be profitable.

The daily contact risk of an individual is inseparable from, but largely determined by, the manner in which he earns his living, though we have shown that it is not correlated with socio-economic status as measured by occupation. In 1949, classifying

cases of poliomyelitis by occupation of father, the Medical Officer of Health for Essex (Cowan, 1950) found that the occupations of bus conductor and bus driver were associated with an unexpectedly high number of cases (in the families, not in the fathers); but small numbers were involved and there have been no further reports confirming this suggestion. Logan (1953) has drawn attention to the frequent mention of school teachers as parents of cases of poliomyelitis in Southend C.B. in 1952.

OCCUPATION.—In order to make a test of these two last suggestions in particular and occupational association (in families) in general, the notified cases of (confirmed) poliomyelitis in children under the age of 15 in the County of London in 1949 and 1950 were collected, and the help of the Health Visitors was enlisted to trace and classify them by occupation of the principal wage earner of each family. The results are shown in Table IV (overleaf).

It was practicable by reference to a random sample of London families, all with at least one child (Hartston and Gore, 1953), to make an allocation, by occupation of principal wage earner of household, of a sample of *all* children under 15 (whether cases of poliomyelitis or not) and thus to provide the relevant numbers at risk, but no direct calculations of attack rates were made in view of the small numbers involved. A comparison was, however, made between actual distribution (Column 5) with that expected on the basis of the occupational distribution of the children (Column 6).

TABLE IV
POLIOMYELITIS CASES AT AGES 0-14 IN LONDON A.C. 1949-50 BY OCCUPATION OF PRINCIPAL WAGE EARNER

1950 Code of Occupation (1)	Occupational Group (2)	Number of Children aged 0-14 with Principal Wage Earner in Group, London Sample (Hartston and Gore) (3)	Cases of Poliomyelitis in Children, by Occupation Group of Principal Wage Earner of Family			
			Actual Number of Cases (4)	Adjusted to Include Rateable Distribution of "Not ascertained" (5)	Expected on Basis of Col. (3) (6)	(5)-(6) (7)
010-030	Agriculture, forestry	6	2	2	2	—
070-079	Glass, glassware	22	1	1	8	- 7
090-109	Coal, gas, coke, chemicals	28	—	—	10	- 10
110-129	Metal, engineering, allied trades	340	109	127	125	+ 2
350-379	Leather, boot, shoe, fur	14	7	8	5	+ 3
380-419	Textile goods, articles of dress	41	25	29	15	+ 14
420-469	Food, drink, tobacco (makers)	27	13	15	10	+ 5
470-489	Wood, cane, cork	100	24	28	37	- 9
500-539	Paper, bookbinding, printing	36	8	9	13	- 4
540-579	Miscellaneous products (rubber, plastics, surgical appliances, musical instruments, etc.)	27	5	6	10	- 4
580-599	Building, contracting	135	41	48	50	- 2
600-609	Painting, decorating	86	24	28	32	- 4
610-629	Administration, directing, managing	29	3	3	11	- 8
630-649	Railway transport	40	12	14	15	- 1
650-669	Road transport	256	79	92	94	- 2
670-689	Water transport	25	14	16	9	+ 7
690-709	Other transport (including Post Office)	73	17	20	27	- 7
710-749	Commercial (wholesale and retail businesses, brokers, advertisers, etc.)	140	64	74	51	+ 23
750-759	Finance, insurance	19	9	10	7	+ 3
760-819	Professional	84	39	45	31	+ 14
820-839	Defence	95	25	29	35	- 6
840-855	Entertainment, sport	19	3	3	7	- 4
861-888	Personal service (domestic service, clubs, hotels, etc.)	108	41	48	40	+ 8
890-895	Clerks, typists	169	34	40	62	- 22
900-909	Warehousemen, packers	58	23	27	21	+ 6
910-921	Stationary engine drivers	29	6	6	11	- 5
930-950	Unskilled occupations	185	59	69	68	+ 1
	Undefined or not specified above	53	16	19	20	- 1
	Not gainfully occupied	5	10	12	2	+ 10
	Not ascertained	—	115	—	—	—
Total		2,249	828	828	828	—

The number of cases of poliomyelitis for whom no occupation of principal wage earner could be stated (mostly "removals" in the intervening period), have been distributed over the occupations in proportion to the "stated" cases. Column 4 includes 26 cases of poliomyelitis where there was no father living, which were classed by occupation of mother, and an unknown but probably small number where the child was not living with the father (e.g. a residential nursery case).

When the actual distribution is compared with that expected from the estimated occupational distribution of all children, there are no differences large enough to be accepted as statistically significant, having regard to sampling errors in both Columns 5 and 6, but there are large excesses over expectation in the families of workers in textile goods and articles of dress (193 per cent. of expected), and in commercial occupations (mainly wholesale or retail businesses) (145 per cent. of expected). There are rather large deficiencies from expectation in the families of clerks (65 per cent.) and administrators and directors (27 per cent.).

There are, however, several factors to be taken into account which lead us to reject these differences as being associated with occupational contact. In the first place, the differences, though large, are within the range of sampling fluctuation. Secondly, the particulars of occupation of principal wage earner as given to the Health Visitor are not always detailed and errors in assignment may have been made. The coding was done carefully and errors were minimized, but this source of possible error must not be overlooked. It is possible that the excess in commercial workers' families and the deficiency in those of clerks and typists represent compensating errors of this kind.

Thirdly, it is important to remember that we are dealing with one member of a family only, viz. the father (and, in a very small number of cases, the mother). There is no reason to suppose either that he is the only person likely to bring virus to his children, or that the other members of the family who may serve as vectors, e.g. elder sisters, have a similar occupational distribution. Thus, the high incidence in children of fathers in a certain occupation

may be due to excessive contacts by other children of same family or to the employment of other members of the family in quite different occupations.

EXPOSURE RISK.—There is in addition another important factor which has been the cause of many epidemiological fallacies in the past (Greenwood, 1935), namely, that the children in families of different occupational groups of fathers may also vary in their exposure and immunity experience not only by virtue of the factors already mentioned above but also as a result of different educational or recreational facilities or different locality of residence.

NEED FOR FURTHER STUDY.—On the whole, the differences in Column 6 of Table IV are very small, and the one or two larger differences may be discounted as sampling fluctuations or coding errors unless confirmed. It seems unlikely that there are real differences in the risk of contracting poliomyelitis which can be associated with the occupation of the principal wage earner of the family. This is perhaps not surprising with so ubiquitous a virus, but supposition is not enough and further study would be justified by the necessity for a clear verdict. Meanwhile, there would seem to be no real justification for premature anxiety or complacency on the part of any occupation.

So far as bus and tram conductors are concerned, the numbers of poliomyelitis cases assigned to their families numbered nine against an expectation (from greater detail than given in Table IV) of ten. School teachers had eight cases in their families against an expectation of five; the excess is not statistically significant and is not proportionately greater than that of the whole professional group in Table IV.

TIMING OF HIGH PREVALENCE

It is possible that the period 1947–50, only the first four years since the emergence of epidemic conditions in England–Wales (on more than a very local scale) is not long enough for a stable pattern of geographical variation in prevalence to have developed. If this is so, then areas which have hitherto suffered under-average prevalence can have no guarantee that this favourable experience will continue.* It is a possibility to be reckoned with that areas which in Table I are shown as significant “minus” may have to deal with larger numbers of cases in the future. This is especially to be borne in mind in view of the fact that only a small part of the variation between areas in 1947–50

has been explained by social factors—this itself is a hint that the pattern is still not permanent, and that spread from area to area, is still disturbed and irregular simply from the play of chance and circumstance. It is, however, also probable that we have not been measuring the variation in the prevalence of *infection* since we have left out of account the presumptively large number of sub-clinical cases which are not detected and are therefore not notified; the ratio of subclinical to overt cases in urban areas may well vary between wide limits with variation in local standards of hygiene.

Aside from all these reservations, we may consider notifications in any one area as a local index of prevalence, geared to the true prevalence of infection in manner perhaps peculiar to the locality, but nevertheless stable. If this is so, we may look at the rhythm of epidemic ebb and flow of cases in individual areas, in order, as we suggested in the introduction, to discern whether or not there is anything in the contour of the epidemic waves which would make it possible to forecast the subsequent attainment of major prevalence. It had been noticed in 1950 that in both Bristol and Birmingham outbreaks of notified poliomyelitis of greater proportions than the average for the country as a whole were preceded by an unusually high incidence in those areas in the winter (the first quarter of the year). In Bristol this occurred also in 1949 and in Birmingham also in 1947.

In order to test the generality of this conjunction of events, the original notifications in the county boroughs and administrative counties of England and Wales have been tabulated by quarters for the period 1947–50, and in each quarter have been compared with “expected” numbers on the basis of the notification rates for England and Wales as a whole (as in Table I). Shortage of space prohibits publication of the full tabulation but a selection is shown in Table V (overleaf) to indicate the method. A plus sign (significant excess over expectation) in the first quarter followed by a plus sign in the third quarter (regardless of the second or fourth quarters, which are nevertheless highly correlated with the third quarter) occurs six times among county Boroughs. There are 83 such towns with four years of experience each; a plus in the first quarter occurred nineteen times and a plus in the third quarter 45 times. On the assumption that winter and summer prevalences are independent, we should expect the occasions on which the two plus signs coincide to amount to:

$$332 \left(\frac{19}{332} \times \frac{45}{332} \right) = 2.6 \pm 1.6.$$

*Preliminary results for 1952 show that of 38 county boroughs in this category only three (Gateshead, West Hartlepool, and Burton-on-Trent) had above-average prevalence.

TABLE V

NUMBER OF ORIGINAL NOTIFICATIONS, EXPECTED NUMBER, PLUS OR MINUS FOR SIGNIFICANT DIFFERENCES, AND ACTUAL NUMBER PER CENT. OF EXPECTED, 1947-50
A selection of County Boroughs and Administrative Counties*

Year	BARNSELY				BIRMINGHAM				HERTFORDSHIRE			
	Actual	Expected	Sig.	Actual % of Expected	Actual	Expected	Sig.	Actual % of Expected	Actual	Expected	Sig.	Actual % of Expected
1947	1	—	0.2	—	10	3.1	+	323	2	1.6		125
	2	2	0.5	—	10	7.7		130	5	4.1		122
	3	12	11.4	105	205	167.2	+	123	82	89.8		91
	4	3	4.2	71	78	66.2		118	42	33.4		126
1948	1	—	0.8	—	24	11.4	+	211	6	6.1		98
	2	—	0.5	—	12	6.7	+	179	3	3.6		83
	3	4	1.4	286	26	19.9		131	13	10.7		121
	4	8	1.3	615	18	19.6		92	14	10.5		133
1949	1	1	0.4	250	9	6.3		143	7	3.4		206
	2	1	0.5	200	4	7.5		53	6	4.0		150
	3	9	5.5	164	50	80.4	—	62	54	43.2		125
	4	23	5.8	397	60	84.5	—	71	61	45.4	+	134
1950	1	3	0.9	333	28	13.1	+	214	4	7.0		57
	2	4	1.3	308	154	18.5	+	832	9	9.9		91
	3	5	9.1	55	287	133.4	+	215	46	71.6	—	64
	4	8	4.1	195	85	60.4	+	141	27	32.4		83

Year	BOOTLE				BRISTOL				LONDON			
	Actual	Expected	Sig.	Actual % of Expected	Actual	Expected	Sig.	Actual % of Expected	Actual	Expected	Sig.	Actual % of Expected
1947	1	—	0.2	—	2	1.2		167	16	9.4	+	170
	2	—	0.5	—	3	3.0		100	30	23.4		128
	3	2	10.5	19	61	66.3		92	785	511.2	+	154
	4	3	3.9	77	26	24.7		105	224	190.4	+	118
1948	1	1	0.7	143	6	4.5		133	48	34.7	+	138
	2	—	0.4	—	6	2.7		222	30	20.4	+	147
	3	2	1.3	154	18	7.9	+	228	76	61.0		125
	4	1	1.2	83	16	7.8	+	205	58	60.1		97
1949	1	1	0.4	250	9	2.5	+	360	22	19.4		113
	2	—	0.5	—	6	3.0		200	31	23.0		135
	3	10	5.1	196	87	31.9	+	273	381	246.0	+	155
	4	1	5.3	19	92	33.5	+	275	460	258.5	+	178
1950	1	—	0.8	—	10	5.2	+	192	49	40.1		122
	2	—	1.2	—	7	7.3		96	58	56.4		103
	3	4	8.4	48	181	52.9	+	342	347	407.9	—	85
	4	1	3.8	26	106	24.0	+	442	128	184.6	—	69

*This is an arbitrary selection to show the method. The full table, comprising 83 County Boroughs and 62 Administrative Counties, may be consulted at the General Register Office on request, and may possibly be published later in an Annual Statistical Review of the Registrar-General.

This is less than the number actually observed but not significantly so. For the administrative counties we have seven observed occurrences, while the expected occurrences amount to:

$$248 \left(\frac{24}{248} \times \frac{52}{248} \right) = 5.$$

The expectation is associated with a standard error of sampling of 2.2, so that the excess is again not statistically significant. If we take combinations of excess prevalence in the first quarter with excess prevalence in either the third or the fourth quarter (or both) we obtain this result:

Region	Coincidences	
	Observed	Expected
County Boroughs	6	3.9 ± 2.0
Administrative Counties ..	11	7.5 ± 2.7

On the assumption that incidence in the winter is entirely independent of that in the ensuing summer, the expected coincidences are small in number and are fewer than those actually observed, though not by statistically significant margins. The observed coincidences were still very small. In the total of 43 instances of high prevalence in the winter,

excessive summer or autumn prevalence followed on only seventeen occasions.

The combination of high prevalence in winter with high prevalence in the ensuing summer observed in Bristol and Birmingham was not a commonly observed phenomenon suggestive of an epidemiological law; high prevalence in winter cannot be presumed to have any general prognostic value.

It might be thought that our test of major prevalence is too stringent, since it depends on excess above average and does not therefore admit the possibility of epidemics of large and equal proportions in every area at the same time (there would then be major prevalence without any plus or minus signs). This last event has not yet occurred. In the full tabulation of which Table V is a sample there were many plus and minus signs. Furthermore, for a prognostic sign to be of value, it must not merely warn of *some* epidemicity in the summer since that is expected by every Medical Officer of Health; it must warn of exceptionally high prevalence. On these grounds the stringency appears justified.

PERIODICITY OF HIGH PREVALENCE

For England and Wales *as a whole* 1947, 1949, and 1950 were each years of epidemic prevalence with numbers of cases far exceeding the pre-1947 figures. The tabulation of which Table V is a sample showed the extent to which this was true of individual areas. If we regard prevalence as "high", "average", or "low", according to whether there is a plus, nil, or minus against the third or fourth quarters, we obtain the following picture for those areas which had more than one "high" year in the period (towns with three "high" years, *i.e.* two intervals, are counted twice):

Interval (yrs) between Two "High" Years	County Boroughs	Administrative Counties
1	16	15
2	6	10
3	3	4
Total Intervals ..	25	29

Only 21 out of 83 towns and 22 out of 62 counties experienced more than one "high" year, but in these areas the two "high" years often succeeded each other.

The nature of the prevalence in the year following a "high" year can be indicated thus:

Prevalence in Year following "High" Year	County Borough	Administrative Counties
High	16	15
Average	25	26
Low	11	10
Total	52	51

The year following a year of high prevalence is more often "high" or "average" than "low". It is clear from this that local areas cannot be assured of any respite following a major outbreak. It appears that in areas which have so far been subjected to epidemic prevalence in excess of the average the "susceptibles" are not exhausted in the single seasonal outbreak; often sufficient escape to support a major prevalence when conditions once more favour epidemicity (Bradley and Richmond, 1953).

The prevalence following "low" years is indicated below:

Prevalence following "Low" Year	County Boroughs	Administrative Counties
High	15	13
Average	38	22
Low	19	10
Total	72	45

In the year following low prevalence "high" and "low" prevalence are almost equally likely, but "average" prevalence is most frequent. Subnormal incidence in one year is therefore not a sure indication that epidemicity will be maximal in the following year.

In the limited experience reviewed here, there have been towns with successive "high" years and towns with successive "low" years, but it is uncommon for "high" and "low" years to occur equally in the same town. The result has been, as indicated in the early part of this paper, an uneven distribution of prevalence of poliomyelitis during the period 1947 to 1950. It remains to be seen whether this experience will be maintained or whether time will level out differences.

SUMMARY

An examination has been made of the geographical variation in the incidence of notified poliomyelitis in England and Wales during 1947 to 1950. There has been a tendency for some areas to suffer successive years with higher than average prevalence, and for other areas to experience successive years with lower than average prevalence; on balance there are some areas of the country which within the period studied had significantly higher prevalence than others. This differential incidence does not appear to be associated with social conditions as measured by the proportion employed in unskilled occupations or housing density. The notifications in the County of London were examined to see whether there was any occupational factor in the transmission of the virus. The results were negative.

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