OPEN ACCESS

Original research

Respiratory management and outcomes in high-risk preterm infants with development of a population outcome dashboard

Tng Chang Kwok [1], Caroline Poulter,[2] Saleh Algarni,[3,4] Lisa Szatkowski [1], Don Sharkey [1]

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/thorax-2023-220174).

[1]Centre for Perinatal Research, School of Medicine, University of Nottingham, Nottingham, UK
[2]Nottingham Neonatal Service, Queen's Medical Centre, Nottingham, UK
[3]Department of Respiratory Therapy, College of Applied Medical Sciences, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia
[4]King Abdullah International Medical Research Center, Riyadh, Saudi Arabia

Correspondence to
Professor Don Sharkey, Centre for Perinatal Research, School of Medicine, University of Nottingham, Nottingham, UK; don.sharkey@nottingham.ac.uk

Received 22 February 2023
Accepted 15 June 2023

To cite: Kwok TC, Poulter C, Algarni S, *et al*. *Thorax* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/thorax-2023-220174

ABSTRACT

Introduction Bronchopulmonary dysplasia (BPD) is associated with adverse long-term respiratory and neurodevelopmental outcomes. No recent studies examined the changing respiratory management and outcomes, particularly severe BPD, across a whole population.

Purpose Evaluate the temporal trends in the respiratory management and outcomes of preterm infants born below 32 weeks gestational age and develop an individualised dashboard of the incidence of neonatal outcome.

Methods Using the National Neonatal Research Database, we determined changes in respiratory management, BPD rates, postdischarge respiratory support and mortality in 83 463 preterm infants in England and Wales from 2010 to 2020.

Results Between 2010 and 2020, antenatal corticosteroids use increased (88%–93%, p<0.0001) and neonatal surfactant use decreased (65%–60%, p<0.0001). Postnatal corticosteroid use increased, especially dexamethasone (4%–6%, p<0.0001). More recently, hydrocortisone and budesonide use increased from 2% in 2017 to 4% and 3%, respectively, in 2020 (p<0.0001). Over the study period, mortality decreased (10.1%–8.5%), with increases in BPD (28%–33%), severe BPD (12%–17%), composite BPD/death (35%–39%) and composite severe BPD/death (21%–24%) (all p<0.0001). Overall, 11 684 infants required postdischarge respiratory support, increasing from 13% to 17% (p<0.0001), with 1843 infants requiring respiratory pressure support at discharge. A population dashboard (https://premoutcome.github.io/) depicting the incidence of mortality and respiratory outcomes, based on gestation, sex and birthweight centile, was developed.

Conclusion More preterm infants are surviving with worse respiratory outcomes, particularly severe BPD requiring postdischarge respiratory support. Ultimately, these survivors will develop chronic respiratory diseases requiring greater healthcare resources.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Despite recent advances in neonatal practices and respiratory management, such as minimising invasive ventilation and cautious use of postnatal corticosteroids, bronchopulmonary dysplasia remains a significant problem in preterm infants born below 32 weeks gestation. The variation in personalised risk perception and outcome estimation in preterm infants by clinicians due to a lack of contemporaneous outcome data impacts treatment decisions and parental discussions.

WHAT THIS STUDY ADDS

⇒ This study of over 83 000 preterm infants born below 32 weeks gestation demonstrates improving survival but associated with significantly worse respiratory outcomes, notably severe bronchopulmonary dysplasia requiring respiratory support at discharge. The study also developed contemporaneous charts and an online dashboard (preterm outcome dashboard—https://premoutcome.github.io/) depicting the incidence of preterm mortality and important respiratory outcomes stratified by sex, gestation and birthweight centile based on recent large population-based data.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study identifies the increasing burden of severe respiratory outcomes, despite the associated improving respiratory management, and provides the first detailed contemporaneous charts and outcome dashboards across an entire population, equipping researchers and healthcare service planners with contemporaneous data on the incidence of respiratory outcomes to target interventions and services in this high-risk population, as well as giving clinicians robust information for benchmarking and to support parental shared clinical decision-making.

INTRODUCTION

Bronchopulmonary dysplasia (BPD) remains one of the most common and costly conditions affecting preterm infants,[1] with associated significant long-term respiratory and neurodevelopmental morbidity into adulthood.[2] Infants with BPD are twice as likely to die or have cognitive and motor delays including cerebral palsy[3] with more respiratory tract infections[4] and abnormal lung function in adulthood.[2] Severe BPD and being discharged on home oxygen are important outcomes for parents who have significant anxiety caring for their child.[5]

BPD, particularly more severe forms requiring postnatal corticosteroid (PNC) treatment, places a significant burden on paediatric and adult respiratory and intensive care services, as well as the wider education and social services.[6]

There has been a greater focus on avoiding invasive ventilation to prevent lung injury and cautious PNC use to facilitate extubation and reduce BPD and mortality risk while minimising the potential neurotoxic effects.[7] With significant changes in neonatal respiratory management in recent years, there are little contemporary data on changes with BPD severity and respiratory support at discharge. Hence, it is crucial to assess the temporal trends in survival, respiratory care and outcomes in preterm infants as these practices evolve. Furthermore, visualisation of contemporaneous population-based outcome data, including detailed important respiratory outcomes, is crucial in addressing the variation in how clinicians perceive risk and estimate outcomes which impacts on treatment decision making and parental discussion.[8]

Objectives

We aimed to describe the recent changes in neonatal respiratory practices, outcomes and mortality in preterm infants born below 32 weeks gestation across a national health service setting. To support clinical care of these high-risk infants, our secondary aim was to develop an online dashboard depicting the incidence of these important outcomes.

MATERIAL AND METHODS

Study design

This was a population-based retrospective cohort study using deidentified data from the National Neonatal Research Database (NNRD). The study was reported using the Strengthening the Reporting of Observational Studies in Epidemiology guideline.

Data source and patient population

NNRD contains detailed neonatal information entered by healthcare professionals at the point of care.[9] A total of 185 neonatal units (online supplemental table 1) contributed to the NNRD covering over 90% of neonatal units in England in 2010, with complete coverage in England from 2012 and Wales from 2014. All preterm infants born below 32 weeks of gestational age (GA) from 2010 to 2020 and admitted to neonatal units in England and Wales contributing to the NNRD were included. Infants who were not admitted for neonatal care were not included, accounting for 9.6% of all live births born below 32 weeks GA as determined from the Office of National Statistics[10] during this period, with 68% of these born below 24 weeks GA. Infants with birthweight z scores below −4 or above 4, based on the UK WHO growth chart,[11] and discharged to non-participating neonatal units were excluded as they were likely erroneous or incomplete entries.

Definition of clinical practices and outcomes

Data were extracted for key clinical practices, including antenatal corticosteroids, surfactant and PNC use. The type and definition of PNC analysed were based on a recent UK survey[12] to ensure that the PNC was intended to treat or prevent BPD: dexamethasone,[13] methylprednisolone[14] and budesonide[15] (all defined as more than two consecutive days of treatment), and hydrocortisone[16 17] (defined as more than six consecutive days of treatment).

Four outcome measures were analysed. First, death before discharge from the neonatal unit. Second, respiratory requirement at discharge in surviving infants. Third, BPD defined as the dependence on any form of respiratory support or oxygen at 36 weeks of corrected GA (CGA). If infants were discharged before 36 weeks CGA, respiratory support at discharge was used. Infants who died before 36 weeks CGA were excluded from this

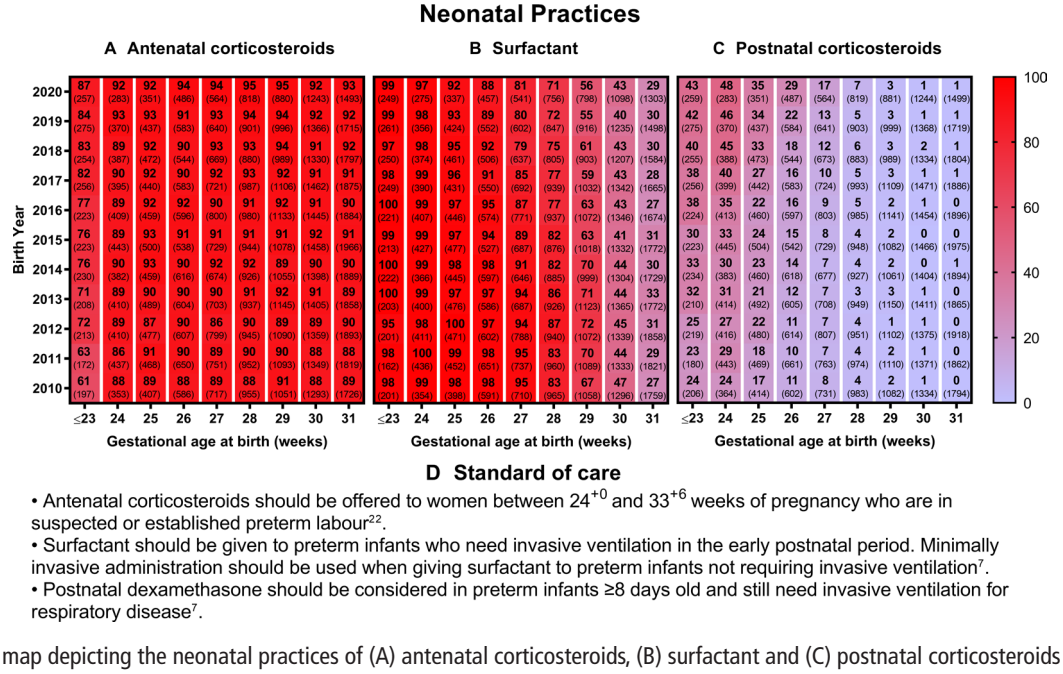


Figure 1 Heat map depicting the neonatal practices of (A) antenatal corticosteroids, (B) surfactant and (C) postnatal corticosteroids use in 83 463 preterm infants born below 32 weeks gestation in the respective years and gestational age as well as the (D) standard of care derived from the National Institute for Health and Care Excellence (NICE) guidelines.[7 40] Data presented as the percentage of infants with the respective neonatal practice within each cell (total number of infants within each cell). Missing data on antenatal corticosteroids (n=693, 0.8%) and surfactant use (n=4778, 5.7%).

denominator. This definition aligns with recent evidence[18] and UK reporting.[19] Information on room air challenge test was not recorded. Fourth, severe BPD, defined as requiring non-invasive (including high flow >2 L/min) and invasive pressure support ventilation at 36 weeks CGA, aligning with the Jensen 2019 grade two and three BPD definitions.[18] Further definitions of the variables used are described in online supplemental table 2.

Analysis

Summary statistics (median, IQR and percentages) were used to describe the data. Trends in the categorical and continuous data across birth years and respiratory support type at discharge were analysed by using the χ^2 test for trend[20] and an extension of the Wilcoxon rank-sum test,[21] respectively. To account for competing risk when analysing respiratory outcomes across the birth year, the composite outcomes of death and/or respiratory outcomes were used.

All statistical analyses were performed using STATA SE V.17 and complete case analysis, with an assumed significance level of $\alpha=0.01$ to reduce the type 1 error due to multiple analyses. Multivariable logistic regression was used to obtain the OR of the outcomes across the birth years (modelled as categorical variable with 2010 as the reference group), adjusted for GA at birth, birthweight z score and sex with robust variance estimator accounting for clustering within units. Restricted cubic spline was used to model the continuous variables of GA at birth and birthweight z scores. Population heat maps specific for gestation, sex and birthweight centile[11] were devised for the incidence of mortality and respiratory outcomes. These were split into 2010–2015 and 2016–2020 to reflect outcome changes from the last 5 years. An online dashboard was produced using Microsoft Power BI. Infants born below 23 weeks GA were excluded due to small numbers and lack of birthweight centiles.[11] Cells with less than 10 infants were suppressed.

RESULTS

Data from 84 440 infants were extracted. A total of 977 (1.2%) infants were excluded as their birthweight z scores were below −4 or above 4 (96 infants) or discharged to non-participating units (881 infants). Hence, 83 463 preterm infants with 4 878 314 daily episodes were analysed.

Neonatal practices

From 2010 to 2020, more mothers received antenatal corticosteroids, especially in infants born below 24 weeks GA (figure 1A). The proportion of infants who received surfactant decreased from 65% in 2010 to 60% in 2020 (figure 1B). The percentage of infants ventilated in the first 48 hours of life initially increased before declining during the latter part of the study period, with the total number of mechanical ventilation days remaining similar at a median of 1–2 days (online supplemental table 3).

Overall, 6307 infants received PNC, increasing from 5% in 2010 to 11% in 2020 (figure 1C). The most commonly used PNCs were dexamethasone (4448 (5%) infants), followed by hydrocortisone (1629 (2%) infants), budesonide (1184 (1%) infants) and methylprednisolone (40 (0.05%) infants). A total of 928 (1%) infants received more than one type of PNC (online supplemental figure 1). Dexamethasone use increased, especially in extremely premature infants born below 28 weeks GA, from 11% in 2010 to 18% in 2020. The use of hydrocortisone remained between 3% and 4% from 2010 to 2016 before increasing to 12% by 2020 in extremely premature infants. Similarly, the use of budesonide increased from 1% to 3% in the first

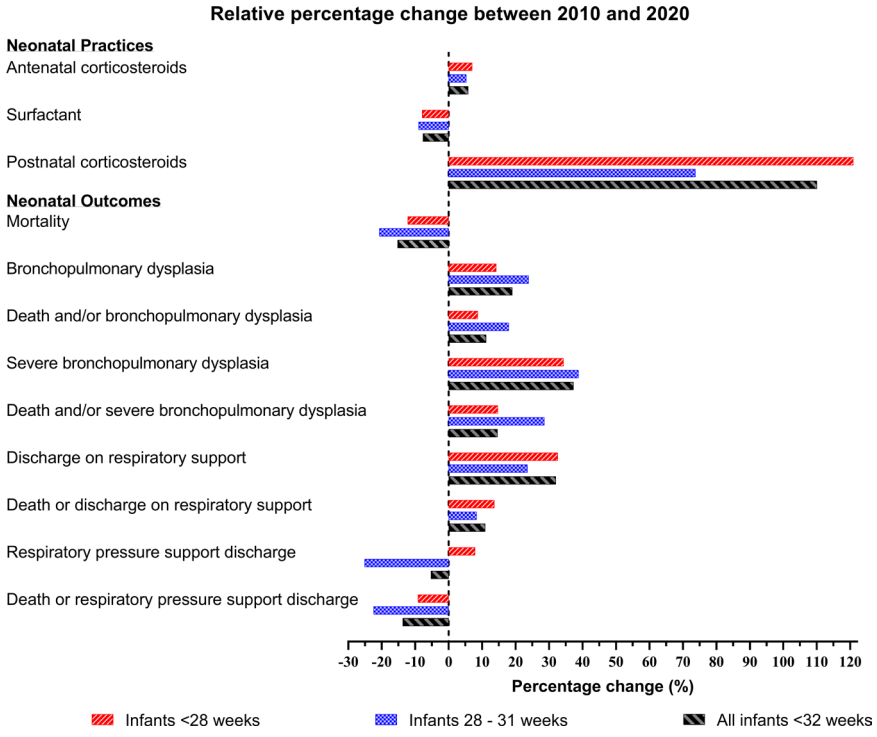


Figure 2 Relative percentage of change for key neonatal practices and the incidence of outcomes from 2010 to 2020 in 83 463 preterm infants born below 32 weeks gestation, 26 098 extremely preterm infants born below 28 weeks gestation and 57 365 very preterm infants born between 28 and 31 weeks of gestation. Missing data on antenatal steroid course (n=693, 0.8%), surfactant use (n=4778, 5.7%), bronchopulmonary dysplasia (BPD) (n=414, 0.5%), severe BPD (n=414, 0.5%), discharge on respiratory support (n=725, 0.9%) and respiratory pressure support at discharge (n=725, 0.9%).

half of the study period to 8% by 2020 in extremely premature infants (online supplemental table 3 and figure 2).

Hydrocortisone was commenced at the earliest chronological age at a median (IQR) of 20 (4–42) days, followed by dexamethasone at 28 (19–43), budesonide at 42 (23–70) and methylprednisolone at 117 (88–156) days old (online supplemental figure 3). Across the birth years, dexamethasone was commenced at an increasingly earlier chronological age from a median (IQR) of 32 (22–49) days in 2010 to 27 (19–39) days in 2020 (p<0.0001). Similarly, hydrocortisone and budesonide were started at 28 (14–51) and 70 (46–119) days, respectively, in 2010 to 4 (1–23) and 34 (14–52) days, respectively, in 2020 (p<0.0001) (online supplemental table 4). In infants receiving dexamethasone, the percentage of infants receiving another PNC type increased from 6% in 2010 to 17% in 2020 (p<0.0001) (online supplemental table 4).

Neonatal outcomes

Overall, mortality reduced from 10.1% in 2010 to 8.5% in 2020 (15% relative decrease) with the adjusted OR (aOR) decreasing to 0.70 (95% CI 0.60 to 0.82) in 2020. Conversely, there was an increase in the percentage of infants with BPD across the birth years from 28% to 33% (19% relative increase) and severe BPD from 12% to 17% (37% relative increase). A similar trend was found for the composite outcome of death and/or BPD as well as death and/or severe BPD with increases in incidence from 35% to 39% (11% relative increase) and from 21% to 24% (15% relative increases), respectively. The proportion of infants discharged on respiratory support increased from 13% to 17% (32% relative increase), with increasing CGA at discharge from a median (IQR) of 37^{+1} (35^{+5}–39^{+1}) to 37^{+1} (36^{+0}–39^{+2}) (p<0.0001). There was no statistically significant trend for the composite outcome of death or respiratory support requirement on discharge across the birth years (figure 2, online supplemental table 3 and figure 4). The increasing incidence of these poor respiratory outcomes matches the increasing aOR seen across the birth years (figure 3, online supplemental table 5). A total of 11 684 (16%) infants who required respiratory support at discharge were born earlier, more likely to be male, of lower birth weight and small for GA (table 1).

Similar improving mortality trend over the birth years (20% to 15%, p=0.004) was seen in the subgroup of 6307 infants who received PNC. However, no statistically significant trend was seen for the respiratory outcomes and the composite mortality and respiratory outcomes in these infants (online supplemental table 6 and figure 5).

Over the study period, the percentage of preterm infants who required invasive ventilation at 36 weeks CGA remained unchanged. However, the percentage of infants who required non-invasive ventilation at 36 weeks CGA and discharge increased from 10% to 15% and 1.1% to 1.4%, respectively (online supplemental tables 8,9 and figures 6,7).

Mortality and respiratory outcome charts

Gestation, sex and birthweight centile heat maps were produced for the 2010–2015 and 2016–2020 cohorts, depicting the incidence of mortality, BPD, severe BPD, postdischarge respiratory support and postdischarge respiratory pressure support requirement (online supplemental figures 8–12). Incidence of these outcomes varied based on birthweight centile and sex, alongside GA at birth. Despite born at the same GA, infants with extreme birthweight centile (≤9th or >91st centiles) generally have poorer outcome, demonstrating a U-shaped relationship. Similarly, male infants have poorer outcome than female infants. An electronic version of the charts, the preterm outcome dashboard (POD), was produced in an online dashboard accessible on (https://premoutcome.github.io/) with example screenshots shown in figure 4.

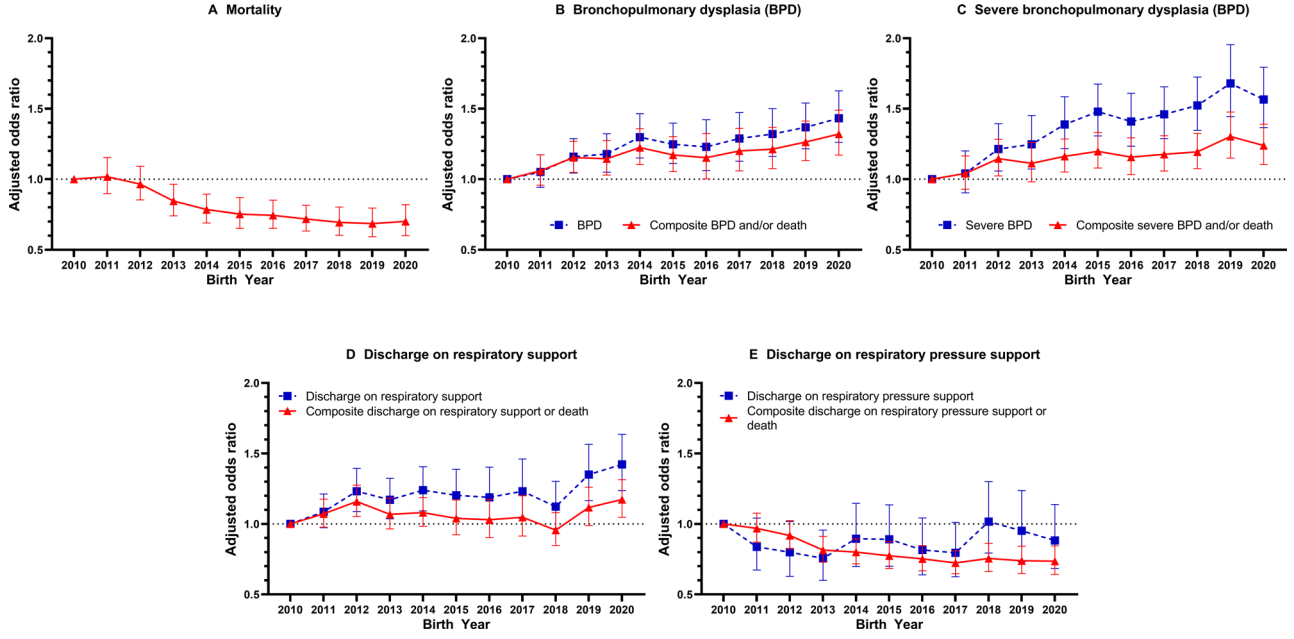


Figure 3 Adjusted OR with 95% CI of the neonatal outcomes of (A) mortality, (B) bronchopulmonary dysplasia (BPD), (C) severe BPD, (D) any respiratory support requirement at discharge from the neonatal unit and (E) respiratory pressure support at discharge and their respective composite outcomes with death in (B–E) in 83 463 preterm infants born below 32 weeks gestation from 2010 to 2020. Missing data on mortality (n=251, 0.3%); BPD (n=492, 0.6%); BPD and/or death (n=661, 0.8%); severe BPD (n=492, 0.6%); severe BPD and/or death (n=661, 0.8%); discharge on respiratory support (n=801, 1.1%); discharge on respiratory support or death (n=970, 1.2%); respiratory pressure support at discharge (n=801, 1.1%) and discharge on respiratory pressure support or death analyses (n=970, 1.2%).

Table 1 Clinical characteristics of preterm infants born below 32 weeks gestation included in the study

Clinical characteristics	All infants (n=83 463)	Respiratory support at discharge*†			P value‡
		None (n=63 562)	Oxygen only (n=9841)	Pressure support (n=1843)	
Gestation at birth (weeks), median (IQR)	29^{+3} (27^{+2}–30^{+6})	30^{+0} (28^{+2}–31^{+1})	27^{+0} (25^{+3}–28^{+4})	27^{+0} (25^{+2}–29^{+0})	<0.0001
Birth weight (g), median (IQR)	1200 (900–1490)	1300 (1036–1550)	870 (710–1085)	859 (680–1150)	<0.0001
Birthweight z score*, median (IQR)	−0.26 (−0.87 to 0.26)	−0.19 (−0.79 to 0.31)	−0.49 (−1.15 to 0.04)	−0.53 (−1.24 to 0.01)	<0.0001
Small for gestational age (n (%))*§	12 335 (15)	8151 (13)	2104 (21)	440 (24)	<0.0001
Sex (n (%))*					
Male	45 552 (55)	33 908 (53)	576 (59)	1110 (60)	<0.0001
Ethnicity (n (%))*					
White	34 845 (70)	26 753 (70)	4235 (74)	722 (69)	<0.0001
South Asian	6573 (13)	5229 (14)	529 (9)	138 (13)	<0.0001
Black	3908 (8)	2946 (8)	446 (8)	98 (9)	0.1
Others/mix	4437 (9)	3428 (9)	515 (9)	96 (9)	0.8
Antenatal corticosteroids (n (%))*	74 791 (90)	57 445 (91)	9000 (92)	1639 (90)	0.2
Apgar 5 min<7 (n (%))*	14 397 (19)	8146 (14)	2409 (29)	504 (31)	<0.0001
Surfactant (n (%))*	50 329 (64)	33 364 (56)	8393 (90)	1514 (86)	<0.0001
Received mechanical ventilation (n (%))	55 696 (67)	37 075 (58)	9167 (93)	1759 (95)	<0.0001
Duration of invasive ventilation (days)†	1 (0–5)	1 (0–3)	11 (3–29)	20 (4–46)	<0.0001
Duration of non-invasive ventilation (days)†	9 (2–33)	6 (2–23)	44 (29–60)	45 (13–76)	<0.0001
PNC use (n (%))	6307 (8)	2024 (3)	2605 (26)	659 (36)	<0.0001
Length of hospital stay (days)*†	52 (37–78)	47 (35–68)	94 (75–118)	97 (58–140)	<0.0001

*Missing data on respiratory support at discharge (n=725, 0.9%), birthweight Z score (n=248, 0.3%), small for gestational age (n=248, 0.3%), sex (n=54, 0.06%), ethnicity (n=33 700, 40%), antenatal corticosteroids (n=693, 0.8%), Apgar scores (n=9157, 11%), surfactant (n=4778, 5.7%) and length of hospital stay (n=25, 0.03%).
†Infants who died before discharge were excluded.
‡The p values for the trends in the categorical and continuous data across the respiratory support type at discharge were analysed using the χ^2 test and an extension of the Wilcoxon rank-sum test, respectively.
§Small for gestational age was defined as birth weight below 10th centile.
n, total number of infants; PNC, postnatal corticosteroids.

DISCUSSION

This national study is one of the largest using a contemporary high-risk preterm population of over 83 000 infants. It highlights the changing perinatal respiratory management,[7] improving survival and increasing BPD rates. Importantly, we found increasing rates of more severe respiratory outcomes with a 37% increase in severe BPD, a 32% increase in respiratory support requirement after discharge and a doubling of PNC use especially dexamethasone. These findings have important implications for preterm infants with BPD as they may be subjected to a 'double hit' of neurodevelopmental impairment associated with both severe BPD and dexamethasone treatment.[22] Furthermore, there is evidence suggesting the negative impact of dexamethasone on lung development into adulthood.[23] Of concern, despite the increasing PNC use, 43% of extremely preterm infants in 2020 had severe BPD and required ongoing respiratory support at discharge, impacting paediatric intensive care services and ongoing respiratory physician follow-up. The development of POD, a preterm respiratory management and outcome dashboard, could help clinical teams to consider treatment options, care pathway planning and parental discussions, alongside international comparisons across populations.

Neonatal practice

Antenatal corticosteroids are known to reduce preterm mortality.[24] The significant increase in mothers receiving antenatal steroids, especially in infants born below 24 weeks GA, may have contributed to the improvement in neonatal mortality seen and may reflect the change in practice among perinatal healthcare professionals in actively treating infants at increasingly earlier gestations.[25]

Optimal early respiratory care can significantly impact outcomes of very preterm infants, particularly respiratory health. Current preterm respiratory management aims to minimise mechanical ventilation,[7] reserving it for infants where other methods of respiratory support, such as non-invasive ventilation, have failed.[26] However, we found increased use of mechanical ventilation in extremely preterm infants, which may be partly explained by the increase in the proportion of infants born below 24 weeks GA being admitted. Surfactant use remained almost universal in infants born below 25 weeks GA across the study period in keeping with published guidance.[26] However, in infants born above 25 weeks GA, its use appeared to be decreasing, perhaps with a switch to non-invasive ventilation strategies.[26] This observation has some support from our recent report on the increasing use of early caffeine especially in extremely preterm infants during the same period.[27] The increasing popularity of less invasive surfactant administration[28] in more recent years may alter these patterns in the future, making these data useful for comparison.

Postnatal corticosteroids

Dexamethasone is the most used PNC to aid extubation and prevent BPD in preterm infants with its use almost doubling over the study period despite lacking good quality evidence on the safety, optimal timing and dosage.[29] Current UK guidance

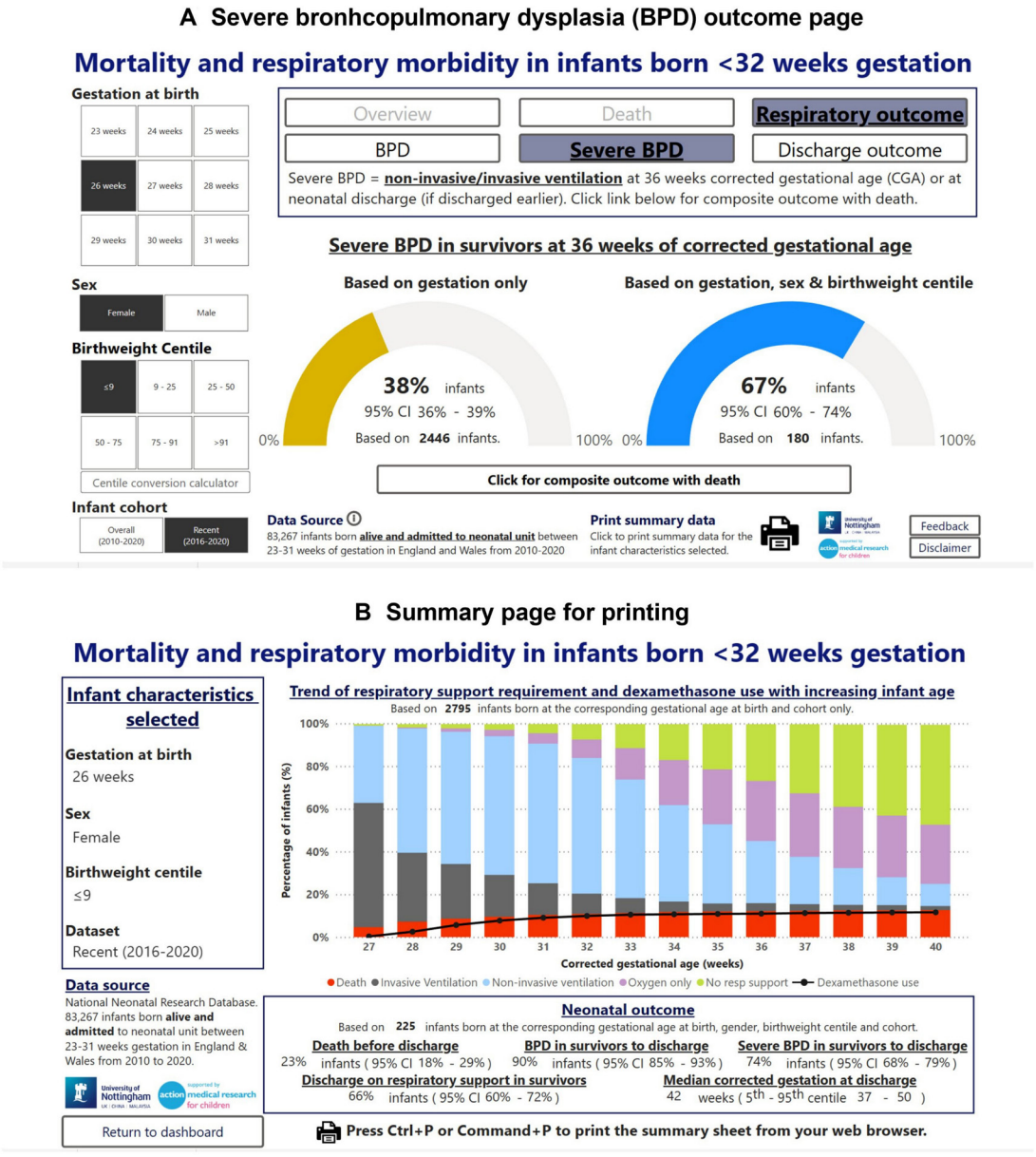


Figure 4 Screenshots depicting the online dashboard displaying the incidence of mortality and respiratory outcomes in premature infants born between 23 and 31 weeks gestation. (A) Demonstrates severe bronchopulmonary dysplasia (BPD) outcome in surviving infants born at 26 weeks gestation, whereby the addition of sex and birthweight centile into the dashboard significantly worsens the outcome from 38% to 67%. (B) Complete respiratory outcome dashboard with data available on a weekly basis until 40 weeks of corrected gestational age (CGA) including those treated with postnatal steroids.

suggests considering giving dexamethasone after 8 days of life,[7] but in this study period, it was commenced at a median age of 28 days, which may reflect clinicians' anxieties about using it and difficulty in identifying which infants to treat. Overall, 29% and 17% of infants who received dexamethasone in 2020 required repeated courses of dexamethasone or another PNC type, respectively. The POD allows clinicians to understand GA-specific ventilation status and treatment with PNC across a whole population and so may provide benchmarking of their own care for infants in their hospitals.

From 2017 onwards, hydrocortisone use doubled and was commenced at an increasingly earlier age. This is likely due to the recent publication of the PREMILOC clinical trial[16] and guidelines[17] on prophylactic hydrocortisone use in extremely preterm infants. Nearly a quarter of infants receiving hydrocortisone in 2020 required another PNC course. Budesonide use has also increased in the latter half of the study period despite lacking evidence supporting its use and possibility of increased mortality.[15 30]

Neonatal outcomes

Overall, around 2000 infants developed BPD annually with a 19% relative increase in rates during the study period. These trends are seen in some, but not all, high-income countries.[31] Similar studies[32] across large populations have not reported such detailed respiratory outcomes, particularly relating to BPD severity, and how these link with key infant characteristics. During the study period, nearly 12 000 very preterm infants (over 30% relative increase) had severe BPD and required respiratory

support at neonatal discharge, both important outcomes for parents.[5]

This rising BPD rates, particularly severe forms, are likely to be multifactorial including the increasing number of extremely premature infants admitted to neonatal units and surviving. In addition, the role of changing respiratory management, such as higher oxygen saturation targets following the BOOST[33] and SUPPORT[34] trials, may have had an effect as these are associated with an increase in BPD rates.

Rates of severe BPD and postdischarge respiratory support will likely continue to increase as many countries, including the UK,[25] consider active management of infants born from 22^{+0} weeks. This could have a significant impact not only on neonatal capacity and healthcare costs, but also on paediatric and adult healthcare services. Infants with BPD, particularly those requiring respiratory pressure support or home oxygen, have increased healthcare use,[4] ongoing community care, respiratory syncytial virus vaccination,[35] more hospital readmissions and longer hospital stays.[3] As early respiratory health is linked to longevity, these infants may also have premature mortality as adults.[36]

Outcome charts and POD online dashboard

Even large tertiary neonatal intensive care units still see relatively small numbers of preterm infants requiring treatment with dexamethasone or postdischarge positive pressure ventilatory support. To better inform on outcomes in this population, we have developed contemporaneous charts and an online dashboard depicting the incidence of mortality and key respiratory outcomes stratified by sex, gestation and birthweight centiles. The variation of the incidence of outcomes based on these key characteristics highlights a need to move away from the 'one-size-fits-all' approach in managing preterm infants based on just their GA at birth. Instead, a holistic approach comparing other key infant characteristics is needed, although this needs to focus on key characteristics so avoiding patient numbers being too small and hence CIs large. These updated mortality and respiratory outcome charts are the largest and most recent to date. Previous outcome charts[37] have not detailed important respiratory outcomes in such a large population. More recent data visualisation tools provide useful mortality data but do not offer individualised detailed incidence of the type of respiratory support requirement, postnatal dexamethasone use or outcome information at weekly intervals during the whole neonatal stay depicted in our online dashboard (figure 4B), something parents and clinicians are keen to understand.[38] The POD dashboard could aid clinicians in tracking the progression of the respiratory outcomes in the infants they care for on a weekly basis with the anticipated outcomes from a national population. The visualisation of the incidence of respiratory outcomes in this manner may help difficult discussions with parents and support the decision-making process on a targeted approach for high-risk treatments such as dexamethasone, especially as good prediction models for BPD are still lacking.[39] The charts also provide clinicians and researchers with more recent data on the incidence of important outcomes when designing research studies, planning care pathways and resource allocation, and considering the needs of these children as they grow and transition into adult services. We anticipate updating the POD data every 2 years with the next update being in mid-2023 once all infants admitted in 2021/2022 are discharged.

Strengths

Our large cohort represents almost all neonatal admissions of infants born below 32 weeks gestation in England and Wales. To the best of our knowledge, our study is one of the largest national cohort studies to investigate the recent trends in the incidence and severity of BPD, respiratory support requirements and mortality. By using nearly 5 million contemporaneous point-of-care electronic daily records, we analysed the respiratory support over a 3-day period at 36 weeks CGA to facilitate an up-to-date assessment of BPD and respiratory support requirements. We have also focused on important outcome measures beyond BPD, which are crucial to healthcare professionals and parents, and align with ongoing respiratory morbidity. The novelty of our study is the data visualisation approach used to demonstrate the variation of the incidence of detailed respiratory outcomes based on key infant characteristics and visualisation of outcomes at weekly intervals.

Limitations

We do not have the true denominator of total live births across whole study period. Hence, this needs to be considered when interpreting these data. This is particularly the case for infants below 24 weeks GA where many may not be admitted for neonatal care and so would not be registered in this database. However, this is unlikely to alter our findings significantly on the trend of neonatal practices and outcomes across the study period as the discrepancy between the number of infants born below 24 weeks GA in our cohort as compared with the number of registered live births[10] remained at around 70% over the study period.

As a retrospective study, we cannot quantify the impact of the evolving clinical practices individually on neonatal outcomes and so causal effects cannot be drawn. Additional changes in practice, such as delayed cord clamping, oxygen saturation targeting or ventilation advances (eg, volume ventilation), cannot be accounted for in this dataset. Although the dose and indication of PNC were not available from the dataset, the definition of PNC was based on the current clinical practice,[12] ensuring that the PNC was intended to prevent BPD. Data are recorded in the database during clinical care so input inaccuracies and missing items could not be controlled for. Caution is required when interpreting some of the heat map cells with small numbers, particularly at the extremes of gestation and birth weight.

Conclusion

Across a national health service, we continue to see improvements in the perinatal care and survival of very preterm infants. However, this is associated with the need for more potentially hazardous treatments, such as PNC, and longer pressure-assisted ventilatory support in high-risk, extremely preterm infants. Importantly, these trends continue with significantly more infants being diagnosed with severe BPD and requiring respiratory support after discharge. These findings have important implications for healthcare professionals and policy-makers as this will require greater resources for neonatal and paediatric respiratory and intensive care services. The burden of medium-term and long-term respiratory morbidity and neurodevelopmental issues will also impact educational and adult healthcare services. There is a need for robust clinical trials in this high-risk population to evaluate the effectiveness of early respiratory care, better targeting and timing of preventative treatments, and post-discharge studies to improve long-term outcomes.

Acknowledgements Electronic patient data recorded at participating neonatal units are transmitted to the Neonatal Data Analysis Unit (NDAU) to form the NNRD (online supplementary table 1). We are grateful to all the families that agreed to include their infant's data in the NNRD, the health professionals who recorded data

and the NDAU team. Professor Don Sharkey had full access to all the data in the study. We are also grateful for the support of Dr Jasper Donelan, Digital Research Specialist from the University of Nottingham for his support in developing the online outcome charts.

Contributors TCK, CP, SA and DS designed the study. TCK carried out the analysis and took the lead in writing the manuscript. TCK, CP, SA, LS and DS contributed to the interpretation of the results, provided critical feedback and helped shape the research, analysis and manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work. DS had full access to all the data in the study and is the guarantor.

Funding TCK received the Action Medical Research training fellowship (Grant application reference GN2941), supported by the Albert Gubay Foundation, as part of this study. DS was supported by a Medical Research Council University of Nottingham Confidence in Concept award (CiC2018045) which help support salary costs for TCK.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval Ethical approval was granted by the Sheffield Research Ethics Committee (REC reference 19/YH/0115).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. All data relevant to the study are included in the article or uploaded as online supplemental information.

ORCID iDs
Tng Chang Kwok http://orcid.org/0000-0003-1841-137X
Lisa Szatkowski http://orcid.org/0000-0003-3295-5891
Don Sharkey http://orcid.org/0000-0002-4989-8697

REFERENCES

1 Russell RB, Green NS, Steiner CA, *et al*. Cost of hospitalization for Preterm and low birth weight infants in the United States. *Pediatrics* 2007;120:e1–9.
2 Doyle LW, Irving L, Haikerwal A, *et al*. Airway obstruction in young adults born extremely Preterm or extremely low birth weight in the Postsurfactant era. *Thorax* 2019;74:1147–53.
3 Mowitz ME, Ayyagari R, Gao W, *et al*. Health care burden of Bronchopulmonary dysplasia among extremely Preterm infants. *Front Pediatr* 2019;7:510.
4 Tan S, Szatkowski L, Moreton W, *et al*. Early childhood respiratory morbidity and antibiotic use in ex-Preterm infants: a primary care population-based cohort study. *Eur Respir J* 2020;56:2000202.
5 Zanardo V, Freato F. Home oxygen therapy in infants with Bronchopulmonary dysplasia: assessment of parental anxiety. *Early Hum Dev* 2001;65:39–46.
6 Short EJ, Klein NK, Lewis BA, *et al*. Cognitive and academic consequences of Bronchopulmonary dysplasia and very low birth weight: 8-year-old outcomes. *Pediatrics* 2003;112:e359.
7 National Institute for Health and Care Excellence. *Specialist neonatal respiratory care for babies born preterm (NG124)*. NICE, 2019.
8 Wood K, Di Stefano LM, Mactier H, *et al*. Individualised decision making: interpretation of risk for extremely Preterm infants—a survey of UK neonatal professionals. *Arch Dis Child Fetal Neonatal Ed* 2022;107:281–8.
9 Gale C, Morris I, Board NDAUNS. The UK national neonatal research database: using neonatal data for research, quality improvement and more. *Arch Dis Child Educ Pract Ed* 2016;101:216–8.
10 Office for National Statistics. N.d Revised gestation-specific infant mortality in England and Wales: 2010 to 2013 (accessed on 25/09/2019) and birth characteristics in England and Wales: 2014 to 2019 (accessed on 25/09/2019 for 2014 - 2017 and 29/09/2021 for 2018 - 2019.
11 Royal College of Paediatrics and Child Health. UK-WHO growth charts - neonatal and infant close monitoring (NICM). 2021. Available: https://www.rcpch.ac.uk/resources/uk-who-growth-charts-neonatal-infant-close-monitoring-nicm
12 Job S, Clarke P. Current UK practices in steroid treatment of chronic lung disease. *Arch Dis Child Fetal Neonatal Ed* 2015;100:F371.
13 Doyle LW, Davis PG, Morley CJ, *et al*. Low-dose dexamethasone facilitates Extubation among chronically ventilator-dependent infants: a multicenter, International, randomized, controlled trial. *Pediatrics* 2006;117:75–83.
14 Hurley M, Khetan R, Bhatt J. Towards a protocol for the management of very severe chronic lung disease. *Thorax* 2015;70:A121.
15 Bassler D, Plavka R, Shinwell ES, *et al*. Early inhaled Budesonide for the prevention of Bronchopulmonary dysplasia. *N Engl J Med* 2015;373:1497–506.
16 Baud O, Maury L, Lebail F, *et al*. Effect of early low-dose hydrocortisone on survival without Bronchopulmonary dysplasia in extremely Preterm infants (PREMILOC): a double-blind, placebo-controlled, Multicentre, randomised trial. *Lancet* 2016;387:1827–36.
17 Lemyre B, Dunn M, Thebaud B. Postnatal corticosteroids to prevent or treat Bronchopulmonary dysplasia in Preterm infants. *Paediatr Child Health* 2020;25:322–31.
18 Jensen EA, Dysart K, Gantz MG, *et al*. The diagnosis of Bronchopulmonary dysplasia in very Preterm infants an evidence-based approach. *Am J Respir Crit Care Med* 2019;200:751–9.
19 National Neonatal Audit Programme (NNAP) Project Board. *National neonatal audit programme annual report 2018 - on 2017 data*. Royal College of Paediatrics and Child Health, 2018.
20 PTREND: STATA Module for trend analysis for proportions [program]: Boston college Department of Economics. 2014.
21 Cuzick J. A Wilcoxon-type test for trend. *Stat Med* 1985;4:87–90.
22 Barrington KJ. The adverse neuro-developmental effects of postnatal steroids in the Preterm infant: a systematic review of Rcts. *BMC Pediatr* 2001;1:1.
23 Harris C, Bisquera A, Zivanovic S, *et al*. Postnatal dexamethasone exposure and lung function in adolescents born very prematurely. *PLoS One* 2020;15:e0237080.
24 McGoldrick E, Stewart F, Parker R, *et al*. Antenatal corticosteroids for accelerating fetal lung maturation for women at risk of Preterm birth. *Cochrane Database Syst Rev* 2020;12:CD004454.
25 British Association of Perinatal Medicine. *Perinatal management of extreme preterm birth before 27 weeks of gestation. A framework for practice*. London: British Association of Perinatal Medicine, 2019.
26 Sweet DG, Carnielli V, Greisen G, *et al*. European consensus guidelines on the management of neonatal respiratory distress syndrome in Preterm Infants-2010 update. *Neonatology* 2010;97:402–17.
27 Szatkowski L, Fateh S, Abramson J, *et al*. Observational cohort study of use of caffeine in Preterm infants and association between early caffeine use and neonatal outcomes. *Arch Dis Child Fetal Neonatal Ed* 2023:fetalneonatal-2022-324919.
28 Aldana-Aguirre JC, Pinto M, Featherstone RM, *et al*. Less invasive surfactant administration versus intubation for surfactant delivery in Preterm infants with respiratory distress syndrome: a systematic review and meta-analysis. *Arch Dis Child Fetal Neonatal Ed* 2017;102:F17–23.
29 Onland W, van de Loo M, Offringa M, *et al*. Systemic corticosteroid regimens for prevention of Bronchopulmonary dysplasia in Preterm infants. *Cochrane Database Syst Rev* 2023;3:CD010941.
30 Onland W, Offringa M, van Kaam A. Late (>= 7 days) inhalation corticosteroids to reduce Bronchopulmonary dysplasia in Preterm infants. *Cochrane Database Syst Rev* 2012;2017:CD002311.
31 Lui K, Lee SK, Kusuda S, *et al*. Trends in outcomes for neonates born very Preterm and very low birth weight in 11 high-income countries. *J Pediatr* 2019;215:32–40.
32 Yao S, Uthaya S, Gale C, *et al*. Postnatal corticosteroid use for prevention or treatment of Bronchopulmonary dysplasia in England and Wales 2012-2019: a retrospective population cohort study. *BMJ Open* 2022;12:e063835.
33 Stenson B, Brocklehurst P, Tarnow-Mordi W, *et al*. Increased 36-week survival with high oxygen saturation target in extremely Preterm infants. *N Engl J Med* 2011;364:1680–2.
34 SUPPORT Study Group of the Eunice Kennedy Shriver NICHD Neonatal Research Network, Carlo WA, Finer NN, *et al*. Target ranges of oxygen saturation in extremely Preterm infants. *N Engl J Med* 2010;362:1959–69.
35 Resch B, Kurath-Koller S, Eibisberger M, *et al*. Prematurity and the burden of influenza and respiratory syncytial virus disease. *World J Pediatr* 2016;12:8–18.
36 Bolton CE, Bush A, Hurst JR, *et al*. Lung consequences in adults born prematurely. *Postgrad Med J* 2015;91:712–8.
37 Manktelow BN, Seaton SE, Field DJ, *et al*. Population-based estimates of in-unit survival for very Preterm infants. *Pediatrics* 2013;131:e425–32.
38 Lammons WB, Moss B, Bignell C, *et al*. Involving multiple Stakeholders in assessing and reviewing a novel data Visualisation tool for a national neonatal data asset. *BMJ Health Care Inform* 2023;30:e100694.
39 Kwok TC, Batey N, Luu KL, *et al*. Bronchopulmonary dysplasia prediction models: a systematic review and meta-analysis with validation. *Pediatr Res* 2023;94:43–54.
40 National Institute for Health and Care Excellence. *Preterm labour and birth (NG25)*. NICE, 2022.

SUPPLEMENTARY DATA

Supplementary Table 1 Participating neonatal units in England and Wales that form the United Kingdom Neonatal Collaborative and their respective lead clinicians. The list was accessed from https://www.imperial.ac.uk/neonatal-data-analysis-unit/neonatal-data-analysis-unit/list-of-national-neonatal-units/ on 06/01/2022.

Institution	Lead clinician
Airedale General Hospital	Dr Matthew Babirecki
Arrowe Park Hospital	Dr Anand Kamalanathan
Barnet Hospital	Dr Tim Wickham
Barnsley District General Hospital	Dr Kavi Aucharaz
Basildon Hospital	Dr Aashish Gupta
Basingstoke & North Hampshire Hospital	Dr Nicola Paul
Bassetlaw District General Hospital	Dr L M Wong
Bedford Hospital	Dr Anita Mittal
Birmingham City Hospital	Dr Lindsay Halpern
Birmingham Heartlands Hospital	Dr Pinki Surana
Birmingham Women's Hospital	Dr Matt Nash
Bradford Royal Infirmary	Dr Sam Wallis
Broomfield Hospital, Chelmsford	Dr Ahmed Hassan
Calderdale Royal Hospital	Dr Karin Schwarz
Chelsea & Westminster Hospital	Dr Shu-Ling Chuang
Chesterfield & North Derbyshire Royal Hospital	Dr Aiwyne Foo
Colchester General Hospital	Dr Jo Anderson
Conquest Hospital	Dr Graham Whincup
Countess of Chester Hospital	Dr Stephen Brearey
Croydon University Hospital	Dr Morris
Croydon University Hospital	Dr Srirambhatla
Cumberland Infirmary	Dr Yee Aung
Darent Valley Hospital	Dr Abdul Hasib
Darlington Memorial Hospital	Dr Mehdi Garbash
Derriford Hospital	Dr Alex Allwood
Diana Princess of Wales Hospital	Dr Pauline Adiotomre
Doncaster Royal Infirmary	Dr Nigel Brooke
Dorset County Hospital	Dr Abby Deketelaere
East Surrey Hospital	Dr Abdul Khader
Epsom General Hospital	Dr Sonia Spathis
Frimley Park Hospital	Dr Sanghavi Rekha
Furness General Hospital	Dr Anas Olabi
George Eliot Hospital	Dr Mukta Jain
Glan Clwyd Hospital	Dr Ian Barnard
Glangwili General Hospital	Dr Prem Pitchaikani
Gloucester Royal Hospital	Dr Jennifer Holman
Good Hope Hospital	Dr Pinki Surana
Great Western Hospital	Dr Stanley Zengeya

Guy's & St Thomas' Hospital	Dr Geraint Lee
Harrogate District Hospital	Dr Sobia Balal
Hereford County Hospital	Dr Cath Seagrave
Hillingdon Hospital	Dr Tristan Bate
Hinchingbrooke Hospital	Dr Hilary Dixon
Homerton Hospital	Dr Narendra Aladangady
Hull Royal infirmary	Dr Hassan Gaili
Ipswich Hospital	Dr Matthew James
James Cook University Hospital	Dr M Lal
James Paget Hospital	Dr Ambadkar
Kettering General Hospital	Dr Poornima Pandey
Kings College Hospital	Dr Ravindra Bhat
King's Mill Hospital	Dr Simon Rhodes
Kingston Hospital	Dr Jonathan Filkin
Lancashire Women and Newborn Centre	Dr Savi Sivashankar
Leeds Neonatal Service	Dr Lawrence Miall
Leicester General Hospital	Dr Jonathan Cusack
Leicester Royal Infirmary	Dr Venkatesh Kairamkonda
Leighton Hospital	Dr Michael Grosdenier
Lincoln County Hospital	Dr Ajay Reddy
Lister Hospital	Dr J Kefas
Liverpool Women's Hospital	Dr Christopher Dewhurst
Luton & Dunstable Hospital	Dr Jennifer Birch
Macclesfield District General Hospital	Dr Gail Whitehead
Manor Hospital	Dr Ashok Karupaiah
Medway Maritime Hospital	Dr Ghada Ramadan
Milton Keynes General Hospital	Dr I Misra
Musgrove Park Hospital	Dr Chris Knight
New Cross Hospital	Dr Matt Nash
Newham General Hospital	Dr Imdad Ali
Nobles Hospital	Dr Prakash Thiagarajan
Norfolk & Norwich University Hospital	Dr Muthukumar
North Devon District Hospital	Dr Michael Selter
North Manchester General Hospital	Dr Ajit Mahaveer
North Middlesex University Hospital	Dr Neeraj Jain
Northampton General Hospital	Dr Subodh Gupta
Northumbria Specialist Emergency Care Hospital	Jess Reynolds
Northwick Park Hospital	Dr Richard Nicholl
Nottingham City Hospital	Dr Steven Wardle
Nottingham University Hospital (QMC)	Dr Steven Wardle
Ormskirk District General Hospital	Dr Andreea Bontea
Oxford University Hospitals, John Radcliffe Hospital	Dr Eleri Adams
Peterborough City Hospital	Dr Katharine McDevitt
Pilgrim Hospital	Dr Ajay Reddy
Pinderfields General Hospital (Pontefract General Infirmary)	Dr David Gibson

Poole General Hospital	Prof Minesh Khashu
Prince Charles Hospital	Dr Iyad Al-Muzaffar
Princess Alexandra Hospital	Dr Chinnappa Reddy
Princess Anne Hospital	Dr Mark Johnson
Princess of Wales Hospital	Dr Kate Creese
Princess Royal Hospital	Dr P Amess
Princess Royal Hospital (previously Royal Shrewsbury Hospital)	Dr Deshpande
Princess Royal University Hospital	Dr Elizabeth Sleight
Queen Alexandra Hospital	Dr Charlotte Groves
Queen Charlotte's Hospital	Dr Lidia Tyszcuzk
Queen Elizabeth Hospital, Gateshead	Dr Anne Dale
Queen Elizabeth Hospital, King's Lynn	Dr Glynis Rewitzky
Queen Elizabeth Hospital, Woolwich - see notes	Dr Olutoyin Banjoko
Queen Elizabeth the Queen Mother Hospital	Dr Bushra Abdul-Malik
Queen's Hospital, Burton on Trent	Dr Dominic Muogbo
Queen's Hospital, Romford	Dr Khalid Mannan
Queen's Hospital, Romford 2	Dr Khalid Mannan
Rosie Maternity Hospital, Addenbrookes	Dr Angela D'Amore
Rotherham District General Hospital	Dr Soma Sengupta
Royal Albert Edward Infirmary	Dr Christos Zipitis
Royal Berkshire Hospital	Dr Peter De Halpert
Royal Bolton Hospital	Dr Paul Settle
Royal Cornwall Hospital	Dr Paul Munyard
Royal Derby Hospital	Dr John McIntyre
Royal Devon & Exeter Hospital	Dr Chrissie Oliver
Royal Gwent Hospital	Dr Sunil Reddy
Royal Hampshire County Hospital	Dr Lucinda Winckworth
Royal Lancaster Infirmary	Dr Joanne Fedee
Royal Oldham Hospital	Dr Natasha Maddock
Royal Preston Hospital	Dr Richa Gupta
Royal Stoke University Hospital	Dr Jyoti Kapur
Royal Surrey County Hospital	Dr Ben Obi
Royal Sussex County Hospital	Dr P Amess
Royal United Hospital	Dr Stephen Jones
Royal Victoria Infirmary	Dr Naveen Athiraman
Russells Hall Hospital	Dr Chandan Gupta
Salisbury District Hospital	Dr Jim Baird
Scarborough General Hospital	Dr Kirsten Mack
Scunthorpe General Hospital	Dr Pauline Adiotomre
Singleton Hospital	Dr Arun Ramachandran
Southend Hospital	Dr Vineet Gupta
Southmead Hospital	Dr Faith Emery
St George's Hospital	Dr Charlotte Huddy
St Helier Hospital	Dr Ralf Hartung
St Mary's Hospital, IOW	Dr Akinsola Ogundiya

St Mary's Hospital, London	Dr Lidia Tyszcuzk
St Mary's Hospital, Manchester	Dr Ngozi Edi-Osagie
St Michael's Hospital	Dr Pamela Cairns
St Peter's Hospital	Dr Peter Martin
St Richard's Hospital	Dr Victoria Sharp
Stepping Hill Hospital	Dr Carrie Heal
Stoke Mandeville Hospital	Dr Sanjay Salgia
Sunderland Royal Hospital	Dr Majd Abu-Harb
Tameside General Hospital	Dr Jacqeline Birch
The Grange University Hospital	Dr Sunil Reddy
The Jessop Wing, Sheffield	Dr Porus Bastani
The Royal Free Hospital	Dr Marice Theron
The Royal London Hospital - Constance Green	Dr Vadivelam Murthy
Torbay Hospital	Dr Siba Paul
Tunbridge Wells Hospital	Dr Hamudi Kisat
University College Hospital	Dr Giles Kendall
University Hospital Coventry	Dr Puneet Nath
University Hospital Lewisham	Dr Ozioma Obi
University Hospital of North Durham	Dr Mehdi Garbash
University Hospital of North Tees	Dr Hari Kumar
University Hospital of Wales	Dr Nitin Goel
Victoria Hospital, Blackpool	Dr Chris Rawlingson
Warrington Hospital	Dr Delyth Webb
Warwick Hospital	Dr Bird
Watford General Hospital	Dr Sankara Narayanan
West Cumberland Hospital	Dr Yee Aung
West Middlesex University Hospital	Dr Eleanor Hulse
West Suffolk Hospital	Dr Ian Evans
Wexham Park Hospital	Dr Sanjay Jaisal
Whipps Cross University Hospital	Dr Caroline Sullivan
Whiston Hospital	Dr Ros Garr
Whittington Hospital	Dr Wynne Leith
William Harvey Hospital	Dr Vimal Vasu
Withybush Hospital	Dr Vishwa Narayan
Worcestershire Royal Hospital	Dr Liza Harry
Worthing Hospital	Dr Katia Vamvakiti
Wrexham Maelor Hospital	Dr Brendan Harrington
Wythenshawe Hospital	Dr Ngozi Edi-Osagie
Yeovil District Hospital	Dr Megan Eaton
York District Hospital	Dr Sundeep Sandhu
Ysbyty Gwynedd	Dr Mike Cronin

Supplementary Table 2 Definition of the variables and the associated data items extracted from the National Neonatal Research Database.

Demographics	
Variable	**Data Items**
Gestational age	• Data extracted from "GESTATIONDAYS" and "GESTATIONWEEKS" variables in the "EPISODES" dataset. • Continuous in days
Birthweight z score	**Definition**: Birthweight z score derived from the UK-WHO growth chart[1]. • Data extracted from "BIRTHWEIGHT", "GESTATIONDAYS", "GESTATIONWEEKS" and "GENDER" variables in the "EPISODES" dataset. • Continuous
Sex	• Data extracted from "GENDER" variable in the "EPISODES" dataset. • Dichotomous (Male/Female)
Birth year	• Data extracted from BIRTHYEAR" variable in the "EPISODES" dataset. • Continuous
Clinical Practice	
Variable	**Data Items**
Maternal antenatal corticosteroids	**Definition**: Any maternal antenatal corticosteroids received before delivery • Data extracted from "STEROIDSANTENATALCOURSES" variable in the "EPISODES" dataset. • Dichotomous (Yes/No)
Surfactant treatment	**Definition**: Surfactant treatment received at resuscitation or after admission to the neonatal unit. • Data extracted from "SURFACTANTGIVENRESUSCITATION" variable in the "EPISODES" dataset and "DAYSURFACTANTGIVEN" and "DRUGSDAY" variables in the "DAILY" dataset. • Dichotomous (Yes/No)
Postnatal corticosteroids (PNC)	**Definition**: Definitions for the PNC below are based on current practices[2] to ensure that they are intended to treat or prevent BPD. A new PNC course is defined as no previous PNC used in the previous 7 consecutive days. • Data extracted from "DRUGSDAY" variable in the "DAILY" dataset. • Dichotomous (Yes/No)
Dexamethasone	**Definition**: Dexamethasone treatment for at least three consecutive days excluding dexamethasone eye drops.
Hydrocortisone	**Definition**: Hydrocortisone treatment for at least seven consecutive days.
Methylprednisolone	**Definition**: Methylprednisolone treatment for at least three consecutive days.
Budesonide	**Definition**: Budesonide treatment for at least three consecutive days.
Days of invasive ventilation	**Definition**: Duration of invasive ventilation in days in survivors to discharge. • Data extracted from "RESPIRATORYSUPPORT", "ADDEDO2", "VENTILATIONMODE" and "NONINVASIVERESPIRATORYSUPPORT" variables from the "DAILY" dataset. • Continuous in days

Days of non-invasive ventilation	**Definition**: Duration of non-invasive ventilation in days in survivors to discharge. • Data extracted from "RESPIRATORYSUPPORT", "ADDEDO2", "VENTILATIONMODE" and "NONINVASIVERESPIRATORYSUPPORT" variables from the "DAILY" dataset. • Continuous in days
Age of first extubation if ventilated in the first 48 hours	**Definition**: Chronological age to first successful extubation for at least 48 hours in infants who are invasively ventilated in the first 48 hours of age. • Data extracted from "RESPIRATORYSUPPORT", "ADDEDO2", "VENTILATIONMODE" and "NONINVASIVERESPIRATORYSUPPORT" variables from the "DAILY" dataset. • Continuous in days
Outcome	
Variable	**Data Items**
Death	**Definition**: Death before discharge from the neonatal unit. • Data extracted from "DATEOFDEATH" and "DISCHARGEDESTINATION" variables from the "EPISODES" dataset. • Dichotomous (Yes/No)
Bronchopulmonary dysplasia (BPD)	• **Definition**: Respiratory support or oxygen requirement over a three-day period at 36 weeks of corrected gestational age (CGA) or at discharge (if discharged before 36 weeks CGA[3 4]). Infants who died before 36 weeks of CGA were excluded from the denominator. • Data extracted from "RESPIRATORYSUPPORT", "ADDEDO2", "VENTILATIONMODE" and "NONINVASIVERESPIRATORYSUPPORT" variables from the "DAILY" dataset over a three-day period at 36 weeks CGA or at discharge. • Dichotomous (Yes/No)
Severe BPD	**Definition**: Non-invasive (including high flow) and invasive ventilation requirement at 36 weeks CGA or at discharge (if discharged before 36 weeks CGA[3 4]). Infants who died before 36 weeks of CGA were excluded from the denominator. • Data extracted from "RESPIRATORYSUPPORT", "ADDEDO2", "VENTILATIONMODE" and "NONINVASIVERESPIRATORYSUPPORT" variables from the "DAILY" dataset over a three-day period at 36 weeks CGA or at discharge. • Dichotomous (Yes/No)
Respiratory support at discharge	**Definition**: Respiratory support or oxygen requirement at discharge in survivors to discharge. • Data extracted from "RESPIRATORYSUPPORT", "ADDEDO2", "VENTILATIONMODE" and "NONINVASIVERESPIRATORYSUPPORT" variables from the "DAILY" dataset at discharge. • Dichotomous (Yes/No)
Length of hospital stay	**Definition**: Duration of hospital stay in days in survivors to discharge. • Data extracted from "DISCHTIMEANON" variables from the "EPISODES" dataset. • Continuous in days

Corrected gestational age at discharge	**Definition**: Corrected gestational age at discharge in survivors to discharge. • Data extracted from "GESTATIONDAYS", "GESTATIONWEEKS" and "DISCHTIMEANON" variables in the "EPISODES" dataset. • Continuous in days

References

1. Royal College of Paediatrics and Child Health. UK-WHO growth charts - neonatal and infant close monitoring (NICM). https://www.rcpch.ac.uk/resources/uk-who-growth-charts-neonatal-infant-close-monitoring-nicm. Date last accessed: March 01 2021.
2. Job S, Clarke P. Current UK practices in steroid treatment of chronic lung disease. *Arch Dis Child Fetal Neonatal Ed* 2015;100(4):F371. doi: 10.1136/archdischild-2014-308060 [published Online First: 2015/03/11]
3. Jensen EA, Dysart K, Gantz MG, et al. The Diagnosis of Bronchopulmonary Dysplasia in Very Preterm Infants An Evidence-based Approach. *American Journal of Respiratory and Critical Care Medicine* 2019;200(6):751-59. doi: 10.1164/rccm.201812-2348OC
4. National Neonatal Audit Programme (NNAP) Project Board. National Neonatal Audit Programme Annual Report 2018 - on 2017 data. Royal College of Paediatrics and Child Health, September 2018.

Supplementary Table 3 Percentage of 83,463 preterm infants born below 32 weeks of gestation, 26,098 extremely preterm infants born below 28 weeks of gestation and 57,365 very preterm infants born between 28 – 31 weeks of gestation in the respective years who received the following neonatal care and had the following outcomes.
[1] Data presented as n/total n (%) unless otherwise stated. [2]Data presented as median (interquartile range).

OVERALL COHORT OF INFANTS <32 WEEKS GESTATION (n = 83,463)												
Characteristics	**Birth Year**											**p value for trend**
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
Neonatal Practices[1]												
Antenatal corticosteroids	6,403/7,285 (88)	6,804/7,691 (88)	6,902/7,793 (89)	6,964/7,759 (90)	6,870/7,629 (90)	7,153/7,879 (91)	7,174/7,929 (90)	7,143/7,825 (91)	6,715/7,332 (92)	6,732/7,283 (92)	5,931/6,375 (93)	p<0.0001
Surfactant	4,792/7,332 (65)	5,048/7,641 (66)	5,149/7,682 (67)	5,047/7,538 (67)	4,720/7,193 (66)	4,677/7,329 (64)	4,696/7,448 (63)	4,497/7,290 (62)	4,160/6,727 (62)	4,037/6,691 (60)	3,506/5,814 (60)	p<0.0001
Ventilated in the first 48 hours	4,409/7,510 (59)	4,668/7,833 (60)	4,881/7,882 (62)	4,980/7,804 (64)	4,771/7,658 (62)	4,912/7,914 (62)	4,987/7,973 (63)	4,815/7,863 (61)	4,434/7,343 (60)	4,200/7,296 (58)	3,587/6,387 (56)	p<0.0001
Age of first extubation if ventilated in the first 48 hours (day)[2]	3 (1–7)	3(1–7)	3 (1–7)	3 (1–7)	3 (1–7)	3 (1–7)	3 (2–7)	3 (2–8)	3 (2–7)	3 (2–8)	3 (2–8)	p<0.0001
Length of mechanical ventilation (day)[2]	1 (0–5)	1 (0–5)	2 (0–6)	2 (0–6)	2 (0–5)	2 (0–5)	2 (0–5)	1 (0–5)	1 (0–5)	1 (0–5)	1 (0–5)	p=0.1
Postnatal corticosteroids	402/7,510 (5)	452/7,833 (6)	471/7,882 (6)	503/7,804 (6)	504/7,658 (7)	543/7,914 (7)	590/7,973 (7)	639/7,863 (8)	729/7,343 (10)	756/7,296 (10)	718/6,387 (11)	p<0.0001
Dexamethasone	287/7,510 (4)	339/7,833 (4)	376/7,882 (5)	391/7,804 (5)	382/7,658 (5)	407/7,914 (5)	427/7,973 (5)	453/7,863 (6)	486/7,343 (7)	503/7,296 (7)	397/6,387 (6)	p<0.0001
Hydrocortisone	104/7,510 (1)	133/7,833 (2)	98/7,882 (1)	105/7,804 (1)	100/7,658 (1)	106/7,914 (1)	129/7,973 (2)	178/7,863 (2)	201/7,343 (3)	201/7,296 (3)	274/6,387 (4)	p<0.0001
Methylprednisolone	0/7,510 (0)	0/7,833 (0)	0/7,882 (0)	2/7,804 (0.03)	7/7,658 (0.09)	5/7,914 (0.06)	4/7,973 (0.05)	7/7,863 (0.09)	2/7,343 (0.03)	5/7,296 (0.07)	8/6,387 (0.1)	p=0.0001
Budesonide	47/7,510 (0.6)	45/7,833 (0.6)	42/7,882 (0.5)	53/7,804 (0.7)	89/7,658 (1)	92/7,914 (1)	117/7,973 (1)	136/7,863 (2)	177/7,343 (2)	197/7,296 (3)	189/6,387 (3)	p<0.0001
Neonatal Outcomes[1]												
Mortality	755/7,510 (10)	821/7,833 (10)	794/7,882 (10)	718/7,804 (9)	667/7,658 (9)	668/7,914 (8)	655/7,973 (8)	648/7,863 (8)	607/7,343 (8)	615/7,296 (8)	544/6,387 (9)	p<0.0001

Bronchopulmonary dysplasia	1,888/6,721 (28)	2,063/7,014 (29)	2,179/7,097 (31)	2,195/7,088 (31)	2,259/7,012 (32)	2,290/7,256 (32)	2,312/7,331 (32)	2,337/7,248 (32)	2,239/6,764 (33)	2,267/6,720 (34)	1,962/5,870 (33)	p<0.0001
Severe bronchopulmonary dysplasia	838/6,721 (12)	921/7,014 (13)	1,035/7,097 (15)	1,058/7,088 (15)	1,115/7,012 (16)	1,192/7,256 (16)	1,169/7,331 (16)	1,193/7,248 (16)	1,172/6,764 (17)	1,244/6,720 (19)	1,005/5,870 (17)	p<0.0001
Discharge on respiratory support	868/6,621 (13)	993/6,911 (14)	1,103/7,014 (16)	1,077/7,008 (15)	1,097/6,936 (16)	1,113/7,186 (15)	1,120/7,254 (15)	1,140/7,180 (16)	1,023/6,707 (15)	1,148/6,640 (17)	1,002/5,789 (17)	p<0.0001
Respiratory pressure support at discharge	174/6,621 (3)	159/6,911 (2)	156/7,014 (2)	151/7,008 (2)	174/6,936 (3)	178/7,186 (2)	166/7,254 (2)	163/7,180 (2)	195/6,707 (3)	183/6,640 (3)	144/5,789 (2)	p=0.1
Composite outcome												
Death and/or bronchopulmonary dysplasia	2,579/7,410 (35)	2,830/7,778 (36)	2,919/7,836 (37)	2,870/7,759 (37)	2,871/7,620 (38)	2,912/7,875 (37)	2,927/7,942 (37)	2,938/7,846 (37)	2,805/7,327 (38)	2,832/7,283 (39)	2,466/6,373 (39)	p<0.0001
Death and/or severe bronchopulmonary dysplasia	1,532/7,410 (21)	1,692/7,778 (22)	1,777 /7,836 (23)	1,739/7,759 (22)	1,732/7,620 (23)	1,818/7,875 (23)	1,788 /7,942 (23)	1,799/7,846 (23)	1,738/7,327 (24)	1,811/7,283 (25)	1,510/6,373 (24)	p<0.0001
Death or discharge on respiratory support	1,623/7,376 (22)	1,814/7,732 (23)	1,897/7,808 (24)	1,795/7,726 (23)	1,764/7,603 (23)	1,781/7,854 (23)	1,775/7,909 (22)	1,788/7,828 (23)	1,630/7,314 (22)	1,763/7,255 (24)	1,546/6,333 (24)	p=0.2
Death or respiratory pressure support at discharge	929/7,376 (13)	980/7,732 (13)	950/7,808 (12)	869/7,726 (11)	841/7,603 (11)	846/7,854 (11)	821/7,909 (10)	811/7,828 (10)	802/7,314 (11)	798/7,255 (11)	688/6,333 (11)	p<0.0001

INFANTS <28 WEEKS GESTATION (A) (n = 26,098)

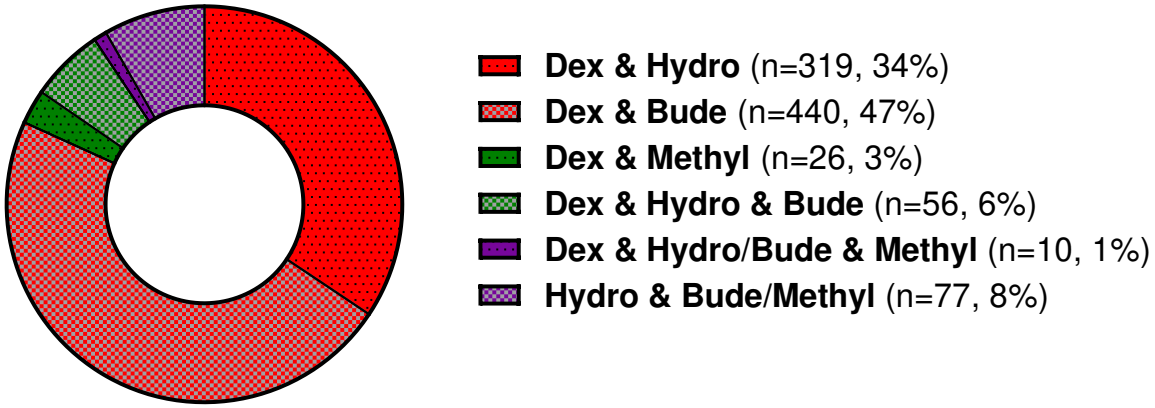
Characteristics	**Birth Year**											**p value for trend**
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
Neonatal Practices[1]												
Antenatal corticosteroids	1,950/2,260 (86)	2,164/2,478 (87)	2,171/2,506 (87)	2,129/2,414 (88)	2,123/2,361 (90)	2,181/2,433 (90)	2,227/2,487 (90)	2,161/2,395 (90)	2,104/2,326 (90)	2,108/2,305 (91)	1,794/1,941 (92)	p<0.0001
Surfactant	2,192/2,254 (97)	2,375/2,438 (97)	2,386/2,473 (96)	2,278/2,352 (97)	2,193/2,276 (96)	2,205/2,331 (95)	2,269/2,419 (94)	2,126/2,312 (92)	2,012/2,228 (90)	1,977/2,195 (90)	1,664/1,859 (90)	p<0.0001
Ventilated in the first 48 hours	2,102/2,317 (91)	2,296/2,516 (91)	2,342/2,536 (92)	2,278/2,429 (94)	2,207/2,372 (93)	2,262/2,443 (93)	2,319/2,497 (93)	2,210/2,404 (92)	2,099/2,333 (90)	2,063/2,307 (89)	1,704/1,944 (88)	p<0.0001
Age of first extubation if ventilated in the first 48 hours (day)[2]	4 (2–15)	5 (2–15)	5 (2–16)	5 (2–17)	5 (2–16)	5.5 (2–19)	6 (2–18)	6 (2–19)	6 (2–18)	6 (2–19)	6 (2–20)	p<0.0001

Length of mechanical ventilation (day)[2]	9 (3–24)	10 (3–26)	11 (4–25)	12 (4–28)	10 (4–26)	11 (3–29)	10 (3–27)	11 (3–28)	10 (3–27)	11 (3–30)	12 (3–30)	p=0.001
Postnatal corticosteroids	328/2,317 (14)	372/2,516 (15)	399/2,536 (16)	429/2,429 (18)	431/2,372 (18)	469/2,443 (19)	495/2,497 (20)	542/2,404 (23)	612/2,333 (26)	646/2,307 (28)	608/1,944 (31)	p<0.0001
Dexamethasone	251/2,317 (11)	284/2,516 (11)	334/2,536 (13)	345/2,429 (14)	331/2,372 (14)	366/2,443 (15)	365/2,497 (15)	399/2,404 (17)	420/2,333 (18)	447/2,307 (19)	357/1,944 (18)	p<0.0001
Hydrocortisone	74/2,317 (3)	105/2,516 (4)	75/2,536 (3)	79/2,429 (3)	84/2,372 (4)	82/2,443 (3)	104/2,497 (4)	142/2,404 (6)	164/2,333 (7)	169/2,307 (7)	227/1,944 (12)	p<0.0001
Methylprednisolone	0/2,317 (0)	0/2,516 (0)	0/2,536 (0)	2/2,429 (0.08)	3/2,372 (0.1)	5/2,443 (0.2)	2/2,497 (0.08)	6/2,404 (0.3)	2/2,333 (0.09)	3/2,307 (0.1)	8/1,944 (0.4)	p=0.0001
Budesonide	33/2,317 (1)	39/2,516 (2)	30/2,536 (1)	46/2,429 (2)	76/2,372 (3)	78/2,443 (3)	94/2,497 (4)	113/2,404 (5)	147/2,333 (6)	167/2,307 (7)	156/1,944 (8)	p<0.0001
Neonatal Outcomes[1]												
Mortality	572/2,317 (25)	633/2,516 (25)	598/2,536 (24)	535/2,429 (22)	512/2,372 (22)	501/2,443 (21)	499/2,497 (20)	486/2,404 (20)	476/2,333 (20)	476/2,307 (21)	420/1,944 (22)	p<0.0001
Bronchopulmonary dysplasia	1,130/1,768 (64)	1,227/1,906 (64)	1,347/1,963 (69)	1,338/1,914 (70)	1,336/1,890 (71)	1,362/1,969 (69)	1,380/2,021 (68)	1,378/1,945 (71)	1,319/1,881 (70)	1,364/1,854 (74)	1,132/1,549 (73)	p<0.0001
Severe bronchopulmonary dysplasia	563/1,768 (32)	619/1,906 (32)	703/1,963 (36)	714/1,914 (37)	757/1,890 (40)	824/1,969 (42)	769/2,021 (38)	718/1,777 (42)	761/1,881 (40)	831/1,854 (45)	666/1,549 (43)	p<0.0001
Discharge on respiratory support	541/1,711 (32)	648/1,861 (35)	725/1,921 (38)	695/1,877 (37)	696/1,846 (38)	727/1,925 (38)	711/1,977 (36)	715/1,905 (38)	658/1,850 (36)	734/1,816 (40)	648/1,508 (43)	p<0.0001
Respiratory pressure support at discharge	102/1,711 (6)	89/1,861 (5)	90/1,921 (5)	94/1,877 (5)	116/1,846 (6)	114/1,925 (6)	105/1,977 (5)	92/1,905 (5)	118/1,850 (6)	111/1,816 (6)	97/1,508 (6)	p=0.05
Composite outcome												
Death and/or bronchopulmonary dysplasia	1,660/2,297 (72)	1,825/2,502 (73)	1,909/2,525 (76)	1,843/2,418 (76)	1,812/2,363 (77)	1,829/2,435 (75)	1,853/2,490 (74)	1,833/2,399 (76)	1,769/2,330 (76)	1,810/2,299 (79)	1,527/1,944 (79)	p<0.0001
Death and/or severe bronchopulmonary dysplasia	1,094/2,297 (48)	1,218/2,502 (49)	1,266/2,525 (50)	1,224/2,418 (51)	1,235/2,363 (52)	1,293/2,435 (53)	1,244/2,490 (50)	1,275/2,399 (53)	1,211/2,330 (52)	1,278/2,299 (56)	1,062/1,944 (55)	p<0.0001
Death or discharge on respiratory support	1,113/2,283 (49)	1,281/2,494 (51)	1,323/2,519 (53)	1,230/2,412 (51)	1,208/2,358 (51)	1,228/2,426 (51)	1,210/2,476 (49)	1,201/2,391 (50)	1,134/2,326 (49)	1,210/2,292 (53)	1,068/1,928 (55)	p=0.08

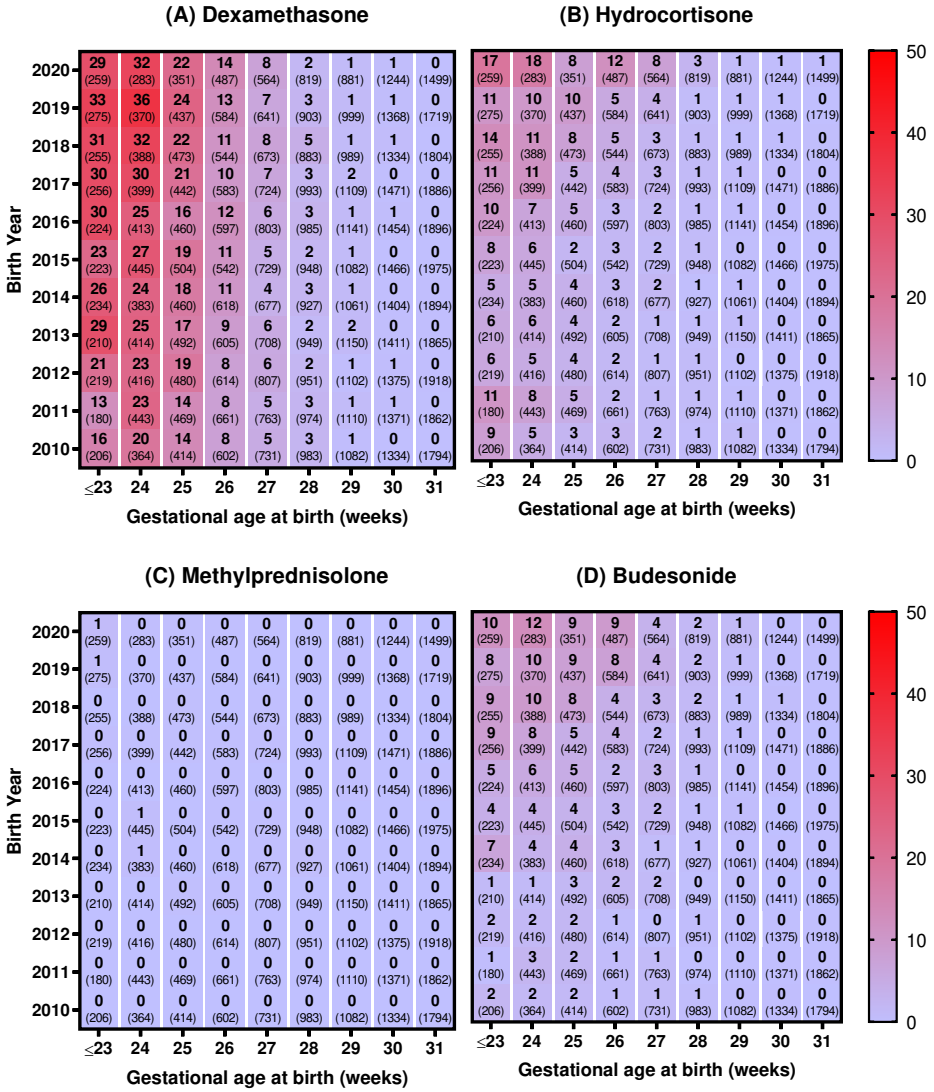
Death or respiratory pressure support at discharge	674/2,283 (30)	722/2,494 (29)	688/2,519 (27)	629/2,412 (26)	628/2,358 (27)	615/2,426 (25)	604/2,476 (24)	578/2,391 (24)	594/2,326 (26)	587/2,292 (26)	517/1,928 (27)	p<0.0001
INFANTS 28 – 31 WEEKS GESTATION (B) (n = 57,365)												
Characteristics	**Birth Year**											**p value for trend**
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
Neonatal Practices[1]												
Antenatal corticosteroids	4,453/5,025 (89)	4,640/5,213 (89)	4,731/5,287 (89)	4,835/5,345 (90)	4,747/5,268 (90)	4,972/5,446 (91)	4,947/5,442 (91)	4,982/5,430 (92)	4,611/4,996 (92)	4,624/4,978 (93)	4,137/4,434 (93)	p<0.0001
Surfactant	2,600/5,078 (51)	2,673/5,203 (51)	2,763/5,209 (53)	2,769/5,186 (53)	2,527/4,917 (51)	2,472/4,998 (49)	2,427/5,029 (48)	2,371/4,978 (48)	2,148/4,499 (48)	2,060/4,496 (46)	1,842/3,955 (47)	p<0.0001
Ventilated in the first 48 hours	2,307/5,193 (44)	2,372/5,317 (45)	2,539/5,346 (47)	2,702/5,375 (50)	2,564/5,286 (49)	2,650/5,471 (48)	2,668/5,476 (49)	2,605/5,459 (48)	2,335/5,010 (47)	2,137/4,989 (43)	1,883/4,443 (42)	p=0.003
Age of first extubation if ventilated in the first 48 hours (day)[2]	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–3)	2 (1–4)	2 (1–4)	2 (1–4)	2 (1–4)	p=0.008
Length of mechanical ventilation (day)[2]	0 (0–2)	1 (0–2)	1 (0–2)	1 (0–2)	1 (0–2)	1 (0–2)	1 (0–2)	1 (0–2)	1 (0–2)	0 (0–2)	0 (0–2)	p=0.001
Postnatal corticosteroids	74/5,193 (1)	80/5,317 (2)	72/5,346 (1)	74/5,375 (1)	73/5,286 (1)	74/5,471 (1)	95/5,476 (2)	97/5,459 (2)	117/5,010 (2)	110/4,989 (2)	110/4,443 (2)	p<0.0001
Dexamethasone	36/5,193 (0.7)	55/5,317 (1)	42/5,346 (0.8)	46/5,375 (0.9)	51/5,286 (1)	41/5,471 (0.8)	62/5,476 (1)	54/5,459 (1)	66/5,010 (1)	56/4,989 (1)	40/4,443 (0.9)	p=0.01
Hydrocortisone	30/5,193 (0.6)	28/5,317 (0.5)	23/5,346 (0.4)	26/5,375 (0.5)	16/5,286 (0.3)	24/5,471 (0.4)	25/5,476 (0.5)	36/5,459 (0.7)	37/5,010 (0.7)	32/4,989 (0.6)	47/4,443 (1)	p=0.0002
Methylprednisolone	0/5,193 (0)	0/5,317 (0)	0/5,346 (0)	0/5,375 (0)	4/5,286 (0.08)	0/5,471 (0)	2/5,476 (0.04)	1/5,459 (0.02)	0/5,010 (0)	2/4,989 (0.04)	0/4,443 (0)	p=0.3
Budesonide	14/5,193 (0.3)	6/5,317 (0.1)	12/5,346 (0.2)	7/5,375 (0.1)	13/5,286 (0.3)	14/5,471 (0.3)	23/5,476 (0.4)	23/5,459 (0.4)	30/5,010 (0.6)	30/4,989 (0.6)	33/4,443 (0.7)	p<0.0001
Neonatal Outcomes[1]												
Mortality	183/5,193 (4)	188/5,317 (4)	196/5,346 (4)	183/5,375 (3)	155/5,286 (3)	167/5,471 (3)	156/5,476 (3)	162/5,459 (3)	131/5,010 (3)	139/4,989 (3)	124/4,443 (3)	p<0.0001

Bronchopulmonary dysplasia	758/4,953 (15)	836/5,108 (16)	832/5,134 (16)	857/5,174 (17)	923/5,122 (18)	928/5,287 (18)	932/5,310 (18)	959/5,303 (18)	920/4,883 (19)	903/4,866 (19)	830/4,321 (19)	p<0.0001
Severe bronchopulmonary dysplasia	275/4,953 (6)	302/5,108 (6)	332/5,134 (6)	344/5,174 (7)	358/5,122 (7)	368/5,287 (7)	400/5,310 (8)	374/5,303 (7)	411/4,883 (8)	413/4,866 (8)	339/4,321 (8)	p<0.0001
Discharge on respiratory support	327/4,910 (7)	354/5,050 (7)	378/5,093 (7)	382/5,131 (7)	401/5,090 (8)	386/5,261 (7)	409/5,277 (8)	425/5,275 (8)	365/4,857 (8)	414/4,824 (9)	354/4,281 (8)	p<0.0001
Respiratory pressure support at discharge	72/4,910 (1)	70/5,050 (1)	66/5,093 (1)	57/5,131 (1)	58/5,090 (1)	64/5,261 (1)	61/5,277 (1)	71/5,275 (1)	77/4,857 (2)	72/4,824 (1)	47/4,281 (1)	p=0.97
Composite outcome												
Death and/or bronchopulmonary dysplasia	919/5,113 (18)	1,005/5,276 (19)	1,010/5,311 (19)	1,027/5,341 (19)	1,059/5,257 (20)	1,083/5,440 (20)	1,074/5,452 (20)	1,105/5,447 (20)	1,036/4,997 (21)	1,022/4,984 (21)	939/4,429 (21)	p<0.0001
Death and/or severe bronchopulmonary dysplasia	438/5,113 (9)	474/5,276 (9)	511/5,311 (10)	515/5,341 (10)	497/5,257 (9)	525/5,440 (10)	544/5,452 (10)	524/5,447 (10)	527/4,997 (11)	533/4,984 (11)	488/4,429 (10)	p<0.0001
Death or discharge on respiratory support	510/5,093 (10)	533/5,238 (10)	574/5,289 (11)	565/5,314 (11)	556/5,245 (11)	553/5,428 (10)	565/5,433 (10)	587/5,437 (11)	496/4,988 (10)	553/4,963 (11)	478/4,405 (11)	p=0.2
Death or respiratory pressure support at discharge	255/5,093 (5)	258/5,238 (5)	262/5,289 (5)	240/5,314 (5)	213/5,245 (4)	231/5,428 (4)	217/5,433 (4)	233/5,437 (4)	208/4,988 (4)	211/4,963 (4)	171/4,405 (4)	p=0.0002

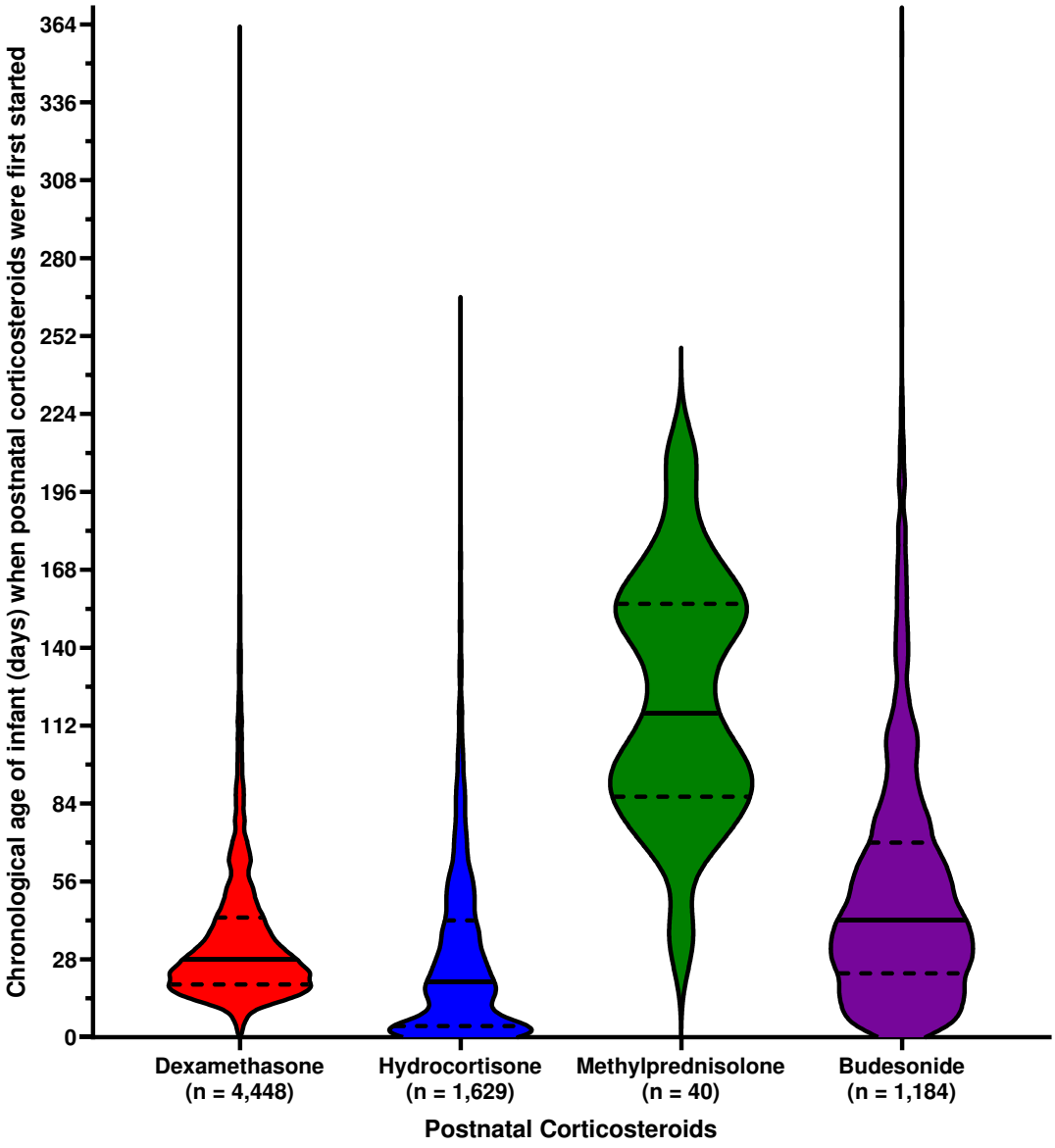
Supplementary Figure 1 Combination of the types of postnatal corticosteroids received by 928 infants receiving more than one type of postnatal corticosteroids. Dex = dexamethasone. Hydro = hydrocortisone. Methyl = methylprednisolone. Bude = budesonide.



Supplementary Figure 2 Heat map depicting the percentage of 83,463 preterm infants born below 32 weeks gestation receiving the respective postnatal corticosteroids who were born in the respective years and gestational age. Data presented as the percentage of infants receiving the respective postnatal corticosteroids within each cell (total number of infants within each cell).



Supplementary Figure 3 Violin plot depicting the chronological age in days (median (solid lines) as well as the 25th and 75th centiles (dotted lines)) when the respective postnatal corticosteroids were first commenced.

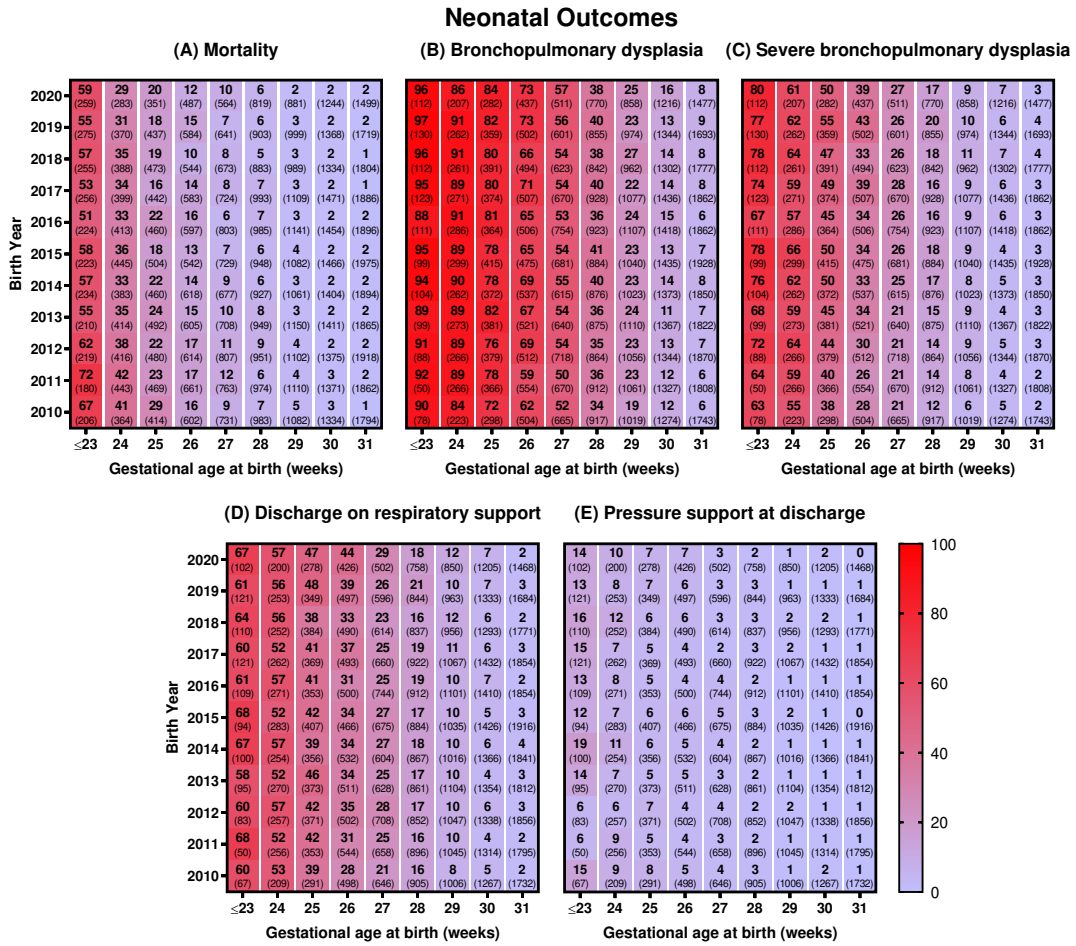


Supplementary Table 4 Chronological age in days (median (interquartile range)) when the respective postnatal corticosteroids were started (A) as well as the percentage of premature infants born below 32 weeks gestation (presented as n/total n (%)) receiving repeated courses of the same type of postnatal corticosteroids (B) and multiple types of postnatal corticosteroids subsequently (C) from 2010 to 2020.

[1] Extension of the Wilcoxon rank-sum test or chi-squared test for trend was performed to examine the association of continuous or categorical variables across the birth years.

Postnatal Corticosteroids	Birth Year											p value for trend[1]
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
(A) Chronological age in days when postnatal corticosteroids were started												
Dexamethasone	32 (22 – 49)	28 (19 – 44)	29 (19 – 50)	28 (19 – 44)	27 (19 – 43)	29 (21 – 42)	28 (20 – 43)	27 (20 – 42)	27 (19 – 43)	26 (18 – 39)	27 (19 – 39)	p<0.0001
Hydrocortisone	28 (14 – 51)	24 (8 – 45)	23 (11 – 51)	28 (13 – 41)	23 (14 – 55)	23 (14 – 43)	24 (11 – 51)	20 (4 – 42)	19 (3 – 41)	14 (2 – 40)	4 (1 – 23)	p<0.0001
Methylprednisolone	N/A	N/A	N/A	152 (147 – 156)	131 (97 – 155)	153 (85 – 166)	102 (81 – 121	96 (73 – 137)	95 (85 – 104)	174 (95 – 176)	126 (83 – 155)	p = 0.5
Budesonide	70 (46 – 119)	98 (59 – 135)	79 (57 – 112)	73 (57 – 109)	52 (35 – 80)	38 (26 – 66)	46 (29 – 70)	42 (26 – 66)	31 (14 – 55)	33 (17 – 53)	34 (14 – 52)	p<0.0001
(B) Repeated course of the same type of postnatal corticosteroids												
Dexamethasone	69/287 (24)	78/339 (23)	100/376 (27)	124/391 (32)	111/382 (29)	115/407 (28)	118/427 (28)	117/453 (26)	131/486 (27)	140/503 (28)	115/397 (29)	p = 0.3
Hydrocortisone	5/104 (5)	2/133 (2)	4/98 (4)	1/105 (1)	5/100 (5)	7/106 (7)	7/129 (5)	10/178 (6)	13/201 (6)	7/201 (3)	11/274 (4)	p = 0.3
Methylprednisolone	N/A	N/A	N/A	1/2 (50)	1/7 (14)	1/5 (20)	1/4 (25)	1/7 (14)	1/2 (50)	1/5 (20)	1/8 (13)	p = 0.6
Budesonide	6/47 (13)	4/45 (9)	3/42 (7)	6/53 (11)	20/89 (22)	20/92 (22)	24/117 (21)	21/136 (15)	29/177 (16)	29/197 (15)	34/189 (18)	p = 0.3
(C) Received multiple types of postnatal corticosteroids												
Dexamethasone	18/287 (6)	31/339 (9)	26/376 (7)	31/391 (8)	50/382 (13)	37/407 (9)	53/427 (12)	73/453 (16)	70/486 (14)	76/503 (15)	66/397 (17)	p<0.0001
Hydrocortisone	14/104 (13)	28/133 (21)	14/98 (14)	12/105 (11)	11/100 (11)	16/106 (15)	17/129 (13)	34/178 (19)	36/201 (18)	44/201 (22)	59/274 (22)	p = 0.01
Methylprednisolone	N/A	N/A	N/A	0/2 (0)	0/7 (0)	0/5 (0)	0/4 (0)	1/7 (14)	0/2 (0)	0/5 (0)	0/8 (0)	p = 0.9
Budesonide	3/47 (6)	6/45 (13)	5/42 (12)	5/53 (9)	12/89 (13)	14/92 (15)	16/117 (14)	27/136 (20)	28/177 (16)	29/197 (15)	24/189 (13)	p = 0.2

Supplementary Figure 4 Heat map depicting the incidence of neonatal outcomes of (A) mortality, (B) bronchopulmonary dysplasia (BPD), (C) severe BPD, (D) any respiratory support requirement at discharge from the neonatal unit and (E) respiratory pressure support at discharge in 83,463 preterm infants born below 32 weeks gestation in the respective years and gestational age. Data presented as the percentage of infants with the respective neonatal outcome within each cell (total number of infants within each cell). Missing data on BPD (n=414, 0.5%), severe BPD (n=414, 0.5%), discharge on respiratory support (n=725, 0.9%) and respiratory pressure support at discharge (n=725, 0.9%).



Supplementary Table 5 Unadjusted and adjusted odds ratio with 95% confidence interval for neonatal outcomes in 83,463 preterm infants born below 32 weeks gestation from 2010 to 2020. Missing data on mortality (n=251, 0.3%); BPD (n=492, 0.6%); BPD and/or death (n=661, 0.8%); severe BPD (n=492, 0.6%); severe BPD and/or death (n=661, 0.8%); discharge on respiratory support (n=801, 1.1%); discharge on respiratory support or death (n=970, 1.2%); respiratory pressure support at discharge (n=801, 1.1%); and discharge on respiratory pressure support or death analyses (n=970, 1.2%).

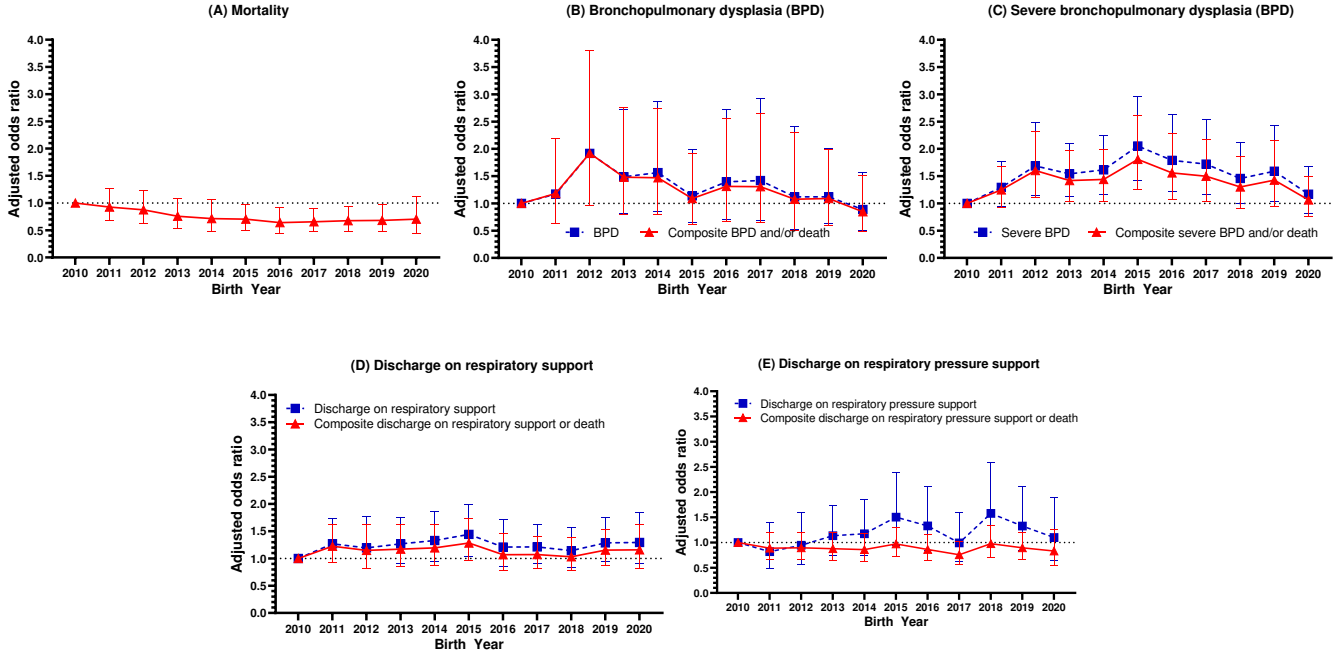
Neonatal outcome	Birth year	Unadjusted odds (95% confidence interval)	Adjusted odds (95% confidence interval)
Mortality	2010	Reference	Reference
	2011	1.05 (0.94 – 1.16)	1.02 (0.90 – 1.15)
	2012	1.00 (0.90 – 1.11)	0.96 (0.85 – 1.09)
	2013	0.91 (0.81 – 1.01)	0.85 (0.74 – 0.96)
	2014	0.85 (0.77 – 0.95)	0.79 (0.69 – 0.89)
	2015	0.82 (0.74 – 0.92)	0.75 (0.65 – 0.87)
	2016	0.80 (0.72 – 0.89)	0.75 (0.65 – 0.85)
	2017	0.80 (0.72 – 0.90)	0.72 (0.63 – 0.81)
	2018	0.81 (0.72 – 0.90)	0.70 (0.60 – 0.80)
	2019	0.82 (0.74 – 0.92)	0.69 (0.59 – 0.80)
	2020	0.83 (0.74 – 0.94)	0.70 (0.60 – 0.82)
Bronchopulmonary dysplasia	2010	Reference	Reference
	2011	1.08 (1.00 – 1.16)	1.05 (0.94 – 1.17)
	2012	1.14 (1.06 – 1.23)	1.16 (1.04 – 1.29)
	2013	1.17 (1.08 – 1.26)	1.18 (1.05 – 1.32)
	2014	1.23 (1.14 – 1.32)	1.30 (1.15 – 1.47)
	2015	1.20 (1.11 – 1.29)	1.25 (1.11 – 1.40)
	2016	1.20 (1.12 – 1.29)	1.23 (1.06 – 1.42)
	2017	1.24 (1.15 – 1.33)	1.29 (1.13 – 1.47)
	2018	1.29 (1.20 – 1.39)	1.32 (1.16 – 1.50)
	2019	1.32 (1.22 – 1.42)	1.37 (1.22 – 1.54)
	2020	1.30 (1.21 – 1.41)	1.43 (1.26 – 1.63)
Composite outcome of death and/or bronchopulmonary dysplasia	2010	Reference	Reference
	2011	1.07 (1.00 – 1.15)	1.06 (0.96 – 1.17)
	2012	1.11 (1.04 – 1.19)	1.15 (1.05 – 1.27)
	2013	1.10 (1.03 – 1.18)	1.15 (1.03 – 1.27)
	2014	1.13 (1.06 – 1.21)	1.22 (1.10 – 1.36)
	2015	1.10 (1.03 – 1.17)	1.17 (1.05 – 1.30)
	2016	1.09 (1.02 – 1.17)	1.15 (1.00 – 1.32)
	2017	1.12 (1.05 – 1.20)	1.20 (1.06 – 1.36)
	2018	1.16 (1.09 – 1.24)	1.21 (1.08 – 1.37)
	2019	1.19 (1.11 – 1.27)	1.26 (1.13 – 1.41)
	2020	1.18 (1.10 – 1.27)	1.32 (1.17 – 1.49)
Severe bronchopulmonary dysplasia	2010	Reference	Reference
	2011	1.08 (0.98 – 1.20)	1.04 (0.90 – 1.20)
	2012	1.23 (1.11 – 1.36)	1.21 (1.06 – 1.39)
	2013	1.28 (1.16 – 1.42)	1.25 (1.07 – 1.45)
	2014	1.37 (1.24 – 1.51)	1.39 (1.22 – 1.58)
	2015	1.44 (1.30 – 1.58)	1.48 (1.31 – 1.67)
	2016	1.39 (1.26 – 1.54)	1.41 (1.23 – 1.61)
	2017	1.44 (1.31 – 1.59)	1.46 (1.29 – 1.66)
	2018	1.53 (1.39 – 1.69)	1.52 (1.35 – 1.72)
	2019	1.65 (1.50 – 1.82)	1.68 (1.44 – 1.95)
	2020	1.50 (1.36 – 1.66)	1.57 (1.37 – 1.79)

Composite outcome of death and/or severe bronchopulmonary dysplasia	2010	Reference	Reference
	2011	1.07 (0.99 – 1.15)	1.04 (0.93 – 1.17)
	2012	1.13 (1.04 – 1.22)	1.15 (1.02 – 1.28)
	2013	1.11 (1.03 – 1.20)	1.11 (0.98 – 1.26)
	2014	1.13 (1.04 – 1.22)	1.16 (1.05 – 1.28)
	2015	1.15 (1.07 – 1.24)	1.20 (1.08 – 1.33)
	2016	1.11 (1.03 – 1.20)	1.16 (1.03 – 1.29)
	2017	1.14 (1.06 – 1.23)	1.18 (1.06 – 1.31)
	2018	1.19 (1.10 – 1.29)	1.19 (1.08 – 1.33)
	2019	1.27 (1.18 – 1.37)	1.30 (1.15 – 1.48)
	2020	1.19 (1.10 – 1.29)	1.24 (1.10 – 1.39)
Discharge on respiratory support	2010	Reference	Reference
	2011	1.11 (1.01 – 1.23)	1.09 (0.97 – 1.21)
	2012	1.24 (1.12 – 1.36)	1.23 (1.09 – 1.39)
	2013	1.20 (1.09 – 1.33)	1.17 (1.04 – 1.32)
	2014	1.25 (1.13 – 1.37)	1.24 (1.09 – 1.41)
	2015	1.21 (1.10 – 1.34)	1.20 (1.04 – 1.39)
	2016	1.21 (1.10 – 1.33)	1.19 (1.01 – 1.40)
	2017	1.25 (1.14 – 1.38)	1.23 (1.04 – 1.46)
	2018	1.19 (1.08 – 1.32)	1.12 (0.97 – 1.30)
	2019	1.39 (1.26 – 1.52)	1.35 (1.17 – 1.57)
	2020	1.39 (1.26 – 1.53)	1.42 (1.24 – 1.64)
Composite outcome of death or discharge on respiratory support	2010	Reference	Reference
	2011	1.09 (1.01 – 1.17)	1.07 (0.98 – 1.18)
	2012	1.14 (1.05 – 1.23)	1.16 (1.05 – 1.28)
	2013	1.07 (0.99 – 1.16)	1.07 (0.96 – 1.18)
	2014	1.07 (0.99 – 1.16)	1.08 (0.98 – 1.19)
	2015	1.04 (0.96 – 1.12)	1.04 (0.92 – 1.17)
	2016	1.03 (0.95 – 1.11)	1.03 (0.90 – 1.18)
	2017	1.05 (0.97 – 1.13)	1.05 (0.91 – 1.20)
	2018	1.02 (0.94 – 1.10)	0.96 (0.85 – 1.08)
	2019	1.14 (1.05 – 1.23)	1.12 (0.99 – 1.26)
	2020	1.14 (1.06 – 1.24)	1.17 (1.05 – 1.31)
Respiratory pressure support at discharge	2010	Reference	Reference
	2011	0.87 (0.70 – 1.08)	0.84 (0.67 – 1.04)
	2012	0.84 (0.68 – 1.05)	0.80 (0.63 – 1.02)
	2013	0.82 (0.65 – 1.02)	0.76 (0.60 – 0.96)
	2014	0.95 (0.77 – 1.18)	0.89 (0.70 – 1.15)
	2015	0.94 (0.76 – 1.16)	0.89 (0.70 – 1.14)
	2016	0.87 (0.70 – 1.08)	0.82 (0.64 – 1.04)
	2017	0.86 (0.69 – 1.07)	0.80 (0.63 – 1.01)
	2018	1.11 (0.90 – 1.37)	1.02 (0.79 – 1.30)
	2019	1.05 (0.85 – 1.30)	0.95 (0.73 – 1.24)
	2020	0.95 (0.76 – 1.18)	0.88 (0.68 – 1.14)
Composite outcome of death or respiratory pressure support at discharge	2010	Reference	Reference
	2011	1.01 (0.92 – 1.11)	0.97 (0.87 – 1.08)
	2012	0.96 (0.87 – 1.06)	0.92 (0.82 – 1.02)
	2013	0.88 (0.80 – 0.97)	0.81 (0.73 – 0.91)
	2014	0.86 (0.78 – 0.95)	0.80 (0.72 – 0.89)
	2015	0.84 (0.76 – 0.93)	0.77 (0.68 – 0.88)
	2016	0.80 (0.73 – 0.89)	0.75 (0.67 – 0.85)
	2017	0.80 (0.73 – 0.89)	0.72 (0.65 – 0.81)
	2018	0.85 (0.77 – 0.95)	0.76 (0.66 – 0.86)
	2019	0.86 (0.78 – 0.95)	0.74 (0.65 – 0.84)
	2020	0.85 (0.76 – 0.94)	0.74 (0.64 – 0.84)

Supplementary Table 6 Percentage of 6,307 preterm infants born below 32 weeks gestation who received postnatal corticosteroids with the following neonatal outcomes.
[1] Data presented as n/total n (%) unless otherwise stated. [2]Data presented as median (interquartile range).

INFANTS RECEIVING POSTNATAL CORTICOSTEROIDS (n = 6,307)												
Neonatal Outcomes[1]	**Birth Year**											**p value for trend**
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
Mortality	80/402 (20)	83/452 (18)	83/471 (18)	81/503 (16)	78/504 (15)	82/543 (15)	82/590 (14)	91/639 (14)	106/729 (15)	112/756 (15)	110/718 (15)	p=0.004
Bronchopulmonary dysplasia	285/321 (89)	333/369 (90)	363/387 (94)	390/421 (93)	395/426 (93)	420/461 (91)	466/508 (92)	504/548 (92)	564/623 (91)	579/644 (90)	529/607 (87)	p=0.03
Severe bronchopulmonary dysplasia	198/321 (62)	247/369 (67)	282/387 (73)	301/421 (72)	308/426 (72)	355/461 (77)	376/508 (74)	402/548 (73)	439/623 (70)	460/644 (71)	392/607 (65)	p=0.7
Discharge on respiratory support	180/319 (56)	225/364 (62)	234/386 (61)	262/421 (62)	271/425 (64)	301/458 (66)	309/506 (61)	335/546 (61)	374/622 (60)	399/639 (62)	374/602 (62)	p=0.5
Respiratory pressure support at discharge	34/319 (11)	32/364 (9)	39/386 (10)	50/421 (12)	53/425 (12)	69/458 (15)	69/506 (14)	59/546 (11)	99/622 (16)	86/639 (13)	69/602 (11)	p=0.03
Composite outcome												
Death and/or bronchopulmonary dysplasia	365/401 (91)	416/452 (92)	446/470 (95)	471/502 (94)	473/504 (94)	502/543 (92)	548/590 (93)	595/639 (93)	670/729 (92)	691/756 (91)	639/717 (89)	p=0.01
Death and/or severe bronchopulmonary dysplasia	278/401 (69)	330/452 (73)	365/470 (78)	382/502 (76)	386/504 (77)	437/543 (80)	458/590 (78)	493/639 (77)	545/729 (75)	572/756 (76)	502/717 (70)	p=0.7
Death or discharge on respiratory support	260/399 (65)	308/447 (69)	317/469 (68)	343/502 (68)	349/503 (69)	383/540 (71)	391/588 (67)	426/637 (67)	480/728 (66)	511/751 (68)	484/712 (68)	p=0.8
Death or respiratory pressure support at discharge	114/399 (29)	115/447 (26)	122/469 (26)	131/502 (26)	131/503 (26)	151/540 (28)	151/588 (26)	150/637 (24)	205/728 (28)	198/751 (26)	179/712 (25)	p=0.6

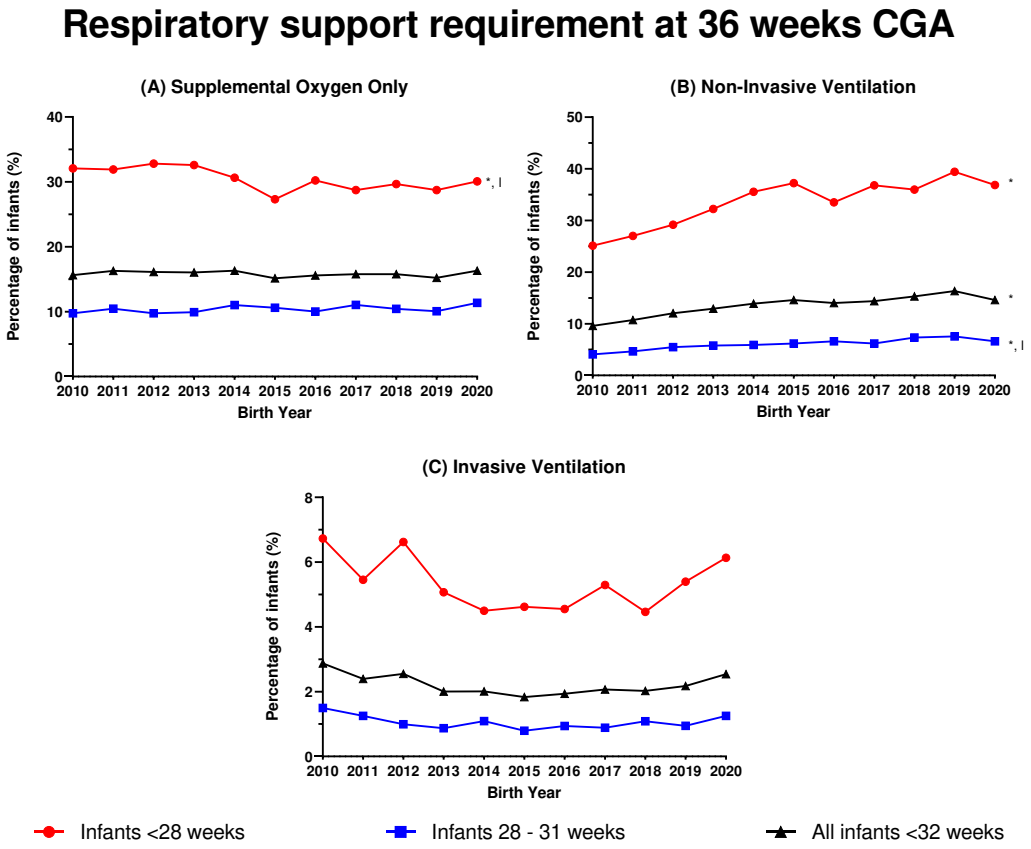
Supplementary Figure 5 Adjusted odds ratio of the neonatal outcomes of (A) mortality, (B) bronchopulmonary dysplasia (BPD), (C) severe BPD, (D) any respiratory support requirement at discharge from the neonatal unit and (E) respiratory pressure support at discharge and their respective composite outcomes with death in (B) to (E) in 6,307 preterm infants born below 32 weeks gestation who received postnatal corticosteroids from 2010 to 2020. Missing data on mortality (n=49, 0.8%); BPD (n=36, 0.7%); BPD and/or death (n=53, 0.8%); severe BPD (n=36, 0.7%); severe BPD and/or death (n=53, 0.8%); discharge on respiratory support (n=62, 1.2%); discharge on respiratory support or death (n=79, 1.3%); respiratory pressure support at discharge (n=62, 1.2%); and discharge on respiratory pressure support or death analyses (n=79, 1.3%).



Supplementary Table 7 Percentage of 76,121 preterm infants born below 32 weeks gestation, 20,660 extremely preterm infants born below 28 weeks gestation and 55,461 very preterm infants born between 28 – 31 weeks of gestation in the respective years who required supplemental oxygen only, non-invasive ventilation and invasive ventilation at 36 weeks of corrected gestational age.

OVERALL COHORT OF INFANTS <32 WEEKS GESTATION (n = 76,121)												
Characteristics (n (%))	**Birth Year**											**p value for trend**
	2010 (n=6,721)	**2011 (n=7,014)**	**2012 (n=7,097)**	**2013 (n=7,088)**	**2014 (n=7,012)**	**2015 (n=7,256)**	**2016 (n=7,331)**	**2017 (n=7,248)**	**2018 (n=6,764)**	**2019 (n=6,720)**	**2020 (n=5,870)**	
Supplemental oxygen only	1,050 (16)	1,142 (16)	1,144 (16)	1,137 (16)	1,144 (16)	1,098 (15)	1,143 (16)	1,144 (16)	1,067 (16)	1,023 (15)	957 (16)	p=0.4
Non-invasive ventilation	645 (10)	753 (11)	854 (12)	916 (13)	974 (14)	1,059 (15)	1,027 (14)	1,043 (14)	1,035 (15)	1,098 (16)	856 (15)	p<0.0001
Invasive ventilation	193 (3)	168 (2)	181 (3)	142 (2)	141 (2)	133 (2)	142 (2)	150 (2)	137 (2)	146 (2)	149 (3)	p=0.02
INFANTS <28 WEEKS GESTATION (n = 20,660)												
Characteristics (n (%))	**Birth Year**											**p value for trend**
	2010 (n=1,768)	**2011 (n=1,906)**	**2012 (n=1,963)**	**2013 (n=1,914)**	**2014 (n=1,890)**	**2015 (n=1,969)**	**2016 (n=2,021)**	**2017 (n=1,945)**	**2018 (n=1,881)**	**2019 (n=1,854)**	**2020 (n=1,549)**	
Supplemental oxygen only	567 (32)	608 (32)	644 (33)	624 (33)	579 (31)	538 (27)	611 (30)	559 (29)	558 (30)	533 (29)	466 (30)	p=0.0002
Non-invasive ventilation	444 (25)	515 (27)	573 (29)	617 (32)	672 (36)	733 (37)	677 (34)	716 (37)	677 (36)	731 (39)	571 (37)	p<0.0001
Invasive ventilation	119 (7)	104 (5)	130 (7)	97 (5)	85 (5)	91 (5)	92 (5)	103 (5)	84 (4)	100 (5)	95 (6)	p=0.07
INFANTS 28 – 31 WEEKS GESTATION (n = 55,461)												
Characteristics (n (%))	**Birth Year**											**p value for trend**
	2010 (n=4,953)	**2011 (n=5,108)**	**2012 (n=5,134)**	**2013 (n=5,174)**	**2014 (n=5,122)**	**2015 (n=5,287)**	**2016 (n=5,310)**	**2017 (n=5,303)**	**2018 (n=4,883)**	**2019 (n=4,866)**	**2020 (n=4,321)**	
Supplemental oxygen only	483 (10)	534 (10)	500 (10)	513 (10)	565 (11)	560 (11)	532 (10)	585 (11)	509 (10)	490 (10)	491 (11)	p=0.04
Non-invasive ventilation	201 (4)	238 (5)	281 (5)	299 (6)	302 (6)	326 (6)	350 (7)	327 (6)	358 (7)	367 (8)	285 (7)	p<0.0001
Invasive ventilation	74 (1)	64 (1)	51 (1)	45 (0.9)	56 (1)	42 (0.8)	50 (0.9)	47 (0.9)	53 (1)	46 (1)	54 (1)	p=0.1

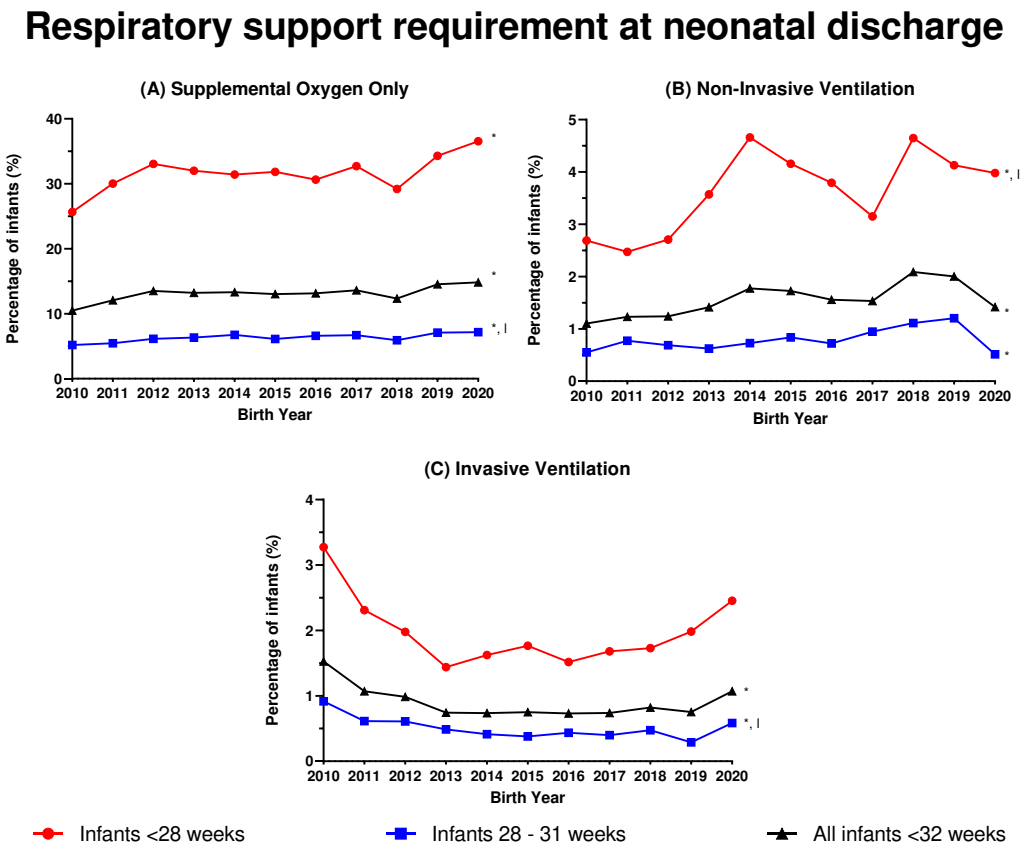
Supplementary Figure 6 Percentage of 76,121 preterm infants born below 32 weeks gestation, 20,660 extremely preterm infants born below 28 weeks gestation and 55,461 very preterm infants born between 28 – 31 weeks of gestation in the respective years who required (A) supplemental oxygen only, (B) non-invasive ventilation and (C) invasive ventilation at 36 weeks of corrected gestational age. * = significant trend seen across the birth years, l =linear trend seen across the birth years.



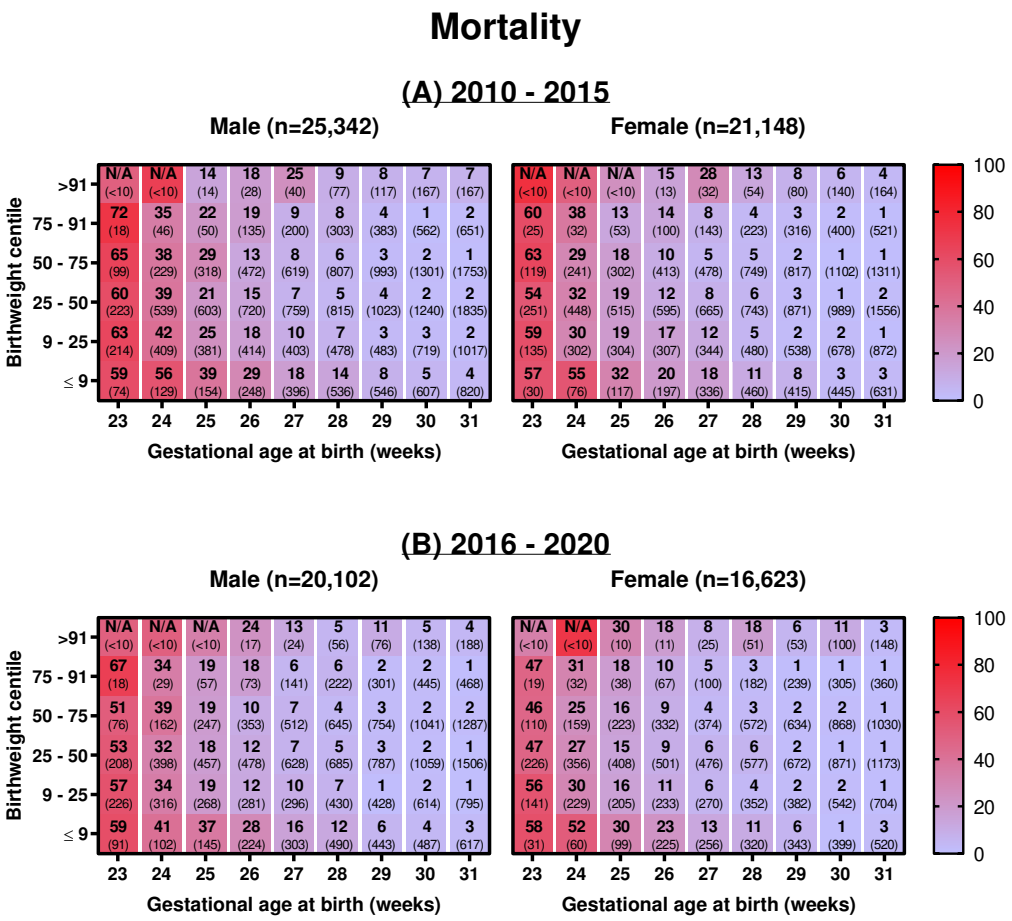
Supplementary Table 8 Percentage of 75,246 preterm infants born below 32 weeks gestation, 20,197 extremely preterm infants born below 28 weeks gestation and 55,049 very preterm infants born between 28 – 31 weeks of gestation in the respective years who required supplemental oxygen only, non-invasive ventilation and invasive ventilation at discharge from the neonatal unit.

OVERALL COHORT OF INFANTS <32 WEEKS GESTATION (n = 75,246)												
Characteristics (n (%))	**Birth Year**											**p value for trend**
	2010 (n=6,621)	**2011 (n=6,911)**	**2012 (n=7,014)**	**2013 (n=7,008)**	**2014 (n=6,936)**	**2015 (n=7,186)**	**2016 (n=7,254)**	**2017 (n=7,180)**	**2018 (n=6,707)**	**2019 (n=6,640)**	**2020 (n=5,789)**	
Supplemental oxygen only	694 (10)	834 (12)	947 (14)	926 (13)	923 (13)	935 (13)	954 (13)	977 (14)	828 (12)	965 (15)	858 (15)	p<0.0001
Non-invasive ventilation	73 (1)	85 (1)	87 (1)	99 (1)	123 (2)	124 (2)	113 (2)	110 (2)	140 (2)	133 (2)	82 (1)	p<0.0001
Invasive ventilation	101 (2)	74 (1)	69 (1)	52 (0.7)	51 (0.7)	54 (0.8)	53 (0.7)	53 (0.7)	55 (0.8)	50 (0.8)	62 (1)	p=0.0005
INFANTS <28 WEEKS GESTATION (n = 20,197)												
Characteristics (n (%))	**Birth Year**											**p value for trend**
	2010 (n=1,711)	**2011 (n=1,861)**	**2012 (n=1,921)**	**2013 (n=1,877)**	**2014 (n=1,846)**	**2015 (n=1,925)**	**2016 (n=1,977)**	**2017 (n=1,905)**	**2018 (n=1,850)**	**2019 (n=1,816)**	**2020 (n=1,508)**	
Supplemental oxygen only	439 (26)	559 (30)	635 (33)	601 (32)	580 (31)	613 (32)	606 (31)	623 (33)	540 (29)	623 (34)	551 (37)	p<0.0001
Non-invasive ventilation	46 (3)	46 (2)	52 (3)	67 (4)	86 (5)	80 (4)	75 (4)	60 (3)	86 (5)	75 (4)	60 (4)	p=0.0002
Invasive ventilation	56 (3)	43 (2)	38 (2)	27 (1)	30 (2)	34 (2)	30 (2)	32 (2)	32 (2)	36 (2)	37 (2)	p=0.08
INFANTS 28 – 31 WEEKS GESTATION (n = 55,049)												
Characteristics (n (%))	**Birth Year**											**p value for trend**
	2010 (n=4,910)	**2011 (n=5,050)**	**2012 (n=5,093)**	**2013 (n=5,131)**	**2014 (n=5,090)**	**2015 (n=5,261)**	**2016 (n=5,277)**	**2017 (n=5,275)**	**2018 (n=4,857)**	**2019 (n=4,824)**	**2020 (n=4,281)**	
Supplemental oxygen only	255 (5)	275 (5)	312 (6)	325 (6)	343 (7)	322 (6)	348 (7)	354 (7)	288 (6)	342 (7)	307 (7)	p<0.0001
Non-invasive ventilation	27 (0.6)	39 (0.8)	35 (0.7)	32 (0.6)	37 (0.7)	44 (0.8)	38 (0.7)	50 (1)	54 (1)	58 (1)	22 (0.5)	p=0.006
Invasive ventilation	45 (0.9)	31 (0.6)	31 (0.6)	25 (0.5)	21 (0.4)	20 (0.4)	23 (0.4)	21 (0.4)	23 (0.5)	14 (0.3)	25 (0.6)	p=0.0006

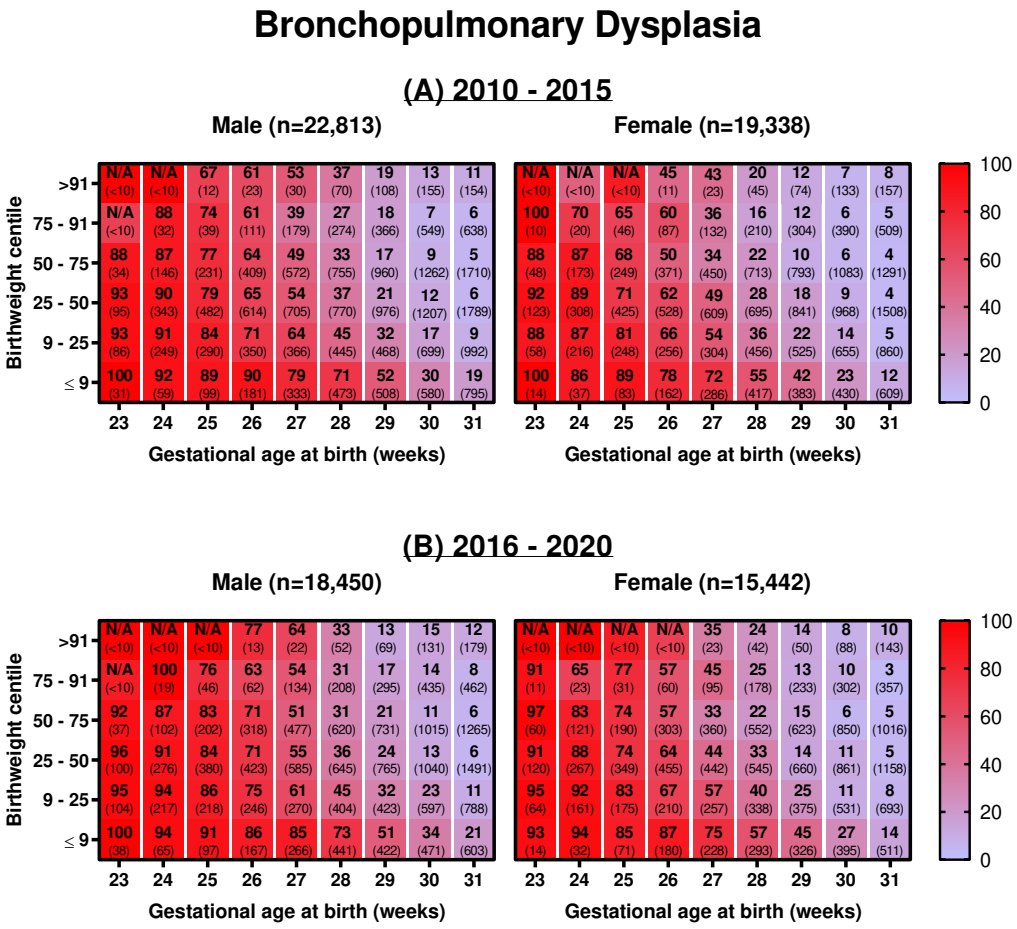
Supplementary Figure 7 Percentage of 75,246 preterm infants born below 32 weeks gestation, 20,197 extremely preterm infants born below 28 weeks gestation and 55,049 very preterm infants born between 28 – 31 weeks of gestation in the respective years who required (A) supplemental oxygen only, (B) non-invasive ventilation and (C) invasive ventilation at discharge. * = significant trend seen across the birth years, l =linear trend seen across the birth years.



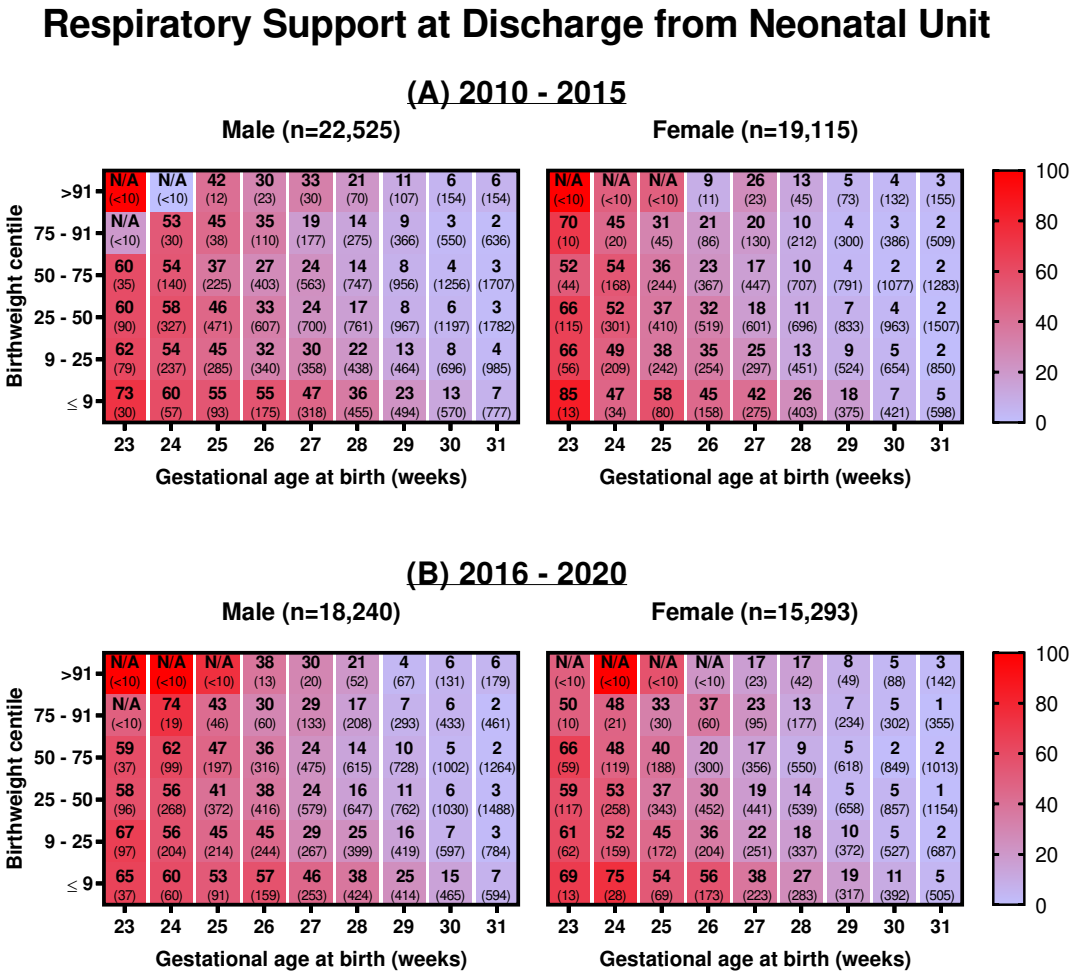
Supplementary Figure 8 Heat map depicting the incidence of mortality of 83,215 preterm infants born below 32 weeks gestation in (A) 2010–2015 and (B) 2016–2020, stratified by sex, gestational age at birth and birthweight centile. Data presented as the percentage of infant deaths within each cell (total number of infants within each cell). **N/A=**cells with <10 infants so are suppressed.



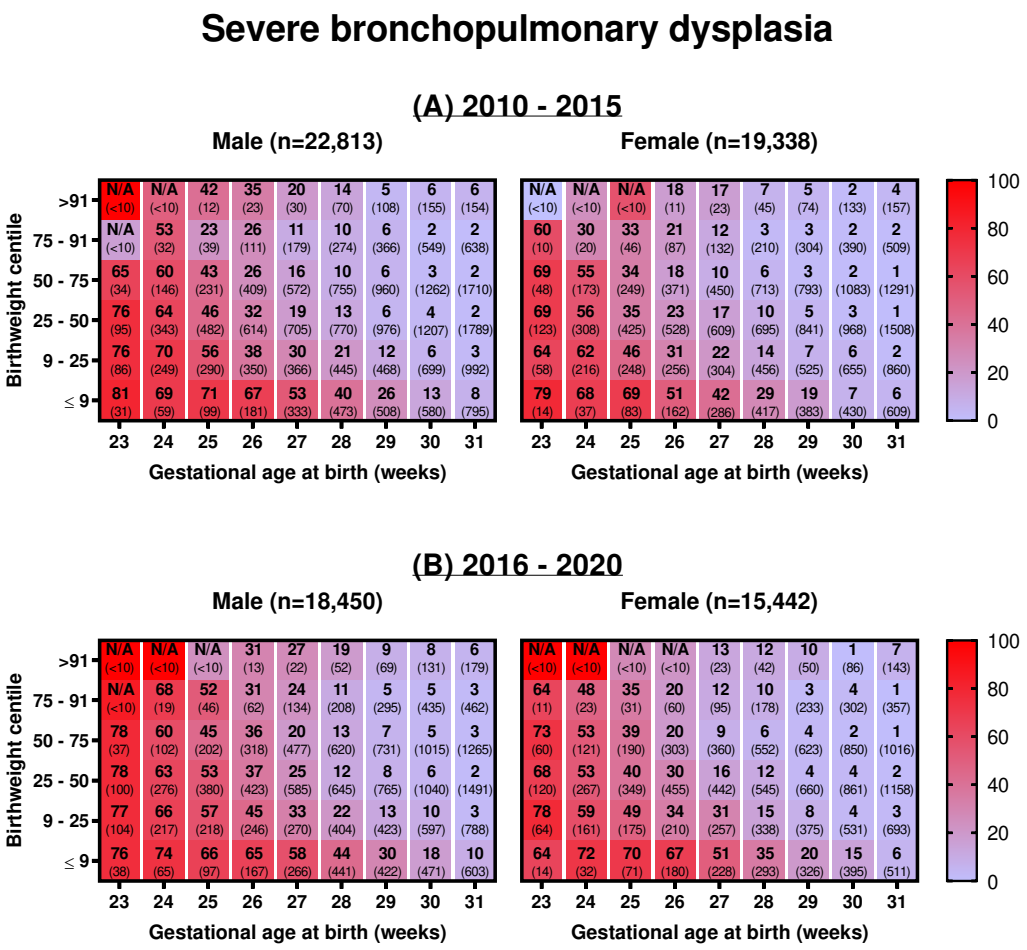
Supplementary Figure 9 Heat map depicting the incidence of bronchopulmonary dysplasia (BPD) of 76,043 preterm infants born below 32 weeks gestation in (A) 2010–2015 and (B) 2016–2020, stratified by sex, gestational age at birth and birthweight centile. Data presented as the percentage of infants with BPD within each cell (total number of infants within cells). **N/A=**cells with <10 infants so are suppressed.



Supplementary Figure 10 Heat map depicting the incidence of respiratory support requirement at discharge from the neonatal unit of 75,173 preterm infants born below 32 weeks gestation in (A) 2010–2015 and (B) 2016–2020, stratified by sex, gestational age at birth and birthweight centile. Data presented as the percentage of infants requiring respiratory support at discharge within each cell (total number of infants within each cell). **N/A=**cells with <10 infants so are suppressed.



Supplementary Figure 11 Heat map depicting the incidence of severe bronchopulmonary dysplasia of 76,043 preterm infants born below 32 weeks gestation in (A) 2010–2015 and (B) 2016–2020, stratified by sex, gestational age at birth and birthweight centile. Data presented as the percentage of infants with severe bronchopulmonary dysplasia within each cell (total number of infants within each cell). **N/A=**cells with <10 infants so are suppressed.



Supplementary Figure 12 Heat map depicting the incidence of respiratory pressure support requirement at discharge of 75,173 preterm infants born below 32 weeks gestation in (A) 2010–2015 and (B) 2016–2020, stratified by sex, gestational age at birth and birthweight centile. Data presented as the percentage of infants requiring respiratory pressure support at 36 weeks CGA within each cell (total number of infants within each cell). **N/A=**cells with <10 infants so are suppressed.