Aim: This study aimed to provide updated information on gestation-specific hospital outcomes of extreme to very preterm infants admitted to neonatal intensive care units.

Methods: A population-based retrospective cohort study of infants born between 23+0 and 31+6 weeks gestation and admitted to a network of neonatal intensive care units between 2007 and 2011 in a well-defined geographic area of New South Wales and the Australian Capital Territory. Main outcome measures were survival and major morbidities prior to hospital discharge.

Results: Of 4454 infants included, hospital survival rates based on gestational age alone were 27%, 59%, 76%, 85%, 91% and over 95% at 23, 24, 25, 26, 27 and 28–31 weeks, respectively. Survival rates for each week up to 29 weeks gestation differed by at least 5% when perinatal risk factors including birthweight percentile, exposure to antenatal steroids, birth outside a tertiary hospital and gender were included in the survival estimation. All the major outcome figures were then simplified and displayed in a simple, easy-to-understand preterm outcome table for counselling purposes.

Conclusion: We report the latest hospital outcomes of extreme to very preterm infants in New South Wales and the Australian Capital Territory. Survival rates based on gestational age alone may not provide the true estimate as the survival for these infants can vary based on the presence or absence of other relevant perinatal factors.

Key words: counselling; hospital survival; infant; outcome; preterm.

What is already known on this topic
1. Clinical outcomes of extreme to very preterm infants can vary among regions.
2. Clinicians require up-to-date information from within their regions to provide accurate counselling, assist in benchmarking and facilitate review of local policies to improve outcomes.

What this paper adds
1. We demonstrated that survival rates of these infants are dependent on many perinatal factors, and these factors can vary for each week.
2. We created gestational age-specific survival figures based on various clinical scenarios and risk factors at each week.

Periodic evaluation of the outcomes of preterm infants within a well-defined region that shares similar health settings and practices provides vital information to the clinicians for counseling the parents and families at risk of preterm delivery. Gestational age-specific estimates are more easily estimated than birthweight prior to delivery and therefore more relevant when attempting to determine the approximate survival of a given infant for the purpose of pre-birth counseling. However, each pregnancy is unique and may have different combinations of risk factors that may influence the outcomes for their infants. Therefore, survival outcomes are better estimated by inclusion of other factors such as gender, antenatal steroid exposure and weight for gestational age besides gestational age. These risk-adjusted outcomes provide more meaningful information to clinicians and families caring for these infants.

We previously published the gestational age-specific outcomes of preterm infants less than 32 weeks gestation born between 2000 and 2001 within New South Wales (NSW) and the Australian Capital Territory (ACT). There have been a number of changes and improvements in clinical practice in the last few years in the industrialised world, and there is a perception within our network that these changes have occurred at various times across the neonatal intensive care units (NICUs) within our own region. Some of these perceived changes include better uptake of antenatal steroids, improved thermoregulation and oxygen titration at resuscitation, changes in respiratory management, and improved nutrition management. Reports from other networks or collaborative efforts have compared outcomes over time and showed mixed results some showing improved outcomes while others showing worsening outcomes.
Our current study aimed to (i) re-evaluate the hospital outcome of the liveborn preterm infants less than 32 weeks gestation at birth admitted to any of the tertiary NICUs within our region between 2007 and 2011 and (ii) develop gestational age-specific hospital survival rates taking into account common risk factors that are known to influence preterm survival including place of birth, lack of antenatal steroid exposure, gender, growth restriction and ethnicity.

**Methods**

Data for this study were sourced from the prospectively collected Neonatal Intensive Care Units’ (NICUS) Data Collection, an ongoing regional audit of liveborn neonates admitted to all the tertiary NICUs and five level 4 special care nurseries in NSW and the ACT. Gestational age was based on the best obstetric assessment, using information on ultrasound measures and the date of last menstrual period. Birthweight percentiles were based on the Australian birthweight percentiles by gestational age.7 In our NICUS Data Collection, ethnicity is defined by the ethnic background of mother, as identified by the mother. Asians are defined as all those infants whose mothers’ ethnic background originates from the countries of Asia, South East Asia and the Indian subcontinent, including Fiji Indians. The data on the migrant status of mother or father or mixed parentage are not available from our database. While some outcomes reported in this study are self-explanatory, definitions for other relevant major outcomes are as follows:

**Hospital survival: survival to first discharge home**

Intraventricular haemorrhage (IVH): The worst grade of IVH using Papile Classification8 seen on either side of the head by ultrasound imaging.

Retinopathy of prematurity (ROP): The worst stage as described by the Committee for Classification of Retinopathy of Prematurity.9

Chronic lung disease (CLD): Any respiratory support at 36 and 40 weeks corrected age.

Early-onset sepsis: Clinical picture consistent with sepsis within the first 48 h of life and a positive bacterial or fungal culture of blood and/or cerebrospinal fluid.

Late-onset sepsis: Clinical picture consistent with sepsis after the first 48 h of life and a positive bacterial or fungal culture of blood and/or cerebrospinal fluid.

For this study, all liveborn infants less than 32 weeks gestation admitted to any of the tertiary NICUs in the region between 1 January 2007 and 31 December 2011 were identified. Infants with major congenital malformations were excluded. All the relevant antenatal and intrapartum characteristics were compared between the survived and died groups, and the significant risk factors for mortality were identified in the univariate and logistic regression analyses. Hospital survival rates for each gestational age week were determined and adjusted for the single and combined risk clinical scenarios that were identified to influence the survival outcomes in the above analyses.

All the major outcomes were then simplified and displayed in a table titled preterm outcome table (POT) for easy understanding by parents and families. For this purpose, outcome figures were rounded to the nearest 5% with the exception of values <5% and >95% to avoid creating an erroneous impression to families that there is either a 100% or zero chance of a particular morbidity or mortality occurring in their infants.

Statistical analyses were performed using SPSS PREDICTIVE ANALYTICS SOFTWARE (version 21; SPSS, IBM, Chicago, IL, USA). Outcomes were summarised as proportions and means (±standard deviation) as appropriate. We derived 95% confidence intervals for the proportions by a method described by Newcombe using Wilson procedure (http://www.vassarstats.net/prop1 .html).10 The study was approved by the South Eastern Sydney Illawarra Area Health Services Northern Hospital Network Human Research Ethics Committee.

**Results**

During the study period, 4501 infants less than 32 weeks gestation were registered in the NICUS database. Forty-seven infants including two infants at 22 weeks gestation, 44 major congenital malformations (four were <27 weeks at birth) and one (24 week gestation) infant elected for palliation prior to birth were excluded (Fig. 1).

Table 1 shows the perinatal characteristics of the remaining 4454 infants. The majority (97.7%) of women received antenatal care, 90% received antenatal steroids and 89% delivered at a tertiary perinatal centre. There were 62% of infants delivered by caesarean section. There were 271 (6.1%) preterm vaginal breech deliveries with 16% of 22- to 26-week gestational age group and 3.7% of 27- to 31-week group delivered by this mode. There were 2355 (53%) male infants and 79 (1.8%) severely growth restricted (birthweight <3rd percentile) infants. In univariate analysis, Asian ethnicity, multiple pregnancy and pregnancy-induced hypertension were found to be protective against hospital mortality, whereas lack of antenatal care, antepartum haemorrhage, chorioamnionitis, lack of antenatal steroids, outborn, vaginal breech delivery, male gender, birthweight percentile <10th percentile and Apgar <7 at 5 min were significantly associated with hospital mortality. All these significant variables except Apgar at 5 min were entered into a logistic regression model using a stepwise backward elimination (likelihood ratio) to identify the significant antenatal and intrapartum risk factors up to the time of birth (Table 2). Lower gestational age, birthweight percentile <10th percentile, male gender, lack of antenatal steroids, outborn and the Caucasian ethnicity are the only independent risk factors for hospital mortality.

**Hospital survival**

Table 3 shows the hospital survival rates stratified by gestational age and the scenarios corresponding to the presence or absence of specific risks. Overall survival rates at 23 and 24 weeks were 27% and 59%, respectively. Between 25 and 28 weeks gestation, there was an increase in survival of greater than 5% for each gestational week. Female gender, antenatal steroid exposure and birth at a tertiary perinatal centre (inborn) improved the survival rates by at least 5% when compared with their counterparts in infants up to 27 weeks gestation at birth. Birthweight <3rd percentile reduced the survival rate by at least 5% up to 29 weeks gestation when compared with infants with...
birthweight ≥3rd percentile. Vaginal breech delivery, in comparison with other modes of delivery, showed reduced survival rates up to 26 weeks gestation. Exception was for 24 weeks gestation where the reduced survival rate did not reach the significance (breech delivery 57.1% (28 out of 49) vs. non-breech 59.9% (82/137)). When combined clinical scenarios were created, 3412 (76.6%) infants were inborn, received antenatal steroids and were appropriately grown with birthweight percentile ≥10th percentile (scenario 1). Their hospital survival rates were 36%, 63%, 82%, 86% and over 90% for 23, 24, 25, 26 and ≥27 weeks, respectively. When matched for these perinatal variables, infants of Asian ethnicity showed significant trends in improved survival compared with Caucasian infants at lower gestations. Australian indigenous infants represented only 3.8% ($n = 170$) of our cohort, and the numbers for each gestational week were too small to make any meaningful interpretation.

**Hospital morbidities and interventions**

Table 4 shows the morbidities and interventions according to gestational age at birth. Over 95% of infants <27 weeks gestation received surfactant. Need for mechanical ventilation decreased with increasing gestational age. High-frequency oscillation ventilation was required in a significant proportion of infants <27 weeks. CLD rates at 36- and 40-week corrected age were 44% and 28%, respectively, at 23–26 weeks gestation. For infants in the 23–26 weeks gestational age group, 17% went home on oxygen, 10% were diagnosed with NEC, 74% required treatment for PDA, and 17% were diagnosed with severe ROP (stage 3+).

**POT**

Table 5 shows the data simplified and presented as the POT as a counselling aid for parents and families. For this purpose, percentages were rounded to the nearest 5% with the exception of values less than <5% and >95% to avoid creating an erroneous impression to parents that there is either a 100% or zero chance of a particular morbidity or mortality occurring in their infant.

**Discussion**

**Survival to discharge**

There was a significant improvement in survival rates for 24–26 weeks gestation in comparison with our 2000–2001 cohort (60% vs. 50% at 24, 75% vs. 60% at 25 and 85% vs. 80% at 26 weeks). When some of the perinatal risk factors known
Table 1  Maternal and neonatal characteristics of the study population

| Characteristic                                      | Whole cohort N = 4454 | Survived to discharge N = 4108 (%) | Died prior to discharge N = 346 (%) | Odds of death OR (95% CI) |
|---------------------------------------------------|-----------------------|------------------------------------|------------------------------------|--------------------------|
| Maternal age (years), mean (±SD)                  | 30.08 (±6.196)        | 30.09 (±6.18)                      | 29.97 (±6.36)                      | –                       |
| Maternal ethnicity                                |                       |                                    |                                    |                          |
| Caucasian                                         | 3499 (78.5%)          | 3217 (78.3%)                       | 282 (81.5)                         | 1.00                     |
| Indigenous                                        | 252 (5.7%)            | 229 (5.5%)                         | 23 (6.6%)                          | 1.15 (0.733, 1.789)     |
| Asian                                             | 537 (12%)             | 510 (12.4%)                        | 27 (7.8%)                          | 0.60 (0.402, 0.906)**   |
| Antenatal care                                     |                       |                                    |                                    |                          |
| Yes                                               | 4351 (97.7%)          | 4020 (92.3%)                       | 331 (7.6%)                         | 1.00                     |
| No                                                | 103 (2.3%)            | 88 (2.1%)                          | 15 (4.3%)                          | 2.07 (1.184, 3.62)***   |
| Infertility treatment                              |                       |                                    |                                    |                          |
| No                                                | 3894 (87.4%)          | 3589 (87.3%)                       | 305 (88.1%)                        | 1.00                     |
| Yes                                               | 560 (12.5%)           | 519 (12.6%)                        | 41 (7.9%)                          | 0.92 (0.66, 1.304)      |
| Singleton pregnancy                               | 3162 (70.9%)          | 2898 (70.5%)                       | 264 (76.3%)                        | 1.00                     |
| Multiple pregnancy                                | 1292 (29%)            | 1210 (29.4%)                       | 82 (23.6%)                         | 0.57 (0.575, 0.916)**   |
| Twins                                             | 1154 (25.9%)          | 1084 (26.3%)                       | 70 (20.2%)                         | 0.77 (0.589, 1.016)     |
| Triplets                                          | 127 (2.9%)            | 115 (2.8%)                         | 12 (3.5%)                          | 1.14 (0.623, 2.103)***  |
| Quadruplet                                        | 11 (0.2%)             | 11 (0.3%)                          | 0                                  | –                       |
| Pregnancy-induced hypertension                    | 849 (19.1%)           | 802 (19.5%)                        | 47 (13.5%)                         | 0.65 (0.471, 0.889)**   |
| Antepartum haemorrhage                            | 1109 (24.9%)          | 985 (23.9%)                        | 124 (35.8%)                        | 1.77 (1.406, 2.231)***  |
| Preterm rupture of membranes                      | 1054 (23.7%)          | 974 (23.7%)                        | 80 (23.1%)                         | 0.96 (0.746, 1.255)     |
| Preterm labour                                    | 1684 (37.8%)          | 1543 (37.5%)                       | 141 (40.7%)                        | 1.14 (0.914, 1.43)      |
| Chorioamnionitis (clinical and/or pathological)   | 931 (20.9%)           | 838 (20.3%)                        | 93 (26.8%)                         | 1.43 (1.118, 1.841)**   |
| I illicit drugs                                    | 207 (4.6%)            | 194 (4.7%)                         | 13 (3.7%)                          | 0.78 (0.444, 1.396)     |
| Antenatal steroids                                |                       |                                    |                                    |                          |
| Yes                                               | 4011 (90.1%)          | 3723 (90.6%)                       | 288 (83.2%)                        | 1.00                     |
| No                                                | 443 (9.9%)            | 385 (9.4%)                         | 58 (16.8%)                         | 1.95 (1.441, 2.631)***  |
| Outborn                                           | 504 (11.3%)           | 452 (11%)                          | 52 (15%)                           | 1.43 (1.049, 1.952)***  |
| Mode of delivery                                  |                       |                                    |                                    |                          |
| Normal vaginal                                    | 1346 (30.2%)          | 1252 (30.4%)                       | 94 (27.1%)                         | 1.00                     |
| Vaginal breech                                    | 271 (6.1%)            | 210 (5.1%)                         | 61 (17.6%)                         | 3.86 (2.716, 5.511)***  |
| Instrumental vaginal                              | 87 (1.9%)             | 84 (2.3%)                          | 3 (0.9%)                           | 0.47 (0.147, 1.533)     |
| LSCS                                              | 2750 (61.7%)          | 2562 (62.3%)                       | 188 (54.3%)                        | 0.97 (0.756, 1.263)     |
| Gestational age (week), mean (±SD)                | 28.6 (±2.169)         | 28.82 (±2.01)                      | 25.94 (±2.17)                      | –                       |
| Male gender                                       | 2355 (52.8%)          | 2133 (51.9%)                       | 222 (64.2%)                        | 1.66 (1.32, 2.082)***   |
| Birthweight (g), mean (SD)                        | 1255.18 (390.46)      | 1285.39 (377.42)                   | 896.48 (363.65)***                 | –                       |
| Birthweight < 10th percentile                     | 323 (7.3%)            | 286 (6.9%)                         | 37 (10.6%)                         | 1.16 (1.115, 2.297)*    |
| Birthweight < 3rd percentile                      | 79 (1.8%)             | 64 (1.6%)                          | 15 (4.3%)                          | 2.9 (1.614, 5.08)***    |
| Apgar < 7 at 5 mi                                  | 915 (20.5%)           | 716 (17.4%)                        | 199 (57.3%)                        | 6.4 (5.106, 8.055)***   |

*P < 0.05; **P < 0.01; ***P < 0.001. Numbers (%) are shown. CI, confidence interval; LSCS, lower segment Caesarian section; OR, odds ratio; SD, standard deviation.

Table 2  Logistic regression analysis to determine the perinatal factors independently associated with hospital mortality

| Characteristic                                      | B coefficient (SE) | Adjusted OR (95% CI) | P-value |
|---------------------------------------------------|--------------------|-----------------------|---------|
| Antepartum haemorrhage                            | 0.297 (0.130)      | 1.345 (1.042, 1.737)  | 0.023   |
| Gestational age group 23–26 weeks                 | 2.303 (0.127)      | 10.008 (7.801, 12.840)| 0.000   |
| Asian ethnicity                                   | −0.628 (0.223)     | 0.533 (0.345, 0.825)  | 0.005   |
| Birthweight <10th percentile                      | 0.778 (0.207)      | 2.177 (1.452, 3.263)  | 0.000   |
| Male gender                                       | 0.522 (0.126)      | 1.686 (1.318, 2.156)  | 0.000   |
| Vaginal breech delivery                           | 0.653 (0.178)      | 1.921 (1.355, 2.723)  | 0.000   |
| Antenatal steroids                                | −0.756 (0.172)     | 0.469 (0.335, 0.657)  | 0.000   |

CI, confidence interval; OR, odds ratio; SE, standard error.
High rates of antenatal care (97.7%) and antenatal steroids (90%) and birth within a tertiary facility (89%) are reflective of the good antenatal care provided for these women in the region. The large sample size in our cohort allowed us to analyse the outcomes based on common clinical scenarios faced by the families and clinicians in their daily practice. These

| Table 3 | Gestational age-specific hospital survival rates |
|---------|-----------------------------------------------|
| Gestation birth | 23 wk | 24 wk | 25 wk | 26 wk | 27 wk | 28 wk | 29 wk | 30 wk | 31 wk | Total |
| N = 41 | N = 186 | N = 295 | N = 349 | N = 449 | N = 566 | N = 614 | N = 834 | N = 1120 | N = 4454 |
| % (Number), 95% CI | 11 (26.8) | 110 (59.1) | 223 (75.6) | 297 (85.1) | 409 (91.1) | 541 (95.6) | 597 (97.2) | 816 (97.8) | 1104 (98.6) | 4108 (92.2) |
| Single scenario | 15.7–41.9 | 51.9–65.9 | 70.4–80.1 | 80.9–88.4 | 88.1–93.4 | 93.6–96.9 | 95.6–98.3 | 96.6–98.6 | 97.7–99.1 | 91.4–92.9 |
| Singleton N = 3162 | 25.7 | 63.2 | 74.8 | 84.2 | 92.4 | 95.0 | 96.9 | 97.0 | 98.5 | 91.7 |
| Twin N = 1154 | † | 54.5 | 77.6 | 86.7 | 86.8 | 97.9 | 98.0 | 99.6 | 99.4 | 93.9 |
| Inborn N = 3950 | 28.6 | 59.9 | 78.8 | 86.1 | 92.0 | 95.6 | 97.2 | 97.6 | 98.5 | 92.6 |
| Outborn N = 504 | 16.7 | 50.0 | 52.8 | 77.5 | 83.3 | 95.2 | 97.7 | 100 | 99.2 | 89.7 |
| ANS given N = 4011 | 32.0 | 60.4 | 78.3 | 85.2 | 92.3 | 95.5 | 97.3 | 98.0 | 98.6 | 92.8 |
| No ANS N = 443 | 18.8 | 47.1 | 50.0 | 83.9 | 75.8 | 96.6 | 95.8 | 98.5 | 86.9 |
| Caucasian N = 3499 | 25.8 | 56.6 | 75.2 | 84.7 | 90.1 | 95.7 | 97.3 | 97.5 | 98.3 | 91.9 |
| Indigenous N = 252 | † | † | † | 80 | 90.3 | 87.5 | 94.1 | 100 | 98.3 | 90.8 |
| Asian N = 537 | 66.6 | 65 | 72.9 | 91.6 | 98.1 | 96.9 | 97.5 | 98.9 | 100 | 94.9 |
| Non-breech delivery | 33 | 59.9 | 77.8 | 85.9 | 91.2 | 96.5 | 97.1 | 97.9 | 98.5 | 93.2 |
| Vaginal breech delivery | 14.2 | 57.1 | 63.8 | 75.9 | 88.9 | 100 | 100 | 96.3 | 100 | 77.5 |
| Male N = 2355 | 16.7 | 55.3 | 70.0 | 79.7 | 89.9 | 93.7 | 97.8 | 97.3 | 98.4 | 90.6 |
| Female N = 2099 | 41.2 | 63 | 82.2 | 91.0 | 92.3 | 98.0 | 96.6 | 98.5 | 98.7 | 94.1 |
| Birthweight ≥ 10th percentile N = 4131 | 28.2 | 60.3 | 76.3 | 84.7 | 92.1 | 96.3 | 97.7 | 97.9 | 98.7 | 92.5 |
| Birthweight < 10th percentile N = 323 | † | † | 62.5 | 89.7 | 76.7 | 88.2 | 92.2 | 97.9 | 96.4 | 88.5 |
| Birthweight ≥ 3rd percentile N = 4375 | 26.8 | 59.5 | 76.3 | 85.5 | 91.2 | 96.2 | 97.7 | 97.8 | 98.6 | 92.4 |
| Birthweight < 3rd percentile N = 79 | † | † | † | 75.0 | † | 73.3 | 75.0 | 100 | 100 | 81.0 |
| Combined scenarios | | | | | | | | | | |
| Scenario 1 N = 3412 | 36.4 | 62.7 | 82.1 | 85.5 | 93.5 | 96.5 | 98.0 | 97.9 | 98.7 | 93.5 |
| Scenario 2 N = 2707 | 36.8 | 60 | 80.5 | 85.6 | 92.7 | 96.8 | 98.3 | 97.6 | 98.4 | 93.1 |
| Scenario 3 N = 406 | † | 71.4 | 87 | 88.5 | 100 | 98 | 96.5 | 98.7 | 100 | 96.6 |

†Number of infants are too small (0–10) to include meaningful survival estimates. Outborn: born outside the tertiary perinatal centre; Inborn: born at a tertiary perinatal centre; Scenario 1: Inborn plus antenatal steroids plus birthweight ≥ 10th percentile and of all ethnicities; Scenario 2: Caucasian inborn plus antenatal steroids plus birthweight ≥ 10th percentile; Scenario 3: Asian inborn plus antenatal steroids plus birthweight ≥ 10th percentile. ANS, antenatal steroids; CI, confidence interval; wk, weeks.
scenario-based outcomes are far more meaningful and accurate for families facing varied risk factors. These scenario-based outcomes will also facilitate benchmarking across the regions to reflect NICU practices after adjusting for common obstetric and infant factors at delivery.

We acknowledge that direct comparison of our findings with other published reports is difficult due to differences in study cohorts, definitions and reporting methods, birth registration, and NICU admission policies. However, it is worth noting a few recent regional studies that reported gestational age-specific outcomes for extreme preterm infants (Table 6). National Institute of Child Health and Human Development (NICHD) Neonatal Research Network from USA published the outcomes for extreme preterm infants born between 2003 and 2007 within their network. They reported the gestational age-specific survival rates for total births. They were 26%, 55%, 72%, 84%, 88% and 92% at 23, 24, 25, 26, 27 and 28 weeks gestation, respectively. Hospital survival rates for liveborn infants admitted to NICUs in 2006 Epicure cohort in England were 30%, 47%, 69% and 78% for 23–26 weeks gestation, respectively. Survival rates for preterm infants of 22–24 weeks gestation born between 2006 and 2008 in the Canadian

| Table 4 | Gestational age-specific hospital morbidities and interventions |
|---------|---------------------------------------------------------------|
| %       | 23 wk N = 41 | 24 wk N = 186 | 25 wk N = 295 | 26 wk N = 349 | 27 wk N = 449 | 28 wk N = 566 | 29 wk N = 614 | 30 wk N = 834 | 31 wk N = 1120 |
| Surfactant therapy | 95.1 | 96.2 | 95.3 | 95.1 | 87.5 | 79.0 | 60.9 | 44.0 | 31.1 |
| CPAP therapy | 48.8 | 74.2 | 85.1 | 92.6 | 95.3 | 97.7 | 96.3 | 90.4 | 79.9 |
| Mechanical ventilation | 92.7 | 97.8 | 93.9 | 86.8 | 79.1 | 67.5 | 55.5 | 40.3 | 28.9 |
| HFV | 61.0 | 52.2 | 32.2 | 22.9 | 12.2 | 8.8 | 5.7 | 2.5 | 2.0 |
| Nasal HiFlow therapy | 9.8 | 18.8 | 32.9 | 31.8 | 27.6 | 20.7 | 15.6 | 9.0 | 2.9 |
| iNO therapy | 0 | 9.1 | 9.5 | 9.2 | 5.3 | 4.9 | 2.6 | 1.8 | 1.3 |
| Pneumothorax | 12.2 | 8.1 | 7.8 | 6.0 | 2.4 | 2.1 | 2.4 | 2.8 | 1.3 |
| CLD at 36 weeks | 26.8 | 44.1 | 47.8 | 43.3 | 28.1 | 21.4 | 11.1 | 5.9 | 3.0 |
| CLD at 40 weeks | 17.1 | 31.7 | 28.8 | 25.8 | 11.4 | 10.2 | 4.6 | 2.2 | 1.6 |
| Steroids for CLD | 24.4 | 32.8 | 28.5 | 18.1 | 5.1 | 4.8 | 1.5 | 0.8 | 0.5 |
| Home O2 | 12.2 | 18.8 | 16.9 | 16.1 | 5.6 | 6.2 | 2.8 | 0.8 | 0.9 |
| PDA requiring any therapy | 61.0 | 81.2 | 73.2 | 71.3 | 58.1 | 43.1 | 31. | 14.5 | 8.7 |
| PDA requiring surgery | 9.8 | 12.4 | 9.2 | 7.4 | 4.5 | 4.2 | 1.5 | 0.8 | 0.4 |
| NEC | 2.4 | 10.2 | 7.5 | 6.0 | 4.7 | 3.4 | 2.1 | 1.6 | 0.3 |
| IVH†, grade 1 | 4.9 | 14.0 | 16.3 | 17.2 | 13. | 12.9 | 13.0 | 10.4 | 10.0 |
| IVH, grade 2 | 14.6 | 14.5 | 11.2 | 9.2 | 6.2 | 4.4 | 2.6 | 1.6 | 1.2 |
| IVH, grade 3 | 12.2 | 5.4 | 3.7 | 2.6 | 2.2 | 1.8 | 1.3 | 0.6 | 0.4 |
| IVH, grade 4 | 17.1 | 14.0 | 8.8 | 8.6 | 3.1 | 2.8 | 0.5 | 1.0 | 0.4 |
| PVL on late ultrasound | 0.0 | 3 | 1.0 | 3.4 | 1. | 1.9 | 1.1 | 1.0 | 0.8 |
| ROP‡, stage 1 | 0.0 | 5.4 | 9.8 | 12.6 | 13. | 11.3 | 8.0 | 2.6 | 1.2 |
| ROP, stage 2 | 12.2 | 25.8 | 31.2 | 30.1 | 17.4 | 9.9 | 5.7 | 1.3 | 0.6 |
| ROP, stage 3–5 | 17 | 24.7 | 18.9 | 12.3 | 4.4 | 1.4 | 1.5 | 0.2 | 0.1 |
| Early-onset sepsis | 2.4 | 4.8 | 5.4 | 5.4 | 1.0 | 1.5 | 2.0 | 0.8 | 0.0 |
| Late-onset sepsis | 29.3 | 53.2 | 43.4 | 41.8 | 27.6 | 17.7 | 14.7 | 7.0 | 5.4 |
| Blood transfusions | 65.9 | 90.3 | 90.2 | 85.1 | 69.3 | 52.7 | 29 | 15.6 | 8.7 |
| Parenteral nutrition | 65.9 | 89.8 | 92.5 | 94.3 | 95.5 | 96.5 | 96.7 | 85.1 | 70.4 |
| Survived to discharge | | | | | | | | | |
| PVL | 0 | 4.5 | 1.3 | 1.3 | 1 | 2 | 1.1 | 1 | 0.6 |
| Porencephalic cyst | 0 | 2.7 | 1.3 | 2.6 | 1 | 1.6 | 0.5 | 1 | 0.4 |
| ROP, stage 1–2 | 36.4 | 50.9 | 53.4 | 50.2 | 33.5 | 22 | 13.9 | 4 | 1.8 |
| ROP, stage 3–5 | 63.6 | 41.8 | 25.1 | 14.5 | 4.6 | 1.5 | 1.5 | 0.2 | 0.1 |
| CLD at 36 weeks | 90.9 | 72.7 | 61.9 | 50.8 | 20.6 | 10.9 | 5.8 | 3.1 |
| CLD at 40 weeks | 63.6 | 52.7 | 37.7 | 30.3 | 12.5 | 10.5 | 4.7 | 2.1 | 1.6 |
| Home oxygen | 45.5 | 31.8 | 22.4 | 18.9 | 6.1 | 6.5 | 2.9 | 0.8 | 0.9 |

Sepsis, culture-proven blood or cerebrospinal fluid infection. †100% of infants at 23–29 wk, 96.6% at 30 wk and 90.2% at 31 wk were examined. §100% of infants at 23–26 wk, 99.3% at 27 wk, 98.7% at 28 wk, 95% at 29 wk, 77.3% at 30 wk and 55% at 31 wk were examined. CLD, chronic lung disease as defined as respiratory support at 36 or 40 weeks corrected age; HFV, high-frequency ventilation; iNO, inhaled nitric oxide; IVH, intraventricular haemorrhage; NEC, necrotising enterocolitis proven either radiologically or by surgery; PDA, patent ductus arteriosus; PVL, periventricular leucomalacia; ROP, retinopathy of prematurity.
Neonatal Network were 47.7% in comparison with our current survival rates of 53% for 23–24 weeks gestation. In contrast, Swedish and Japanese reports indicate higher survival rates. Itabashi and colleagues from Japan reported a nationwide hospital survival rate of 82% for liveborn infants of 23–27 weeks gestation in 2005 (1767 out of 2156 cases). NICU survival rate among the infants of Asian origin in our cohort for the same gestational age group was comparable at 85% (129 out of 151 cases). EXPRESS Group from Sweden published nationwide 1-year survival rates in their 2004–2007 cohort of liveborn infants at 23–26 weeks gestation. Overall survival during the neonatal period was 74.5% and at 1 year of age 71.7%. In contrast, the hospital survival rate in our cohort for the same gestational age group was 61.6%. The survival rates in Swedish network remained high in comparison to ours even after excluding risk factors such as outborn, lack of antenatal steroid exposure and growth restriction. It would therefore be important to investigate any management practice variations among the networks and share this information with clinicians to help improve or amend the clinical practice in local units.

### Scenario-based survival outcomes

Survival outcomes in preterm infants are more accurately predicted by addition of multiple factors in addition to gestational age alone. In this study, we created several scenario-based outcomes pertinent to daily practice. In our study, we identified perinatal factors including antenatal steroids, gender, place of birth and birthweight percentile for gestational age impacted the survival rates by at least 5% at lower gestational ages. In our cohort, multiple birth impact on hospital survival was not consistent. We reported a similar finding in a previous cohort from our region. Twins showed higher mortality compared with singletons only in infants <25 weeks in that study.

There are a number of studies from various networks on the predictive models for preterm mortality. The Australian and New Zealand Neonatal Network’s study on the cohort of 1998–1999 involving all 29 tertiary NICUs in both countries identified a model containing gestational age, gender, low birthweight for gestational age and hypertension of pregnancy was a good predictor of mortality between 25 and 31 weeks. Outborn and vaginal breech deliveries were not significant predictors in this

#### Table 5: Suggested preterm outcome table (POT) for counselling purposes

| Gestational age (weeks) | 23 (%) | 24 (%) | 25 (%) | 26 (%) | 27 (%) | 28 (%) | 29 (%) | 30 (%) | 31 (%) |
|------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Overall survival       | 25     | 60     | 75     | 85     | 90     | 95     | 97     | 98     | 99     |
| Mechanical ventilation | >95    | >95    | 95     | 90     | 80     | 70     | 55     | 40     | 30     |
| CLD at 36 weeks        | 25     | 45     | 50     | 45     | 30     | 20     | 10     | 5      | <5     |
| Corticosteroids for CLD| 25     | 35     | 30     | 20     | 5      | 5      | <5     | <1     | <1     |
| Home oxygen            | 10     | 20     | 15     | 15     | 5      | 5      | <5     | <1     | <1     |
| PDA requiring any therapy | 60  | 80     | 75     | 70     | 60     | 45     | 30     | 15     | 10     |
| PDA requiring surgery  | 10     | 10     | 10     | 5      | <5     | <5     | <5     | <1     | <1     |
| NEC                    | 2.4    | 10     | 10     | 5      | 5      | <5     | <5     | <1     | <1     |
| IVH, grade 1–2         | 10     | 15     | 15     | 10     | 10     | 10     | 10     | 5      | 5      |
| IVH, grade 3–4         | 10     | 10     | 5      | 5      | <5     | <5     | 1      | <1     | <1     |
| PVL                    | <5     | <5     | <5     | <5     | <5     | <5     | <5     | <1     | <1     |
| ROP, stage 1–2         | 5      | 15     | 20     | 15     | 10     | 10     | 10     | <5     | <5     |
| ROP, stage 3–5         | 15     | 15     | 10     | 5      | 2.2    | <1     | <1     | <1     | <1     |
| Early-onset infection  | <5     | <5     | 5      | <5     | <5     | <5     | <5     | <1     | <1     |
| Late-onset infection   | 30     | 55     | 45     | 40     | 30     | 20     | 15     | 5      | 5      |

Note: Sepsis is culture proven blood or cerebrospinal fluid infection. CLD, chronic lung disease defined as any respiratory support at 36 weeks corrected age; IVH, intraventricular haemorrhage; NEC, necrotising enterocolitis proven either radiologically or by surgery; PDA, patent ductus arteriosus; PVL, periventricular leukomalacia; ROP, retinopathy of prematurity.

#### Table 6: Survival rates of extreme preterm infants among different regional networks

| Country                  | Birth cohort | 23 weeks (%) | 24 weeks (%) | 25 weeks (%) | 26 weeks (%) |
|--------------------------|--------------|--------------|--------------|--------------|--------------|
| NSW and ACT, Australia   | 2007–2011    | 27           | 60           | 75           | 85           |
| NICHD network, USA       | 2003–2007    | 26           | 55           | 72           | 84           |
| EpiCure, UK              | 2006         | 30           | 47           | 69           | 78           |
| Sweden                   | 2004–2007    | 54           | 71           | 86           | 87           |
| Japan                    | 2005         | 54           | 77           | 85           | 90           |
Extreme to very preterm infant outcomes

In summary, we determined the regional outcomes of extreme to very preterm infants from a well-defined region. Our study adds to the growing number of other studies that many perinatal factors influence the outcomes besides gestational age. Our study also highlights that these influencing factors may vary from region to region. Therefore, regional networks should consider developing their own regional-specific survival estimates derived from their own data.

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