

## **Urban variation in infant mortality from birth injury and atelectasis in England and Wales in 1958–67**

BY PERCY STOCKS

*34 Brompton Avenue, Colwyn Bay, North Wales*

*(Received 31 August 1971)*

### SUMMARY

Variations in mortality attributed to birth injury and atelectasis in the 10 years 1958–67 have been investigated for each county borough of England and Wales. It became evident that diagnostic difficulties in separating these two causes must have been such that for statistical purposes they should be combined in a single rate.

Variables likely to affect the local rates such as the sex ratio of births, and rates of illegitimacy and immaturity as an ill-defined cause of death appeared to affect the mortality levels in certain towns but not sufficiently to account for the wide variations apparent in those levels. It is concluded that local surveys are necessary in the towns with highest rates to uncover differences in numbers of births in hospital, in obstetric techniques and in quality of medical care.

During the four decades from 1911 to 1951 the rate of infant mortality from all causes in England and Wales fell from 130 to 30 per 1000 live births, but in the same period the rate attributed to injury at birth and atelectasis increased from 2·7 to 6·3. Since 1951 total infant mortality has continued to fall to 18 in 1967 whilst the combined birth injury and atelectasis rate remained at its high level above six until 1961 and then declined to 4·6 in 1967, as shown in Table 1.

One of the factors responsible for this recent improvement may well have been the nation-wide investigation of peri natal mortality which was carried out by the National Birthday Trust Fund of some 25,000 babies born in March 1958 and of the 3242 neonatal deaths which occurred in England, Wales and Scotland during March, April and May of that year, reported on by Butler & Bonham (1963). Detailed inquiries concerning the deaths were made from the midwives and medical attendants at the births, and necropsies were made on most of the deaths occurring during March. This investigation must have improved the accuracy of diagnosis and registration of cause where this was obscure and it may have contributed to some of the apparent local changes and contrasts in the mortality registered during 1958–67 which are the main subject of study in the present paper.

Only the deaths of live-born infants are dealt with here, and no attempt is made to relate findings with those obtained in the 1958 survey. In the peri natal survey the coverage was not large enough to permit comparison of rates in separate

For the whole 10-year period the actual and expected deaths were then aggregated to obtain the overall comparative mortality ratios  $100D/E$ , where  $D$  were the actual and  $E$  the expected deaths. Where there is an excess over expectation the significance of this is measured by  $d^2/E$ , where  $d$  is the difference between  $D$  and  $E$ . If  $d^2/E$  exceeds 3.8 the excess is significant at the conventional level  $P < 0.05$  and is shown in the final column of Table 4; other cases where  $D$  exceeds  $E$  are indicated by 'ns'.

In Table 2 the hospital regions are examined to see whether in 1963–7 there were important differences between the rates for birth injury in the regions or between the county boroughs and other areas within each region. The regions are ranked in descending order of the C.M.R. for the region as a whole, and it is seen that those levels of mortality range from 124 and 123 in Manchester and Birmingham hospital regions to 89 and 84 in the Metropolitan and the East Anglia divisions. The four Metropolitan regions have been aggregated and the Oxford and Wessex regions combined for the purposes of Tables 2 and 3.

The C.M.R.s in the parts of the regions outside the county boroughs show some contrasts from the figures in the county boroughs, and the highest rates for such residual areas occur in the South West, Birmingham, Manchester and Welsh regions. The final column of Table 2 indicates a large excess of urban mortality in Leeds, Manchester and Liverpool hospital regions and a large urban deficiency in the South West, Oxford–Wessex and Welsh regions. Since the factors affecting the incidence of injury at birth include method of delivery, use of forceps and whether the delivery took place in a hospital, the higher mortality in the Lancashire and Yorkshire county boroughs than in residual areas of those counties is not easily explained. Why should the risk of birth injury be greater in Leeds and Bradford than in the Yorkshire dales? Are employment of women in factories or

Table 2. *Post-natal mortality from injury at birth (nos. 760–1) in 1963–7 based on numbers of live births and expressed in terms of national rate, in hospital regions, distinguishing county borough aggregates from the rest of each region*

Hospital regions ranked by C.M.R. for whole region	No. of deaths in		Comparative mortality (C.M.R.) for			Difference between C.B.S. and the rest
	County boroughs	Rest of region	Whole region	County boroughs	Rest of region	
Manchester	515	521	124	141	111	+ 30
Birmingham	583	612	123	125	121	+ 4
South western	165	432	115	92	126	- 34
Leeds	381	246	112	133	85	+ 48
Newcastle	235	372	107	112	105	+ 7
Welsh	104	388	106	89	114	- 25
Oxford and Wessex	93	506	98	65	96	- 31
Sheffield	314	513	97	103	94	+ 9
Liverpool	293	130	96	107	78	+ 29
Metropolitan*	1507	813	89	91	87	+ 4
East Anglia	49	193	84	94	83	+ 11

\* Including Greater London with the county boroughs.

larger proportions of foreign immigrants factors of importance? To those questions answers are unknown. In the South West and Wales, however, there are few large towns and in many of the country districts ready availability of specialist services for difficult births is restricted, so higher rural than urban rates are understandable. The Newcastle, Sheffield and Metropolitan regions show no important differences between the urban and rural parts.

The analysis in Table 3, unlike that in the previous table, comprises the whole 10-year period, and the C.M.R.s for birth injury and also for atelectasis in the county borough aggregates within each region are shown for each of the 5-year periods and the whole period. The regions are ranked in descending order of the overall ratios for birth injury only, which ranged from 133 in Manchester and 124 in Liverpool and Birmingham regions to below 85 in the Oxford and Wessex regions and East Anglia. The north-west to south-east downward trend of rates characteristic of mortality from so many causes was very evident in both periods for birth injury. Atelectasis rates in 1958-62, however, were highest in Wales, followed by Liverpool and the Oxford-Wessex area, but in 1963-7 they were high in the Manchester and Leeds regions. In addition to showing the facts for both causes of death, a purpose of the table is to see whether the changes in registered mortality occurring in the second 5-year period indicated in any region a transfer of diagnosis from one cause to the other. There was a transfer to atelectasis in Manchester and Newcastle regions and one of the opposite kind, from atelectasis to birth injury, was indicated in Wales and the Oxford and Wessex area.

The most remarkable change occurring during the 10 years was the decline in Liverpool mortality from both causes (141 to 107 for birth injury and 139 to

Table 3. *Comparative post-natal mortality from birth injury and atelectasis based on numbers of live births in 1958-62 and 1963-7 in the county boroughs of each hospital region*

Hospital regions in which county boroughs are located	Birth injury (760-761)					Atelectasis (762)						
	Total deaths	C.M.R. in			C.M.R. change in	Total deaths	C.M.R. in			C.M.R. change in		
		1958-67	1958-62				1958-7	1958-67	1958-62		1958-7	
			1958-62	1963-7					1958-62			1963-7
Manchester	1028	125	141	133	+16	1377	109	140	129	+31		
Liverpool	717	141	107	124	-34	1005	139	101	121	-38		
Birmingham	1218	123	125	124	+2	1387	103	101	102	-2		
Leeds	723	105	133	120	+25	1017	108	126	117	+18		
Newcastle	540	118	112	115	-6	665	96	108	101	+12		
Sheffield	658	102	103	103	+1	970	107	102	104	-5		
Metropolitan*	3008	91	100	94	+9	4588	100	106	102	+6		
Welsh	247	94	89	92	-5	445	162	98	132	-64		
South western	342	84	92	90	+8	476	85	99	92	+14		
East Anglia	88	70	94	82	+24	88	53	69	60	+16		
Oxford and Wessex	224	86	65	75	-21	472	129	95	112	-34		

\* The C.M.R.s are for Greater London conurbation: the total deaths include 97 from birth injury and 179 from atelectasis in the five county boroughs of the region which were outside Greater London.

Table 4. Comparative mortality based on numbers of live births and attributed to birth injury and atelectasis in each county borough of England and Wales

County boroughs alphabetically in each hospital region	Birth injury (760, 761)					Atelectasis (762)				
	Total deaths	C.M.R.s (per 100 expected)			Significant excess ( $d^2/E$ )*	Total deaths	C.M.R.s (per 100 expected)			Significant excess ( $d^2/E$ )*
		1958-67	1958-62	1963-7			1958-67	1958-62	1963-7	
<b>Manchester region</b>										
Barrow in Furness	18	85	47	65	—	44	82	173	128	ns
Blackburn	24	59	65	62	—	71	121	141	130	5
Blackpool	49	123	112	117	ns	75	121	130	126	4
Bolton	66	80	145	111	ns	145	174	182	177	8
Burnley	48	169	166	167	13	65	159	163	161	15
Bury	21	81	83	82	—	44	136	110	123	ns
Manchester C.B.	420	147	154	149	68	466	109	129	118	13
Oldham	128	190	391	287	16	88	180	96	140	12
Preston	48	97	116	104	ns	74	125	101	114	ns
Rochdale	42	95	157	125	ns	58	106	188	140	6
Salford	87	114	151	131	6	126	90	181	133	11
Stockport	48	140	49	93	—	95	129	133	131	4
Wigan	29	124	73	100	—	26	50	79	61	—
Total C.B.s	1028	125	141	133	—	1377	109	140	129	—
<b>Liverpool region</b>										
Birkenhead	96	146	171	156	19	83	143	78	116	ns
Bootle	42	121	81	104	ns	60	128	63	106	ns
Chester	36	143	157	109	6	24	61	82	71	—
Liverpool C.B.	384	151	93	123	18	594	148	95	125	30
St Helens	34	87	77	82	—	94	145	181	159	21
Southport	23	111	79	96	—	21	45	82	65	—
Warrington	41	157	110	134	4	55	101	158	129	4
Wallasey	61	122	142	132	5	74	133	122	124	4
Total C.B.s	717	141	107	124	—	1005	137	101	127	—
<b>Birmingham region</b>										
Birmingham C.B.	588	123	123	125	27	752	112	115	117	10
Burton-on-Trent	21	99	99	99	—	31	114	93	106	ns
Coventry	253	128	245	176	83	229	65	69	67	—
Dudley †	33†	142	116‡	128†	ns	35†	117	79‡	97†	—
Smethwick†	21†	111	44‡	77†	—	23†	83	37†	60†	—
Stoke-on-Trent	60	87	33	62	—	168	123	122	123	7
Walsall	70	130	154	141	8	79	111	95	103	ns
West Bromwich†	41†	73	128‡	104†	ns	46†	117	103‡	111†	ns
Wolverhampton†	107†	207	121‡	163‡	15	102†	97	128‡	113†	ns
Worcester	24	77	115	95	—	29	65	100	90	—
Total C.B.s	1218	123	125	124	—	1494	103	101	102	—

Table 4 (cont.)

County boroughs alphabetically in each hospital region	Birth injury (760,761)					Atelectasis (762)				
	Total deaths	C.M.R.s (per 100 expected)			Significant excess ( $d^2/E$ )*	Total deaths	C.M.R.s (per 100 expected)			Significant excess ( $d^2/E$ )*
		1958-67	1958-62	1958-1963-7			1958-67	1958-62	1958-1963-7	
Leeds region										
Bradford	161	144	115	131	12	302	149	204	174	97
Dewsbury	24	107	128	117	ns	29	101	100	100	—
Halifax	31	69	104	86	—	43	71	100	84	—
Huddersfield	27	56	48	52	—	75	109	86	103	ns
Kingston upon Hull	109	75	96	86	—	198	126	97	109	ns
Leeds C.B.	301	119	185	150	51	299	94	121	106	ns
Wakefield	21	82	124	101	ns	45	197	104	155	8
York	49	112	146	129	ns	26	20	77	43	—
Total C.B.s	723	105	133	120	—	1017	108	126	117	—
Newcastle region										
Carlisle	41	190	83	143	5	27	67	66	66	—
Darlington	54	175	169	172	16	34	67	88	77	—
Gateshead	36	81	88	83	—	40	82	45	66	—
Middlesbrough	74	56	107	97	—	85	66	102	81	—
Newcastle upon Tyne C.B.	107	112	89	102	ns	115	73	86	78	—
South Shields	67	149	153	151	11	85	85	92	88	—
Sunderland	99	113	145	125	5	201	178	192	184	16
Tynemouth	31	109	114	111	ns	51	124	146	134	4
West Hartlepool	31§	61	80	80§	—	57§	118	106	113§	ns
Total C.B.s	540	118	112	115	—	695	96	108	101	—
Sheffield region										
Barnsley	24	73	98	84	—	68	172	163	167	11
Derby	61	119	123	124	4	92	150	113	132	4
Doncaster	31	92	99	93	—	59	116	139	132	5
Grimsby	24	52	65	58	—	55	83	101	91	—
Leicester	125	126	103	116	ns	151	92	85	88	—
Lincoln	24	57	72	79	—	36	93	71	87	—
Nottingham	111	78	139	107	ns	229	163	78	128	10
Rotherham	61	182	164	163	15	65	126	125	124	ns
Sheffield C.B.	167	115	65	91	—	215	56	115	87	—
Total C.B.s	628	102	103	103	—	970	107	102	104	—
Metropolitan regions										
Brighton	33	62	67	64	—	61	89	79	84	—
Canterbury	6	54	58	56	—	12	57	96	75	—
Eastbourne	9	57	68	63	—	20	115	69	93	—
Hastings	20	96	106	66	—	16	67	54	61	—
Southend-on-Sea	29	75	31	56	—	70	92	97	94	—
Greater London	2911	91	106	94	—	4409	100	106	102	—
Total C.B.s plus Greater London	3008	—	—	—	—	4588	—	—	—	—

Table 4 (cont.)

County boroughs alphabetically in each hospital region	Birth injury (760, 761)					Atelectasis (762)				
	Total deaths	C.M.R.s (per 100 expected)			Significant excess ( $d^2/E$ )*	Total deaths	C.M.R.s (per 100 expected)			Significant excess ( $d^2/E$ )*
		1958-67	1958-62	1963-7			1958-67	1958-67	1958-62	
East Anglia region										
Ipswich	41	70	99	83	—	45	60	83	70	—
Great Yarmouth	11	65	62	65	—	13	47	63	55	—
Norwich	36	72	104	87	—	30	48	57	52	—
Total C.B.s	88	70	94	82	—	88	53	69	60	—
Oxford and Wessex regions										
Northampton	39	82	91	87	—	72	139	92	115	ns
Oxford C.B.	31	94	68	81	—	50	90	102	96	—
Portsmouth	42	41	63	51	—	139	138	96	115	ns
Reading	45	137	44	90	—	80	143	80	114	ns
Southampton	67	102	58	82	—	131	123	102	113	ns
Total C.B.s	224	86	64	75	—	472	129	95	112	—
South Western region										
Bath	42	168	131	151	7	39	85	117	100	—
Bournemouth	37	130	62	96	—	37	39	97	69	—
Bristol	169	80	130	105	ns	234	97	115	105	ns
Exeter	13	35	57	46	—	54	159	114	137	5
Gloucester	17	64	44	54	—	31	58	82	70	—
Plymouth	54	81	47	64	—	81	68	69	68	—
Total C.B.s	332	84	92	90	—	476	85	99	92	—
Welsh region										
Cardiff	115	106	102	104	ns	222	183	100	144	8
Merthyr Tydfil	21	127	57	94	—	70	294	151	223	47
Newport	45	111	65	86	—	84	158	77	114	ns
Swansea	66	109	103	105	ns	69	84	96	86	—
Total C.B.s	247	110	81	100	—	445	162	98	132	—

\* Excess over expectation but not statistically significant ( $P > 0.05$ ) is denoted by 'ns', the value of  $d^2/E$  being smaller than 3.8.

† Deaths and rates are for 7 years 1958-64.

‡ Ratios for 1963-4.

§ Deaths and rates are for 9 years 1958-66.

|| Ratios for 1962-6.

101 for atelectasis) contrasted with increases in the Manchester region (125 to 141 and 109 to 140).

*Mortality in separate county boroughs*

Table 4 shows the number of post-natal deaths in the 10 years 1958–67 from birth injury (intracranial and other) and from atelectasis in each of the county boroughs. The total deaths in all county boroughs and Greater London combined attributed to birth injury were 8653, and the total attributed to atelectasis and post-natal asphyxia were 12,627. The county boroughs are arranged according to the hospital region in which they are located, and in alphabetical order within each region. The towns where the total number of deaths exceeded the number expected (if the national rates in Table 1 within the appropriate 5-year period had been applied to the total number of live births in each instance) are indicated in the final column by the values of  $d^2/E$  if the excess was statistically significant or by the letters ns where that figure was below the critical value of 3.8 (corresponding to probability  $P < 0.05$ ).

The towns which showed a statistically significant excess of actual over expected deaths at the 5% level of probability ( $P < 0.05$  for  $d^2/E = 3.8$ ) for the whole period 1958–67 for both causes of death are listed in Table 5 in their regional groups, and also those where there was significant excess for one of the causes combined with an insignificant excess (ns) for the other cause.

There were 20 towns thus identified as having noteworthy excessive mortality from birth injury and atelectasis, and eleven of these were clustered round Manchester and Liverpool, and another seven were in the Newcastle, Leeds and Sheffield regions, leaving one in the Midlands, one in Wales and none in the southern half of England. After each town is shown in parentheses the mean annual combined death rate from the two causes in 1958–67, and in every case

Table 5. *County boroughs with notably high mortality in Table 4*

Hospital region	A	B	C
Manchester	Burnley (8.6)*	—	Blackpool (6.5)
	Manchester (7.0)	—	Bolton (7.4)
	Oldham (11.5)	—	Rochdale (6.1)
	Salford (6.1)	—	—
Liverpool	Liverpool (6.3)	Birkenhead (7.3)	—
	Warrington (6.7)	—	—
	Wallasey (7.2)	—	—
Birmingham	Birmingham (6.3)	—	—
Leeds	Bradford (8.3)	Leeds (6.6)	—
Newcastle	Sunderland (8.8)	—	Tynemouth (6.6)
Sheffield	Derby (6.9)	Rotherham (6.6)	Nottingham (6.1)
Welsh	—	—	Cardiff (6.8)

A. C.B.s with statistically significant excess of actual over expected mortality from both birth injury and atelectasis.

B. C.B.s with significant excess for birth injury and insignificant excess from atelectasis.

C. C.B.s with significant excess for atelectasis and insignificant excess for birth injury.

\* Figures in parentheses show the mean annual combined death rates from the two causes in 1958–67.



this figure exceeded six per 1000 live births. In addition there were 9 other towns with rates of six or more but which failed to satisfy the criteria of statistical significance of groups A, B or C, namely: Preston (6.0), Stockport (6.1), St Helens (6.9), Wakefield (6.8), Barnsley (7.1), Doncaster (6.1), Coventry (6.1), Walsall (6.1), Bath (6.4).

Apart from the disturbances arising from differential diagnosis of the cause of death, factors likely to affect the comparisons between towns are differences in sex ratio of births and in rates of illegitimacy and immaturity and these will be examined below. Although many environmental factors can be cited to account for the northern excess of infant mortality generally, it is not clear why these should affect deaths arising from injury at birth.

*Sex ratio variations*

Since the risk of birth injury is greater for male than for female infants this might be a factor in some of the differences between death rates in large towns. In England and Wales during 1958-67 there were 4,218,000 live births of males and, 3,983,500 of females, giving a sex ratio of 1.06. The rates per 1000 live births are shown in Table 6. The sex ratio between numbers of deaths was greatest for brain injuries (1.71) as might be expected since the size of head tends to be larger in male infants; but the male excess was also pronounced (1.54) for other birth injuries, and for all combined it was 1.66. For atelectasis and post-natal asphyxia the ratio was 1.42. The two birth injury groups are not distinguished in the statistics for separate county boroughs and they have to be aggregated for the comparisons which follow. The expected deaths of males from birth injury in a county borough would be 2.70 times the total live births of males in the 10 years divided by 10,000, and the expected deaths of females would be 1.73 times the total live births of females divided by 10,000. Among the 20 towns with specially high death rates for the combined sexes, in some the high rate might be enhanced by an unusual excess of males born alive and in others by an unusually large excess of the male over the female death rate.

Table 7 shows the various sex ratios (male/female) and the numbers of deaths and rates per 1000 live births for each sex in 1958-67 in five groups of county boroughs where mortality from birth injury for the combined sexes was high compared with Greater London and the country as a whole. The variations in sex ratio among the births did not exceed 3% and are less important than the differences between sex ratios shown by the death rates. The five urban groups all had high death rates among male infants, exceeding 3.6 per 1000 compared with the national figure of 2.70 and the Greater London rate of 2.60, but the last two

Table 6. *Deaths from birth injury and atelectasis, 1958-67, according to sex*

	No. of deaths		Sex ratio (deaths)	Rate/1000	
	M	F		M	F
Intracranial injury (760)	8,508	4,971	1.71	2.70	1.73
Other birth injury (761)	2,870	1,869	1.54		
Atelectasis (762)	15,348	10,778	1.42	3.64	2.71



columns show that the excess in female rates (compared with 1.73) was relatively less than in males, though not appreciably so in Manchester area. Testing the rates for each sex for significance of the excess, in Manchester area the actual deaths exceeded the numbers expected by highly significant amounts ( $d^2/E$  being 107 for males and 53 for females) so the cause of this operated for each sex alike.

In Liverpool area, however, the excess for males, 367 actual compared with 271 expected, was highly significant ( $d^2/E = 34$ ) but for females the excess, 181 compared with 161 expected, was inconsiderable. In Bradford the expected deaths were 77 males and 45 females, the excess of males being statistically significant ( $d^2/E = 9.5$ ) but for females it was below the conventional level ( $d^2/E$  less than 3.8). In Rotherham the expected deaths of males were 22 and the excess was significant ( $d^2/E = 17$ ) whilst for females the actual and expected deaths were 20 and 14 giving an insignificant excess. In Derby the expected deaths of males were 32 and the excess was significant ( $d^2/E = 6.1$ ) but for females there was no excess.

It is apparent that the multiple factors responsible for mortality excess from birth injury in certain towns affect each sex but tend to enhance the risk for male infants more than that for females. The much stronger tendency for males to be more affected than females in the Liverpool area than was the case in the Manchester area is connected with a curious contrast between the trends in the proportions of atelectasis and birth injury in the two areas, as will be seen in the next section.

#### *Atelectasis and post-natal asphyxia*

In the absence of an autopsy a differential diagnosis of cause of death between birth injury and atelectasis is often difficult and the choice of which to write on the death certificate may be affected by personal bias, obstetric experience and perhaps by teaching at the medical school in the neighbourhood. Indications of

Table 7. Sex ratios for birth injury in urban areas with a specially high mortality from that cause, 1958-67

Urban group	Sex ratio between			Numbers of deaths in 1958-67		Rate/1000 live births		% of national	
	Live births	Deaths M/F	Rates M/F	M	F	M	F	M	F
Manchester	1.05	1.74	1.63	433	265	4.52	2.82	167	163
Salford									
Oldham									
Rochdale									
Liverpool	1.08	2.03	1.89	367	181	3.66	1.94	136	112
Birkenhead									
Wallasey									
Bradford	1.09	1.82	1.68	104	57	3.65	2.17	135	125
Rotherham	1.08	2.55	1.98	41	20	5.06	2.55	187	146
Derby	1.07	2.42	2.24	46	19	3.93	1.75	146	101
Greater London	1.06	1.58	1.50	1,788	1,129	2.60	1.73	97	100
England and Wales	1.06	1.63	1.56	11,369	6,993	2.70	1.73	100	100

such effects are seen when the death rates in Manchester and Liverpool areas are compared in the periods 1958–62 and 1963–7. There appears to have been a change in fashion in the Liverpool area causing transfer of deaths from atelectasis to birth injury during the 10-year period, as shown by the rates and numbers of deaths in Table 8 in the Manchester and Liverpool groups of county boroughs.

In England and Wales as a whole atelectasis rates declined between 1958–62 and 1963–7 by 23 % among males and by 15 % among females. In the Manchester area the rates fell by only 4 % in males and 7 % in females, but in the Liverpool area the rates fell sharply by 47 % in males and by 54 % in females. The national rates for birth injury also declined, by 16 % in males and 10 % in females, slighter falls than occurred for atelectasis. In the Manchester area, however, the birth injury rates increased by 15 % for each sex, suggesting some transfer from atelectasis as the certified cause. In Liverpool area on the other hand the birth injury rate fell by 28 % in males but by only 5 % in females in strong contrast with the 54 % fall for atelectasis in that sex. The very large drop in the 5-year total of deaths attributed to atelectasis between 1958–62 and 1963–7, from 497 to 231, must have been due to a progressive change in diagnostic fashion in that area causing many such deaths to be classified to other causes but not to birth injury.

In Table 4 the changes in rate of dying from birth injury or from atelectasis between 1958–62 and 1963–7 are indicated approximately by the differences between the C.M.R.s for those periods. Thus for Bolton the C.M.R. for birth injury was 80 in the first period and 145 in the second and the difference of + 65 is a rough index of the change in mortality which occurred during the 10 years (the mean annual change being one fifth of this). For atelectasis in the same town the C.M.R. showed no appreciable change (174 to 182). Apart from the Manchester group of boroughs referred to above, the towns showing *increases* of 10 or more in the C.M.R.s for *both* causes were: Halifax, Leeds, York, Chester, Middlesbrough,

Table 8. *Atelectasis and birth injury rates in Manchester (with Salford, Oldham and Rochdale) and Liverpool (with Birkenhead and Wallasey)*

		Manchester area		Liverpool area		England and Wales	
		1958–62	1963–7	1958–62	1963–7	1958–62	1963–7
Number of deaths							
Atelectasis	M	232	220	293	144	8058	7290
	F	144	136	204	87	5298	4880
Birth injury	M	207	226	221	146	5938	5437
	F	122	143	96	85	3446	3394
Rate/1000 live births							
Atelectasis	M	4.71	4.51	5.50	2.94	4.29	3.32
	F	3.09	2.87	4.10	1.88	2.78	2.35
Birth injury	M	4.21	4.82	4.15	2.98	2.94	2.48
	F	2.62	3.02	1.93	1.83	1.81	1.63
Rate % of previous period							
Atelectasis	M	—	96	—	53	—	77
	F	—	93	—	46	—	85
Birth injury	M	—	115	—	72	—	84
	F	—	115	—	95	—	90

Grimsby, Bristol and Worcester. No reason can be suggested here for the upward trends for both causes in these towns, but they are not likely to have arisen from mere changes in fashion of diagnosis on death certificates. In contrast there were six towns showing decreases in the C.M.R. between 1958-62 and 1963-7 amounting to 10 or more for each of the causes, viz. Bootle, Liverpool, Dudley, Smethwick, Southampton and Newport.

Table 9. *Combined rates of mortality per 1000 live births from birth injury and atelectasis in 78 county boroughs during 1958-67 with separate indices for each cause in 1938-62 and 1963-7. Rates of illegitimacy and of mortality attributed to immaturity per 1000 live births in 1963-7*

Rank	Combined rate		Birth injury only		Atelectasis only		Illegitimacy 1963-7	Immaturity 1963-7	Number of live births in		
	Mean annual 1958-67	Change in 5 years	1958-62	1963-7	1958-62	1963-7			1958-62	1963-7	
											1958-62
Oldham	1	11.47	-1.46	4.60	8.04	6.14	4.16	124	1.75	1,954	2,063
Sunderland	2	8.83	+0.18	2.68	2.98	6.06	5.94	63	3.42	3,860	3,629
Burnley	3	8.60	-1.12	4.02	3.40	5.14	4.64	104	2.32	1,291	1,292
Bradford	4	8.33	-0.34	3.46	2.36	5.04	5.80	111	3.07	5,381	5,729
Bolton	5	7.47	-1.24	1.88	2.98	4.82	5.16	89	2.02	2,617	2,754
Birkenhead	6	7.34	-2.72	4.70	3.64	4.00	2.34	75	4.22	2,611	2,800
Wallasey	7	7.15	+0.12	2.40	3.68	4.96	3.46	76	4.03	1,858	1,845
Barnsley	8	7.11	-0.98	1.76	2.14	5.84	4.58	73	2.70	1,374	1,182
Manchester	9	7.03	-0.45	3.52	3.16	3.72	3.66	141	3.49	13,506	12,467
Wakefield	10	6.96	-3.17	1.81	2.54	6.74	2.84	78	2.97	920	942
Derby	11	6.89	-2.10	2.84	2.12	5.10	3.22	115	0.76	2,116	2,364
St Helens	12	6.88	-0.28	2.08	1.54	4.94	5.20	58	4.43	1,916	1,806
Cardiff	13	6.85	-3.82	2.54	2.10	6.22	2.84	89	2.95	4,787	5,150
Warrington	14	6.75	+0.06	3.46	2.26	3.26	4.52	83	3.81	1,327	1,419
Tynemouth	15	6.65	-0.68	2.80	2.24	4.12	4.14	76	4.85	1,275	1,156
Wolverhampton	16	6.64	—	4.96	2.42†	3.52	2.38†	119	2.87†	2,665	3,184†
Leeds	17	6.64	+1.20	2.84	3.82	3.20	3.42	104	2.36	8,797	9,216
Rotherham	18	6.57	+0.02	3.88	3.38	2.28	3.60	61	0.76	1,545	1,832
Blackpool	19	6.49	-0.96	2.84	2.30	4.14	3.70	124	1.35	1,837	2,000
Bath	20	6.44	-0.88	4.00	2.68	2.88	3.32	84	1.74	1,246	1,266
Newport	21	6.37	-3.30	2.64	1.80	5.38	2.92	78	3.47	1,967	2,129
Birmingham	22	6.30	-1.04	2.94	2.52	3.88	3.26	112	2.40	20,819	21,841
Liverpool	23	6.28	-3.36	2.72	1.90	5.24	2.70	85	3.67	15,850	14,372
Rochdale	24	6.15	+1.92	1.96	3.22	3.18	3.94	108	2.72	1,435	1,618
Salford	25	6.14	+0.56	2.72	3.10	3.14	3.32	128	4.46	3,005	2,960
Nottingham	26	6.18	-2.66	1.86	2.52	5.58	2.26	143	4.44	5,806	6,077
Coventry	27	6.10	-1.72	3.68	4.28	2.28	1.96	81	2.82	5,886	6,535
Stockport	28	6.09	-3.38	3.38	1.06	4.40	3.34	70	6.85	2,089	2,586
Walsall	29	6.08	-1.62	3.06	2.60	3.84	2.68	64	4.64	2,188	2,760
Doncaster	30	6.06	+0.02	2.10	2.16	3.90	3.96	99	6.42	1,525	1,464
Preston	31	6.00	-1.28	2.32	2.38	4.32	2.98	96	3.57	2,065	2,014
South Shields	32	5.97	-0.42	3.28	3.14	2.90	2.60	70	2.94	2,069	1,909
Dudley	33	5.84*	—	3.38	2.38†	3.68	2.24†	65†	3.24†	1,006	1,038†
Darlington	34	5.77	-1.42	4.18	2.66	2.30	2.40	81	2.66	1,389	1,435
Merthyr Tydfil	35	5.76	+3.54	3.04	0.98	1.46	6.06	52	5.47	958	1,024

Table 9 (cont.)

	Rank	Combined rate		Birth injury only		Atelectasis only		Illegitimacy 1963-7	Immacurity 1963-7	Number of live births in	
		Mean annual 1958-67	Change in 5 years	1958-62	1963-7	1958-62	1963-7			1958-62	1963-7
Bury	36	5.72	-1.74	1.94	1.72	4.66	3.12	81	3.29	1,030	1,278
Dewsbury	37	5.71	-0.50	2.56	2.62	3.40	2.84	85	5.91	939	913
Bristol	38	5.70	+0.72	1.92	2.80	3.42	3.46	92	1.47	6,987	7,298
Burton-on-Trent	39	5.66	-1.22	2.38	2.20	3.88	2.56	163	2.04	907	986
Leicester	40	5.64	-0.92	3.08	2.12	3.02	3.06	111	4.84	5,057	5,086
Sheffield	41	5.62	+0.82	2.74	3.34	1.90	3.28	77	2.50	8,000	8,490
Barrow in Furness	42	5.60	+1.56	2.04	1.24	2.80	5.12	73	3.16	1,076	1,138
Chester	43	5.53	+0.06	3.42	3.22	2.08	2.34	83	1.79	1,055	1,113
West Hartlepool	44	5.44	-2.36	2.58	1.26	4.04	3.00	72	1.91	1,630	1,593
Blackburn	45	5.43	-0.18	1.40	1.34	4.12	4.00	86	3.56	1,702	1,796
Bootle	46	5.40	-3.88	2.82	1.64	4.54	1.80	56	4.55	1,943	1,672
Exeter	47	5.38	-1.96	0.94	1.18	5.42	3.22	84	1.03	1,180	1,361
Southampton	48	5.37	-2.54	2.44	1.20	4.20	2.90	105	1.63	3,616	3,801
Kingston upon Hull	49	5.33	-1.26	1.98	1.98	4.08	2.62	97	2.86	5,830	5,750
Stoke-on-Trent	50	5.25	-1.18	2.10	0.68	4.24	3.48	63	2.25	4,302	4,439
Eastbourne	51	5.25	+0.14	1.22	1.38	3.96	3.94	100	2.50	657	720
Carlisle	52	5.17	-3.22	4.52	1.70	2.26	1.86	79	3.80	1,326	1,288
Swansea	53	4.97	-0.58	2.60	2.12	2.16	2.06	60	4.16	2,768	2,828
Northampton	54	4.97	-1.98	1.84	1.86	4.62	2.62	83	1.53	1,731	2,358
Portsmouth	55	4.92	-1.43	0.98	1.30	4.70	2.86	140	2.54	3,905	3,707
Huddersfield	56	4.85	+2.40	1.34	1.98	3.64	2.74	121	6.53	2,219	2,451
Newcastle upon Tyne	57	4.74	-0.92	2.63	1.84	2.52	2.44	102	4.24	4,985	4,346
Oxford	58	4.72	-0.84	2.26	1.40	2.58	2.90	111	1.94	1,574	1,860
Middlesbrough	59	4.71	+0.84	2.20	2.20	2.24	2.88	92	5.24	3,538	3,170
Worcester	60	4.64	+1.24	1.82	2.38	2.20	2.88	61	4.07	1,092	1,180
Halifax	61	4.51	+0.90	1.64	2.12	2.42	2.84	111	4.49	1,575	1,693
Lincoln	62	4.35	-0.36	1.36	2.16	3.16	2.02	86	2.91	1,328	1,370
Hastings	63	4.27	-1.06	2.52	2.20	2.28	1.54	117	1.33	790	911
Bournemouth	64	4.25	-0.42	3.10	1.28	1.36	2.76	128	4.13	1,617	1,888
Wigan	65	4.22	-0.96	2.98	1.50	1.74	2.22	48	4.79	1,278	1,335
Grimsby	66	4.16	+0.04	1.24	1.28	2.90	2.90	102	4.39	1,926	1,867
Southport	67	4.06	-0.22	2.66	1.62	1.52	2.34	42	2.94	1,050	1,111
Brighton	68	4.03	-1.87	3.42	1.80	3.02	2.22	131	2.48	2,330	2,444
Reading	69	3.90	-1.97	3.26	0.81	1.62	2.10	92	4.27	2,092	2,443
Gateshead	70	3.89	-1.62	1.90	1.80	2.80	1.28	62	3.88	2,000	1,884
Ipswich	71	3.85	+0.30	1.66	2.00	2.04	2.00	72	2.31	2,053	2,405
York	72	3.77	+2.86	1.52	3.00	0.82	2.20	92	5.09	1,716	1,729
Canterbury	73	3.67	+0.50	1.28	1.18	2.14	2.74	79	2.74	471	511
Southend-on-Sea	74	3.65	-0.51	1.83	0.74	2.22	2.82	100	4.82	2,232	2,408
Norwich	75	3.49	+0.50	1.62	2.04	1.62	1.60	94	2.47	1,047	1,864
Gloucester	76	3.34	+0.72	1.52	0.88	1.96	2.32	106	3.10	1,315	1,547
Plymouth	77	3.20	+0.56	1.26	0.98	2.22	1.94	82	2.77	3,698	3,896
Great Yarmouth	78	3.15	-0.18	1.62	1.28	1.62	1.78	117	7.41	737	783
England and Wales		5.35	-0.90	2.39	2.06	3.41	2.89	76	3.02	—	—

Towns which ceased to be county boroughs before 1963 have been omitted as also when boundary changes during 1963-7 interfered with the rate computation and correction was not possible.

\* Annual means for 1958-65.

† Annual means for 1963-5.

In 37 of the towns, however, the changes in mortality with time during 1958–67 for birth injury and atelectasis showed no correspondence in sign (i.e. up or down) and in some instances such as Nottingham and Wakefield the opposing changes were large in amount. The conclusion must be that *uncertainty as to which cause to enter on the death certificate is often such that no reliance can be placed on the separate figures resulting, and it is more realistic to combine the statistics for categories 760–2 as a single cause group* and observe whether the combined rate rose or fell during the 10 years. For this purpose the combined death rates attributed to birth injury and atelectasis in the two 5-year periods are shown in Table 9. In England and Wales the combined rate was 5.80 per 1000 live births in the first period and 4.90 in the second, and 5.35 in the whole 10 years. The table shows also the difference between the combined rates in the two periods, and the 25 towns where that difference was positive (including five where the difference was less than 0.1), indicating a rising trend during the 10 years, are seen to be:

(a) Showing increases over: 1.0 Merthyr Tydfil (3.5), York (2.9), Huddersfield (2.4), Rochdale (1.9), Barrow-in-Furness (1.6), Worcester (1.2) and Leeds (1.2).

(b) Showing increases of 0.1 to 0.9: Halifax, Middlesbrough, Sheffield, Bristol, Gloucester, Plymouth, Salford, Canterbury, Norwich, Ipswich, Sunderland, Eastbourne and Wallasey.

Of these 20 towns where mortality rose appreciably during the 10 years, five were in the West Riding of Yorkshire and five in Lancashire and Cheshire, and another group of adjacent towns were Bristol, Gloucester and Worcester. Since in England and Wales as a whole the death rate from the combined causes in 1963–7 was *less* than in 1958–62 by 0.9 per 1000 live births, the reasons for the increases in the towns named above seem to need investigation by the Health Departments concerned.

By way of contrast, substantial improvements of 2.0 or more occurred in the combined rate in the following county boroughs: Bootle, Liverpool, Stockport, Cardiff, Newport, Carlisle, Wakefield, Birkenhead, Nottingham, Southport, West Harlepool and Derby.

*Frequency of illegitimacy and of deaths from  
immaturity without other cause*

Table 9 shows that the illegitimacy rate per 1000 live births during 1958–67 ranged from 163 in Burton-on-Trent to 42 in Southport, and it is conceivable that towns with a high rate of illegitimacy may tend to have a higher risk of birth injury and atelectasis. This can be tested by comparing the median illegitimacy rates in successive groups of 10 towns in the table, where they are ranked in descending order of the combined mortality rate, and by looking at the towns with highest illegitimacy rates in detail.

In successive groups of 20, 20, 20, 18 towns in the order of the table the median illegitimacy rates were 85, 87, 88, 95, showing no positive relationship with the combined birth injury and atelectasis death rates, but rather the reverse. However, the 10 towns with illegitimacy rates over 120 were as shown in Table 10 and their median death rate from birth injury and atelectasis was 5.90, slightly above the

median 5.68 for all county boroughs. In five of those towns the death rate was high, namely the Manchester, Salford and Oldham group and also Blackpool and Nottingham. The average illegitimacy rate in England and Wales was 76 per 1000 live births and any rates of 100 or more may be considered abnormally high. There were 18 such towns in addition to those listed in Table 10 (with rates over 120), and 9 of them were textile or Midland industrial towns, viz. Wolverhampton (119), Derby (115), Birmingham (112), Bradford, Halifax and Leicester (111), Rochdale (108), Burnley and Leeds (104). All of these except Halifax had combined birth injury and atelectasis rates much above average (median 6.64). The others were seven coastal towns, Great Yarmouth and Hastings (117), Southampton (105), Grimsby and Newcastle (102), Eastbourne and Southend (100), together with Oxford (111), and Gloucester (106), with median combined mortality 4.27. In the coastal towns high prevalence of illegitimacy is common, but no association with an enhanced mortality from birth injury seems to result.

Immaturity without mention of a more definite cause of death peculiar to early infancy (No. 776 of the International Classification) accounted in the years 1963-7 for mean annual rates ranging from 0.76 per 1000 live births in Derby and Rotherham to 7.41 in Great Yarmouth. The correlation between these rates and death rates from birth injury and atelectasis was -0.37, and the negative association arises almost entirely from two towns at the extremes of Table 9. Oldham recorded an abnormally high rate from birth injury in 1963-7, namely 8.04 with no other town exceeding four, and its immaturity rate of 1.75 was low compared with the national rate of 3.02. It seems probable that a considerable number of deaths of immature infants were classified to birth injury as most likely cause in the absence of definite indications of any other reason for the death. If so that would help to account for the position of Oldham at the top of the table with a figure of 11.47 for the combined rate with atelectasis in the whole period.

At the other end of the table Great Yarmouth recorded the highest rate for immaturity (7.41) and the lowest rate for combined birth injury and atelectasis

Table 10. *County boroughs with illegitimacy frequencies exceeding 120 per 1000 live births, with corresponding immaturity rates, in 1963-7*

County borough	Illegitimacy rate 1963-7	Death rate attributed to immaturity 1963-7	Death rate from birth injury and atelectasis 1958-67
Burton-on-Trent	163	2.04	5.66
Nottingham	143	4.44	6.18
Manchester	141	3.49	7.03
Portsmouth	140	2.54	4.92
Brighton	131	2.48	4.03
Bournemouth	128	4.13	4.25
Salford	128	4.46	6.14
Oldham	124	1.75	11.47
Blackpool	124	1.35	6.49
Huddersfield	121	6.53	4.85
Median	130	3.02	5.90



which suggests that some deaths of immature infants with uncertain evidence of either of those causes may have been classed to the ill-defined category of immaturity. There is no significant evidence of an association in the other 76 towns though transfers either way between Nos. 760–62 and No. 766 no doubt occurred in some of them.

Although the variables illegitimacy frequency, deaths from immaturity without other known cause and unusual excess of male infants affect some of the combined rates of death from birth injury and atelectasis, most of the differences between county boroughs, ranging from three to eight per 1000 live births as shown by the third column of Table 9, must arise from local variations in the number of births in hospital, obstetric techniques and quality of medical care of births. These cannot be evaluated statistically without local surveys on the lines of the investigation of Perinatal Mortality which was carried out in 1958 under the auspices of the National Birthday Trust (Butler & Bonham, 1963). Such surveys seem to be desirable, particularly in the first 18 towns in Table 9 where the mortality rate in 1958–67 was 6·5 or more per 1000 live births annually.

#### REFERENCES

- BUTLER, N. R. & BONHAM, D. G. (1963). *Perinatal Mortality*. London: Livingstone.  
REGISTRAR GENERAL (1958–67). *Statistical Reviews for Each Year*.