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Does neonatal care delivery in England and Wales vary by deprivation and ethnicity: a retrospective cohort study

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ABSTRACT

Objective To investigate whether perinatal care delivery in England and Wales varies by ethnicity and socio-economic deprivation, using National Neonatal Audit Programme (NNAP) measures.

Design Retrospective observational study using NNAP (2017–2023) data.

Setting Neonatal units in England and Wales participating in the NNAP.

Participants Admitted infants born at ≥22 weeks with recorded data on ethnicity, deprivation and relevant NNAP measures.

Outcome measures Fourteen NNAP measures covering perinatal optimisation, neonatal care, breastfeeding and parental partnership were explored by ethnicity (White, Black, Asian, Mixed and Other) and deprivation.

Results Ethnicity and deprivation were associated with several measures of care. Compared with White infants, Black, Asian, Mixed and 'Other' ethnicity babies had lower odds of receiving deferred cord clamping (adjusted ORs (aOR) 0.76 (95% CI 0.70 to 0.84), 0.88 (95% CI 0.82 to 0.95), 0.79 (0.68 to 0.92) and 0.75 (0.64 to 0.88), respectively) and had higher odds of abnormal admission temperature. White infants had higher odds of receiving early breastmilk compared with infants from minority ethnic groups, but had lower odds of receiving it at 14 days or at discharge. Compared with the least deprived, the most deprived infants had lower odds of receiving breastmilk, within 48 hours (aOR: 0.58 (95% CI 0.54 to 0.63)) and at discharge (aOR: 0.39 (95% CI 0.36 to 0.43)). There were lower odds of early parental updates and involvement in ward rounds for minoritised ethnic groups (compared with White families) and most deprived (compared with least deprived) families.

Conclusions Disparities exist in the delivery of perinatal care by ethnicity and deprivation. There are opportunities to improve equity, particularly around deferred cord clamping, breastfeeding support and parental partnership.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Disparities in maternal and neonatal outcomes in the UK according to socioeconomic position and ethnicity are well described. Less is known about disparity in delivery of perinatal care practices by these characteristics.

WHAT THIS STUDY ADDS

⇒ Using national audit data, consistent disparities in perinatal care delivery by ethnicity and deprivation were found. Differences were particularly evident in deferred cord clamping, breastfeeding support and parental partnership in care.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ These findings highlight opportunities for quality improvement and system-wide initiatives to ensure equitable perinatal care. Addressing disparities in early care and parental partnership may help reduce broader inequalities in infant health outcomes.

INTRODUCTION

In the UK, perinatal outcomes, including premature labour, preterm delivery, low birth weight and neonatal death, are associated with ethnicity.[1–11] These differences in outcomes are not explained by intersection with deprivation;[12–17] disparities in care provided may play a role.[7 8] Women from minoritised ethnic groups express more mistrust in health services, as well as poorer maternity care experiences and birth outcomes.[18] Actionable evidence from high quality research is necessary to enable perinatal health workers to strive towards the eradication of health disparities.[19]

The National Neonatal Audit Programme (NNAP) was created in 2006 to explore whether infants admitted to neonatal units in England and Wales receive consistently high-quality care. Audit measures are developed by consensus, based on existing standards where possible, and reviewed annually.[20] They cover the following themes: optimal perinatal care; outcomes of neonatal care; maternal breastmilk feeding; parental partnership in care; neonatal nurse staffing; and healthcare processes.

The aim of this study is to determine if perinatal care delivery differs according to ethnicity and socio-economic deprivation.

METHODS

Data, study design and population

We used routinely collected data, held by the NNAP. The use of personal data without patients' consent was approved by the National Health Service (NHS) Health Research Authority under section 251 of the Health and Social Care Act (21/CAG/0007). The data were collated to evaluate service provision and performance, and the work was therefore exempt from ethical review by the NHS Health Research Authority. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting standards for observational studies was used.

Population

Children born in England and Wales between 2017 and 2023, who met the following criteria:

- Admitted to a neonatal unit for neonatal care.
- Care provided by a unit participating in the NNAP.
- Key NNAP data: birth year, gestational age, admission time and national identifier.
- Born at >=22 weeks gestation.
- Birth weight >=250 grams

Exposures

The following case characteristics were explored:

- Ethnicity as per the Office of National Statistics: White (British, Irish, Gypsy or Irish Traveller, Roma, any other White background), Black (African, Caribbean or any other Black background), Asian (Bangladeshi, Chinese, Indian, Pakistani or any other Asian background), Mixed or multiple ethnic groups (White and Asian, White and Black African, White and Black Caribbean, Other Mixed or Multiple ethnic groups) and other (Arab or any other racial or ethnic group).[21] Where the mother's ethnicity was missing, the baby's was used.
- Deprivation was derived from the Children in Low Income Families measure (CiLIF).[22] CiLiF data were derived from the maternal postcodes in quintiles (least deprived; second least deprived; third least deprived; second most deprived; most deprived).

Outcomes

Fourteen NNAP healthcare delivery measures were explored. These differ in definition and inclusion criteria[23] (online supplemental eFigure 1 and eTable 1)

1. In utero transfer (IUT).
   - Capacity IUT.
   - 'Long' capacity IUT.
2. Perinatal optimisation.
   - Birth in a centre with a neonatal intensive care unit (NICU).
   - Antenatal steroids.
   - Antenatal magnesium sulphate.
   - Deferred cord clamping (DCC) ≥ 1 min.
   - Normal admission temperature.
3. Non-invasive respiratory support during the first week of life.
4. Parent consultation.
   - Consultation with parents by a senior neonatal team member within 24 hours of admission.
   - Number of days parents included in consultant ward rounds.
5. Maternal breastmilk feeding.
   - Maternal breastmilk feeding in the first 2 days of life.
   - Mother's own milk on day 14.
   - Mother's own milk at discharge.
6. Two-year follow-up.

Covariables and confounders

These were chosen based on existing evidence and clinical experience (see online supplemental eFigure 2).

Maternal measures

Maternal age at child's birth (<20 years; 20–39 years; >= 40 years).

- Maternal gravidity
- Multiplicity (number of babies).
- Labour onset (spontaneous delivery, non-spontaneous delivery).
- Hypertensive disorder*.
- Placental abruption*.
- Mental health difficulties*.
- Drug and/or alcohol abuse*.
- Smoking.

*Where not positive, assumed to be negative.

Infant measures

- Gestational age (number of completed weeks).
- Birth weight (categorised by deciles[24]).
- Sex of baby (female, male or 'mixed' for antenatal measures where there was a male-female multiple pregnancy).
- Time.
  - Year of birth.
  - Month of birth.
- Level of neonatal service at birth hospital (special care unit, local neonatal unit, (NICU)).

Analysis period

Antenatal steroids, magnesium sulphate, delivery in a NICU, admission temperature, DCC, non-invasive respiratory support, in-utero transfer, early breastmilk and parental consultation within 24 hours measures were applied to babies *born* between 2020 and 2023. Receipt of mother's own breastmilk on day 14 and on discharge measures were applied to babies *discharged* between 2020 and 2023. Two-year follow-up measure was applied to babies who reached 30 months old between 2020 and 2023.

Statistical analysis

Infants with missing data were identified and their characteristics compared. All analyses were based on complete case methodology. Characteristics of included mothers and infants were compared by ethnicity and deprivation.

Next, the univariable associations between the exposures (ethnicity and deprivation) and the outcome measures were derived. We used a staged modelling approach to explore the associations between ethnicity, deprivation and each outcome, with White children and children from the 'least deprived' groups as the reference categories in the ethnicity and deprivation models respectively. Unadjusted logistic regression models were derived first, and then confounders were added to the model in stages, initially adjusting for maternal and infant characteristics (the 'partially adjusted model'), and then adjusted for the other social measure, that is, adjusting for deprivation in the ethnicity model and vice versa (the 'fully adjusted model'). This staged modelling strategy allowed exploration of the incremental contribution of different groups of factors, particularly the extent to which social factors explained variation beyond maternal and infant characteristics.

To assess for multicollinearity, variance inflation factors (VIFs) for all predictors in the model were calculated.

Predicted probabilities of each outcome measure by ethnicity and deprivation were calculated using the *margins* command to aid interpretation of absolute differences between groups.

Analyses were carried out in Stata V.18 (StataCorp). Results are presented as ORs, (95% CI), median (IQR) or number (%). All tests were two-sided.

Patient and public involvement

The planning and execution of this work was discussed with the NNAP parental partnership group which includes parents and parent representatives.

RESULTS

A total of 208 921 babies met the NNAP-defined inclusion criteria for at least one outcome measure. Of these, 8409 were excluded due to missing outcome data, and a further 76 357 were excluded due to missing data on ethnicity, deprivation or covariates; missing data by ethnicity and deprivation are shown in online supplemental eTable 2. This left 124 155 babies with complete data for inclusion in at least one of the regression analyses (figure 1).

Of the full NNAP dataset of 597 449 babies, 375 449 did not meet the outcome-specific eligibility criteria (eg, some measures apply only to very preterm infants), and 13 888 were excluded due to missing key data (eg, missing gestational age or birth year).

The ethnicity of 6571 (6%) mothers was derived from the baby's data. All maternal and infant characteristics appeared to vary by ethnicity (table 1, all p values <0.05) except placental abruption. Median gestational age was lowest in Black infants, median 35, IQR 31–39. All maternal and infant characteristics appeared to vary by deprivation (table 1, all p values <0.05) except hypertensive disorders which appeared similar (p=0.2).

Ethnicity and deprivation were also associated with each other (online supplemental eTable 3, eFigure 3), with 54% (n=8736) of Asian mothers and 43% (n=3355) of Black mothers living in the most deprived quintile, compared with only 28% (24,230) of White mothers.

Ethnicity

There was strong evidence in univariable analysis that receipt of antenatal steroids, DCC, normal admission temperature, breastmilk feeding in the first 2 days of life, receiving mother's own milk on day 14, receiving mother's own milk at discharge, non-invasive respiratory support, early parental consultation, parental inclusion on consultant ward round and birth in a centre with a NICU (all p<0.01) were associated with ethnicity (online supplemental eTable 4), but not antenatal magnesium sulphate (p=0.2) or either type of capacity transfer.

Deprivation

There was also strong evidence in the univariable analysis that DCC, normal admission temperature, breastmilk feeding in the first 2 days of life, receiving mother's own milk on day 14, receiving mother's own milk at discharge, non-invasive respiratory support, early parental consultation, parental inclusion on consultant ward round and birth in a centre with a NICU (all p<0.01) were associated with deprivation, and there was some evidence that antenatal steroids (p=0.03) were. However, there was no association between deprivation and 2-year follow-up (p=0.06) or either type of capacity transfer (online supplemental eTable 5).

Regression models: ethnicity

In the regression model, compared with White babies, all other ethnic groups had lower odds of DCC, and this association persisted after adjustment for deprivation (Black aOR 0.76 (95% CI 0.70 to 0.84), Asian aOR 0.88 (95% CI 0.82 to 0.95), Mixed aOR 0.79 (95% CI 0.68 to 0.92), Other aOR 0.75 (95% CI 0.64 to 0.88)) (table 2, online supplemental eTable 6, figure 2). The predicted probabilities of the least deprived White, Black, Asian, Mixed and Other babies receiving DCC are 56% (95% CI 54 to 57%), 49% (95% CI 47 to 52%), 53% (95% CI 51 to 53%), 50% (95% CI 47 to 54%) and 49% (95% CI 45 to 53%) respectively (see online supplemental eTable 7).

In unadjusted analyses Black and Asian women appeared to have higher odds of receiving antenatal steroids OR 1.17 (1.07–1.29) and 1.09 (1.02–1.17), respectively (see online supplemental eTable 6), but after full adjustment, the association was no longer apparent (p=0.4). There was no observed association between ethnicity, in unadjusted or adjusted analyses, and receipt of antenatal magnesium sulphate (p=0.1 and 0.7 respectively).

Black, Asian and Mixed ethnicity babies also had lower odds of having a normal temperature on admission to the neonatal unit than White babies, and this association persisted after adjustment (aOR Black: 0.87 (95% CI 0.78 to 0.96); Asian 0.89 (95% CI 0.82 to 0.97); aOR mixed

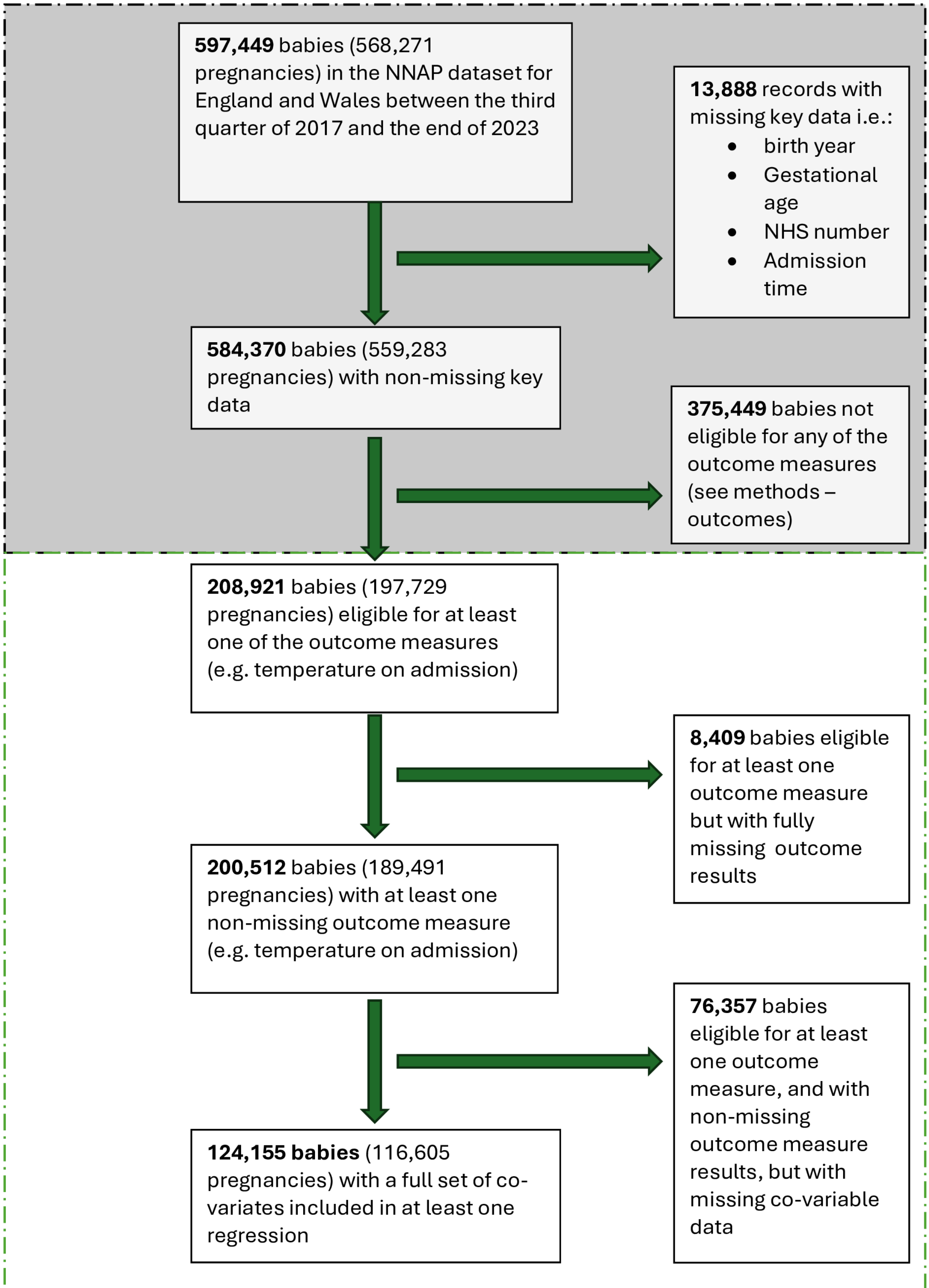

Figure 1 Participant flow diagram. NHS, National Health Service; NNAP, National Neonatal Audit Programme.

0.82 (95% CI 0.70 to 0.97). Black and Asian babies also had higher odds of being delivered in a hospital with an onsite NICU where clinically indicated, unadjusted ORs 1.58 (95% CI 1.25 to 1.99) and 1.38 (95% CI 1.14 to 1.66), respectively (online supplemental eTable 6). After full adjustment, this difference was only apparent for the Black babies (aOR 1.37 (95% CI 1.07 to 1.74)). No associations were seen in the Mixed and 'Other' ethnicity groups. No differences were observed by ethnicity in the proportion of babies experiencing IUT (p=0.8) or long IUTs (p=0.09).

Black and Asian babies had lower odds of receiving breastmilk in the first 2 days of life, an observation unaffected by adjustment. The adjusted OR for receiving

Table 1 Cohort characteristics by ethnicity and then deprivation

Ethnicity							
	Total	White	Black	Asian	Mixed	Other	Test statistic (p value)
Maternal characteristics (N)	116605	86824	7862	16312	2844	2763	
Age at child's birth mean (SD) median (range)	31 (6) 31 (27 to 35)	30 (6) 31 (26 to 34)	32 (6) 32 (28 to 36)	32 (5) 32 (28 to 35)	31 (6) 31 (26 to 35)	31 (6) 32 (27 to 36)	1036.8 (<0.001)†
Maternal gravidity: primigravida (0 previous)	42868 (37%)	31872 (37%)	2426 (31%)	6449 (40%)	1032 (36%)	1089 (39%)	180.6 (<0.001)*
Multiplicity: singleton	105780 (91%)	78465 (90%)	7088 (90%)	15094 (93%)	2585 (91%)	2548 (92%)	86.6 (<0.001)*
Labour onset: spontaneous	48050 (41%)	35602 (41%)	3062 (39%)	7019 (43%)	1205 (42%)	1162 (42%)	42.8 (<0.001)*
Hypertensive disorders (yes)	9964 (9%)	7049 (8%)	1044 (13%)	1445 (9%)	218 (8%)	208 (8%)	254.2 (<0.001)*
Placental abruption (yes)	1432 (1%)	1070 (1%)	108 (1%)	196 (1%)	31 (1%)	27 (1%)	3.4 (0.5)*
Mental health problems (yes)	8973 (8%)	8096 (9%)	261 (3%)	325 (2%)	217 (8%)	74 (3%)	1381.2 (<0.001)*
Drug and/or alcohol abuse (yes)	1320 (1%)	1176 (1%)	59 (1%)	26 (0%)	52 (2%)	7 (0%)	217.9 (<0.001)*
Smoking (yes)	17660 (15%)	16272 (19%)	319 (4%)	347 (2%)	499 (18%)	223 (8%)	3897.1 (<0.001)*
Infant characteristics (N)	124155	92602	8447	17169	3022	2915	
Gestational age in number of weeks mean (SD) and median (range)	35 (4) 36 (33 to 39)	35 (4) 36 (33 to 38)	34 (5) 35 (31 to 39)	35 (5) 36 (32 to 39)	35 (4) 36 (32 to 39)	35 (5) 36 (33 to 39)	63.2 (<0.001)†
Birth weight, mean (SD) and median (range)	2.5 (1.0) 2.6 (1.8 to 3.3)	2.6 (1.0) 2.6 (1.8 to 3.4)	2.4 (1.1) 2.4 (1.4 to 3.3)	2.4 (1.0) 2.4 (1.6 to 3.2)	2.5 (1.0) 2.5 (1.7 to 3.3)	2.5 (1.0) 2.6 (1.7 to 3.3)	788.7 (<0.001)†
Sex of baby (male)	71116 (57%)	53449 (58%)	4531 (54%)	9812 (57%)	1699 (56%)	1625 (56%)	57.2 (<0.001)*
Year of birth							
2017	1291 (1%)	929 (1%)	130 (2%)	182 (1%)	21 (1%)	29 (1%)	145.3 (<0.001)*
2018	2376 (2%)	1693 (2%)	230 (3%)	341 (2%)	59 (2%)	53 (2%)	
2019	3101 (2%)	2226 (2%)	273 (3%)	464 (3%)	68 (2%)	70 (2%)	
2020	28280 (23%)	21106 (23%)	1893 (22%)	3937 (23%)	630 (21%)	714 (24%)	
2021	30312 (24%)	22875 (25%)	1858 (22%)	4110 (24%)	754 (25%)	715 (25%)	
2022	28971 (23%)	21737 (23%)	1893 (22%)	3941 (23%)	769 (25%)	631 (22%)	
2023	29824 (24%)	22036 (24%)	2170 (26%)	4194 (24%)	721 (24%)	703 (24%)	
Level of neonatal service at birth hospital							
Special care unit	15378 (12%)	13546 (15%)	396 (5%)	962 (6%)	239 (8%)	235 (8%)	2233.5 (<0.001)*
Local neonatal unit	53703 (43%)	40616 (44%)	3427 (41%)	7268 (42%)	1271 (42%)	1121 (38%)	
Neonatal intensive care unit	55074 (44%)	38440 (42%)	4624 (55%)	8939 (52%)	1512 (50%)	1559 (53%)	

Continued

Table 1 Continued

Deprivation							
	Total	**Least deprived**	**Second least deprived**	**Third least deprived**	**Second most deprived**	**Most deprived**	**P value**
Maternal characteristics (N)	116605	15599	17707	20845	24037	38417	
Age at child's birth, mean (SD) and median (range)	31 (6) 31 (27 to 35)	32 (5) 33 (29 to 36)	31 (6) 32 (28 to 35)	31 (6) 31 (27 to 35)	30 (6) 30 (26 to 35)	30 (6) 30 (25 to 34)	2751.5 (<0.001)†
Maternal gravidity: primigravida (0 previous)	42868 (37%)	6385 (41%)	7006 (40%)	8029 (39%)	8730 (36%)	12718 (33%)	427.2 (<0.001)*
Multiplicity: singleton	105780 (91%)	13943 (89%)	15909 (90%)	18836 (90%)	21833 (91%)	35259 (92%)	103.9 (<0.001)*
Labour onset: spontaneous	48050 (41%)	6558 (42%)	7222 (41%)	8488 (41%)	10012 (42%)	15770 (41%)	10.2 (0.04)*
Hypertensive disorders (yes)	9964 (9%)	1355 (9%)	1555 (9%)	1772 (9%)	2100 (9%)	3182 (8%)	6.2 (0.2)*
Placental abruption (yes)	1432 (1%)	166 (1%)	189 (1%)	237 (1%)	330 (1%)	510 (1%)	15.9 (0.003)*
Mental health problems (yes)	8973 (8%)	1113 (7%)	1378 (8%)	1637 (8%)	1968 (8%)	2877 (7%)	18.3 (0.001)*
Drug and/or alcohol abuse (yes)	1320 (1%)	93 (1%)	131 (1%)	188 (1%)	311 (1%)	597 (2%)	141 (<0.001)*
Smoking (yes)	17660 (15%)	1082 (7%)	1922 (11%)	2713 (13%)	4087 (17%)	7856 (20%)	2050.7 (<0.001)*
Infant characteristics (N)	124155	16713	18990	22244	25598	40610	
Gestational age in number of weeks, mean (SD) and median (range)	35 (4) 36 (33 to 39)	35 (4) 36 (33 to 39)	35 (4) 36 (33 to 39)	35 (4) 36 (33 to 39)	35 (4) 36 (32 to 38)	35 (4) 36 (32 to 38)	204.3 (<0.001)†
Birth weight, mean (SD) and median (range)	2.5 (1.0) 2.6 (1.8 to 3.3)	2.6 (1.0) 2.7 (1.9 to 3.4)	2.6 (1.0) 2.6 (1.8 to 3.4)	2.6 (1.0) 2.6 (1.8 to 3.4)	2.5 (1.0) 2.5 (1.7 to 3.3)	2.5 (1.0) 2.5 (1.7 to 3.3)	389.7 (<0.001)†
Sex of baby (male)	71116 (57%)	9600 (57%)	11046 (58%)	12752 (57%)	14514 (57%)	23204 (57%)	10.1 (0.04) *
Year of birth							
2017	1291 (1%)	135 (1%)	226 (1%)	219 (1%)	272 (1%)	439 (1%)	332 (<0.001)*
2018	2376 (2%)	268 (2%)	283 (1%)	401 (2%)	483 (2%)	941 (2%)	
2019	3101 (2%)	361 (2%)	429 (2%)	415 (2%)	703 (3%)	1193 (3%)	
2020	28280 (23%)	3690 (22%)	4049 (21%)	4977 (22%)	5785 (23%)	9779 (24%)	
2021	30312 (24%)	4171 (25%)	4631 (24%)	5360 (24%)	6672 (26%)	9478 (23%)	
2022	28971 (23%)	4033 (24%)	4633 (24%)	5347 (24%)	5852 (23%)	9106 (22%)	
2023	29824 (24%)	4055 (24%)	4739 (25%)	5525 (25%)	5831 (23%)	9674 (24%)	
Level of neonatal service at birth hospital							

Continued

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Table 1 Continued

Deprivation							
Special care unit	15378 (12%)	2052 (12%)	2419 (13%)	2976 (13%)	3729 (15%)	4202 (10%)	3404.5 (<0.001)*
Local neonatal unit	53703 (43%)	8624 (52%)	9375 (49%)	10390 (47%)	11545 (45%)	13769 (34%)	
Neonatal intensive care unit	55074 (44%)	6037 (36%)	7196 (38%)	8878 (40%)	10324 (40%)	22639 (56%)	

*Pearson's $\chi2$ test.
†Kruskal-Wallis equality of populations rank test (with ties).

breastmilk within the first 2 days was 0.76 (95% CI 0.70 to 0.84) and 0.89 (0.83–0.95) for Black and Asian babies, respectively, compared with White babies. No associations were evident in the Mixed or 'Other' ethnicity groups; aORs 1.12 (95% CI 0.97 to 1.30) and 0.83 (95% CI 0.71 to 0.97), respectively. However, by day 14 and on discharge, all minority ethnicities had higher odds than White babies of receiving breastmilk. For example, Black babies had more than twice the odds of receiving maternal breastmilk at discharge; Black aOR 2.24 (95% CI 2.01 to 2.50), Asian 1.56 (95% CI 1.44 to 1.69), Mixed 1.39 (95% CI 1.18 to 1.64) and 'Other' 2.00 (95% CI 1.65 to 2.42). Asian babies had higher odds than White babies of attending the 2-year follow-up (aOR 1.18 95% CI 1.01 to 1.37). Black babies and babies of 'Other' ethnicity had lower odds than White babies of receiving follow-up at 2 years of age (aOR 0.66 (95%CI 0.56 to 0.77) and 0.54 (95%CI 0.41 to 0.73), respectively. Black, Asian and 'Other' ethnicity babies had higher odds than White babies to have been managed during their first week without the use of invasive ventilation (aORs 1.21 (95%CI 1.05 to 1.38), 1.52 (95%CI 1.37 to 1.69) and 1.60 (95%CI 1.25 to 2.05), respectively). Parents of Asian babies had lower odds of being updated by a senior member of the neonatal team within 24 hours of admission (aOR 0.82 (95%CI 0.75 to 0.89)) and parents of babies from minoritised ethnic groups had lower odds of being included in consultant ward rounds.

Regression models: deprivation

There was a deprivation gradient in the odds of receiving early breastmilk, mother's own milk at 14 days and mother's own milk at discharge (table 2). Compared with the least deprived group, the adjusted OR of receiving early breastmilk for the most deprived group was 0.58 (95%CI 0.54 to 0.63), at 14 days 0.51 (95%CI 0.45 to 0.57) and at discharge 0.39 (95%CI 0.36 to 0.43) (figure 3); this means there is a 58% (95% CI 56 to 59%) probability of a White baby in the least deprived group having early breastmilk, compared with 45% in the most deprived group (95% CI 44 to 46%) (online supplemental eTable 7).

There was no association between deprivation and antenatal steroid exposure. Unadjusted analyses showed some association between deprivation and reduction in odds of receiving DCC (OR most deprived cf. least deprived 0.92 (95% CI 0.86 to 1.00)) (online supplemental eTable 6), but this effect disappeared on adjustment (OR most deprived cf. least deprived 0.96 (95% CI 0.88 to 1.04). There was an association between deprivation and receiving 2-year follow-up: compared with the least deprived groups, the most deprived group had an adjusted OR of 0.79 (95% CI 0.70 to 0.90). The odds of receiving solely non-invasive respiratory care decreased with deprivation; the adjusted OR, compared with the least deprived group, in the most deprived group was 0.79 (95%CI 0.70 to 0.90). Early parental consultation and inclusion in ward rounds had a gradient response to deprivation; compared with the least deprived groups, the adjusted ORs were 0.65 (95%CI 0.59 to 0.72) and 0.65 (95%CI 0.64 to 0.65), respectively. 48% of 'least deprived' White parents are likely to be included in ward rounds, whereas in the most deprived groups this is only 37%. In Asian families, the equivalent figures are 36% and 27% (online supplemental eTable 7).

There was no observed association between deprivation and birth in a centre with a NICU and capacity in utero transfers (of either type) or receipt of either antenatal magnesium or steroids.

Post-estimation diagnostics

Across all models, the VIFs ranged from 1 to 8.4, with a mean of 1.7 and a median of 1.3 (online supplemental eTable 8). Year of birth and place of birth occasionally exceeded five in some models due to a degree of collinearity, but these variables were retained given their conceptual importance.

DISCUSSION

There is evidence that some aspects of perinatal and neonatal care delivery differ according to ethnicity and deprivation. The scale of the differences is important and identifies opportunities for both better understanding and improvement in care delivery. Indeed, only three measures were patterned neither by ethnicity nor deprivation.

In context

These findings may help reduce inequalities seen across the UK. More focus on delivery of equitable perinatal

Table 2 Logistic regression output. OR (95% CIs) of achieving each NNAP measure by ethnicity and then by deprivation

Measure	N	White	Black	Asian	Mixed	Other	Test statistic (p value)*
In utero capacity transfer	14 767	1.00 (ref)	0.96 (0.67–1.35)	0.98 (0.75–1.29)	1.09 (0.62–1.92)	1.43 (0.84–2.45)	1.8 (0.8)
In utero long capacity transfer	14 722	1.00	0.47 (0.24–0.94)	0.65 (0.41–1.03)	0.75 (0.28–2.06)	1.04 (0.42–2.56)	8.2 (0.09)
Birth in a centre with a NICU	5230	1.00	1.37 (1.07–1.74)	1.15 (0.94–1.41)	1.36 (0.90–2.07)	1.32 (0.85–2.06)	9.7 (0.05)
Antenatal steroids	25 942	1.00	0.98 (0.89–1.08)	0.97 (0.90–1.05)	0.89 (0.76–1.04)	1.08 (0.91–1.27)	3.7 (0.4)
Antenatal magnesium sulphate	9460	1.00	1.08 (0.87–1.35)	1.08 (0.90–1.30)	1.20 (0.83–1.73)	0.94 (0.64–1.37)	2.0 (0.7)
Deferred cord clamping	30 228	1.00	0.76 (0.70–0.84)	0.88 (0.82–0.95)	0.79 (0.68–0.92)	0.75 (0.64–0.88)	53.6 (<0.0001)
Normal admission temperature	30 293	1.00	0.87 (0.78–0.96)	0.89 (0.82–0.97)	0.82 (0.70–0.97)	1.02 (0.85–1.22)	17.3 (0.002)
Non-invasive respiratory support	16 578	1.00	1.21 (1.05–1.38)	1.52 (1.37–1.69)	0.94 (0.74–1.18)	1.60 (1.25–2.05)	71.6 (<0.0001)
Early parental consultation	128 117	1.00	1.02 (0.91–1.14)	0.82 (0.75–0.89)	1.00 (0.83–1.20)	0.91 (0.76–1.10)	24.0 (<0.0001)
Parent included on consultant ward round	1 381 421	1.00	0.70 (0.69–0.71)	0.62 (0.62–0.63)	0.78 (0.76–0.80)	0.70 (0.68–0.71)	9868.0 (<0.0001)
Breastmilk feeding in the first 2 days of life	30 848	1.00	0.76 (0.70–0.84)	0.89 (0.83–0.95)	1.12 (0.97–1.30)	0.83 (0.71–0.97)	47.7 (<0.0001)
Receiving mother's own milk on day 14	27 675	1.00	1.48 (1.30–1.68)	1.42 (1.28–1.56)	1.29 (1.06–1.58)	1.71 (1.35–2.17)	92.3 (<0.0001)
Receiving mother's own milk at discharge	28 314	1.00	2.24 (2.01–2.50)	1.56 (1.44–1.69)	1.39 (1.18–1.64)	2.00 (1.65–2.42)	337.8 (<0.0001)
2-year follow-up	9202	1.00	0.66 (0.56–0.77)	1.18 (1.01–1.37)	0.75 (0.55–1.01)	0.54 (0.41–0.73)	53.9 (<0.0001)
		Least deprived	**Second least deprived**	**Third least deprived**	**Second most deprived**	**Most deprived**	**Test statistic (p-value)***
In utero capacity transfer	14 767	00 (ref)	0.91 (0.62–1.33)	1.33 (0.94–1.88)	1.05 (0.74–1.49)	1.21 (0.87–1.67)	6.9 (0.1)
In utero long capacity transfer	14 722	1.00	1.00 (0.55–1.83)	1.09 (0.62–1.94)	1.15 (0.66–2.01)	1.54 (0.92–2.58)	5.5 (0.2)
Birth in a centre with a NICU	5230	1.00	0.81 (0.62–1.06)	0.89 (0.69–1.16)	0.84 (0.65–1.08)	1.24 (0.97–1.59)	24.1 (<0.0001)
Antenatal steroids	25 942	1.00	1.01 (0.92–1.11)	1.00 (0.91–1.09)	1.05 (0.96–1.15)	0.95 (0.87–1.03)	9.1 (0.06)
Antenatal magnesium sulphate	9460	1.00	1.15 (0.89–1.49)	0.94 (0.74–1.19)	0.90 (0.71–1.13)	0.85 (0.68–1.05)	10.0 (0.04)
Deferred cord clamping	30 228	1.00	0.98 (0.89–1.07)	0.97 (0.89–1.07)	0.92 (0.84–1.00)	0.96 (0.88–1.04)	4.8 (0.3)
Normal admission temperature	30 293	1.00	0.99 (0.90–1.10)	1.04 (0.94–1.15)	0.93 (0.84–1.03)	0.91 (0.83–1.00)	12.3 (0.02)
Non-invasive respiratory support	16 578	1.00	0.88 (0.76–1.01)	0.86 (0.75–0.98)	0.72 (0.63–0.82)	0.79 (0.70–0.90)	27.2 (<0.0001)
Early parental consultation	128 117	1.00	0.96 (0.86–1.08)	0.93 (0.83–1.04)	0.88 (0.79–0.98)	0.65 (0.59–0.72)	140.8 (<0.0001)
Parent included on consultant ward round	1 381 421	1.00	0.89 (0.88–0.90)	0.85 (0.84–0.86)	0.77 (0.76–0.78)	0.65 (0.64–0.65)	6663.3 (<0.0001)

Continued

Table 2 Continued

		Least deprived	Second least deprived	Third least deprived	Second most deprived	Most deprived	Test statistic (p-value)*
Breastmilk feeding in the first 2 days of life	30 848	1.00	0.85 (0.77–0.92)	0.73 (0.67–0.79)	0.67 (0.61–0.72)	0.58 (0.54–0.63)	222.8 (<0.0001)
Mother's own milk on day 14	27 675	1.00	0.78 (0.68–0.88)	0.72 (0.64–0.82)	0.61 (0.54–0.69)	0.51 (0.45–0.57)	188.1 (<0.0001)
Mother's own milk at discharge	28 314	1.00	0.72 (0.65–0.80)	0.64 (0.58–0.71)	0.55 (0.50–0.61)	0.39 (0.36–0.43)	492.7 (<0.0001)
2-year follow-up	9202	1.00	0.74 (0.60–0.90)	0.90 (0.74–1.09)	0.74 (0.61–0.89)	0.83 (0.70–0.99)	16.4 (0.003)

Adjusted for: maternal age at child's delivery, gravidity, multiplicity, labour onset, hypertensive disorders, placental abruption, mental health difficulties, drug and/or alcohol abuse, smoking, gestational age, birth weight, sex, year of birth, month of birth, place of birth and deprivation (in the ethnicity model) or ethnicity (in the deprivation model).
*Likelihood ratio $\chi2$ test, comparing the fit of the models with and without the exposure variable included.
NNAP, National Neonatal Audit Programme.

care will be valued by professionals and communities alike. This should comprise both emphasis on equitable delivery and improved understanding of possible mechanisms for inequity; not least given the effectiveness of DCC in reducing mortality; and up to one-third reduction in extremely preterm infants.[25] DCC is an easily deliverable therapy[26] and has been integrated into a number of care bundles.[27] Delivery of care may be patterned by individual patient characteristics (largely accounted for in this analysis) but also by local hospital policies, with wider variation across units.[28] Conscious or unconscious bias among clinicians might affect decision making for DCC, including ascertainment of infant colour.[29]

Babies from minoritised ethnic groups had lower odds of having a normal admission temperature recorded, a key measure associated with neonatal outcomes.[30] Equally, for important measures of parental partnership in care, parents of babies from minoritised ethnic groups had lower odds of being involved in consultant ward rounds, while Asian parents had lower odds of being seen by a senior neonatal team member shortly after admission. Language barriers are an obvious potential barrier to early communication and inclusion of parents within ward rounds. Digital tools, interpreters and resources available in multiple languages offer relatively simple potential solutions or mitigations to some of the inequity demonstrated within this study. However, communication barriers are often more complex than language proficiency. Families from the more deprived areas had lower odds of being involved in ward rounds, and these associations are likely additive. Similar effects were observed for other measures of parental partnership,

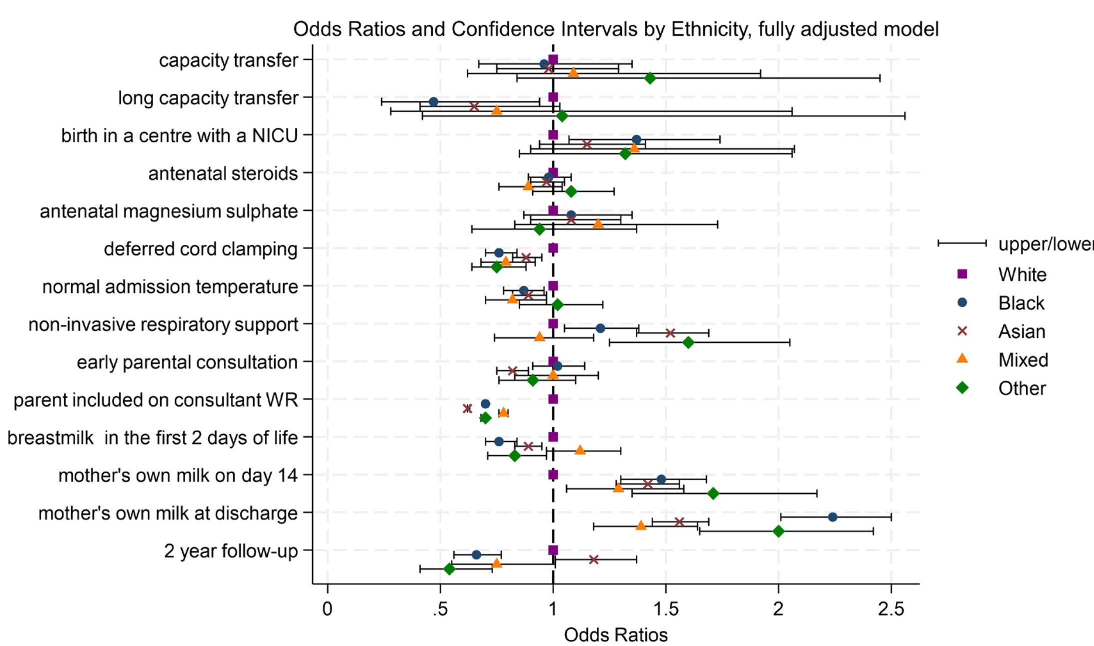

Figure 2 OR of each outcome measure, by ethnicity, compared with White reference group. NICU, neonatal intensive care unit. WR, ward round.

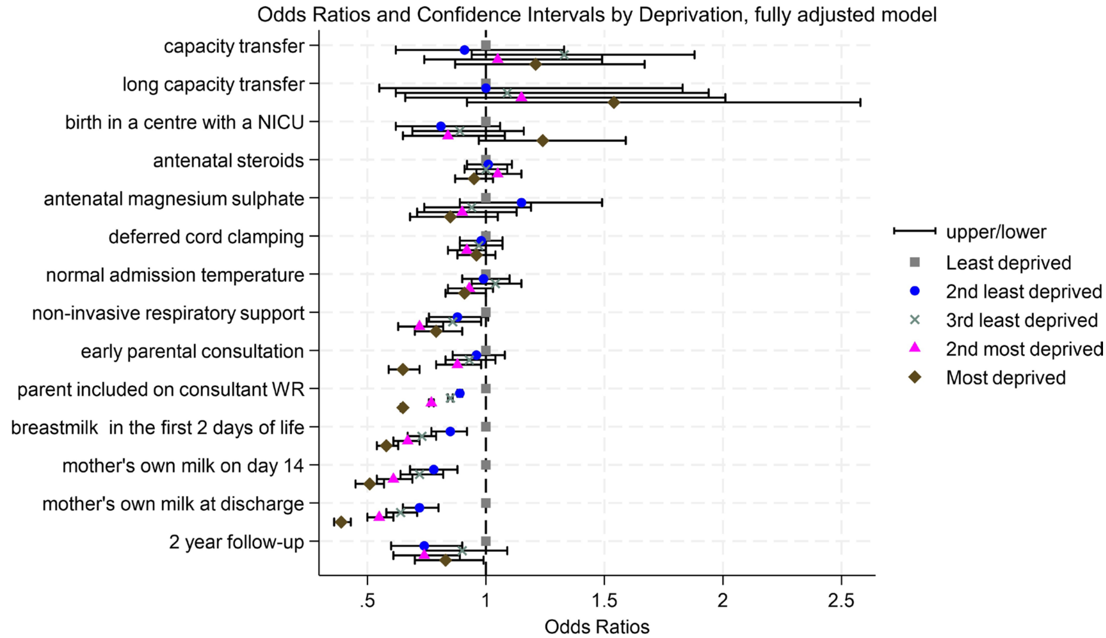

Figure 3 OR of each outcome measure, by deprivation, compared with least deprived reference group. NICU, neonatal intensive care unit.

including engagement in follow-up, a key outcome which guides future support and healthcare access in the most vulnerable children.[31]

Babies from more deprived backgrounds had lower odds of receiving solely non-invasive respiratory support in the first 2 weeks. Black and Asian babies had higher odds than White babies of receiving solely non-invasive respiratory support in the first week of life. It may be that babies from minoritised groups experience lower incidence and severity of hyaline membrane disease.[32 33] Alternatively, differential healthcare delivery might explain observed differences.

While there was a gradient response between deprivation and odds of receiving either early breastmilk, mother's own milk at 14 days and mother's own milk at discharge, the relationship with ethnicity was more complex. Black and Asian babies had lower odds of receiving early breastmilk. However, by day 14, all ethnicities had higher odds than White babies of receiving breastmilk. In order to facilitate expressing shortly after birth, midwives, obstetricians and neonatal staff must work together providing the mother with assistance and support throughout this crucial period.[34] Personal choices and inequitable delivery of effective multidisciplinary support for expression are two possible explanations for this finding. Despite this lack of early breastmilk, the odds of receiving breastmilk on day 14 and at discharge are higher in Black, Asian, Mixed and other ethnicities than White babies, perhaps indicating parental preference overcoming lack of clinician support. These data are in keeping with large cohort studies showing that White women are less likely to breastfeed.[35] However, breastmilk is a key benefit for preterm infants,[36] as well as there being cultural sensitivities which likely need supporting.[37]

Disparities within neonatal care must be considered within the broader maternity care pathway, acknowledging the complexity in perinatal healthcare delivery, since the measures explored in this study require coordinated input from (but not limited to) obstetrics, midwifery and neonatal services, as well as coordination within those teams locally and regionally. Reducing the disparity evident in perinatal care requires system-wide efforts, including organisational change, workforce training and culturally competent care.[7]

Limitations

This study examined multiple separate outcomes, but we did not apply a formal correction for multiple comparisons. This was because the outcomes were separate and predefined as per NNAP. However, with multiple tests, there is a risk of false positives, and the findings should be interpreted with appropriate caution.

Some selection bias, due to missing data, may have influenced the relationships seen. Children with missing ethnicity or deprivation data were excluded, as these were the key independent variables. In addition, for 6% of the babies included, the baby's ethnicity was used when the mother's ethnicity was missing. The missing data on ethnicity do limit the interpretation of the results. Differential recording of ethnicity (as an exposure) in this work is unlikely to substantially bias the point estimates reported (but will of course reduce precision), unless the missingness is also patterned by the outcomes. This remains a possibility in this work, and some bias in the results is likely but difficult to predict. In addition, poor validity (eg, misclassification) will likely attenuate any real associations.

Variation at the level of each unit has not been investigated here. Differences in local practice and resource availability, such as breastfeeding support, across sites may have influenced the observed outcomes.

A further limitation is the restriction to infants admitted to a neonatal unit, with around 300 preterm infants per year dying before admission.[16] Those not admitted are likely to be of lower gestations and less likely to have antenatal optimisation.

Despite its population coverage, CIs were often wide; therefore, important differences may have been missed. As a consequence, it was not possible to explore differences for more detailed measures of ethnicity.

Finally, we used a single ordinal measure of local deprivation in this study, whereas multicomponent measures, used over time, likely capture the complexity of this construct more fully.[38] However, we were still able to identify clear patterns between groups.

CONCLUSION

This complex patterning of health delivery, irrespective of the causes, may contribute to the inequalities in maternity and neonatal outcomes reported in the UK.[39] Identifying disparity is the first step towards eliminating it; quality improvement projects could investigate local care delivery by ethnicity and by deprivation. DCC, thermoregulation, early breastmilk and measures of parental partnership should be priority areas which may help to reduce the stark inequalities in infant mortality seen in the UK.

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Patient and public involvement Patients and/or the public were involved in the design, conduct, reporting or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval Not applicable. This study was exempt from ethical review, and the use of personal data without consent was approved under section 251 of the Health and Social Care Act.

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