NDAU 2011 Report – Mortality

Unadjusted and case-mix adjusted Standardised Mortality Ratios (SMRs) for babies born ≤32^{+6} weeks gestation by network of booking

The Neonatal Data Analysis Unit (NDAU) has been reporting case-mix adjusted standardised mortality ratios (SMR) for neonatal networks since 2006. The analysis in this report has been carried out in line with guidance from the National Clinical Audit Advisory Group (NCAAG) guidelines for the detection of outliers[1].

Methods (full methods given in Appendix A)

Mortality is shown attributed to **network of booking**. Therefore results for a network will include babies whose mothers booked to deliver at the network, but were not actually delivered there, nor received any care there. Only babies born at or below 32+6 weeks gestation who were booked and had their final stay in neonatal care (prior to discharge home, ward or foster care, or who died before discharge from neonatal care) in a contributing unit between 01 January 2011 and 31 December 2011 were included. The neonatal units of booking and discharge did not have to be the same for the baby to be included in the analysis.

For the adjusted SMR, the expected number of deaths in a network was calculated adjusting for the following risk factors (i) gestational age at birth, (ii) birth weight, (iii) sex, (iv) antenatal steroid use, (v) multiplicity of pregnancy. To calculate the case-mix adjusted expected number of deaths, a logistic regression model was constructed to predict the probability of death for each baby using variables (i)-(v) as predictors.

For each network, the coefficients of the model were recalculated omitting the network in question so that the predicted probabilities of death were made based only on data from other networks. Predicted probabilities are summed to obtain the expected number of deaths in each network. The adjusted SMR was calculating by dividing the observed number of deaths by the expected number of deaths.

Results

There were 9376 babies born at or below 32^{+6} weeks gestation who were booked and had their final stay in neonatal care (prior to discharge home, ward or foster care, or who died before discharge from neonatal care) in a contributing unit between 01 January 2011 and 31 December 2011.

Table 15.1 shows the total babies, number of deaths, unadjusted and adjusted expected deaths and SMR, and the proportion of units in the network contributing data. Figure 15.1 shows a funnel plot of the case-mix adjusted SMR.

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[1] Department of Health/HQIP. *Detection and Management of Outliers*. http://www.dh.gov.uk/ab/NCAAG

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Table 15.1

Neonatal mortality (≤32^{+6} weeks gestation at birth) by complete (not shaded) and incomplete (shaded) *neonatal network of booking*

(All babies with a final neonatal unit discharge between 01 January - 31 December 2011)

Network code	Total babies ≤32^{+6} weeks	Observed deaths	Expected deaths		SMR		Label for Figure 1
			Unadjusted	Adjusted	Unadjusted	Adjusted	
100011	300	18	25.05	28.43	0.72	0.63	1
100012	284	20	23.61	21.95	0.85	0.91	2
100059	700	48	58.71	57.51	0.82	0.83	3
100070	380	35	31.30	30.19	1.12	1.16	4
100071	380	33	31.38	35.34	1.05	0.93	5
100078	280	24	23.14	25.80	1.04	0.93	6
100088	502	46	41.29	44.65	1.11	1.03	7
100106	288	16	24.08	19.77	0.66	0.81	8
100108	514	39	42.73	47.57	0.91	0.82	9
100109	314	21	26.15	26.16	0.80	0.80	10
100110	627	63	51.10	48.57	1.23	1.30	11
100111	417	42	34.16	31.15	1.23	1.35	12
100113	223	20	18.42	16.91	1.09	1.18	13
100115	578	56	47.30	51.22	1.18	1.09	14
100118	232	19	19.20	15.04	0.99	1.26	15
100142	588	47	48.77	43.84	0.96	1.07	16
100150	404	31	33.54	29.34	0.92	1.06	17
100162	179	15	14.81	16.21	1.01	0.93	18
100196	458	25	38.55	32.56	0.65	0.77	19
100208	497	32	41.63	42.09	0.77	0.76	20
100209	443	48	36.11	39.25	1.33	1.22	21
100210	395	23	33.10	33.13	0.69	0.69	22
100524	393	38	32.29	32.65	1.18	1.16	23

Figure 15.1

Case-mix adjusted SMR of babies born ≤32^{+6} weeks gestation by complete (closed circles) and incomplete (open circles) *neonatal network of booking* for 01 January 2011 and 31 December 2011. Neonatal networks corresponding to label numbers are given in Table 15.1.
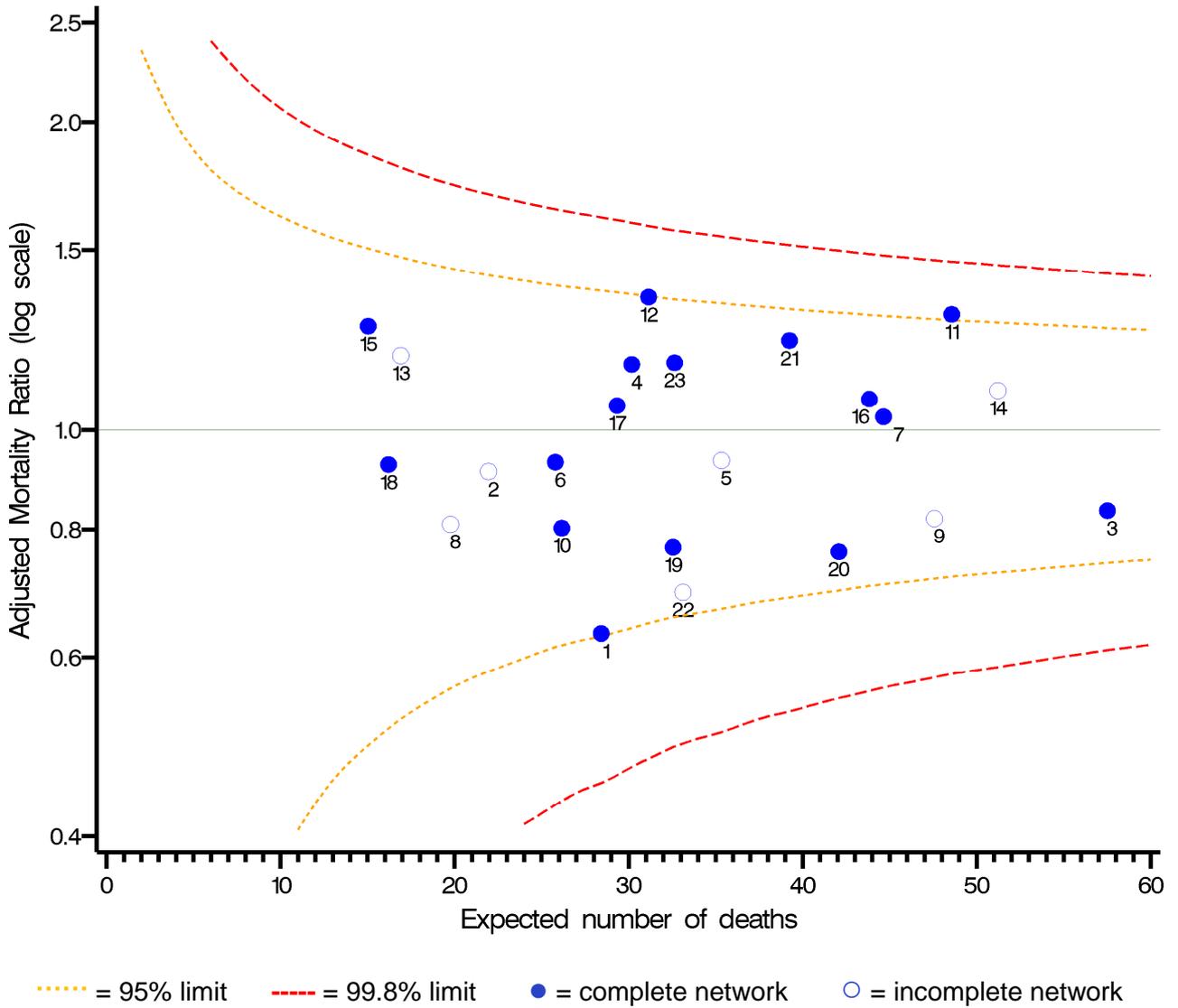
Appendix A

Methods

Only babies born ≤32[+6] weeks gestation were included as older babies would not necessarily be admitted to a neonatal unit. Babies born ≤32[+6] weeks gestation comprise the majority of neonatal unit deaths and the predictors for mortality are currently better understood in this group than in more mature babies. It is also important to note that the denominators for these rates do not include deaths before admission to a neonatal unit, or stillbirths.

Unadjusted and case-mix adjusted standardised mortality ratios (SMRs) were calculated for each network. Babies were assigned to the network of booking. The SMR is calculated by dividing the observed number of deaths by the 'expected' number of deaths, where the expected number of deaths is the number that would have occurred in the network if the mortality rate was the same as the rate in the other networks combined (i.e. the overall mortality rate, total deaths/total babies). The unadjusted SMR do not take into account the variation in case mix across networks.

For the adjusted SMR, the expected number of deaths in a network was calculated adjusting for the following risk factors: gestational age at birth, birth weight, sex, antenatal steroid use, and multiplicity of pregnancy[2]. To calculate the case-mix adjusted expected number of deaths, a logistic regression model was constructed to predict the probability of death for each baby using the five variables given above as predictors. The functional form of the model was determined using data from 2009 and 2011 to increase power, but the SMRs are for 2011 only; furthermore only complete networks were used for the model to reduce risk of bias. For the model-building, babies whose birth weight was more than 4 standard deviations from the mean (specific to gestational age and sex, calculated internal to the data) were excluded, as were babies who had missing data for any covariate. Quadratic terms were used to allow for non-linear effects and all possible interactions were tested. A multilevel model was used to account for the lack of independence in the data at the network level. We assumed the data were missing at random (MAR) and used multiple imputation by chained equations. This procedure predicts the missing values for multiple copies of the dataset, carries out the logistic regression on the imputed datasets and combines the results.

The calibration of the model was checked using the Hosmer-Lemeshow goodness-of-fit test and by plotting predicted and observed proportions of deaths for gestational age subgroups. Discrimination was checked using the area under the receiver operating characteristic (ROC) curve. To assess predictive performance on an external dataset the model was applied to 2008 data (which had not been used to build the model) and validation procedures repeated. For each network, the coefficients of the model were recalculated omitting the network in question so that the predicted probabilities of death were made based only on data from other networks. Predicted probabilities were calculated for each baby, then summed to obtain the case-mix adjusted expected number of deaths in each network in 2011.

Variation in case-mix adjusted SMR may be due to chance. Funnel plots of the case-mix adjusted SMRs against the expected number of deaths were drawn with 95% and 99.8% prediction intervals to indicate whether calculated SMRs were statistically significantly different from an SMR of 1 (observed deaths=expected deaths)[3].

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[2] Tyson JE, Parikh NA, Langer J et al. *Intensive care for extreme prematurity – moving beyond gestational age*. NEJM 2008;358:1672-81.
[3] Spiegelhalter DJ. *Funnel plots for comparing institutional performance*. Stat Med 2005;24(8):1185-1202.

Case-mix adjustment model

Three years of data (2009-2011) were used to develop the case-mix adjustment model to increase precision. The case mix-adjustment model was based on data from 17,644 babies born at or below 32^{+6} completed weeks gestation who had their final discharge between 2009-2011 from a contributing unit in a complete neonatal network. The overall mortality rate for these babies was 7.7% (1363/17,644). 550/17644 babies (3%) had missing data for one or more fields, and 21 babies (0.1%) were excluded as birth weight outliers. Details of the final model using data from all networks are given in Table A1. Note that where higher order polynomials / interactions improved model fit, lower order polynomials / main effects were retained in the model though they may not be significant.

Model validation: The model had good discrimination and calibration for both 2009-11 data which it was based on, and the independent 2008 dataset. For 2009-11 (2008) data the area under the ROC curve was 0.89 (0.87). The p-values for the Hosmer-Lemeshow goodness-of-fit test were 0.92 (0.25) using 10 groups of equal size, and 0.90 (0.17) using the 11 gestational age weeks. For this test, small p-values indicate poor fit.

Table A1   Parameters from logistic regression model

Variable	Coefficient (SE)	OR (95% CI)	p-value
Intercept	3.26 (0.136)	26.04 (19.95,33.99)	<0.001
Gestational age (GA) / 1 week increase†	0.395 (0.044)	1.484 (1.363,1.616)	<0.001
GA^2	-0.029 (0.01)	0.972 (0.952,0.992)	0.005
Birth weight (BWT) /100g increase†	0.082 (0.022)	1.085 (1.038,1.134)	<0.001
BWT^2	-0.032 (0.003)	0.969 (0.962,0.975)	<0.001
GA*BW	0.058 (0.014)	1.06 (1.031,1.09)	<0.001
BW^2*GA	0.003 (0.001)	1.003 (1.001,1.004)	0.002
Male	-0.29 (0.07)	0.748 (0.653,0.858)	<0.001
Multiple pregnancy	0.033 (0.117)	1.034 (0.821,1.302)	0.776
GA*multiple pregnancy	0.072 (0.031)	1.074 (1.011,1.142)	0.021
Antenatal steroids given	0.858 (0.097)	2.359 (1.951,2.852)	<0.001

† GA centred on the mean value of 29.45 weeks, BW centred on mean value of 1364g