

# Analysis of neonatal mortality data for year 2016

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This report presents an analysis of neonatal mortality in infants born in 2016 at a gestational age (GA) less than 32 weeks, and who were admitted to neonatal units that form the UK Neonatal Collaborative in England, Wales and Scotland (part). Every neonatal unit was informed of the analysis in advance and was requested to confirm the accuracy and completeness, or make amendments, in the data they had entered on the `Badger.Net` platform. The analysis in this report is based on these data, held in the National Neonatal Research Database (NNRD).

## Methods

Data were extracted for infants born in year 2016 at a GA < 32 weeks who were admitted to neonatal care and for whom the neonatal network of booking was known to be one of the Operational Delivery Networks (ODN) in England, or in Scotland or Wales. For the purposes of the analysis Scotland and Wales are treated as a single ODN each. The outcome variable is defined as death while in neonatal care (before final discharge). Missing values of the outcome and some of the covariates were imputed multiply by chain equations (van Buuren, 2012) implemented in software R.

In the analysis, the standardised mortality ratios (SMR) are estimated for each ODN. Crude and adjusted estimates of SMR are evaluated. The adjustment is by a logistic regression of the outcome (death/survival) on the following five clinical variables: GA, birth weight, sex, use of antenatal steroids and multiple births, and their transformations and interactions.

The SMR is defined for each ODN as the ratio of the recorded number of deaths and the expected number of deaths assuming a model that applies for all the ODN. Adjusted estimates of SMR are derived from the probabilities fitted by the logistic regression model. Standard errors and two-sided 95% confidence limits are estimated by bootstrap (Efron and Tibshirani, 1993). Adjustment for multiple testing (for 16 ODN) is made by controlling the false discovery rate at 5%. The values of SMR are multiplied by 100, in order to be presented as percentages.

The logistic regression model for estimating the probability of death was derived by backward selection, eliminating one term at a time (a covariate or an interaction) using a conservative criterion. In accordance with the approach adopted in past reports (Santhakumaran, 2015; Longford, 2017), spline terms were included to enable greater flexibility of dependence on GA. A quadratic term for the birth weight z score was included. Interactions of GA and z score with multiplicity (of birth) were retained.

The estimated SMR for the ODN are presented in a funnel plot. The limits of the funnel are drawn 2 standard deviations from the target SMR (100). One set of limits is drawn without adjustment for multiple testing, and another, wider set of limits, with adjustment for multiple testing. The 16 ODN recorded 8400 admissions in 2016 at a GA < 32 weeks; 7502 infants (89.3%) were discharged alive, 692 (8.2%) died before discharge, and the survival status was not established for 206 infants (2.4%). Data items were missing in 376 instances for 362 distinct infants.

Table 1 displays the estimated SMR for the ODN, without and with adjustment for the five clinical variables. The codes for the ODN are uppercase letters A–P assigned in ascending order of the caseloads. The ranks of the crude (unadjusted) and adjusted SMR differ.

The estimates are presented in Figure 1 in a combined funnel plot. Each ODN is represented by a vertical segment connecting the adjusted SMR (black dots) and unadjusted SMR (grey dots). Longer dashes indicate the funnel limits with adjustment for multiple testing and shorter dashes the limits without this adjustment. These limits apply to both sets of estimates of SMR.

After adjustment for multiple testing there are no outliers. Without this adjustment, there are two high-SMR outliers (ODN B and O) for the rates adjusted for the five variables and two other high-SMR outliers (ODN G and P) for the rates without adjustment for the five variables. There are two low-SMR outliers for the crude rates (ODN C and E).

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Table 1: Estimates, standard errors and confidence limits for the ODN-level SMR without and with adjustment for clinical variables

ID	ODN	Infants*				Unadjusted		Adjusted	
		S	D	M	All	SMR	Conf. limits	SMR	Conf. limits
A	Thames Valley	281	20	5	306	77.1	( 39.9, 114.4)	81.9	( 50.2, 113.6)
B	Staff-Shrop BC	272	32	16	320	124.9	( 86.1, 163.7)	140.4	(100.9, 180.0)
C	Wales	328	17	4	349	59.6	( 33.7, 85.5)	75.5	( 44.0, 107.0)
D	London NW	323	27	7	357	91.7	( 53.6, 129.7)	85.4	( 54.8, 116.0)
E	Wessex (TV)	332	18	10	360	64.3	( 36.1, 92.4)	66.0	( 42.0, 90.0)
F	Northern	353	35	11	399	106.9	( 71.3, 142.5)	115.2	( 82.8, 147.7)
G	Midlands SW	362	48	22	432	138.0	(104.8, 171.1)	116.9	( 93.4, 140.4)
H	Penins & West	432	32	2	466	81.5	( 53.2, 109.8)	84.3	( 57.8, 110.7)
I	Scotland	432	44	15	491	106.4	( 78.3, 134.5)	124.1	( 96.9, 151.3)
J	South East	498	36	14	548	82.3	( 54.7, 110.0)	88.6	( 61.3, 115.8)
K	London South	499	40	11	550	86.9	( 57.9, 115.9)	80.9	( 56.2, 105.5)
L	London N C&E	573	45	8	626	85.9	( 63.0, 108.7)	73.3	( 55.3, 91.3)
M	Trent	580	67	9	656	121.3	( 95.9, 146.8)	115.5	( 94.1, 136.9)
N	East of England	650	48	16	714	81.0	( 56.4, 105.6)	87.6	( 63.8, 111.3)
O	Yorkshire	704	76	15	795	114.1	( 91.7, 136.4)	131.4	(110.1, 152.7)
P	North West	883	107	41	1031	128.5	(107.5, 149.6)	111.1	( 96.1, 126.1)
	England & Wales	7502	692	206	8400	100.0		100.0	

Notes: \* — the counts of infants are for survived (S), died (D), survival status not known (M), and their total (All).

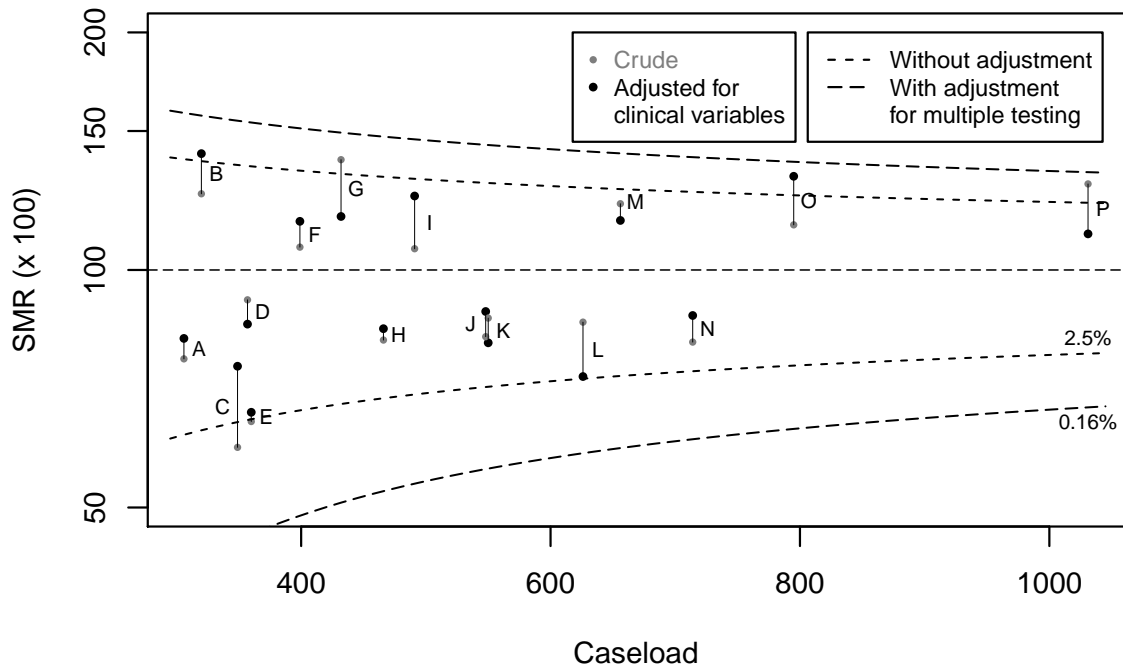


Figure 1: Funnel plot of the ODN-level SMR with and without adjustment for multiple testing, with respective (one-sided) levels 0.16% (the outer funnel) and 2.5% (the inner funnel); SMR estimates with adjustment for the clinical variables (black dots) and without (grey dots)

## References

- Efron B, and Tibshirani R (1993). *An Introduction to Bootstrap*. Chapman and Hall, New York
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- Santhakumaran S (2015). Analysis of neonatal mortality data 2013–2014. Neonatal Data Analysis Unit, Imperial College London
- van Buuren S (2012). *Flexible Imputation of Missing Data*. Chapman and Hall/CRC, London