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Original Article

Socio-economic disadvantage and utilisation of labour epidural analgesia in Scotland: a population-based study†

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Summary

Socio-economic deprivation is associated with adverse maternal and childhood outcomes. Epidural analgesia, the gold standard for labour analgesia, may improve maternal well-being. We assessed the association of socio-economic status with utilisation of epidural analgesia and whether this differed when epidural analgesia was advisable for maternal safety. This was a population-based study of NHS data for all women in labour in Scotland between 1 January 2007 and 23 October 2020, excluding elective caesarean sections. Socio-economic status deciles were defined using the Scottish Index of Multiple Deprivation. Medical conditions for which epidural analgesia is advisable for maternal safety (medical indications) and contraindications were defined according to national guidelines. Of 593,230 patients in labour, 131,521 (22.2%) received epidural analgesia. Those from the most deprived areas were 16% less likely to receive epidural analgesia than the most affluent (relative risk 0.84 [95%CI 0.82–0.85]), with the inter-decile mean change in receiving epidural analgesia estimated at -2% ([95%CI -2.2% to -1.7%]). Among the 21,219 deliveries with a documented medical indication for epidural analgesia, the socio-economic gradient persisted (relative risk 0.79 [95%CI 0.75–0.84], inter-decile mean change in receiving epidural analgesia -2.5% [95%CI -3.1% to -2.0%]). Women in the most deprived areas with a medical indication for epidural analgesia were still less likely (absolute risk 0.23 [95%CI 0.22–0.24]) to receive epidural analgesia than women from the most advantaged decile without a medical indication (absolute risk 0.25 [95%CI 0.24–0.25]). Socio-economic deprivation is associated with lower utilisation of epidural analgesia, even when epidural analgesia is advisable for maternal safety. Ensuring equitable access to an intervention that alleviates pain and potentially reduces adverse outcomes is crucial.

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Introduction

Socio-economic inequality is associated with maternal morbidity and mortality and is a major public health challenge. Epidural analgesia is the gold standard for labour analgesia. Recommended by the World Health Organization, it is associated with improved maternal pain scores and satisfaction, reduced rates of post-traumatic stress disorder and postnatal depression, and may reduce severe maternal morbidity [1–5]. Despite this, rates of epidural analgesia during labour vary widely, even in high-income countries, suggesting that sociodemographic factors are likely to influence utilisation of epidural analgesia [6].

The Pregnancy Mortality Surveillance System (PMSS) in the USA and the Mothers and Babies: Reducing Risk through Audits and Confidential Enquires across the UK (MBRRACE-UK) reports have highlighted the increased risk of adverse maternal and perinatal outcomes in patients with socio-economic and multiple disadvantages [7, 8]. Previous studies assessing overall indices of socio-economic position with labour epidural analgesia have yielded inconsistent results [9, 10]. Similarly, lower levels of education have been associated with reduced epidural analgesia use in some, but not all, studies [11, 12]. Residing in areas of lower socio-economic position is associated with higher levels of adverse pregnancy outcome risk factors, and therefore a greater underlying obstetric risk and potential need for obstetric anaesthesia [7].

Scotland is a country with a publicly funded national health service which aims to deliver equitable treatment that is free at the point of care. Despite this, socio-economic inequality remains a problem, with women living in areas of greatest socio-economic deprivation experiencing 22 fewer years of good health compared with those in the least deprived areas [13]. The aims of this study were to investigate the association of socio-economic position with utilisation of epidural analgesia and determine whether the degree of inequality varied between women with a defined clinical indication for epidural analgesia.

Methods

This was a whole population study. Five Scotland-wide databases were linked: Scottish Morbidity Record-1; Scottish Morbidity Record-2; Scottish Birth Record; National Records of Scotland; and the Scottish Stillbirth Infant Death Survey. The Scottish Morbidity Record-1 records all inpatient and day-case admissions and records diagnoses according to the International Classification of Diseases 9th or 10th revisions (ICD-9/ICD-10) [14]. The Scottish Morbidity Record-2 records all maternity inpatient and day-case admissions, including maternal and infant characteristics. The Scottish Birth Record records all neonatal care and the National Records of Scotland registers all births, stillbirths and infant deaths in Scotland. The Scottish Stillbirth Infant Death Survey then obtains additional information from the Scottish Stillbirth Infant Death Survey co-ordinator (an obstetrician, paediatrician or midwife) at each hospital. The Public Benefit and Privacy Panel for Health and Social Care (HSC-PBPP) of NHS Scotland provided regulatory approvals for the linkage.

We analysed all births in Scotland between 1 January 2007 and 23 October 2020, the most recent data available at extraction. Analyses were restricted to all births between 24+0 and 43+6 gestational weeks, including stillbirths and known congenital abnormalities. We did not study elective caesarean sections and unrecorded mode of delivery. This article follows STROBE guidelines for reporting [15].

Epidural analgesia was defined as conventional lumbar epidural analgesia, excluding combined spinal–epidural (CSE). We were unable to identify CSE utilisation, as it is classified as "*spinal anaesthesia*" in the Scottish Morbidity Record-2. There are no published data on CSE use in labour utilisation in Scotland. Reports from anaesthetic colleagues across all major Scottish maternity units suggest that < 1% of labour epidural analgesia is provided using CSE. The small proportion of women having CSE in labour were included in the non-epidural analgesia group. Since recording of anaesthetic intervention is hierarchical, we could not identify if a woman who had a spinal or general anaesthetic also had an epidural earlier. Around 5% of epidurals are converted to spinal or general anaesthesia [16].

The Scottish Index of Multiple Deprivation (SIMD) was used as a proxy for individual-level socio-economic position. This is a tool developed by the Scottish Government to assess relative deprivation, by dividing Scotland into 6976 geographical data zones, each with a mean population of 750. Zones are assessed across seven domains: employment; income; health; education; access to services; crime; and housing. Thirty-two indicators are used to generate deciles of SIMD (online Supporting Information Table S1), with SIMD 1 the most socio-economically deprived and SIMD 10 the least deprived [17]. During our study period, the SIMD tool has been updated four times to account for the fluctuation in relative deprivation of an area with time (2009; 2012; 2016; and 2020). The use of the SIMD is in keeping with the MBRRACE-UK reports which use the English Index of Multiple Deprivation, incorporating the same domains with slightly different weighting [7].

Ethnic group was defined according to the 2011 Scottish census categories. Location of birth was divided into obstetric unit, freestanding midwifery unit or home birth. Obstetric unit was defined as a hospital with on-site obstetric and obstetric anaesthetic services (including the provision of epidural analgesia), or a midwifery-led unit which was co-located with an obstetric-led unit and which had direct access to obstetric and anaesthetic services.

Freestanding midwifery units were defined as midwifery-led units without direct access to obstetric or anaesthetic services [18]. All women who received epidural analgesia were coded as delivering in an obstetric unit. Comorbidities as defined by the Elixhauser Comorbidity Index, were identified using the ICD-9/ICD-10 edition codes from the Scottish Morbidity Record-1 data set [14, 19]. Gestational age at birth was defined based on ultrasound assessment in the first half of pregnancy.

Medical conditions for which epidural analgesia is advisable for maternal safety (medical indications) were defined as serious cardiovascular or respiratory disease as identified from the Bateman Comorbidity Index; pre-eclampsia; previous caesarean section; breech delivery; multiple pregnancy; and patients with severe obesity (defined by a BMI ≥ 40 and (in a sensitivity analysis) with a BMI ≥ 50, as listed within the Scottish Morbidity Record-2 (online Supporting Information Table S2)). Collectively these indications are recognised within obstetric guidelines [20–24]. Contraindications to labour epidural analgesia included: coagulation factor deficits; Von Willebrand disease; thrombocytopenia; fever or infection during labour; and chorioamnionitis [5]. The ICD-9 and ICD-10 codes for indications and contraindications are in online Supporting Information Table S2. As asthma is a spectrum of disease and may not always represent a medical indication for epidural analgesia, we performed a sensitivity analysis which excluded asthma as a medical indication.

A robust Poisson regression model with a sandwich estimator was employed to calculate unadjusted relative risks (RR) and absolute risks (AR) for graphical interpretation, including 95%CIs per incremental increase in area deprivation (tenths of SIMD). This analysis was unadjusted. The definition of a confounder is anything that is known to cause, or is a plausible cause of, the exposure (here socio-economic position) and outcome (here epidural utilisation) [25, 26]. While maternal age, parity, spontaneous labour and other factors might influence the use of labour epidural, these cannot affect a woman's socio-economic position at the start of pregnancy. They could potentially mediate an effect of socio-economic position on epidural utilisation (online Supporting Information Figure S1). However, our aim here was to determine the total effect of socio-economic position on epidural utilisation and hence we did not want to remove any impact via mediators (factors on the causal path). Furthermore, the strong assumptions of multivariable regression approaches to mediation analyses can result in biased results, which are then difficult to interpret [25, 27]. The date of delivery could be considered a confounder variable as the socio-economic position of an area, as well as peripartum practice, can fluctuate with time. For this reason, two sensitivity analyses were carried out: one which adjusts for the date of delivery as a continuous variable, and another which adjusts for the date of delivery as a categorical variable in accordance with the SIMD updates.

Identical analyses were conducted separately in women with a medical indication/no contraindication for epidural analgesia, and in those who did not have a clinical indication. These were presented as both RR and AR with associated 95%CI for each SIMD decile. Additionally, differences between each consecutive SIMD decile were calculated and averaged to calculate the inter-decile mean change in absolute probability of receiving epidural analgesia overall, and for those with a medical indication/no contraindication for epidural analgesia.

A sensitivity analysis evaluated the influence of birth hospital location on socio-economic position and epidural analgesia use, restricting cases to women delivering in one major Scottish city with 24-h access to obstetric and anaesthetic services. As analgesia requirements may vary between nulliparous and parous women, we performed a further sensitivity analysis restricted to cases including only primiparous women. Additional sensitivity analyses explored the relationship between socio-economic position epidural analgesia utilisation and white or non-white ethnicity; the robustness of medically indicated epidural analgesia results with a higher severe obesity threshold (BMI ≥ 50); and with asthma excluded as a medical indication for labour epidural analgesia. Similar methods were applied in these sensitivity analyses. Although we do not believe these are true confounders, multivariable regression analysis was carried out as a sensitivity analysis, with adjustment for the following: age at delivery; maternal BMI; ethnicity; maternal diabetes; the presence of single or multiple comorbidities; use of injectable drugs; parity; and location of birth.

Missing data, excluding those for outcome variables, were imputed using multiple imputations via chained equations, creating 10 imputed data sets with predictive mean matching. Ten iterations provided optimal stability, while 10 imputations ensured accurate pooled variable effect size estimates. Missingness ranged from 0% (delivery location) to 38.3% for ethnicity (Table 1). Missing data were dealt with by using a robust imputation method using all available variables (including those not used in the current analysis). Non-imputed analysis is in online Supporting Information Table S3 and Figure S3. Outcomes for ≤ 5 patients were recorded as ≤ 5 complying with the electronic Data Research and Innovation Service (eDRIS) policy. A p value of < 0.05 indicated statistical significance,

Table 1 Patient characteristics of study population by epidural use. Values are median (IQR) or number (proportion).

	Epidural n = 131,521	No epidural n = 461,709
Age; y*	29 (24–33)	29 (25–33)
Maternal BMI*	25.1 (22.3–29.4)	24.7 (22.0–28.7)
Missing	14,637 (11.1%)	56,131 (12.2%)
Ethnicity		
White	79,274 (60.3%)	259,485 (56.2%)
Asian	3878 (2.9%)	12,236 (2.7%)
Black	1184 (0.9%)	4322 (0.9%)
Mixed	482 (0.4%)	1301 (0.3%)
Other	892 (0.7%)	2761 (0.6%)
Missing	45,811 (34.8%)	181,604 (39.3%)
SIMD decile		
10 (least deprived)	11,320 (8.6%)	33,608 (7.3%)
9	11,623 (8.9%)	37,392 (8.1%)
8	12,659 (9.7%)	40,281 (8.7%)
7	11,887 (9.1%)	42,024 (9.1%)
6	11,593 (8.8%)	42,871 (9.3%)
5	12,041 (9.2%)	45,780 (9.9%)
4	13,592 (10.3%)	48,169 (10.4%)
3	14,480 (11.0%)	51,645 (11.2%)
2	15,464 (11.8%)	56,758 (12.3%)
1 (most deprived)	16,532 (12.6%)	61,896 (13.4%)
Missing	430 (0.3%)	1285 (0.3%)
Smoking History		
Current smoker	20,763 (15.8%)	85,576 (18.5%)
Former smoker	19,750 (15.0%)	53,420 (11.6%)
Never smoked	85,107 (64.7%)	302,769 (65.6%)
Missing	5901 (4.5%)	19,944 (4.3%)
Injected illicit drugs	638 (0.7%)	2604 (0.8%)
Missing	38,840 (29.5%)	147,415 (31.9%)
Number of comorbidities**		
0	113,914 (86.6%)	401,184 (86.9%)
1	13,938 (10.6%)	47,921 (10.4%)
2 or more	3669 (2.8%)	12,604 (2.7%)
Pre-eclampsia	2645 (2.0%)	5468 (1.2%)
Diabetes	3915 (3.1%)	10,750 (2.4%)
Missing	4160 (3.2%)	17,107 (3.7%)
Previous spontaneous abortions		
Missing	503 (0.4%)	1950 (0.4%)
Previous therapeutic abortions	11,801 (9.0%)	37,638 (8.2%)
Missing	501 (0.4%)	1939 (0.4%)
Previous caesarean sections	7878 (6.0%)	24,884 (5.4%)
Missing	272 (0.2%)	1401 (0.3%)
Parity	0 (0–1)	1 (0–1)
Missing	654 (0.5%)	2525 (0.5%)

(continued)

Table 1 (*continued*)

	Epidural n = 131,521	No epidural n = 461,709
Estimated gestation; weeks*	40 (39–41)	40 (38–40)
Location of birth		
Freestanding midwifery unit	0	25,830 (5.6%)
Obstetric unit	131,521 (100%)	435,454 (94.3%)
Home	0	415 (0.1%)
Missing	0	10 (< 0.1%)
Induction of labour	60,839 (46.3%)	123,972 (26.9%)
Missing	2056 (1.6%)	5522 (1.2%)
Multiple births	2344 (1.8%)	4216 (0.9%)

SIMD, Scottish Index of Multiple Deprivation.
*Range for these data not provided to avoid potential breaches of confidentiality.
**Comorbidities are classified according to the Elixhauser Comorbidity Index.

calculated using 2-sided Wilcoxon rank sum and χ^2 tests. All analyses used R (Version 4.2.0, R Foundation for Statistical Computing, Vienna, Austria). Additional methods are in the online Supporting Information Appendix S1.

Results

Between 1 January 2007 and 23 October 2020, 735,650 deliveries were recorded in Scotland. After exclusions, the analysis cohort comprised 593,230 deliveries of which 131,521 (22.2%) received epidural analgesia during labour (online Supporting Information Figure S2). As compared with women who did not receive epidural analgesia during labour, women who received epidural analgesia were more likely to: be older; have a higher BMI; be of non-white ethnicity; be diabetic or pre-eclamptic; have comorbidities; be smokers; use illicit drugs; and be primiparous (Table 1).

For each increase in SIMD decile, women were on average: 0.6 years younger; had a 0.14 unit higher mean BMI; were 0.8 times as likely to smoke; and were 1.8 times more likely to take illicit drugs (Fig. 1). Despite women in the most deprived area (SIMD 1) being significantly younger than women in the most affluent area (SIMD 10; median (IQR [range]) age 26 [22–31] vs. 32 [29–36] y), they were more likely to be diabetic (SIMD 1 RR 1.49 [95%CI 1.37–1.61]) and were around three times as likely to have two or more comorbidities (SIMD 1 RR 3.34 [95%CI 3.05–3.66]) (online Supporting Information Table S4). The prevalence of pre-eclampsia was similar across all SIMD deciles (online Supporting Information Table S4). Higher BMI, Asian or mixed ethnicity, higher SIMD, comorbidities and being primiparous were associated with having epidural analgesia (Table 2). Younger age, smoking and a history of injected illicit drug use were associated with lower use of labour epidural analgesia (Table 2).

Patients living in the most deprived area (SIMD 1) were less likely to have epidural analgesia during labour compared with patients living in the most affluent (SIMD 10 RR 0.84 [95%CI 0.82–0.85] (Table 2)). In general, the probability of having epidural analgesia decreased with increasing levels of socio-economic deprivation (Fig. 2a, online Supporting Information Table S5), with the exception of SIMD deciles 5, 6, 7, reflecting their rural location and lack of proximity to an obstetric unit with anaesthetic services (Fig. 3). The inter-decile mean change in having epidural analgesia was estimated at -2% (95%CI -1.7% to -2.2%) with increasing deprivation. Sensitivity analyses which adjusted for the date of delivery as both a continuous and a categorical variable were consistent with the results of the main analysis (SIMD 1 vs. SIMD 10, RR 0.84 [95%CI 0.82–0.85] and 0.84 [95%CI 0.82–0.85], respectively) (online Supporting Information Tables S6 and S7). When the analysis was restricted to births occurring within one major Scottish city where all hospitals had full 24 h access to obstetric and anaesthetic services (n = 143,077), patients living in SIMD 1, 2 and 3 residential areas (i.e. more deprived areas) were still less likely to receive epidural analgesia than women living in SIMD 10 (SIMD 1 vs. SIMD 10, RR 0.86 [95%CI 0.83–0.90]; SIMD 2 vs. SIMD 10, RR 0.90 [95%CI 0.87–0.94]; SIMD 3 vs. SIMD 10 RR 0.95 [95%CI 0.91–1.00]). No difference was seen between women from SIMD 4–9 and SIMD 10 (online Supporting Information Figure S4 and Table S8). Results for a subgroup analysis including only primiparous women (n = 282,340) were consistent with the results of the main paper, though the difference between groups was attenuated (SIMD 1 vs.

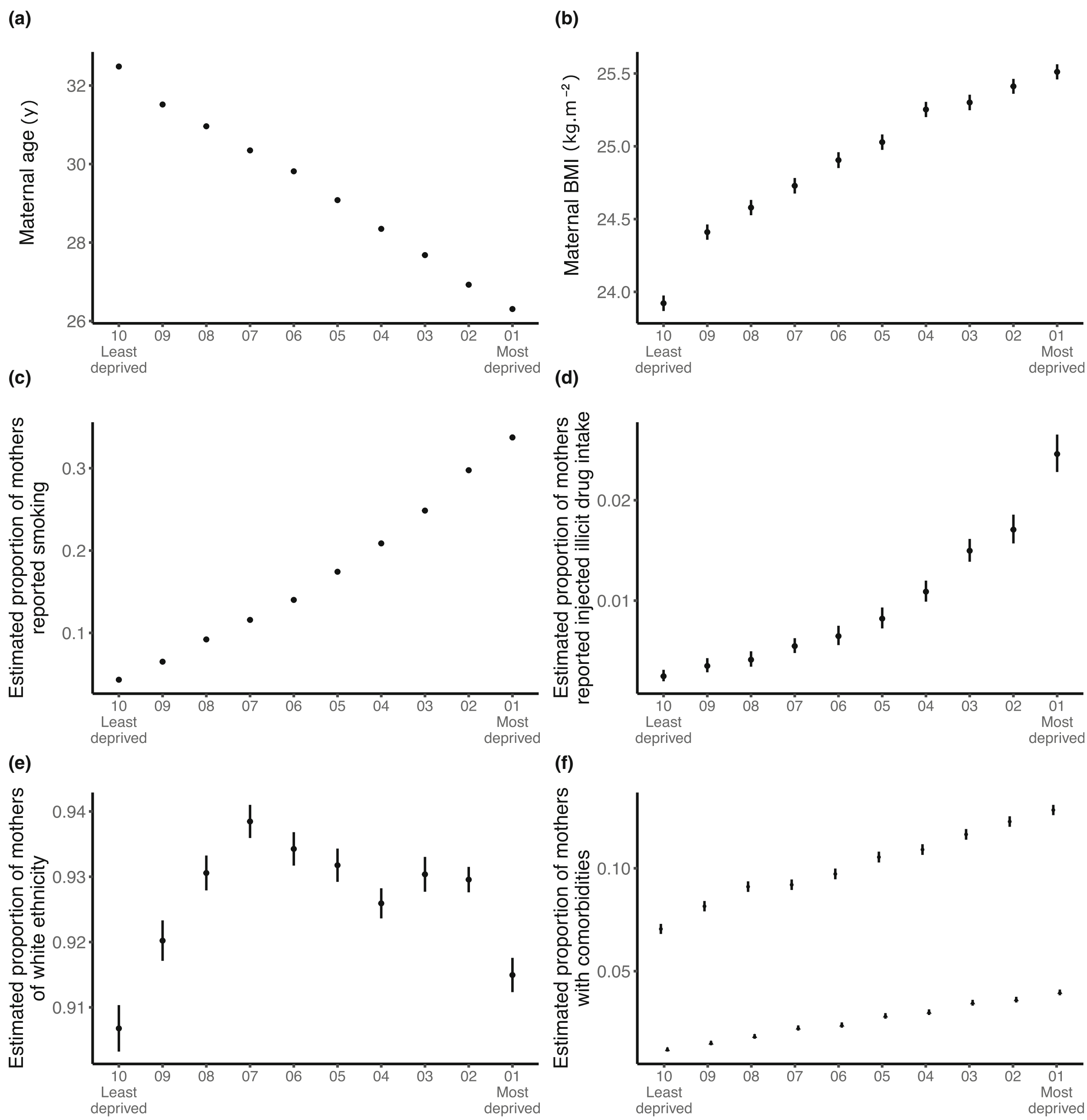

Figure 1 Scottish Index of Multiple Deprivation decile (SIMD) and maternal health characteristics. Panel (a) age, (b) BMI, (c) smoking history, (d) history of Injected drug use, (e) ethnicity (white, compared to non-white) and (f) maternal comorbidity (• = single comorbidity, Δ = multiple comorbidities). The point estimate represents the estimated proportion with the outcome including error bars for 95%CI (imputed).

SIMD 10, RR 0.91 [95%CI 0.89–0.93]) (online Supporting Information Table S9).

Of the 85,530 (14.4%) deliveries where there was a documented medical indication and no contraindication to epidural analgesia, 21,219 (24.8%) women received epidural analgesia (online Supporting Information Table S10). Among the women with a medical indication and no contraindication, those in the most disadvantaged socio-economic decile (SIMD 1) were less likely to use epidural analgesia than women in the least disadvantaged decile (SIMD 10) (online Supporting Information Table S11). Further information on the incidence of indications and

Table 2 Association between maternal characteristics and epidural analgesia.

	Risk ratio	95%CI	p value
Age at delivery	0.99	0.99–0.99	< 0.001
Maternal BMI	1.01	1.01–1.01	< 0.001
Ethnicity			
White	—	—	
Asian	1.04	1.01–1.07	0.010
Black	0.96	0.92–1.01	0.120
Mixed	1.10	1.02–1.19	0.018
Other	1.04	0.98–1.10	0.200
Not white (combined)	1.02	0.99–1.04	0.150
SIMD decile			
10 (least deprived)	—	—	
9	0.94	0.92–0.96	< 0.001
8	0.95	0.93–0.97	< 0.001
7	0.88	0.86–0.90	< 0.001
6	0.84	0.83–0.86	< 0.001
5	0.83	0.81–0.85	< 0.001
4	0.87	0.85–0.89	< 0.001
3	0.87	0.85–0.89	< 0.001
2	0.85	0.83–0.86	< 0.001
1 (most deprived)	0.84	0.82–0.85	< 0.001
Booking smoking history			
Non-smoker	—	—	
Current smoker	0.89	0.88–0.90	< 0.001
Former smoker	1.22	1.20–1.24	< 0.001
Injected illicit drugs			
No	—	—	
Yes	0.86	0.80–0.93	< 0.001
Comorbidities			
0	—	—	
1	1.02	1.00–1.03	0.018
2 or more	1.02	0.99–1.05	0.200
Pre-eclampsia			
No pre-eclampsia	—	—	
Pre-eclampsia	1.48	1.43–1.53	< 0.001
Diabetes			
No	—	—	
Yes	1.20	1.17–1.24	< 0.001
Previous spontaneous abortions			
No	—	—	
Yes	0.93	0.92–0.94	< 0.001
Previous therapeutic abortions			
No	—	—	
Yes	1.08	1.07–1.10	< 0.001
Previous caesarean sections			
No	—	—	
Yes	1.09	1.07–1.11	< 0.001

(continued)

Table 2 (*continued*)

	Risk ratio	95%CI	p value
Parity	0.64	0.63–0.64	< 0.001
Estimated gestation	1.09	1.09–1.10	< 0.001
Location of birth			
Obstetric unit	—	—	
Freestanding midwifery unit	0.00	0.00–0.00	< 0.001
Home	0.00	0.00–0.00	< 0.001
Multiple birth			
No	—	—	
Yes	1.62	1.57–1.68	< 0.001

SIMD, Scottish Index of Multiple Deprivation.

contraindications can be found in the online Supporting Information Table S12. While women with a medical indication were more likely to have epidural analgesia, the socio-economic gradient persisted with women living in the most deprived areas less likely to have epidural analgesia during labour than those living in the most affluent area (SIMD 1 vs. SIMD10; RR 0.79 [95%CI 0.75–0.84]) (Fig. 2b, online Supporting Information Table S13). The inter-decile mean change in having epidural analgesia was estimated at -2.5% [95%CI -3.1% to -2.0%] with increasing deprivation. Similar results were seen in the subgroup of women who did not have a medical indication (or contraindication) to epidural. Despite having a medical indication for epidural analgesia, women living in the most deprived areas were still less likely to receive epidural analgesia than women from the least deprived SIMD decile who did not have a medical indication (AR 0.23 [95%CI 0.22–0.24] vs. 0.25 [95%CI 0.24–0.25], respectively) (online Supporting Information Table S14). The results were similar when the threshold for obesity was increased to BMI ≥ 50 (AR 0.22 [95%CI 0.22–0.23] vs. 0.25 [95%CI 0.24–0.25], respectively) (online Supporting Information Figure S5 and Table S15), and when the definition of medical indication was changed to exclude asthma (AR 0.24 [95%CI 0.23–0.25] vs. 0.25 [95%CI 0.24–0.25], respectively) (online Supporting Information Table S16).

When analyses were stratified by ethnicity, a steeper socio-economic gradient was observed in women of non-white ethnicity (Fig. 2c, online Supporting Information Table S17). The likelihood of receiving epidural analgesia was highest in the least deprived women of non-white ethnicity (AR 0.29 [95%CI 0.27–0.31]), as compared with the most deprived where the non-white population were least likely to receive epidural analgesia (AR 0.19 [95%CI 0.17–0.20]) (Fig. 2c, online Supporting Information Table S17).

Discussion

In this Scottish population-based cohort study, we found that women from areas of greater socio-economic disadvantage were substantially less likely to receive epidural analgesia during labour. These results were consistent when the analysis was restricted to births occurring within an inner-city environment with uniform access to obstetric and obstetric anaesthetic services, or when restricted to only include births in primiparous women. We may have expected a weaker or no socio-economic gradient in women with a medical indication for epidural analgesia, but in these women the socio-economic gradient persisted. Reduced use of epidural analgesia in more socio-economically deprived women was also more marked in those of non-white ethnicity. Increasing socio-economic disadvantage was associated with a stepwise increase in a range of adverse maternal characteristics known to be causally related to adverse perinatal outcomes including maternal BMI, comorbidities, smoking and illicit drug use. That labour epidural analgesia, even when medically indicated, shows a socio-economic gradient in Scotland is concerning and may highlight potential institutional biases contributing to maternal and perinatal health disparities.

Seven other studies have explored the association of socio-economic position with the use of epidural analgesia [9–12, 28–30]. These have mostly used individual measures (private healthcare insurance, income, education) or overall socio-economic position measures and, consistent with our findings, have generally shown that women of lower socio-economic positions have lower utilisation of epidural analgesia. These studies include an observational study from the USA of 2,625,950 women, and a Canadian study of 220,814 women that both showed lower use of labour in women of lower socio-economic position, as determined by income and education level; however, maternal care was

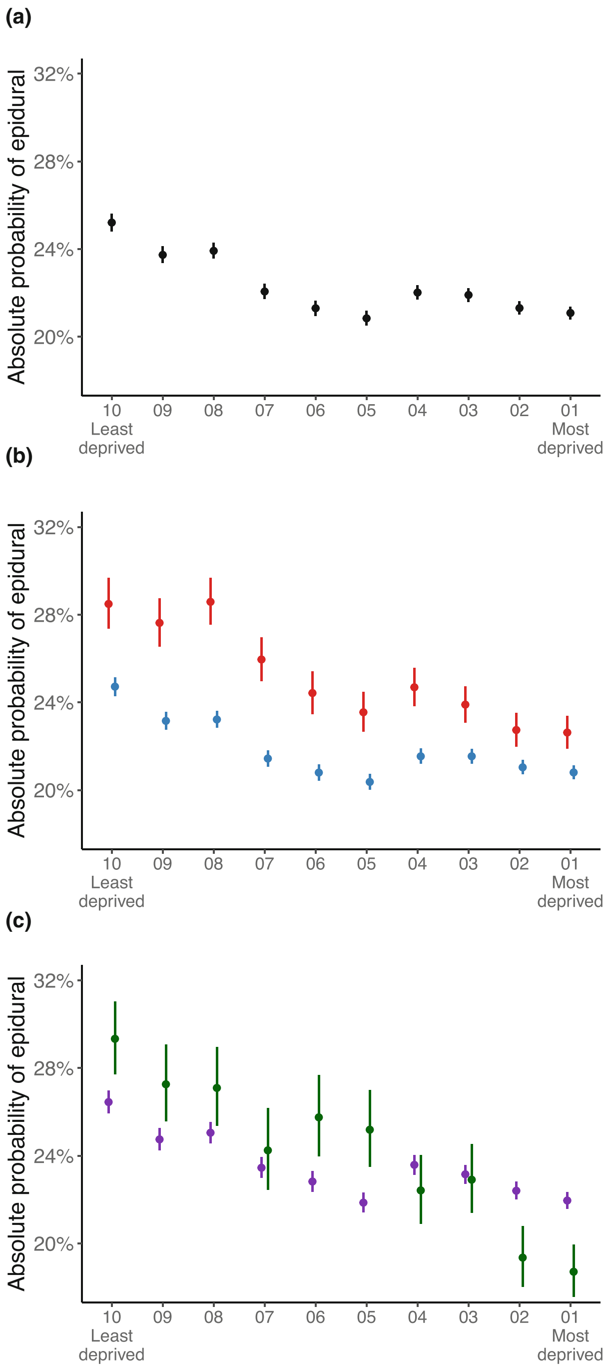

Figure 2 Scottish Index of Multiple Deprivation decile and absolute risk of epidural analgesia. Panel (a) all participants (online Supporting Information Table S5); (b) risk stratified by documented indication and no contraindication to epidural (online Supporting Information Table S14); and (c) risk stratified by white or non-white ethnicity (online Supporting Information Table S17). The point estimate represents the median absolute risk and the error bars indicate the 95%CIs (imputed). In (b) the red line represents the women who had a medical indication and no contraindication to labour epidural analgesia and the blue represents the women who did not have a medical or indication or had a contraindication. In (c) the purple represents women of white origin and the green represents women of a non-white origin.

not free at the point of care [12, 28]. Two observational studies were from countries with publicly funded maternity healthcare. A Finnish study of 521,179 women found a small reduction in labour epidural use in multiparous women of lower socio-economic position as inferred from occupation type; however, occupation data were missing for 17.4% [10]. A French study (10,419 parturients), classed women as `socio-economically deprived´ or not. It reported no difference in the use of labour neuraxial analgesia in this group (aOR 0.97 [95%CI 0.87–1.07], p = 0.54), but found reduced use of labour neuraxial analgesia in those who had not completed high school education (aOR 0.80 [95%CI 0.72–0.89], p = 0.0001) [9]. In France, rates of labour neuraxial analgesia are considerably higher compared with Scotland (over 90% in their cohort) and all women undertake a mandatory pre-anaesthetic evaluation at 33–37 weeks [9]. None of these studies investigated whether differences persisted in women with a medical indication. Furthermore, while geographical location and type of birthing unit may influence epidural analgesia use, the socio-economic gradient persisted when we restricted our analysis to inner-city teaching hospitals with 24-h access to obstetric and anaesthetic services. This further strengthens our confidence in the findings. While the slightly stronger socio-economic gradient in women with a medical indication for epidural analgesia in our analysis is surprising, this is further exemplified by the lower rate of epidural analgesia use in women from more deprived areas even if they had a medical indication compared with women from the most advantaged areas who had no such indication. Socio-economic inequalities in treatments, even when indicated, have previously been described for induction of labour and in other areas, for example the use of statins in patients who have cardiovascular disease and in recommended treatments for lung cancer [31–33].

Several factors may contribute to the lower epidural analgesia utilisation in women from lower socio-economic position, even when clinically indicated. Age, comorbidities, smoking and illicit drug use may be potential mediators rather than true confounders of this relationship, and including these variables in the analysis are likely to bias the effect estimates. These women may lack knowledge about indications for epidural analgesia; have life circumstances

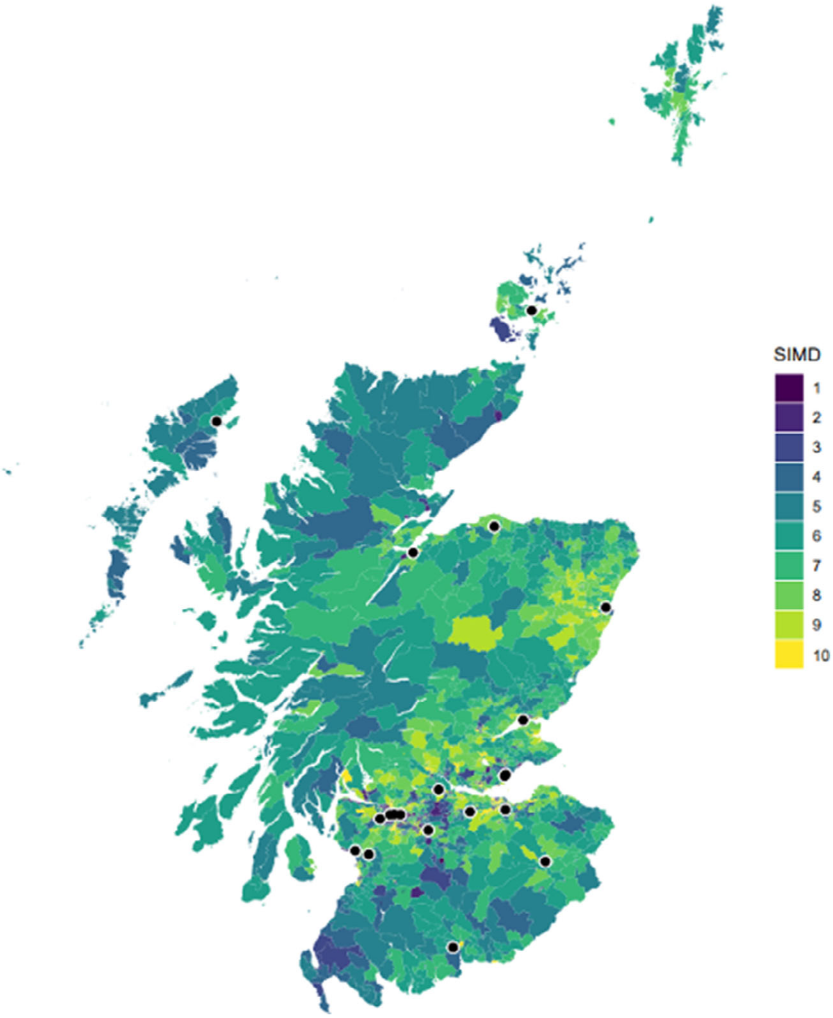

Figure 3 Scottish Index of Multiple Deprivation areas and Scottish Obstetric units. Black dots indicate the location of Scottish Obstetric Units.

that may adversely impact antenatal care attendance; mistrust medical staff; feel disempowered during labour; hold misconceptions about epidural analgesia safety; or have differing expectations and societal pressures regarding the pain of childbirth. Differences in healthcare professionals' attitudes and potential institutional and structural biases might also influence epidural analgesia use. Addressing implicit bias and ensuring cross-disciplinary education and appropriate patient information for all cultures and health literacy levels are crucial for effective shared decision-making. Group antenatal care may help achieve these goals [34]. The scope of the problem in wider society is vast and requires strategies to address any systems and policies that might inadvertently perpetuate the economic divide. Modern epidural analgesic regimes have been shown to be safe for both mother and baby, are associated with improved maternal outcomes and may be associated with improved neonatal outcomes [2–5, 35]. Understanding barriers to accessing and receiving high-quality healthcare is imperative if all patients are to receive optimal maternal care.

This study utilised high quality, nationally representative, routinely collected datasets reflecting contemporary clinical practice. We acknowledge several limitations, including the observational study design and area-based socio-economic position measure. As our aim was to explore inequalities in epidural utilisation, multivariable mediation analyses are likely to be biased [25]. With the exception of parity and date of delivery, we did not adjust for factors that might mediate the observed association between socio-economic position and epidural use. Since associations were attenuated when analyses were restricted to primiparous women, some of the inequality we observe might be due to parity. Alternatively, differences might be explained by bias from the exposure and mediator not being continuous variables, confounding between parity and socio-economic position/epidural use, and measurement error or other violations of multivariable mediation analyses [25, 27]. While covering many aspects of socio-economic position, our area-based measure may introduce ecological bias, i.e. it is possible that there is little or no association between individual socio-economic position and epidural analgesia use. Differences between rural and urban areas could be related to proximity to an obstetric unit providing analgesic services or differences in the number of people in rural areas, which may be more likely to include areas of mixed deprivation, potentially affecting the SIMD level allocated to each woman [17]. This is partially, but not fully, mitigated by a sensitivity analysis of inner-city teaching hospitals that cover an almost entirely urban population. Given the broadly similar results in studies of the association of individual socio-economic position measures with epidural analgesia, this is less likely [9–12, 28–30]. Furthermore, MBRRACE-UK reports highlight that women who live in deprived areas are at increased risk of adverse maternal and perinatal outcomes, and this study is investigating differences in the perinatal care between those who live in more deprived compared with more affluent areas. Area-based measures of socio-economic position, such as SIMD, are highly appropriate to assess the use of healthcare provision in which the area of residence of people influences which healthcare provider (for example, maternity unit) they access. As CSE is not differentiated from spinal anaesthesia in our dataset, we were unable to identify women who had a CSE for labour epidural analgesia. In our collective experience, this technique is uncommon in Scotland, but this is an area where further data are required. We recognise that the list of indications/contraindications may be contested, but the stratification aimed to identify trends to support our main analysis results. We also acknowledge that some pregnant women may decline epidural analgesia even when medically indicated, potentially more so in women of lower socio-economic positions. It is of note that of the women who were identified as having a medical condition for which epidural may be indicated (and no contraindication) only 24.8% received labour epidural analgesia, regardless of socio-economic position. This suggests either intransigent patient beliefs regarding epidural analgesia or a different staff–patient interaction, further highlighting possible institutional biases. While our results are generalisable to Scotland's obstetric population, they may not be to more ethnically diverse populations. Exploring associations of a more refined ethnicity classification with epidural analgesia use and determining how socio-economic position and ethnicity interact with the use of labour epidural analgesia would be valuable. However, as Scotland is predominantly European, we could only explore white Europeans.

Our data from a large ethnically similar population with freely accessible healthcare finds that socio-economic deprivation is associated with lower utilisation of epidural analgesia in labour, independent of maternal risk factors, and irrespective of whether medically indicated. Addressing institutional and societal barriers to equitable access for an established and internationally recommended intervention that alleviates pain and may mitigate adverse maternal and neonatal outcomes is of paramount importance.

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Supporting Information

Additional supporting information may be found online via the journal website.

Figure S1. Directed acyclic graph exploring the relationship between socio-economic position and epidural utilisation.

Figure S2. Definition of cohort for analysis.

Figure S3. Relative risk of having epidural analgesia for each Scottish Index of Multiple Deprivation (SIMD) decile (unimputed), compared with SIMD decile 10.

Figure S4. Absolute risk of having epidural analgesia for each SIMD decile (imputed), compared with SIMD decile 10.

Figure S5. Scottish Index of Multiple Deprivation decile and absolute risk of epidural analgesia.

Table S1. Scottish Index of Multiple Deprivation domains and indicator descriptions.

Table S2. ICD-9 and ICD-10 codes used to define indications and contraindications to labour epidural analgesia.

Table S3. Association between maternal characteristics and epidural analgesia.

Table S4. Cohort characteristics by SIMD decile 1–10.

Table S5. Scottish Index of Multiple Deprivation decile and absolute probability of epidural analgesia.

Table S6. Scottish Index of Multiple Deprivation decile and relative risk of epidural analgesia.

Table S7. Scottish Index of Multiple Deprivation decile and relative risk of epidural analgesia, adjusted for date of delivery.

Table S8. Unadjusted sensitivity analysis, limited to teaching hospitals in one major Scottish city.

Table S9. Unadjusted sensitivity analysis, limited to primiparous parturients.

Table S10. Incidence of epidural analgesia and documented indication or contraindication to epidural.

Table S11. Epidural use by SIMD decile.

Table S12. Incidence of indications and contraindications to labour epidural analgesia.

Table S13. Relative risk of receiving an epidural for subgroup of women with a medical indication/no contraindication for epidural.

Tables S14–S17. Scottish Index of Multiple Deprivation deciles and absolute probability of epidural analgesia (imputed) with risk stratifications and exclusions.

Appendix S1. Supplementary methods