

Changes in admissions, survival, care processes and outcomes for very and extremely preterm infants in England and Wales: a 10-year whole population study

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Summary

Background: Preterm birth is a major health and societal issue and the largest contributor globally to loss of disability adjusted life years. We aimed to evaluate changes in admissions, care processes, and outcomes and by maternal ethnicity over a ten-year period in England and Wales in very preterm (VPT) and extremely preterm (EPT) infants.

Methods:

Design: Retrospective, 10-year, whole population analysis from 01-01-2013 to 31-12-2022 using data from the National Neonatal Research Database and Office for National Statistics.

Setting: National Health Service neonatal units in England and Wales

Participants: Admissions of infants born VPT (28^{+0} to 31^{+6} weeks ^{days} gestation) and EPT ($<28^{+0}$ weeks ^{days} gestation)

Main outcomes: Trend analysis and relative risks (modified Poisson regression), of admissions, 7 clinical outcomes and 8 care processes nationally and by maternal ethnicity, adjusted for sex, gestational age (weeks), multiplicity, and birth weight z-score.

Findings: Over the 10-year period, there were 23,829 EPT and 51,140 VPT neonatal admissions, with no statistically significant changes in admission rates of either group nationally. Rates have been highest for mothers of Black ethnicity. There has been a significant decrease over time in VPT admission rates for Black and Asian mothers (Black: RR=0.97, 95% CI 0.96 to 0.99; Asian: RR=0.97, 95%CI 0.96 to 0.98). In White mothers, both EPT and VPT admission rates have decreased (EPT: RR=0.98, 95% CI 0.97 to 0.99; VPT: RR=0.97, 95% CI 0.97 to 0.98). EPT and VPT admission rates have increased in mothers of “Other” ethnicities (EPT: RR=1.05, 95% CI 1.01 to 1.09; VPT: RR=1.04, 95% CI 1.01 to 1.07). There have been significant increases in births by emergency Caesarean section (EPT: RR 1.04, 95% CI 1.03 to 1.04; VPT: RR 1.02 95% CI 1.01 to 1.02); and receiving any own mother’s milk at discharge (EPT: RR 1.02, 95% CI 1.01 to 1.02), and significant decreases in rates of delivery room intubation (EPT: RR 0.97, 95% CI 0.96 to 0.97; VPT: RR 0.94, 95% CI 0.93 to 0.94), any intubated respiratory support (VPT: RR 0.97, 95% CI 0.96 to 0.97), surgical or device closure of patent ductus arteriosus (EPT: RR 0.83, 95% CI 0.81 to 0.85; VPT: RR 0.87, 95%CI 0.81 to 0.93), and early postnatal transfers to a lower intensity neonatal unit (EPT: RR 0.79, 95% CI 0.71 to 0.89; VPT: RR 0.97, 95% CI 0.95 to 0.99). For EPT admissions there has been a decrease in mortality (RR 0.98, 95% CI 0.97 to 0.99) and for VPT admissions, a decrease in the rate of treated retinopathy of prematurity (RR 0.94, 95% CI 0.90 to 0.98). Rates of severe necrotising enterocolitis, severe brain injury, and survival to discharge without major morbidity have not altered significantly in either group.

Interpretation: Over the decade to 2022, there has been persisting ethnic variation in EPT and VPT admissions in England and Wales. There has been improved delivery of high-quality care processes, a decrease in mortality in EPT admissions, but limited improvement in other outcomes.

Keywords: Infant preterm; Care processes; Mortality; Bronchopulmonary dysplasia; Retinopathy of prematurity; Necrotising enterocolitis; Brain injury

What is known on this topic

- Preterm birth is a major health and societal issue necessitating highly specialised care, with survivors at substantial risk of life-long physical and mental health problems
- Reducing preterm births and improving outcomes in babies born preterm are national policy targets
- In the last decade operational networks, clinical audit, and quality improvement programmes have been widely promoted as approaches to improve patient care and outcomes, and reduce health inequalities

What this study adds

- Over the decade to December 2022, national rates of EPT and VPT admissions to neonatal units in England and Wales have remained largely unchanged
- There has been improved delivery of processes indicative of high-quality care, a decrease in EPT mortality, but little substantive decrease in major morbidities
- There is evidence of persisting ethnic disparity with mothers of Black ethnicity experiencing the highest rates of EPT and VPT admissions

Introduction

Preterm birth is a major health and societal issue and the largest contributor globally to loss of disability adjusted life years¹. Globally, the complications of preterm birth are the leading cause of mortality in children under the age of five years. On average, around one in ten of all births are preterm (less than 37 weeks gestation). Worldwide, approximately 15% of all preterm births occur at less than 32 weeks gestation, of which around a third are <28 weeks and around two-thirds are 28–32 weeks².

Babies born EPT and VPT require care that is highly specialised, and often prolonged. Mortality and morbidity can be high especially in the most immature infants, born below 24 weeks gestation, often referred to as the margins of viability. In England and Wales, neonatal care is delivered through National Health Service (NHS) Operational Delivery Networks. Each network includes a variable number of neonatal units; designated a Special Care Unit (SCU), Local Neonatal Unit (LNU) or Neonatal Intensive Care Unit (NICU). These respectively provide increasing intensity of care. Depending on care needs, a baby may undergo transfer between neonatal units usually within a regional network. NHS hospitals deliver care for all EPT and most VPT infants.

Neonatal care influences life-long health; hence, survival and morbidities to neonatal unit discharge are important intermediary outcome measures, widely considered indicative of quality of care. Reducing preterm birth and its consequences, and ethnic disparities in care and outcomes are major national goals^{3,4}. We therefore aimed to investigate changes in EPT and VPT admissions, care processes and outcomes, and by maternal ethnicity over a ten-year period in England and Wales.

Methods

Population

We performed a trend analysis of all EPT and VPT admissions to neonatal units in England and Wales. We utilised data from the National Neonatal Research Database (NNRD). This is a National Information Asset containing a standard data extract (the Neonatal Data Set, an NHS Information Standard; DAPP1595) from the Electronic Patient Records of all admissions to NHS neonatal units⁵. The NNRD holds detailed, de-identified demographic (e.g., gestational age), daily (e.g., daily respiratory support), episodic (e.g., transfer within 48 hours), diagnostic (e.g., results of ophthalmic examinations) and outcome (e.g., mortality) data. Data undergo a quality assurance process prior to inclusion in the NNRD. The team managing the NNRD notify neonatal units of potentially erroneous or missing data (e.g., those failing out-of-range, internal consistency, and logic checks) to enable correction of the infants Electronic Patient Record entry. This is then provided to the NNRD team in the next quarterly extract.

We included all admissions over the period 1st January 2013 to 31st December 2022 in the analysis. The NNRD contains data from 2007 but we limited the start of this analysis to 1st January 2013 to coincide with the complete coverage of all neonatal units in England and Wales. We grouped admissions by gestational age, and maternal ethnicity. Babies were excluded from analyses by maternal ethnicity if that information was missing from the NNRD. We categorised gestational age in accordance with World Health Organisation definitions

(EPT: $<28^{+0}$ (weeks ^{days}); VPT: 28^{+0} to 31^{+6}) and used location of birth to assign region. We categorised maternal ethnicity using Office for National Statistics (ONS) definitions⁶. These were Asian (Indian, Pakistani, Bangladeshi, Chinese, other Asian background); Black (African, Caribbean, other Black background); Mixed (White and Black Caribbean, White and Black African, White, and Asian, other Mixed background); Other (Arab, any other background); White (English/Welsh/Scottish/Northern Irish/British, Irish, Gypsy or Irish traveller, other White background).

We obtained denominator data from the ONS for total births, livebirths, and stillbirths, and from the NNRD for total number of infants admitted to neonatal care by gestational age category. We also obtained ONS denominator data for live births and stillbirths by ethnicity. All ONS data cover live births from 1st Jan 2013 to 31st Dec 2022. We also evaluated changes in stillbirth rates to determine if that might explain any changes in EPT or VPT admissions.

We conducted the study under UK Health Research Authority Research Ethics Committee approval 21/LO/0024.

Outcomes

We examined the trend over time in admissions to neonatal care, eight key care processes, and seven core clinical outcomes, nationally and by maternal ethnicity.

The care processes were any antenatal steroid exposure; birth by emergency Caesarean section; birth in a hospital with a Neonatal Intensive Care Unit (providing tertiary neonatal care); intubation in the delivery room; any intubated respiratory support during hospital stay; receiving any own mother's milk at discharge; patent ductus arteriosus (PDA) surgical ligation or closure by device, and postnatal transfers in the first 48 hours after birth (upwards, downwards, and horizontal). Upward transfer is movement from a lower to higher designation neonatal unit; downward transfer is from a higher to lower designation unit; horizontal transfer is movement between units of the same designation.

The clinical outcomes were treated retinopathy of prematurity (ROP); severe necrotising enterocolitis (NEC) defined as requiring surgery or resulting in death⁷; bronchopulmonary dysplasia (BPD) defined as receiving any respiratory support or added oxygen at 36 weeks postmenstrual age; severe brain injury using the UK Department of Health definition as relevant to EPT and VPT infants⁸ (intracranial haemorrhage grade 3 or 4, perinatal stroke, central nervous system infection, kernicterus, seizures or white matter injury); late onset bloodstream infection, defined as a pure growth positive blood culture after 72 hours from birth; mortality; and survival to discharge without severe morbidity (treated ROP, severe NEC, BPD, severe brain injury).

Statistical analyses

We report the number of EPT and VPT admissions to neonatal care and by maternal ethnicity, as absolute counts, and as a proportion of total live births and stillbirths, as absolute counts and rates per thousand total births. Rate of admissions by ethnicity was calculated using baby ethnicity as the denominator because only information on baby ethnicity is available in ONS data. For each clinical outcome and care process, we report the proportion in relation to the

total number of admissions to neonatal care. We report the number of missing values for each analysis.

Babies born at the margins of viability can contribute disproportionately to aggregate outcomes as they have higher mortality and morbidity rates. Hence, to account for any possible increase in the number of such babies admitted to neonatal care over time influencing results, we conducted a sensitivity analysis excluding those born below 24⁺⁰ weeks gestation.

We used a modified Poisson regression for cases with complete data using a robust error variance to estimate the trend for each clinical outcome and care process over the years 2013 to 2022⁹. We adjusted the trend effect for sex, gestational age at birth (weeks), birth weight z-score, and multiplicity. We report Relative Risks (RR) with year 2013 as the reference category and 95% Confidence Intervals (CI) as the output of the Poisson regression. The assumption of the Poisson regression was evaluated by the Pearson deviance statistic. In the case of violation, occurring when the square root of the Pearson deviance statistic differs from 1, a modification on error variance of relative risk was applied. Smoothed line in graphs were plotted across years by estimating the means of locally fitted regression lines. Missing data were not imputed. Data preparation and statistical analyses was performed using R version 4.2.2¹⁰ and STATA version 18.

Patient and Public Involvement

A parent/patient advisory group supports the NNRD and the NNRD Steering Board includes parent representatives. Our focus group work has shown that parents wish to see maximal use of NNRD data and that they consider ethnic disparities of major concern.

Results

Admissions, livebirths, and stillbirths (Figure 1; Table 1): There were 924,676 infants admitted to neonatal care in England and Wales over the ten-year period 1st Jan 2013 to 31st Dec 2022. Of these, 23,829 (2.6%) were EPT and 51,140 (5.5%) were VPT. Figure 1 shows the total number of monthly EPT and VPT admissions. Table 1 shows total births, livebirths, stillbirths, EPT and VPT admissions, and admissions below 24 weeks gestation, by year. The number of admissions of infants born below 24 weeks gestation has almost doubled, from 211 in 2013, to 383 in 2022. In 2022, VPT admissions represented 0.75%, and EPT admissions 0.39%, of total livebirths. Nationally, across the 10-year period there has been no statistically significant change in the rate of EPT and VPT admissions.

Admissions and stillbirths by maternal ethnicity (Figure 2; Supplementary Tables 1A, 1B and 2): There were 19,884 EPT and 42,241 VPT admissions. Of these 3,945 and 8,899 were excluded because of missing maternal ethnicity data. Across all years, mothers of Black ethnicity had the highest rates of EPT and VPT admissions, followed by Asian, then White mothers; the lowest rates were in mothers of Mixed ethnicity (Figure 2). Mothers of Black ethnicity have EPT admission rates that are around double that of Asian mothers, and almost 2.5 times higher than White mothers; VPT admission rates are over 40% higher (Supplementary Tables 1A and 1B). There has been a significant decrease over time in the rate of VPT admissions in Black and Asian mothers but no significant change in EPT admissions. In White mothers, rates of both EPT and VPT admissions have decreased significantly over

time. Rates of EPT admissions have increased over time for mothers in the “Other” ethnicity category. Stillbirth rates fell over time in all ethnic groups except those self-defining as Other but have remained consistently highest for mothers of Black ethnicity, followed by Asian, with the lowest rates in White ethnic groups (Supplementary Table 2).

Care processes (Figure 3; Tables 2A and 2B; Supplementary Table 3): There has been an increase over time in EPT and VPT admissions born by emergency Caesarean section, representing 45% and 62% of EPT and VPT births respectively in 2022. There has also been an increase in EPT admissions receiving any own mother’s milk at discharge, to 39% in 2022. In both EPT and VPT admissions there have been significant decreases over time in delivery room intubation, any intubated respiratory support, and PDA closure by surgery or device. In 2022, for EPT and VPT admissions respectively, 68% and 18% were intubated in the delivery room, 90% and 39% received any intubated respiratory support, and less than 1% had PDA closure by surgery or device.

There were 4,646 EPT and 5,229 VPT transfers within the first 48 hours of birth over the study period. On average, around a fifth of EPT and a tenth of VPT admissions to neonatal units in England and Wales are transferred in the first 48 hours each year (Figure 3). There has been a significant decrease over time in the proportion of early EPT transfers, driven by a reduction in downward, horizontal, and upward transfers. There has been a significant decrease in early VPT horizontal and downward transfers. Sensitivity analyses excluding babies born below 24 weeks gestation did not alter these conclusions (Supplementary Table 3).

Clinical outcomes (Figures 4 and 5; Tables 3A and 3B; Supplementary Table 4): Mortality has decreased significantly over time among EPT admissions. The rate of late onset bloodstream infection has increased. The sensitivity analysis excluding infants born below 24 weeks gestation did not alter these conclusions (Supplementary Table 4).

In VPT admissions, the rate of treated ROP has decreased significantly. There has been no significant change over time in mortality or rates of severe NEC, severe brain injury and survival to discharge without major morbidity.

In 2022, for EPT and VPT admissions respectively, mortality was 22.0% and 2.9%; bronchopulmonary dysplasia 55.4% and 18.5%; severe brain injury 24.1% and 6.0%; late onset bloodstream infection 11.6% and 1.5%; severe NEC 7.9% and 1.2%; treated retinopathy of prematurity 11.8% and 0.5%; and survival to discharge without major morbidity 17.7% and 74.1%.

Care processes by maternal ethnicity (Supplementary Tables 5A, 5B and 6): Among EPT and VPT admissions, there has been an increase in deliveries by emergency Caesarean section in Asian, Black, White, and Other ethnicities; in Mixed ethnicities there has been a reduction only for VPT admissions. Delivery room intubations decreased in Asian, Black, Mixed, Other and White ethnicities among EPT and VPT admissions. There has been an increase in receipt of any maternal milk at discharge in EPT infants born to mothers of White and Mixed ethnicities (Supplementary table 5A and 5B). Sensitivity analyses excluding babies born below 24 weeks gestation did not alter the conclusions (Supplementary table 6).

Clinical outcomes by maternal ethnicity (Supplementary tables 7A, 7B and 8): Among EPT admissions, there has been a significant increase in BPD and decrease in morbidity-free survival in infants of Black maternal ethnicities; a decrease in mortality in Asian and White ethnicities; and an increase in bloodstream infection in White maternal ethnicities.

In sensitivity analyses, excluding infants born below 24 weeks gestation, mortality decreased in Asian and White ethnicities, and BPD increased in Black ethnicities. Late onset bloodstream infection increased in Black and White ethnicities. Severe NEC increased in mixed ethnicity infants.

Among VPT admissions, there has been a significant increase in BPD in infants of Asian maternal ethnicity, and a significant decrease in severe brain injury in mothers of Other ethnicities.

Discussion

We examined trends in EPT and VPT admissions to neonatal units, care processes, and outcomes in England and Wales over a 10-year period. We found evidence of persisting ethnic variation, changing clinical practice, and minimal improvement in clinical outcomes. EPT and VPT admissions have not fallen over time, and mothers of Black and Asian ethnicities continue to have the highest rates.

There has been an increase in the proportion of EPT and VPT admissions delivered by emergency Caesarean section, and a decrease in the proportion intubated in the delivery room and receiving any intubated respiratory support during the neonatal in-patient stay. In EPT admissions, there has been a decrease in PDA closure by surgery or device. These observations are consistent with clinical practice that has moved towards more frequent obstetric intervention and less invasive postnatal neonatal care.

Among EPT and VPT admissions, we also identified a significant increase over time in three care processes that are evidenced to improve outcomes, namely antenatal steroids, birth in a hospital with a tertiary level Neonatal Intensive Care Unit and receiving own mother's milk at discharge. However, rates of severe NEC, and severe brain injury in both EPT and VPT admissions have not changed significantly over time, and there has been no improvement in survival without major morbidity. We did identify a decrease in mortality among EPT admissions, which remained in sensitivity analyses excluding infants born below 24 weeks gestation.

Our study has several strengths. We used quality-assured real-world data from a national database that has a high level of completeness and reliability^{11, 12}. In England and Wales, NHS hospitals provide neonatal care for all EPT and most VPT infants, hence, we were able to include all admissions to neonatal care for England and achieved similarly complete geographically defined population coverage for Wales from 2013. The availability of gestational age data enabled results to be reported separately for EPT and VPT admissions and for sensitivity analyses to be conducted excluding infants below 24 weeks gestation. Our use of a non-parametric test provided flexibility to characterise non-linear trends. To assess whether alterations in stillbirth rates might have influenced change in admissions, we provided data on total live and stillbirths over the study period. We used objective metrics and as the

NNRD incorporates a consistent approach to derive complex outcomes such as BPD, NEC and severe brain injury, any likelihood of reporting bias is minimised. We adjust trends for sex, gestational age, birth weight z-score, and multiplicity; as these are well, recognised influences on outcomes. We also acknowledge weaknesses. Seventeen percent of maternal ethnicity data were missing. We do not know the proportion of missing data for late onset bloodstream infection where a null entry in the NNRD may represent non-occurrence or non-entry into the patient Electronic Patient Record. We therefore did not include late onset bloodstream infection in the composite “survival without major morbidity” and are therefore unable to exclude the possibility that the significant increase in late onset infection in EPT admissions might be due to changes in data entry and better case ascertainment.

Our study raises several important issues. Marked ethnic disparity remains evident with Black and Asian mothers at persisting disadvantage in relation to admissions, stillbirths, care processes and outcomes. Previous studies have shown that compared to mothers of White ethnicity, stillbirth rates are around twice as high for mothers of Black ethnicity and 60% higher for Asian mothers¹³. Our study, extending over 10 years, highlights the lack of change over time despite this recognition. The delivery of high-quality care processes to mothers of Black ethnicity has remained largely unchanged, with the only improvement an increase in VPT births at a hospital with a tertiary level Neonatal Intensive Care Unit. Additionally, in sensitivity analyses excluding infants born below 24 weeks gestation, EPT mortality decreased in Asian and White, but not Black ethnicities. We relied on standard NHS ethnicity classification, which in principle is self-defined. However, this construct has major weaknesses as it assumes a shared set of cultural attributes, which in modern-day Britain may not hold true. Additionally, healthcare professionals often assign ethnicity, which increases the possibility of misclassification. Taken together, our data highlight the need for research to identify the separate contributions of genetic, cultural, and economic influences on perinatal outcomes.

There has been a reduction in treated ROP in VPT infants, but the lack of improvement in other outcomes, the rise in BPD, and static rates of severe NEC, severe brain injury, mortality, and survival to discharge without major morbidity, are concerning. The UK introduced a National Neonatal Audit Programme in 2007 that evaluates adherence to key care processes and monitors outcomes such as bloodstream infection and BPD¹⁴. Several national and regional quality improvement initiatives aiming to improve perinatal outcomes have also been implemented, such as the East of England care bundle to increase preterm breast-feeding¹⁵, and the “Saving Babies Lives” care bundle, initiated in 2014 to halve stillbirths in England from 4.7 per thousand to 2.3 per thousand by 2030¹⁶. Several national “ambitions” and targets have also been set during the period covered by our study. These include a national ambition announced by the UK Secretary of State for Health in 2015 to reduce perinatal brain injuries by 20% by 2020 and 50% by 2030 and halve stillbirths and neonatal deaths by 2030¹⁷. In 2019, the NHS Long Term Plan included a target to halve neonatal deaths by 2025¹⁸. In the same year, following an evidence review, NHS England launched an implementation plan to improve neonatal services and reduce disparities¹⁹. Given these initiatives, the lack of evidence of substantially improved outcomes is disappointing. It is possible that alterations in the complexity of the neonatal population may have contributed to the lack of improvement. However, other than for the decrease in EPT mortality in Asian and White ethnicity infants

following exclusion of those born below 24 weeks gestation, this was not borne out by the sensitivity analyses. Additionally, we have previously shown little change in preterm birthweights over the last 12 years²⁰. Audit and quality improvement programmes can be beneficial, but can also be costly, impose burdens on clinical teams, and benefits seen in some settings may not necessarily translate well across all locations, hence an inherent assumption of universal benefit may not be justified, and such programmes should incorporate a priori evaluation of impacts.

In keeping with observations from around the world, the proportion of EPT and VPT infants with BPD is increasing, the reasons for which are uncertain but are likely to be multifactorial, and include changes in definitions, assessment of oxygen requirements, and contributing pathophysiological processes²¹. The decrease over time in EPT early postnatal transfers is also welcome. However, the proportion of EPT and VPT infants undergoing early postnatal transfer remains high at around 20% and 10% respectively. This is a concern as postnatal transfer in the first days after birth increases the risk of severe brain injury²². Our data indicate need to improve processes for transfer of mothers to a centre with tertiary neonatal care prior to delivery of a high-risk infant. Our data also highlight the profound impact of decreasing gestational age on the likelihood of intact survival, with less than a fifth of EPT admissions surviving to discharge without major morbidity. This points to the need for greater effort to reduce preterm births. However, though preterm birth is widely perceived as a medical issue, healthcare interventions have been largely ineffective in reducing rates. Of note, we identified a highly significant fall in EPT births during the COVID19 pandemic²³. We therefore suggest that a major focus for future research should be identification of the causal determinants underpinning the strong associations between preterm birth and socio-economic and environmental conditions, as public health and societal policies may prove to be more effective than medical interventions.

International comparisons of perinatal and preterm outcomes are hampered by a lack of consistency in definitions and denominators, and hospital as opposed to population-based reports. Varying attitudes to non-initiation or withdrawal of life-sustaining interventions also hamper international comparisons of perinatal and preterm outcomes. Thus, data for treated ROP from the USA refer to rates of 6-7% in “high-risk” or “low-birthweight” categories making precise comparison with our data difficult²⁴. A comparison of ROP treatment rates in 24⁺⁰-27⁺⁶ week gestation infants across eleven high-income countries showed substantial variation, ranging from 4.3% in Switzerland to 30.4% in Japan²⁵. Of note, Swiss rates remained unchanged over a decade²⁶. The controversy around whether babies born below 24 weeks gestation should receive intensive care, extends to whether this should be continued in the face of severe brain injury or other conditions considered incompatible with survival or quality of life, and if data on these infants should be included in national statistics. These considerations have evolved and will continue to evolve over time but indicate that both within and between country comparisons relating to outcomes of extremely low gestational age infants must consider the possibility that differences do not necessarily reflect quality of care, but rather, varying ethical and legal perspectives, and inclusion criteria.

Conclusions

In conclusion, ethnic disparities in EPT and VPT admissions to neonatal care in England and Wales, the delivery of care processes, and outcomes, have persisted over the last decade, and improved delivery of high-quality care processes has not been accompanied by substantive decreases in mortality or major morbidities.

Contributor: NM did Funding acquisition. NM, SU, CB, and CG initiated the research question and did validation; All authors did literature search. JL and KO prepared the data for analysis; MC and JL conducted the study design and analysis; MC developed the statistical analysis and made initial version of tables and figures. NM wrote the first draft of the paper; all authors reviewed and contributed to subsequent drafts and approved the final version for submission. All authors confirm they had full access to all the data in the study and accept responsibility to submit for publication.

Funding: This work represents independent research supported in part by the Imperial NIHR Biomedical Research Centre. The funder had no influence over study design, collection, analysis, and interpretation of the data, in writing the report and in the decision to submit this article for publication.

For the purpose of open access, the author has applied a ‘Creative Commons Attribution (CC BY) licence to any Author Accepted Manuscript (AAM) version arising’.

Competing interests: All authors have completed the ICMJE uniform disclosure form at <http://www.icmje.org/disclosure-of-interest/> and declare support in part from the Imperial NIHR Biomedical Research Centre. NM is the chief investigator for the National Neonatal Research Database; JL and KO are data analysts and MC is senior statistician for the National Neonatal Research Database.

Data sharing statement: The study data file is available upon reasonable request subject to approval by the NNRD Steering Board; please contact NM stating the purpose of the request.

Transparency statement

The lead author (the manuscript's guarantor) affirms that the manuscript is an honest, accurate, and transparent account of the reported study.

Acknowledgements: We gratefully acknowledge the contributions of UK Neonatal Collaborative neonatal units to the National Neonatal research Database; a full list of UK Neonatal Collaborative neonatal units and lead clinicians is available at the National Neonatal Research Database website (<https://www.imperial.ac.uk/neonatal-data-analysis-unit/neonatal-data-analysis-unit/list-of-national-neonatal-units/>)

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Figure legends

Figure 1

Dots represent the number of Extremely Preterm and Very Preterm admissions per month in England and Wales, 2013 to 2022. Solid lines and shading represent the mean and 95% Confidence Interval

Figure 2

Extremely Preterm and Very Preterm admissions as a proportion of livebirths by maternal ethnicity and year, 2013 to 2022; at the time of writing, ONS live birth data for 2022 were not available

Figure 3

Proportion of Extremely Preterm and Very Preterm admissions transferred within the first 48 hours, 2013 to 2022

Figure 4

Dots represent the proportion with A) bronchopulmonary dysplasia, B) late onset bloodstream infection and C) treated retinopathy of prematurity for Extremely Preterm and Very Preterm admissions in England and Wales, 2013 to 2022; solid lines and shading represent the mean and 95% Confidence Interval

Figure 5

Dots represent the proportion with A) severe necrotising enterocolitis, B) severe brain injury, C) mortality, D) survival without major morbidity, for Extremely Preterm and Very Preterm admissions in England and Wales, 2013 to 2022; solid lines and shading represent the mean and 95% Confidence Interval

Table 1**Total births, live births, stillbirths, and admissions by year, England and Wales**

VPT: Very Preterm; EPT: Extremely Preterm; RR: Risk ratio; CI: Confidence Interval (RR; 95% CI); estimated by modified Poisson regression; reference year is 2013

Year	Total births	Live births	Stillbirths N (rate per thousand total births); RR (95% CI)	VPT admissions (28w - <32w gestation) N (% of live births); RR (95% CI)	EPT admissions (21w - <28w gestation) N (% of live births); RR (95% CI)	<24 ⁺⁰ w gestation admissions N (% of live births)
2013	701,796	698,512	3,284 (4.68) Ref	5,410 (0.77) Ref	2,458 (0.35) Ref	211 (0.03)
2014	698,487	695,233	3,254 (4.66) 0.99 (0.95 to 1.04)	5,352 (0.77) 0.99 (0.94 to 1.05)	2,407 (0.35) 0.99 (0.90 to 1.07)	237 (0.03)
2015	700,999	697,852	3,147 (4.49) 0.96 (0.91 to 1.01)	5,526 (0.79) 1.02 (0.96 to 1.08)	2,484 (0.36) 1.01 (0.94 to 1.08)	225 (0.03)
2016	699,383	696,271	3,112 (4.45) 0.95 (0.91 to 0.99)	5,452 (0.78) 1.01 (0.96 to 1.06)	2,496 (0.36) 1.02 (0.96 to 1.08)	223 (0.03)
2017	681,979	679,106	2,873 (4.21) 0.90 (0.86 to 0.95)	5,440 (0.80) 1.03 (0.98 to 1.09)	2,418 (0.36) 1.01 (0.93 to 1.10)	261 (0.04)
2018	659,765	657,076	2,689 (4.08) 0.87 (0.83 to 0.92)	5,058 (0.77) 0.99 (0.93 to 1.06)	2,373 (0.36) 1.03 (0.94 to 1.11)	260 (0.04)
2019	642,892	640,370	2,522 (3.92) 0.84 (0.80 to 0.88)	5,053 (0.79) 1.02 (0.96 to 1.07)	2,346 (0.37) 1.04 (0.97 to 1.11)	285 (0.04)
2020	616,307	613,936	2,371 (3.85) 0.82 (0.78 to 0.87)	4,581 (0.75) 0.96 (0.89 to 1.03)	2,164 (0.35) 1.0 (0.92 to 1.08)	292 (0.05)
2021	627,425	624,828	2,597 (4.14) 0.88 (0.84 to 0.93)	4,698 (0.75) 0.97 (0.90 to 1.04)	2,330 (0.37) 1.06 (0.98 to 1.15)	312 (0.05)
2022	607,912	605,479	2,433 (4.00) 0.85 (0.81 to 0.90)	4,570 (0.75) 0.97 (0.92 to 1.04)	2,353 (0.39) 1.10 (1.0 to 1.22)	383 (0.06)

Table 2A**Care processes by year; extremely preterm (EPT) admissions**

Adjusted risk ratio and 95% confidence interval (aRR; 95% CI) estimated by modified Poisson regression; reference year is 2013; adjustment variables are sex, gestational age (weeks), birth weight z-score, and multiplicity; this analysis includes 23,829 EPT admissions

	2013 % (95% CI)	2014 % (95% CI)	2015 % (95% CI)	2016 % (95% CI)	2017 % (95% CI)	2018 % (95% CI)	2019 % (95% CI)	2020 % (95% CI)	2021 % (95% CI)	2022 % (95% CI)	Overall trend
Any antenatal steroids aRR (95% CI)	87.5 (85.9,89.1)	89.1 (88.1,90.1)	88.7 (87.2,90.2)	88.8 (87.1,90.4)	89.9 (88.5,91.3)	90.2 (89.9,91.4)	91.3 (90.4,92.1)	92.7 (91.0,94.3)	92.3 (91.1,93.5)	89.5 (88.0,91.0)	
Ref				1.02 (1.0 to 1.03)	1.01 (1.0 to 1.02)	1.01 (1.0 to 1.02)	1.02 (1.01 to 1.04)	1.03 (1.01 to 1.04)	1.04 (1.03 to 1.05)	1.06 (1.04 to 1.07)	1.06 (1.04 to 1.07)
Birth in hospital with a Neonatal Intensive Care Unit (tertiary neonatal unit) aRR (95% CI)	67.8 (65.8,69.8)	68.2 (66.8,69.5)	69.0 (66.5,71.5)	70.2 (68.3,72.1)	70 (68.1,71.8)	72.2 (70.0,74.3)	73.8 (71.8,75.7)	76.6 (74.7,78.6)	75.2 (72.6,77.8)	74.5 (72.7,76.2)	
Ref				1.0 (0.98 to 1.03)	1.01 (0.99 to 1.04)	1.04 (1.01 to 1.07)	1.03 (1.0 to 1.06)	1.06 (1.03 to 1.09)	1.08 (1.05 to 1.11)	1.12 (1.10 to 1.15)	1.11 (1.08 to 1.14)
Birth by emergency Caesarean section aRR (95% CI)	36.0 (33.8,38.2)	35.4 (33.5,37.3)	37.3 (35.4,39.1)	37.7 (35.6,39.8)	36.5 (34.2,38.8)	38.7 (36.8,40.7)	39.9 (37.3,42.5)	41.4 (39.1,43.8)	47.1 (44.6,49.6)	45 (43.7,46.4) 1.36 (1.29 to 1.43)	1.04 (1.03 to 1.04)
Ref		1.0 (0.94 to 1.06)	1.05 (0.99 to 1.11)	1.05 (0.99 to 1.11)	1.05 (0.99 to 1.11)	1.03 (0.97 to 1.09)	1.10 (1.04 to 1.16)	1.11 (1.05 to 1.17)	1.18 (1.12 to 1.25)		
Intubation in delivery room aRR (95% CI)	87.7 (86.1,89.3)	87.3 (86.0,88.5)	87.2 (86.1,88.2)	84.3 (83.0,85.7)	82.9 (81.7,84.1)	79.4 (78.1,80.7)	76.5 (74.1,78.9)	73.9 (72.4,75.3)	68.8 (65.9,71.6)	67.7 (64.9,70.5)	0.97 (0.96 to 0.97)
Ref		0.99 (0.98 to 1.0)	0.99 (0.98 to 1.0)	0.96 (0.95 to 0.98)	0.94 (0.92 to 0.95)	0.90 (0.88 to 0.91)	0.87 (0.85 to 0.88)	0.83 (0.81 to 0.84)	0.77 (0.76 to 0.79)	0.75 (0.74 to 0.77)	
Transfer within first 48 hours (any direction) aRR (95% CI)	21.2 (19.3, 23.1)	21.1 (19.4,22.8)	20.7 (18.4,23.0)	20.3 (18.6,22.0)	20.8 (19.2,22.4)	20.0 (18.5,21.5)	18.4 (17.0,19.8)	15.8 (14.1,17.5)	17.6 (15.2,20.0)	18.1 (16.5,19.7)	0.97 (0.96 to 0.98)
Ref		0.98 (0.89 to 1.09)	0.97 (0.87 to 1.07)	0.96 (0.87 to 1.06)	0.99 (0.89 to 1.10)	0.94 (0.84 to 1.04)	0.87 (0.78 to 0.97)	0.76 (0.68 to 0.86)	0.84 (0.75 to 0.94)	0.85 (0.76 to 0.95)	
Transfer within first 48 hours (upwards) aRR (95% CI)	19.1 (17.4, 20.8)	19.1 (17.7,20.5)	18.7 (16.6,20.8)	18.2 (16.7,19.7)	18.8 (17.2,20.4)	18.3 (16.5,20.1)	16.9 (15.5,18.3)	15.1 (13.5,16.7)	16.4 (14.0,18.8)	16.8 (15.3,18.3)	0.98 (0.97 to 0.99)
Ref		0.99 (0.89 to 1.11)	0.97 (0.87 to 1.08)	0.96 (0.86 to 1.07)	0.99 (0.89 to 1.11)	0.95 (0.85 to 1.06)	0.88 (0.79 to 0.99)	0.81 (0.72 to 0.92)	0.86 (0.77 to 0.97)	0.87 (0.77 to 0.98)	

Transfer within first 48 hours (horizontal) aRR (95% CI)	1.8 (1.3, 2.3) Ref	1.7 (1.1, 2.3) 0.87 (0.56 to 1.34)	1.8 (1.2, 2.4) 1.01 (0.67 to 1.54)	2.0 (1.7, 2.3) 1.04 (0.69 to 1.57)	1.9 (1.3, 2.5) 1.05 (0.69 to 1.60)	1.4 (1.1, 1.7) 0.71 (0.44 to 1.14)	1.2 (0.9, 1.5) 0.74 (0.46 to 1.18)	0.7 (0.5, 0.9) 0.28 (0.14 to 0.56)	1.2 (0.7, 1.7) 0.57 (0.34 to 0.95)	0.9 (0.5, 1.3) 0.45 (0.26 to 0.79)	0.91 (0.88 to 0.95)
Transfer within first 48 hours (downwards) aRR (95% CI)	1.0 (0.7, 1.3) Ref	1.0 (0.7, 1.3) 0.60 (0.30 to 1.19)	0.5 (0.5, 0.5) 0.09 (0.02 to 0.38)	0.7 (0.4, 1.0) 0.26 (0.11 to 0.65)	0.8 (0.5, 1.1) 0.23 (0.09 to 0.61)	0.7 (0.2, 1.2) 0.19 (0.06 to 0.55)	1.1 (1.1, 1.1) 0.19 (0.07 to 0.57)	0.5 (0.5, 0.5) 0.10 (0.02 to 0.45)	0.5 (0.4, 0.6) 0.10 (0.02 to 0.41)	0.5 (0.4, 0.6) 0.25 (0.10 to 0.67)	0.79 (0.71 to 0.89)
Any intubated respiratory support aRR (95% CI)	96.8 (96.1,97.4) Ref	96.4 (95.7,97.1) 0.99 (0.99 to 0.99)	95.9 (95.0,96.7) 0.99 (0.98 to 0.99)	95.2 (94.3,96.1) 0.98 (0.97 to 0.98)	95.5 (94.6,96.4) 0.98 (0.97 to 0.98)	94.1 (93.5,94.8) 0.97 (0.96 to 0.97)	93.2 (92.4,94) 0.96 (0.95 to 0.96)	92.8 (91.9,93.8) 0.95 (0.94 to 0.96)	90.4 (89.3,91.5) 0.93 (0.92 to 0.94)	90.3 (88.9,91.7) 0.92 (0.92 to 0.93)	0.99 (0.99 to 0.99)
PDA closure by ligation or device aRR (95% CI)	5.6 (4.6,6.6) Ref	4.0 (3.4,4.5) 0.72 (0.56 to 0.92)	4.4 (3.6,5.2) 0.77 (0.60 to 0.98)	3.5 (2.9,4.2) 0.63 (0.49 to 0.82)	2.8 (2.1,3.5) 0.50 (0.37 to 0.66)	2.8 (1.9,3.8) 0.47 (0.35 to 0.63)	2.0 (1.4,2.6) 0.34 (0.24 to 0.47)	1.4 (1.0,1.8)0.24 (0.16 to 0.36)	1.5 (1.1,1.9)0.26 (0.18 to 0.38)	0.6 (0.2,1.0)0.11 (0.06 to 0.18)	0.83 (0.81 to 0.85)
Receiving any own mother's milk at discharge aRR (95% CI)	37.7 (35.7,39.7) Ref	36.7 (34.7,38.7) 0.97 (0.92 to 1.03)	37.0 (35.0,38.9) 0.97 (0.92 to 1.02)	38.8 (36.9,40.7) 1.02 (0.97 to 1.08)	38.2 (35.7,40.6) 0.99 (0.94 to 1.04)	40.1 (37.7,42.5) 1.05 (0.99 to 1.10)	39.1 (36.3,42) 1.05 (0.99 to 1.10)	42.4 (39.9,44.9) 1.15 (1.10 to 1.21)	39.2 (37.3,41.0) 1.06 (1.01 to 1.12)	39.1 (36.8,41.4) 1.10 (1.05 to 1.16)	1.02 (1.01 to 1.02)

Table 2B**Care processes by year; very preterm (VPT) admissions**

Adjusted risk ratio and 95% confidence interval (aRR; 95% CI) estimated by modified Poisson regression; reference year is 2013; adjustment variables are sex, gestational age (weeks), birth weight z-score, and multiplicity; this analysis includes 51,140 VPT admissions

	2013 % (95% CI)	2014 % (95% CI)	2015 % (95% CI)	2016 % (95% CI)	2017 % (95% CI)	2018 % (95% CI)	2019 % (95% CI)	2020 % (95% CI)	2021 % (95% CI)	2022 % (95% CI)	Overall trend
Any antenatal steroids aRR (95% CI)	89.7 (88.6,90.8) Ref	89.6 (88.9,90.3) 0.99 (0.98 to 1.0)	90.6 (89.9,91.2) 1.0 (1.0 to 1.01)	90.1 (89.5,90.7) 1.0 (0.99 to 1.0)	91.1 (90.2,92) 1.01 (1.0 to 1.02)	92.0 (91.3,92.8) 1.02 (1.01 to 1.03)	92.7 (91.9,93.5) 1.03 (1.02 to 1.03)	93.2 (92.5,93.8) 1.03 (1.02 to 1.04)	92.5 (91.8,93.1) 1.03 (1.02 to 1.04)	92.3 (91.2,93.5) 1.03 (1.02 to 1.03)	1.0 (1.0 to 1.0)
Birth in hospital with a Neonatal Intensive Care Unit (tertiary level unit) aRR (95% CI)	46.0 (44.0,48.1) Ref	47.7 (46.2,49.1) 1.03 (99 to 1.07)	49.1 (46.9,51.2) 1.06 (1.03 to 1.10)	48.5 (46.2,50.9) 1.05 (1.02 to 1.09)	49.6 (47.7,51.5) 1.07 (1.04 to 1.11)	49.8 (48.5,51.0) 1.08 (1.04 to 1.12)	49.8 (48.5,51.1) 1.08 (1.04 to 1.12)	49.6 (48.2,51.0) 1.08 (1.04 to 1.11)	51.2 (50.3,52.1) 1.12 (1.08 to 1.15)	49.5 (47.9,51.1) 1.08 (1.04 to 1.12)	1.01 (1.0 to 1.01)
Birth by emergency Caesarean section aRR (95% CI)	53.8 (53.0,54.7) Ref	56.3 (54.0,58.7) 1.03 (1.0 to 1.06)	55.3 (54.2,56.5) 1.02 (0.99 to 1.04)	54.5 (53.4,55.7) 1.01 (0.98 to 1.03)	56.5 (55.7,57.4) 1.04 (1.02 to 1.07)	57.1 (55.2,59.0) 1.06 (1.04 to 1.09)	56.6 (54.6,58.6) 1.04 (1.02 to 1.07)	58.2 (57.4,59.0) 1.10 (1.07 to 1.13)	59.0 (57.3,60.7) 1.14 (1.11 to 1.17)	61.9 (59.8,64) 1.20 (1.17 to 1.23)	1.02 (1.01 to 1.02)
Intubation in delivery room aRR (95% CI)	35.9 (35.1,36.7) Ref	33.4 (32.3,34.4) 0.94 (0.90 to 0.98)	33.1 (31.6,34.6) 0.94 (0.90 to 0.98)	32.6 (31.9,33.3) 0.91 (0.87 to 0.95)	30.1 (29.31.2) 0.84 (0.80 to 0.88)	27.8 (26.4,29.3) 0.78 (0.74 to 0.82)	25.5 (23.6,27.4) 0.71 (0.68 to 0.75)	23.8 (22.4,25.2) 0.65 (0.62 to 0.69)	22.5 (21.2,23.9) 0.63 (0.59 to 0.67)	17.9 (16.5,19.3) 0.50 (0.47 to 0.54)	0.94 (0.93 to 0.94)
Transfer within first 48 hours (any direction) aRR (95% CI)	9.6 (8.7, 10.5) Ref	10.0 (9.1, 10.9) 1.05 (0.94 to 1.17)	11.3 (10.5,12.1) 1.19 (1.07 to 1.33)	10.3 (9.7, 10.9) 1.07 (0.96 to 1.19)	10.3 (9.3, 11.3) 1.08 (0.96 to 1.20)	10.3 (9.2, 11.4) 1.08 (0.97 to 1.21)	10.5 (9.4, 11.6) 1.10 (0.98 to 1.23)	9.4 (8.3, 10.5) 0.98 (0.87 to 1.10)	10.4 (9.0, 11.8) 1.10 (0.98 to 1.23)	9.9 (9.1, 10.7) 1.03 (0.92 to 1.16)	0.99 (0.98 to 1.01)
Transfer within first 48 hours (upwards) aRR (95% CI)	6.6 (5.9, 7.3) Ref	6.7 (6.1, 7.3) 1.04 (0.90 to 1.19)	7.5 (6.7, 8.3) 1.17 (1.02 to 1.34)	6.5 (5.9, 7.1) 1.0 (0.87 to 1.16)	7.1 (6.1, 8.1) 1.10 (0.95 to 1.26)	6.6 (5.6, 7.6) 1.03 (0.89 to 1.19)	7.1 (6.4, 7.8) 1.10 (0.96 to 1.27)	6.9 (6.2, 7.6) 1.06 (0.91 to 1.22)	7.1 (6.3, 7.9) 1.09 (0.95 to 1.26)	7.2 (6.4, 8.0) 1.10 (0.96 to 1.28)	1.0 (0.99 to 1.02)

Transfer within first 48 hours (horizontal) aRR (95% CI)	1.3 (1.,0 1.6)	1.6 (1.3, 1.9)	1.8 (1.4, 2.2)	1.8 (1.4, 2.2)	1.5 (1.1, 1.9)	1.6 (1.4, 1.8)	1.2 (0.8, 1.6)	1.0 (0.7, 1.3)	1.2 (0.8, 1.6)	1.3 (1.0, 1.6)	
Transfer within first 48 hours (downwards) aRR (95% CI)	1.6 (1.2, 2.0)	1.6 (1.0, 2.2)	2.0 (1.4, 2.6)	2.0 (1.6, 2.4)	1.6 (1.2, 2.0)	1.7 (1.3, 2.1)	1.5 (0.9, 2.1)	1.3 (0.9, 1.7)	1.6 (0.7, 2.5)	1.2 (0.9, 1.5)	0.97 (0.95 to 0.99)
Any intubated respiratory support aRR (95% CI)	54.2 (53.5,54.9)	52.2 (51.1,53.3)	51.9 (50.7,53.1)	51.9 (50.8,52.9)	50.9 (49.6,52.3)	49.5 (47.8,51.3)	45.7 (43.7,47.8)	44.5 (43.5,45.4)	43.1 (41.3,45)	38.7 (37.1,40.3)	
PDA closure by ligation or device aRR (95% CI)	0.3 (0.1,0.4) Ref	0.2 (0.0,0.3) 0.61 (0.27 to 1.40)	0.2 (0.1,0.3) 0.59 (0.26 to 1.34)	0.3 (0.2,0.5) 1.17 (0.59 to 2.32)	0.3 (0.2,0.4) 0.89 (0.43 to 1.85)	0.1 (0.1,0.2) 0.43 (0.17 to 1.11)	0.1 (0.0,0.2) 0.28 (0.09 to 0.83)	0.1 (0.0,0.2) 0.38 (0.14 to 1.05)	0.1 (0.0,0.3) 0.55 (0.22 to 0.135)	0.0 (0.0,0.0) 0.0 (0.0 to 0.0)	0.87 (0.81 to 0.93)
Receiving any own mother's milk at discharge aRR (95% CI)	56.7 (55.5,57.9)	55.6 (53.7,57.5)	56.0 (54.1,57.8)	56.1 (54.4,57.9)	55.9 (54.5,57.3)	56.5 (55.0,58.0)	59.4 (58.0,60.7)	60.6 (59.2,61.9)	59.9 (58.2,61.5)	60.5 (59.1,61.9)	
				1.0 (0.97 to 1.02)	0.98 (0.96 to 1.01)	0.99 (0.97 to 1.02)		1.04 (1.02 to 1.07)	1.09 (1.06 to 1.12)	1.05 (1.02 to 1.08)	1.07 (1.04 to 1.09)
											1.01 (1.0 to 1.01)

Table 3A**Clinical outcomes by year; extremely preterm (EPT) admissions**

Adjusted risk ratio and 95% confidence interval (aRR; 95% CI) estimated by modified Poisson regression; reference year is 2013; adjustment variables are sex, gestational age (weeks), birth weight z-score, and multiplicity; this analysis included 23,829 EPT admissions

	2013 % (95% CI)	2014 % (95% CI)	2015 % (95% CI)	2016 % (95% CI)	2017 % (95% CI)	2018 % (95% CI)	2019 % (95% CI)	2020 % (95% CI)	2021 % (95% CI)	2022 % (95% CI)	Overall trend
Mortality	21.6 (19.3,23.9)	21.3 (20.0,22.6)	20.2 (18.3,22.1)	20.0 (18.5,21.6)	20.1 (18.7,21.5)	20.0 (18.6,21.4)	20.2 (18.7,21.8)	20.0 (18,22.1) 0.82 (0.74 to 0.92)	21.8 (20.5,23.1)	22.0 (20.6,23.3)	0.98 (0.97 to 0.99)
aRR (95% CI)	Ref	0.96 (0.87 to 1.06)	0.91 (0.82 to 1.0)	0.94 (0.85 to 1.04)	0.89 (0.81 to 0.99)	0.89 (0.81 to 0.98)	0.87 (0.79 to 0.96)	0.93 (0.85 to 1.03)	0.93 (0.85 to 1.03)	0.83 (0.75 to 0.92)	
Bronchopulmonary dysplasia	54.6 (52.2,57.1)	55.0 (53.4,56.5)	54.2 (52.3,56.2)	54.1 (52.5,55.8)	56.0 (54.3,57.7)	54.8 (52.7,56.8)	57.7 (54.6,60.8)	59.2 (57.3,61.2)	55.6 (53.7,57.6)	55.4 (53.5,57.3)	1.0 (1.0 to 1.01)
aRR (95% CI)	Ref	1.01 (0.97 to 1.06)	1.0 (0.96 to 1.04)	1.0 (0.96 to 1.04)	1.03 (0.98 to 1.07)	1.0 (0.96 to 1.04)	1.06 (1.02 to 1.10)	1.10 (1.05 to 1.14)	1.04 (1.0 to 1.08)	1.05 (1.0 to 1.09)	
Severe brain injury	22.7 (20.5,24.9)	23.4 (22.3,24.5)	23.1 (21.4,24.8)	23.2 (21.9,24.5)	25.3 (23.6,27) 1.10 (1.0 to 1.20)	24.1 (22.5,25.8)	23.2 (21.3,25) 1.0 (0.91 to 1.10)	22.4 (20.4,24.4)	24.0 (22.2,25.8)	24.1 (22.4,25.7)	1.0 (0.99 to 1.01)
aRR (95% CI)	Ref	1.02 (0.93 to 1.12)	1.0 (0.91 to 1.10)	1.02 (0.93 to 1.12)		1.04 (0.94 to 1.14)	0.96 (0.87 to 1.06)	1.05 (0.95 to 1.15)	0.99 (0.90 to 1.09)		
Late onset bloodstream infection	9.7 (8.4,11.0)	8.1 (7.0,9.2)	8.7 (7.1,10.2)	10.5 (9.5,11.6)	10.6 (9.5,11.6)	10.8 (9.7,11.9)	11.3 (9.7,12.9)	13.9 (12.1,15.7)	11.5 (10.7,12.3)	11.6 (10.2,12.9)	1.04 (1.02 to 1.05)
aRR (95% CI)	Ref	0.85 (0.71 to 1.0)	0.88 (0.74 to 1.05)	1.10 (0.94 to 1.3)	1.10 (0.93 to 1.3)	1.08 (0.92 to 1.27)	1.15 (0.98 to 1.36)	1.40 (1.20 to 1.64)	1.17 (1.0 to 1.38)	1.16 (0.99 to 1.36)	
Severe necrotising enterocolitis	8.3 (6.9,9.7)	7.8 (6.8,8.9)	8.3 (6.6,9.9)	7.8 (7.1,8.4)	10.0 (8.5,11.5)	8.0 (7.0,8.9)	9.7 (8.9,10.6)	8.4 (7.3,9.5)	8.2 (7.1,9.3)	7.9 (6.8,9.0)	0.99 (0.98 to 1.01)
aRR (95% CI)	Ref	0.94 (0.78 to 1.13)	0.98 (0.81 to 1.18)	0.95 (0.79 to 1.14)	1.18 (0.99 to 1.41)	0.93 (0.77 to 1.12)	1.12 (0.94 to 1.34)	0.96 (0.79 to 1.17)	0.96 (0.79 to 1.16)	0.90 (0.74 to 1.10)	
Treated retinopathy of prematurity	11.6 (10.6,12.5)	12.1 (10.9,13.3)	13.0 (10.9,15.0)	9.6 (8.5,10.6) 0.83 (0.71 to 0.97)	9.0 (7.7,10.3) 0.75 (0.64 to 0.88)	10.0 (8.2,11.7)	11.3 (10.1,12.5)	11.4 (9.8,13) 0.94 (0.81 to 1.10)	12.3 (10.9,13.8)	11.8 (10.2,13.3)	0.99 (0.98 to 1.01)
aRR (95% CI)	Ref	1.03 (0.89 to 1.19)	1.09 (0.94 to 1.25)			0.81 (0.69 to 0.95)	0.93 (0.80 to 1.08)	1.03 (0.89 to 1.19)	1.03 (0.89 to 1.19)	0.96 (0.83 to 1.11)	

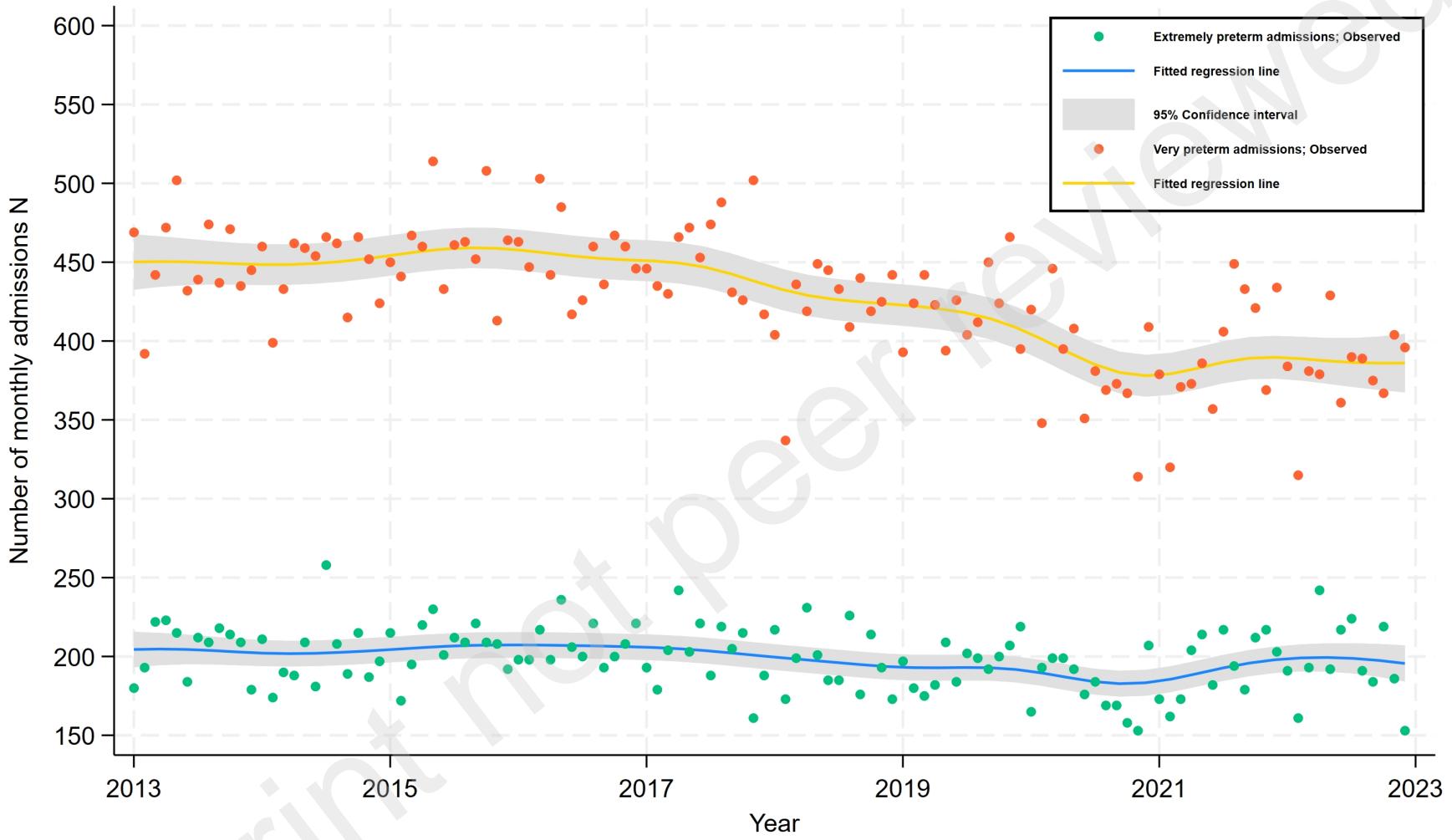
Survival without major morbidity aRR (95% CI)	18.3 (16.6,20.0) Ref	19.6 (17.8,21.3) 1.08 (0.97 to 1.19)	20.2 (18.4,21.9) 1.10 (1.0 to 1.22)	20.9 (18.7,23) 1.10 (0.99 to 1.21)	18.6 (17.4,19.9) 1.02 (0.92 to 1.13)	21.0 (19.3,22.8) 1.18 (1.07 to 1.31)	18.0 (15.8,20.2) 1.03 (0.93 to 1.14)	17.6 (15.8,19.4) 0.99 (0.89 to 1.10)	18.2 (16.3,20.1) 1.0 (0.91 to 1.12)	17.7 (15.9,19.5) 1.06 (0.95 to 1.18)	0.99 (0.98 to 1.0)
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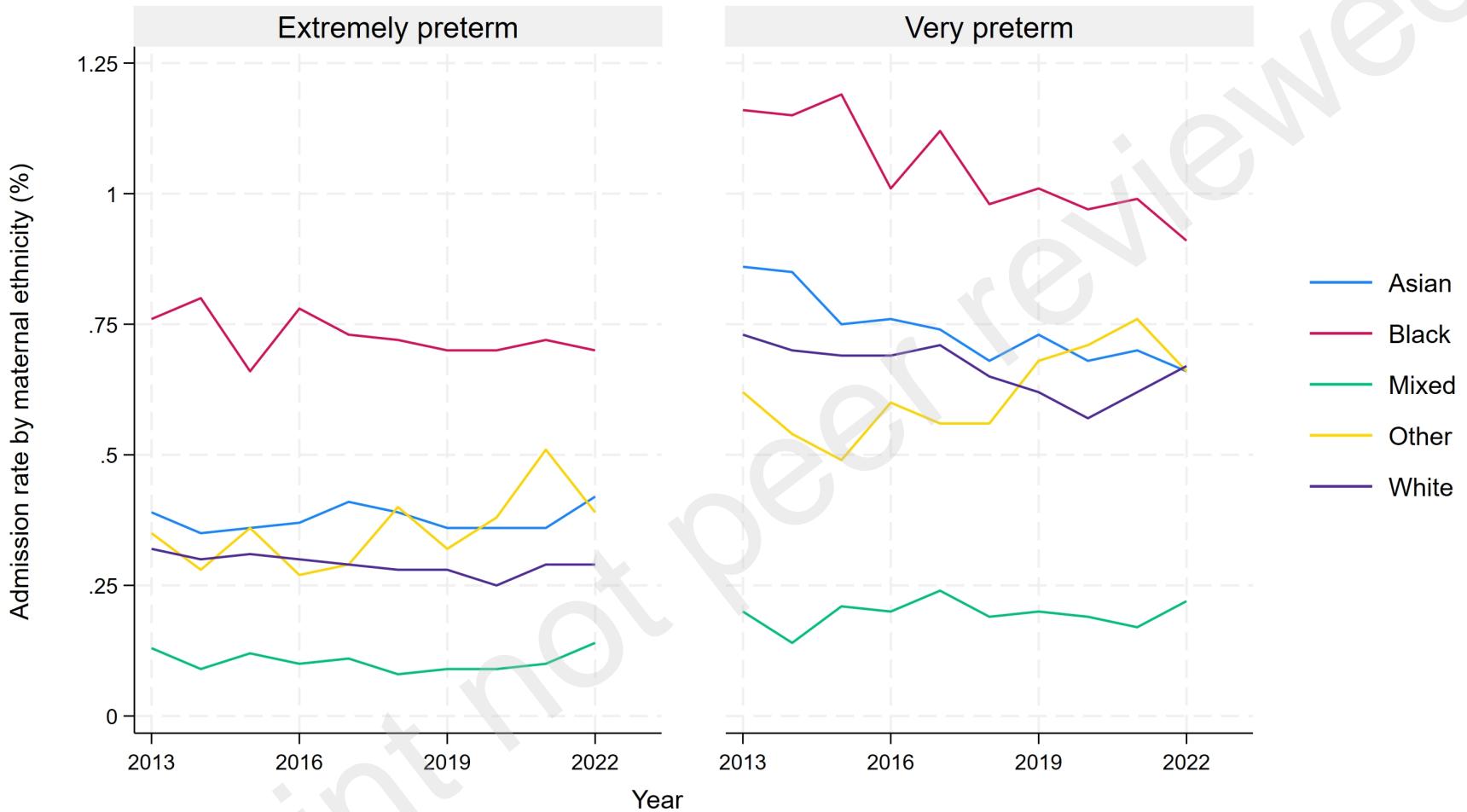
Table 3B**Clinical outcomes by year; very preterm (VPT) admissions**

Adjusted risk ratio and 95% confidence interval (aRR; 95% CI) estimated by modified Poisson regression; reference year is 2013; adjustment variables are sex, gestational age (weeks), birth weight z-score, and multiplicity; this analysis included 51,140 VPT admissions

	2013 % (95% CI)	2014 % (95% CI)	2015 % (95% CI)	2016 % (95% CI)	2017 % (95% CI)	2018 % (95% CI)	2019 % (95% CI)	2020 % (95% CI)	2021 % (95% CI)	2022 % (95% CI)	Overall trend
Mortality aRR (95% CI)	3.4 (2.8,4.0) Ref	2.9 (2.5,3.3) 0.87 (0.71 to 1.08)	3.1 (2.8,3.3) 0.92 (0.75 to 1.13)	2.9 (2.4,3.4) 0.87 (0.71 to 1.07)	3.1 (2.6,3.5) 0.90 (0.73 to 1.10)	2.6 (2.1,3.1) 0.78 (0.63 to 0.97)	2.8 (2.4,3.2) 0.84 (0.68 to 1.04)	2.8 (2.3,3.2) 0.80 (0.64 to 1.0)	2.9 (2.4,3.5) 0.86 (0.69 to 1.07)	2.9 (2.6,3.3) 0.87 (0.70 to 1.08)	0.98 (0.97 to 1.0)
Bronchopulmonary dysplasia aRR (95% CI)	15.7 (14.8,16.6) Ref	16.7 (16.1,17.4) 1.08 (0.99 to 1.16)	16.3 (15.2,17.5) 1.05 (0.97 to 1.14)	16.3 (15.1,17.5) 1.03 (0.96 to 1.11)	17.0 (16.2,17.7) 1.05 (0.97 to 1.14)	17.8 (16.8,18.8) 1.13 (1.05 to 1.22)	17.6 (16.5,18.7) 1.11 (1.02 to 1.19)	18.6 (17.3,19.9) 1.17 (1.08 to 1.26)	17.2 (16.2,18.1) 1.11 (1.02 to 1.20)	18.5 (17.6,19.4) 1.20 (1.11 to 1.29)	1.01 (1.0 to 1.02)
Severe brain Injury aRR (95% CI)	5.6 (4.8,6.5) Ref	6.2 (5.3,7.2) 1.13 (0.97 to 1.31)	5.8 (5.3,6.2) 1.05 (0.90 to 1.22)	6.1 (5.6,6.5) 1.09 (0.93 to 1.26)	5.6 (4.9,6.2) 0.99 (0.85 to 1.16)	6.0 (5.4,6.7) 1.09 (0.93 to 1.27)	5.7 (4.9,6.5) 1.02 (0.88 to 1.20)	5.7 (5.4,6.0) 1.0 (0.85 to 1.17)	5.8 (5.1,6.4) 1.02 (0.87 to 1.20)	6.0 (5.4,6.7) 1.07 (0.92 to 1.25)	0.99 (0.98 to 1.01)
Late onset bloodstream infection aRR (95% CI)	1.8 (1.4,2.2) Ref	2.0 (1.6,2.4) 1.12 (0.85 to 1.46)	2.0 (1.6,2.4) 1.09 (0.83 to 1.43)	1.8 (1.5,2.1) 0.97 (0.74 to 1.28)	2.0 (1.6,2.3) 1.06 (0.81 to 1.39)	1.8 (1.4,2.1) 0.97 (0.73 to 1.28)	2.0 (1.7,2.3) 1.09 (0.83 to 1.43)	2.1 (1.8,2.3) 1.12 (0.85 to 1.47)	1.9 (1.5,2.3) 1.06 (0.80 to 1.40)	1.5 (1.2,1.9) 0.84 (0.62 to 1.14)	0.99 (0.97 to 1.01)
Severe necrotising enterocolitis aRR (95% CI)	1.4 (1.1,1.7) Ref	1.6 (1.2,2.1) 1.15 (0.85 to 1.55)	1.4 (1.1,1.6) 0.96 (0.70 to 1.32)	1.4 (1.2,1.6) 0.98 (0.72 to 1.34)	1.4 (1.0,1.8) 0.94 (0.68 to 1.29)	1.1 (0.7,1.6) 0.81 (0.58 to 1.13)	1.5 (1.1,1.8) 1.02 (0.75 to 1.40)	1.3 (0.9,1.7) 0.92 (0.66 to 1.29)	1.1 (0.8,1.4) 0.80 (0.56 to 1.13)	1.2 (0.9,1.6) 0.89 (0.63 to 1.24)	0.98 (0.95 to 1.0)
Treated retinopathy of prematurity aRR (95% CI)	0.8 (0.6,1.0) Ref	0.8 (0.6,1.1) 1.01 (0.67 to 1.53)	0.8 (0.5,1.1) 0.91 (0.60 to 1.39)	0.6 (0.3,0.8) 0.67 (0.42 to 1.07)	0.3 (0.2,0.4) 0.35 (0.20 to 0.62)	0.4 (0.2,0.5) 0.46 (0.27 to 0.79)	0.4 (0.3,0.6) 0.55 (0.33 to 0.91)	0.6 (0.3,0.8) 0.66 (0.41 to 1.08)	0.6 (0.4,0.8) 0.74 (0.46 to 1.19)	0.5 (0.3,0.7) 0.62 (0.38 to 1.04)	0.94 (0.90 to 0.98)

Survival without major morbidity aRR (95% CI)	75.6 (74.2,77.1) Ref	74.7 (73.7,75.7) 0.98 (0.97 to 0.99)	75.5 (74.4,76.7) 0.99 (0.98 to 1.0)	76 (74.7,77.4) 0.99 (0.98 to 1.01)	76.2 (75.4,77) 1.0 (0.99 to 1.02)	75.5 (74.3,76.7) 0.99 (0.97 to 1.0)	75.6 (74.3,76.8) 0.99 (0.98 to 1.01)	73.7 (72.4,74.9) 0.98 (0.96 to 0.99)	74.7 (73.6,75.9) 0.98 (0.97 to 1.0)	74.1 (72.8,75.3) 0.98 (0.96 to 0.99)	0.99 (0.99 to 0.99)
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Source: Office for National Statistics. Live birth reported for 2013-2022 by babies ethnicity was used as the denominator.

