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Variation in severe maternal morbidity according to socioeconomic position: a UK national cohort study.

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ARTICLE SUMMARY

Article Focus

- To explore the relationship between socioeconomic position and severe maternal morbidity using data obtained from a series of UKOSS studies
- To estimate the risk of severe morbidity by socioeconomic group, independent of ethnicity, maternal age, smoking, pre-existing medical condition, BMI, multiple pregnancy and past pregnancy complications

Key Messages

- The results suggested that women from the lowest socioeconomic group are 1.22 times (95%CI: 0.92 – 1.61) more likely than women from the highest group to experience severe maternal morbidity
- The results also showed that other risk factors for severe maternal morbidity include non-white ethnicity, older maternal age (≥35 years), BMI ≥25 kg/m^2, pre-existing medical condition/s, multiple pregnancy or past pregnancy complications

Strengths and Limitations

- Study strengths include the robust case ascertainment, minimisation of sampling bias through collection of data from all consultant-led obstetric units in the UK and the clear definition of severe maternal morbidity
- Limitations relate to the data available to define socioeconomic position and the application of the findings to other non-UK setting

ABSTRACT

Objectives: This study aimed to explore the independent association between socioeconomic position, defined by occupation, and severe maternal morbidity amongst women in the UK. **Design:** Cohort study. **Setting:** The analysis was conducted as a case-control analysis, using data from a series of studies of direct causes of severe maternal morbidity undertaken through the UK Obstetric Surveillance System (UKOSS), with data collected throughout all consultant-let obstetric units in the UK. **Participants:** The analysis included 1,144 cases and 2.256 comparison women (controls). UKOSS studies from which data on case women were obtained included amniotic fluid embolism, acute fatty liver of pregnancy, eclampsia, peripartum hysterectomy, therapies for peripartum haemorrhage and uterine rupture. **Primary outcome measure:** Odds of severe maternal morbidity by socioeconomic group, independent of ethnicity, maternal age, smoking, pre-existing medical condition, BMI, multiple pregnancy and past pregnancy complications. Occupation was used to classify different socioeconomic groups. **Secondary outcome measure:** Odds of morbidity related to ethnic group, maternal age, smoking, pre-existing medical condition, BMI, multiple pregnancy and past pregnancy complications. **Results**: Across the socioeconomic groups, adjusted odds ratios were 1.17 (95%CI: 0.94 – 1.45) for the 'intermediate group', 1.16 (95%CI: 0.93 – 1.45) for 'routine/manual', 1.22 (95%CI: 0.92 – 1.61) for 'unemployed' women, and 1.51 (95%CI: 1.18 – 1.94) for women with missing socioeconomic information. Women of non-white ethnicity, older maternal age (≥35 years), BMI ≥25 kg/m^2 and those with pre-existing medical condition/s, multiple pregnancy or past pregnancy complications were shown to have a significantly increased odds of severe maternal morbidity. **Conclusion**: This study suggests that socioeconomic position may be an independently associated with an increased risk of severe maternal morbidity. Further research is warranted to investigate why this association exists in a country where healthcare is universal and free at the point of access.

INTRODUCTION

Maternal morbidity is of major public health concern with some estimates suggesting that as many as ten million women worldwide suffer from pregnancy-related complications each year[1]. In countries where maternal deaths are infrequent, the information that mortality audits provide cannot be generalised readily across the general population of pregnant women, nor can it necessarily accurately predict which women are at increased risk of adverse outcomes[2]. In these circumstances, additional focus on maternal morbidity is now widely recognised as a robust approach to improving maternal health and the quality of healthcare provision[3-6].

Identifying high-risk women is imperative to prevent adverse outcomes, since it allows more intensive clinical management to be directed towards these women and is the fundamental purpose of antenatal care. Extensive research has demonstrated convincing links between severe maternal morbidity and advanced maternal age, pre-existing medical conditions and obesity[1 7 8]. However, these factors are unable to explain entirely the differences in maternal morbidity found between different populations of women both within and between countries. Other evidence suggests that ethnicity and social disadvantage may have a significant role to play, with UK data suggesting that women from ethic minority groups are more likely to experience severe maternal morbidity than white women, and also to be at higher risk of dying from specific maternal morbidities[9-11]. However, as highlighted by several studies exploring ethnic differences in maternal health, it is unclear whether ethnicity itself is directly related to poor outcomes or, more likely, whether it is a marker for factors such as low socioeconomic position and lower levels of education[12]. Because minority ethnic groups are often disproportionately represented in lower socioeconomic groups, ethnicity and socioeconomic position are often confounded and results attributed to ethnic difference, may be due, at least in part, to socioeconomic differences[13]. The aim of the analysis reported here was to explore the independent risk of severe maternal morbidity associated with socioeconomic position in the UK.

METHODS

Data Collection and Definitions

A case-control analysis was performed using data derived from a series of UK-wide studies of direct causes of maternal morbidity undertaken through the UK Obstetric Surveillance System (UKOSS)[14]. These studies were of amniotic fluid embolism (AFE), acute fatty liver of pregnancy (AFLP), eclampsia, peripartum hysterectomy, therapies for peripartum haemorrhage and uterine rupture[15-21]. For the purpose of this analysis, these cases are collectively referred to as 'severe maternal morbidity' (Box 1).

Box 1. Criteria used to define cases of severe maternal morbidity used in the UKOSS studies included in the analysis

Condition	Definition
Amniotic fluid embolism	EITHER a clinical diagnosis of AFE (acute hypotension or cardiac arrest, acute hypoxia or coagulopathy in the absence of any other potential explanation for the symptoms and signs observed) OR a pathological diagnosis (presence of fetal squames or hair in the lungs)
Acute fatty liver of pregnancy	EITHER AFLP confirmed by biopsy or post-mortem examination OR a clinician has made a diagnosis of AFLP with signs and symptoms consistent with AFLP
Eclampsia	The occurrence of convulsions during pregnancy or in the first ten days postpartum, together with at least two of the following features within 24 hours after the convulsions: 1) Hypertension (a booking diastolic pressure of <90mmHg, a maximum diastolic of ≥90mmHg, and a diastolic increment of ≥25mmHg) 2) Proteinuria (at least + protein in a random urine sample or ≥0.3g in a 24hr collection) 3) Thrombocytopenia (platelet count of $<100X10^9$/l) 4) An increased plasma alanine aminotransferase (ALT) concentration (≥42 iu/l) or an increased plasma aspartate transaminase aminotransferase (AST) concentration (≥42iu/l)

Peripartum hysterectomy	Any woman giving birth to an infant and having a hysterectomy during the same clinical episode
Therapies for major peripartum haemorrhage	All women in the UK treated therapeutically or prophylactically for major peripartum haemorrhage with: EITHER Activated factor VIIa OR B-lynch suture or other brace suture OR Arterial ligation or embolisation
Uterine rupture	Any woman in the UK identified as having a uterine rupture using the following definition: A complete separation of the wall of the pregnant uterus, with or without explusion of the fetus, involving rupture of the membranes at the site of the uterine rupture or extension into the uterine muscle separate from any previous scar, and endangering the life of the mother or fetus Excluded: any asymptomatic palpable or visualised defect (for example dehiscence noted incidentally at caesarean delivery)

The UKOSS methodology used to carry out a following programme of studies has been described in detail elsewhere[14]. In brief, monthly mailing of notification cards to all obstetric-led maternity units in the UK enables identification of all cases under study. Data collection forms despatched in response to a case notification are used by the clinician responsible for care to report de-identified information from the woman's medical notes. Follow-up of non-responders maximises the completeness of data collection and confirms denominator numbers for incidence estimates.

For many of the UKOSS studies, data about a representative sample of women without the specific condition under study were obtained by collecting information on the two women delivering immediately prior to each case in the same obstetric unit; these were defined as controls. The same information was collected about the controls as for case women. Data were thus available for analysis on 1,144 cases of severe maternal morbidity and 2,256 controls.

Maternal occupation was used to classify cases and controls by socioeconomic group, where this was not available her husband's/partner's occupation was used. Using the National

Statistics Socio-Economic Classification (NS-SEC)[22], occupation was coded into three categories plus an additional group for unemployed women.

Statistical Analysis

All analyses were carried out using STATA version 11.0. Following univariable analysis multivariable unconditional logistic regression was used to examine the independent relationship between socioeconomic position and severe maternal morbidity and to generate adjusted odds ratios (aORs) with their 95% confidence intervals (95%CIs). Due to the high proportion and distribution of missing data for some variables, particularly for socio-economic position (Table 1), 'missing' was included as a separate group for each categorical variable.

Table 1. Distribution of missing data for cases of severe maternal morbidity and controls

Variable	Number of cases with missing information (% of total cases)	Number of controls with missing information (% of total controls)
Socioeconomic Group	193 (16.9)	303 (13.4)
Ethnicity	18 (1.6)	78 (3.5)
Age	3 (0.3)	18 (0.8)
Smoking	28 (2.5)	61 (2.7)
Pre-existing medical condition(s)	6 (0.5)	27 (1.2)
Body mass index	128 (11.2)	219 (9.7)
Parity	3 (0.3)	22 (1.0)
Multiple pregnancy	2 (0.2)	18 (0.8)
Past pregnancy complication(s)	9 (0.8)	31 (1.4)

Variables likely to confound the relationship between socioeconomic position and severe maternal morbidity were identified *a priori* based on evidence from the published literature and the results of univariable analysis. These included ethnicity, maternal age, smoking, pre-existing medical conditions and body mass index (BMI)[1 7 10 23-35]. Other variables included in the analysis as possible confounders were parity, multiple pregnancy and past pregnancy complications.

Model building using unconditional logistic regression proceeded by the inclusion of severe maternal morbidity (outcome) and socio-economic position, with each of the potential confounders added in turn one-by-one. The individual effect of each variable on the fit of the data was assessed using the likelihood ratio test. The variables with *a priori* evidence of effect were included in the final model. Of the additional three variables examined (parity, multiple pregnancy and past pregnancy conditions) only those demonstrating a statistically significant effect ($p<0.05$) on the fit of the data were retained; parity was thus excluded.

Age, included as a continuous variable, was tested for departure from linearity; the results are for ease of presentation, shown as categorical. BMI was included as a categorical variable due to the high proportion of missing data and the concern that by including it as continuous, women with missing data would be excluded and the effect size underestimated. There was no evidence of a significant interaction between socioeconomic position and any of the other variables included in the final model ($p<0.01$).

Sensitivity analyses were conducted to explore the effect of missing data for socioeconomic position and BMI. The final multivariable regression model was re-run after redistributing missing values into the lowest and highest categories for each of these variables.

Study Power

The analysis included a fixed number of cases and controls derived from specified UKOSS studies. Based on 1,144 cases and 2,256 controls, and with a prevalence of 13% for the lowest (unemployed) socioeconomic group, the analysis had 80% power to detect as statistically significant ($p<0.05$) an odds of 1.32 or greater and 90% power to detect as statistically significant ($p<0.05$) an odds of 1.37 or greater, for comparisons with the highest (managerial/professional) socioeconomic group.

RESULTS

The analysis included a total of 1,144 cases of severe maternal morbidity and 2,256 controls Compared with the controls cases were more likely to be older, multiparous, of non-white ethnicity, to have missing socio-economic position and BMI information, to be non-smokers, to have a pre-existing medical condition, a history of past pregnancy complications and a multiple pregnancy in the index pregnancy (Table 2).

Table 2. Unadjusted and adjusted odds of severe maternal morbidity by maternal characteristics

Characteristic	Cases n= (%) N= 1,144	Controls n= (%) N=2,256	Unadjusted OR (95% CI)	Adjusted* OR (95%CI)
Socioeconomic group				
Managerial/ Professional	292 (25.5)	567 (25.1)	1.0	1.0
Intermediate	244 (21.3)	482 (21.4)	0.98 (0.80 – 1.21)	1.17 (0.94 – 1.45)
Routine/Manual	273 (28.7)	595 (26.4)	0.89 (0.73 – 1.09)	1.16 (0.93 – 1.45)
Unemployed	142 (14.9)	309 (13.7)	0.89 (0.70 – 1.14)	1.22 (0.92 – 1.61)
Missing	*193 (16.9)*	*303 (13.4)*	*1.24 (0.98 – 1.56)*	*1.51 (1.18 – 1.94)*
Ethnic group				
White	827 (72.3)	1796 (79.6)	1.0	1.0
Asian	139 (12.2)	197 (8.7)	1.53 (1.22 – 1.93)	1.57 (1.23 – 2.00)
Black	108 (9.4)	116 (5.1)	2.02 (1.54 – 2.66)	1.77 (1.32 – 2.36)
Other	52 (4.6)	69 (3.1)	1.64 (1.13 – 2.37)	1.50 (1.02 – 2.19)
Missing	*18 (1.6)*	*78 (3.5)*	*0.50 (0.30 – 0.84)*	*0.51 (0.28 – 0.91)*
Age				
Age <20	56 (4.9)	139 (6.2)	0.98 (0.70 – 1.39)	1.08 (0.75 – 1.56)
Age 20 – 24	127 (11.1)	449 (19.9)	0.69 (0.54 – 0.89)	0.71 (0.55 – 0.92)
Age 25 – 29	225 (19.7)	549 (24.3)	1.0	1.0
Age 30 – 34	341 (29.8)	622 (27.6)	1.34 (1.09 – 1.64)	1.33 (1.08 – 1.64)
Age ≥35	392 (34.3)	479 (21.2)	2.00 (1.63 – 2.45)	1.98 (1.60 – 2.45)
Missing	*3 (0.3)*	*18 (0.8)*	*0.41 (0.12 – 1.39)*	*2.66 (0.22 – 26.00)*
Smoking status				
Non-Smokers	899 (78.6)	1,642 (72.8)	1.0	1.0
Smokers	217 (19.0)	553 (24.5)	0.72 (0.60 – 0.86)	0.89 (0.73 – 1.08)
Missing	*28 (2.5)*	*61 (2.7)*	*0.84 (0.53 – 1.32)*	*0.95 (0.54 – 1.67)*
BMI				
Continuous (per kg/m^2 increase in BMI)			1.01 (1.00 – 1.03)	
< 25 kg/m^2	513 (44.8)	1,121 (49.7)	1.0	1.0
25-29.9 kg/m^2	297 (26.0)	545 (24.2)	1.19 (1.00 – 1.42)	1.10 (0.92 – 1.32)
≥ 30 kg/m^2	206 (18.0)	371 (16.5)	1.21 (0.99 – 1.48)	1.09 (0.88 – 1.34)
Missing	*128 (11.2)*	*219 (9.7)*	*1.28 (1.00 – 1.63)*	*1.24 (0.95 – 1.61)*
Co-existing medical conditions**				
No	1,045 (91.4)	2,126 (94.2)	1.0	1.0
Yes	93 (8.1)	103 (4.6)	1.84 (1.38 – 2.46)	1.60 (1.18 – 2.17)
Missing	*6 (0.5)*	*27 (1.2)*	*0.45 (1.18 – 1.10)*	*0.76 (0.17 – 3.41)*
Parity				
Nulliparous	403 (35.2)	984 (43.6)	1.0	No significant effect on fit of model (excluded)
Multiparous	738 (64.5)	1,250 (55.4)	1.44 (1.24 – 1.67)	
Missing	*3 (0.3)*	*22 (1.0)*	*0.33 (0.10 – 1.12)*	

Multiple pregnancy				
No	1,083 (94.7)	2,211 (98.0)	1.0	1.0
Yes	59 (5.2)	27 (1.2)	4.46 (2.81 – 7.08)	3.88 (2.42 – 6.22)
Missing	*2 (0.2)*	*18 (0.8)*	*0.23 (0.53 – 0.98)*	*0.20 (0.02 – 2.54)*
Past pregnancy conditions* **				
No	1,041 (91.0)	2,121 (94.0)	1.0	1.0
Yes	94 (8.2)	104 (4.6)	1.81 (1.38 – 2.46)	1.58 (1.16 – 2.14)
Missing	*9 (0.8)*	*31 (1.4)*	*0.59 (0.28 – 1.25)*	*1.12 (0.36 – 3.54)*

*All variables adjusted for all other variables in the table

**Cardiac disease, diabetes mellitus, epilepsy, essential hypertension, haematological disorders, past thrombotic event, recent/current anticoagulation, IV drug use and/or alcohol abuse

***Amniotic fluid embolism, gestational diabetes, pregnancy-induced hypertension, pre-eclampsia, eclampsia, thrombotic event, acute fatty liver of pregnancy, manual removal of placenta, placenta accreta, past classical caesarean section

Following adjustment, compared with the controls, cases were 1.17 (95%CI 0.94-1.45) times more likely to be in the 'intermediate' socioeconomic group than the 'managerial/professional' group, 1.16 (95%CI: 0.93 – 1.45) times more likely to be in the 'routine/manual' group, 1.22 (95%CI: 0.92 – 1.61) times more likely to be unemployed and 1.51 (95%CI: 1.18 – 1.94) times more likely to be have missing socioeconomic information. Compared with controls cases were 1.77 (95%CI 1.32-2.36) times more likely to be black than white, 1.57 (1.23-2.00) times more likely to be Asian and 1.50 (95%CI 1.02-2.19) times more likely to be from another minority ethnic group. The relationship between the odds severe maternal morbidity and maternal age was J-shaped with cases having significantly raised adjusted odds of being 30-34yrs (aOR 1.33; 95%CI 1.08-1.64) or 35+yrs (aOR 1.98; 95%CI 1.60-2.45). After adjustment, cases had a non-significant 10% increase in the odds of having a BMI of 25 or over and a 24% increase in the odds of having missing BMI data which was similarly non-significant. Cases were significantly more likely than controls to have a history of pre-existing medical conditions (aOR 1.60; 95%CI 1.18-2.17), past pregnancy complications (aOR 1.58; 95%CI 1.16-2.14) and to have a multiple pregnancy (aOR 3.54; 95%CI 2.18-5.76).

Sensitivity analysis

Redistributing all the missing socioeconomic observations into the managerial/professional group reduced the aOR associated with unemployment to 1.02 (95%CI 0.79-1.32) whereas, redistribution of all the missing socioeconomic observations into the unemployed group produced an aOR of 1.38 (95%CI 1.11–1.72) associated with unemployment (Table 3).

Table 3. Sensitivity analysis for missing observations

Missing values	Sub-category	Cases (%)	Controls (%)	Adjusted OR (95% CI)
Socioeconomic group				
Missing SEP values recoded to 'Managerial/ Professional' (best case)	Managerial Intermediate Routine/Manual Unemployed	485 (42.4) 244 (21.3) 273 (23.9) 142 (12.4)	870 (38.6) 482 (21.4) 595 (26.4) 309 (13.7)	1.0 1.01 (0.83 – 1.23) 0.99 (0.82 – 1.21) 1.02 (0.79 – 1.32)
Missing SEP values recoded to 'unemployed' (worst case)	Managerial Intermediate Routine/Manual Unemployed	292 (25.5) 244 (21.3) 273 (23.9) 335 (29.3)	567 (25.1) 482 (21.37) 595 (26.4) 612 (27.1)	1.0 1.17 (0.94 – 1.46) 1.17 (0.94 – 1.46) 1.38 (1.11 – 1.72)

Re-running the multivariable model including only those cases and controls with complete information for every variable generated an aOR of 1.31 (95%CI 0.97–1.77) associated with unemployment, an aOR of 1.13 (95%CI 0.89-1.43) for the routine/manual group and 1.19 (95%CI 0.94-1.49) for the intermediate group.

DISCUSSION

Findings

The results of this study suggest that there is an independent association between socioeconomic position and severe maternal morbidity. Although not statistically significant, this analysis showed that compared to women from the highest managerial/professional socioeconomic group, unemployed status was associated with a 22% increase in the odds of severe morbidity. Women with missing socioeconomic information had a more than 50% increase in the odds of severe morbidity and this finding was unlikely to be due to chance. Sensitivity analysis suggests that if all the women with missing socioeconomic data were

unemployed, the estimate of the odds of severe morbidity increased to 38%; with a result unlikely to be due to chance.

Despite universal health care which is free at the point of delivery, and significant investment in researching social inequalities in health in the UK, socially-marginalised groups continue to fare poorly as compared with more affluent sections of society, across a range of health outcomes including, as suggested by our analysis, maternal health. The reasons for the social gradient in maternal health in the UK have not yet been thoroughly explored. It is therefore unclear whether the observed association is as a result of differences in the underlying risk of disease, differences in health-seeking behaviour, or differences in access to, or provision and quality of services during pregnancy, delivery and the post-partum period.

In addition to finding an association between severe morbidity and factors such as pre-existing medical conditions, multiple pregnancy and past pregnancy complications, this study also reflected the findings of past studies in France and the Netherlands[6 26 32] which have demonstrated a significantly increased risk of severe morbidity amongst women from minority ethnic groups. The association with socioeconomic position was, however, independent of these associations.

Implications of the Study Findings

Health research in various settings worldwide has illuminated the ongoing existence of the 'inverse care law', first described in 1971 by Tudor Hart as the tendency for the "availability of good medical care to vary inversely with the need for it in the population served"[36].

Since the global financial crisis in 2008, the World Health Organisation has stressed that "as standards of living decrease in many countries, and government revenues are tightened, [we would argue that] it is even more urgent that the distributional effects on all policies are taken into account in policy decision making"[37]. In a paper that argues that social welfare spending is

as important as protecting health through safeguarding the healthcare budget, Stuckler et al have proposed that the economic crisis presents the opportunity to reorganise the provision of services to those most in need[38]. Our findings clearly identify one such group in need.

'Maternity Matters' guidance for service commissioning in England released in 2007 emphasised the Government's commitment to providing choice guarantees for women regarding type of antenatal care and place of birth and also highlighted the need for future maternity services to address disproportionately higher rates of maternal morbidity amongst disadvantaged women[39]. Although it described a comprehensive approach to delivering improved maternity care the guidance did not provide any specific recommendations as to how to improve services for women from socially disadvantaged backgrounds. Our study emphasises the need for developing such recommendations within the currently changing structure of health service commissioning in England.

Strengths and Limitations of the Study

UKOSS, the first system of its kind in obstetrics worldwide, has provided an invaluable wealth of information on uncommon but serious disorders of pregnancy. The active, negative surveillance approach has ensured robust case ascertainment, and many of the UKOSS studies are the largest-scale studies of rare disorders of pregnancy worldwide.

By studying disorders of pregnancy and childbirth in separate studies, UKOSS provided the means by which to explore 'severe maternal morbidity' due to direct pregnancy causes as an aggregate of multiple conditions, thereby avoiding the challenges encountered by previous studies which have used combined clinical and intervention criteria. It also avoids the perennial difficulty that there is no universally agreed definition of what constitutes 'severe maternal morbidity'. One disadvantage of this approach is that 'indirect causes' of maternal morbidity were excluded from our analysis, including several major contributors to maternal mortality in the UK such as cardiac disease, thromboembolic disease and puerperal psychosis/suicide[40].

The design of UKOSS studies ensures that sampling bias is minimised by recruiting cases from all obstetric units across the UK, thus including women from all different ethnic, age and socioeconomic groups. Selection of controls is also aimed at attaining a representative sample of the general population of women giving birth by recruiting women from the same obstetric units as cases throughout the UK during the same time period. Comparison between UKOSS controls and national maternity data suggests that the controls recruited for UKOSS studies are closely representative of the general, child-bearing population[19].

A universal challenge for studies that seek to explore the impact of social disadvantage in society is how to best capture the concept of 'social disadvantage' and define socioeconomic position. There are multiple dimensions to social disadvantage and there are many different approaches to defining a person's position in the social structure of society. The retrospective collection of data for UKOSS from patient records limited the definition of socioeconomic position to maternal occupation (or paternal where maternal was not available). Using the national classification of socioeconomic position (NS-SEC) ensured the study population was categorised using a system that is used nationally. However, the collection of other socioeconomic indicators such as level of education, years of schooling, residential location or income was not possible although this would have allowed further analysis of social disadvantage by using composite measures of disadvantage such as the Index of Multiple Deprivation. There is thus a place for further research using other indicators of socioeconomic position to see whether the results of this study are replicated.

The results of this study clearly apply only to high resource countries with well-developed healthcare systems. However, other high resource countries have different models of health care, such that pregnancy and delivery care may not be free at the point of access, as is the case in the UK. This study used only UK data and the results may therefore not be generalisable to women giving birth in other countries. Further research using information from other settings is therefore important to investigate whether socioeconomic position is associated

with severe maternal morbidity in countries with differing health systems as this may give insights into the causes and where on the causal pathway modifiable risks might lie.

Conclusions

This study suggests that socioeconomic position is associated with an increased risk of severe maternal morbidity, independent of risks associated with maternal age, ethnic group or known medical and pregnancy complications. However, the reasons for this association remain unclear, suggesting a need for further research to investigate whether there are differences in disease risks, health-seeking behaviour, access to care or the quality of care received by women from different socioeconomic groups. Further information about these differences would allow development of specific recommendations for the care of women from socially disadvantaged backgrounds in order to minimise future risks.

Competing interests: None declared

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STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			**4**
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5-6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	6 & 8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	11
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-10
		(b) Indicate number of participants with missing data for each variable of interest	9-10
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	9-10
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-10
		(*b*) Report category boundaries when continuous variables were categorized	9-10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	11-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	14-15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Variation in severe maternal morbidity according to socioeconomic position: a UK national case-control study.

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Variation in severe maternal morbidity according to socioeconomic position: a UK national case-control study.

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ARTICLE SUMMARY

Article Focus

- To explore the relationship between socioeconomic position, defined by occupation, and severe maternal morbidity using data obtained from a series of UKOSS studies
- To estimate the risk of severe morbidity by socioeconomic group, independent of ethnicity, maternal age, smoking, pre-existing medical condition, BMI, multiple pregnancy and past pregnancy complications

Key Messages

- The results suggested that women from the lowest socioeconomic group are 1.22 times (95%CI: 0.92 – 1.61) more likely than women from the highest group to experience severe maternal morbidity
- The results also showed that other risk factors for severe maternal morbidity include non-white ethnicity, older maternal age (≥35 years), BMI ≥25 kg/m^2, pre-existing medical condition/s, multiple pregnancy or previous pregnancy complications

Strengths and Limitations

- Study strengths include the robust case ascertainment, minimisation of sampling bias through collection of data from all consultant-led obstetric units in the UK and the clear definition of severe maternal morbidity
- Limitations relate to the data available to define socioeconomic position and the application of the findings to other non-UK setting

ABSTRACT

Objectives: This study aimed to explore the independent association between socioeconomic position, defined by occupation, and severe maternal morbidity amongst women in the UK.

Design: Case-control study.

Setting: The analysis was conducted as a case-control analysis, using data from a series of studies of direct causes of severe maternal morbidity undertaken through the UK Obstetric Surveillance System (UKOSS), with data collected throughout all consultant-let obstetric units in the UK.

Participants: The analysis included 1,144 cases and 2,256 comparison women (controls). UKOSS studies from which data on case women were obtained included amniotic fluid embolism, acute fatty liver of pregnancy, eclampsia, peripartum hysterectomy, therapies for peripartum haemorrhage and uterine rupture.

Primary outcome measure: Odds of severe maternal morbidity by socioeconomic group, independent of ethnicity, maternal age, smoking, pre-existing medical condition, BMI, multiple pregnancy and past pregnancy complications. Occupation was used to classify different socioeconomic groups.

Secondary outcome measure: Odds of morbidity related to ethnic group, maternal age, smoking, pre-existing medical condition, BMI, multiple pregnancy and past pregnancy complications.

Results: Across the socioeconomic groups, compared to the 'managerial/professional' group, adjusted odds ratios were 1.17 (95%CI: 0.94 – 1.45) for the 'intermediate group', 1.16 (95%CI: 0.93 – 1.45) for 'routine/manual', 1.22 (95%CI: 0.92 – 1.61) for 'unemployed' women, and 1.51 (95%CI: 1.18 – 1.94) for women with missing socioeconomic information. Women of non-white ethnicity, older maternal age (≥35 years), BMI ≥25 kg/m^2 and those with pre-existing medical condition/s, multiple pregnancy or past pregnancy complications were shown to have a significantly increased odds of severe maternal morbidity.

Conclusion: This study suggests that socioeconomic position may be independently associated with an increased risk of severe maternal morbidity, although the observed association was not statistically significant. Further research is warranted to confirm this and investigate why this association might exist in a country where healthcare is universal and free at the point of access.

INTRODUCTION

Maternal morbidity is of major public health concern with some estimates suggesting that as many as ten million women worldwide suffer from pregnancy-related complications each year[1]. In countries where maternal deaths are infrequent, the information that mortality audits provide cannot be generalised readily across the general population of pregnant women, nor can it necessarily accurately predict which women are at increased risk of adverse outcomes[2]. In these circumstances, additional focus on maternal morbidity is now widely recognised as a robust approach to improving maternal health and the quality of healthcare provision[3-6].

Identifying high-risk women is imperative to prevent adverse outcomes, since it allows more intensive clinical management to be directed towards these women and is the fundamental purpose of antenatal care. Extensive research has demonstrated convincing links between severe maternal morbidity and advanced maternal age, pre-existing medical conditions and obesity[1 7 8]. However, these factors are unable to explain entirely the differences in maternal morbidity found between different populations of women both within and between countries. Other evidence suggests that ethnicity and social disadvantage may have a significant role to play, with UK data suggesting that women from ethnic minority groups and from socially disadvantaged groups are more likely to experience severe maternal morbidity than white women, and also to be at higher risk of dying from specific maternal morbidities[9-11]. However, as highlighted by several studies exploring ethnic differences in maternal health, it is unclear whether ethnicity itself is directly related to poor outcomes or, more likely, whether it is a marker for factors such as low socioeconomic position and lower levels of education[12]. Because minority ethnic groups are often disproportionately represented in lower socioeconomic groups, results attributed to ethnic differences are likely to be confounded by socioeconomic differences[13]. The aim of the analysis reported here was to explore whether there is an independent risk of severe maternal morbidity associated with socioeconomic position in the UK.

METHODS

Data Collection and Definitions

A case-control analysis was performed using data derived from a series of UK-wide studies of direct causes of maternal morbidity undertaken through the UK Obstetric Surveillance System (UKOSS)[14]. These studies were of amniotic fluid embolism (AFE), acute fatty liver of pregnancy (AFLP), eclampsia, peripartum hysterectomy, therapies for peripartum haemorrhage and uterine rupture[15-21]. For the purpose of this analysis, these cases are collectively referred to as 'severe maternal morbidity' (Box 1).

Box 1. Criteria used to define cases of severe maternal morbidity used in the UKOSS studies included in the analysis

Condition	Definition	UKOSS Study Timeframe
Amniotic fluid embolism	EITHER a clinical diagnosis of AFE (acute hypotension or cardiac arrest, acute hypoxia or coagulopathy in the absence of any other potential explanation for the symptoms and signs observed) OR a pathological diagnosis (presence of fetal squames or hair in the lungs)	01/02/2005 – 31/01/2010
Acute fatty liver of pregnancy	EITHER AFLP confirmed by biopsy or post-mortem examination OR a clinician has made a diagnosis of AFLP with signs and symptoms consistent with AFLP	01/02/2005 – 30/04/2006
Eclampsia	The occurrence of convulsions during pregnancy or in the first ten days postpartum, together with at least two of the following features within 24 hours after the convulsions: 1) Hypertension (a booking diastolic pressure of <90mmHg, a maximum diastolic of ≥90mmHg, and a diastolic increment of ≥25mmHg) 2) Proteinuria (at least + protein in a random urine sample or ≥0.3g in a 24hr collection) 3) Thrombocytopenia (platelet count of $<100X10^9/l$)	01/02/2005 – 29/02/2006

	4) An increased plasma alanine aminotransferase (ALT) concentration (≥42 iu/l) or an increased plasma aspartate transaminase aminotransferase (AST) concentration (≥42iu/l)	
Peripartum hysterectomy	Any woman giving birth to an infant and having a hysterectomy during the same clinical episode	01/02/2005 – 29/02/2006
Therapies for major peripartum haemorrhage	All women in the UK treated therapeutically or prophylactically for major peripartum haemorrhage with: EITHER Activated factor VIIa OR B-lynch suture or other brace suture OR Arterial ligation or embolisation	01/09/2007 – 30/09/2008
Uterine rupture	Any woman in the UK identified as having a uterine rupture using the following definition: A complete separation of the wall of the pregnant uterus, with or without expulsion of the fetus, involving rupture of the membranes at the site of the uterine rupture or extension into the uterine muscle separate from any previous scar, and endangering the life of the mother or fetus Excluded: any asymptomatic palpable or visualised defect (for example dehiscence noted incidentally at caesarean delivery)	01/04/2009 – 30/04/2010

The UKOSS methodology used to carry out a rolling programme of studies has been described in detail elsewhere[14]. In brief, monthly mailing of notification cards to all obstetric-led maternity units in the UK enables identification of all cases under study. Data collection forms despatched in response to a case notification are used by the clinician responsible for care to report de-identified information from the woman's medical notes. Follow-up of non-responders maximises the completeness of data collection and confirms denominator numbers for incidence estimates.

For many of the UKOSS studies, data about a representative sample of women without the specific condition under study were obtained by collecting information on the two women

delivering immediately prior to each case in the same obstetric unit; these were defined as controls. The same information was collected about the controls as for case women. Data were thus available for analysis on 1,144 cases of severe maternal morbidity and 2,256 controls.

Maternal occupation was used to classify cases and controls by socioeconomic group, where this was not available her husband's/partner's occupation was used. Using the National Statistics Socio-Economic Classification (NS-SEC)[22], occupation was coded into three categories plus an additional group for unemployed women.

Statistical Analysis

All analyses were carried out using STATA version 11.0. Following univariable analysis multivariable unconditional logistic regression was used to examine the independent relationship between socioeconomic position and severe maternal morbidity and to generate adjusted odds ratios (aORs) with their 95% confidence intervals (95%CIs). Due to the high proportion and distribution of missing data for some variables, particularly for socio-economic position (Table 1), 'missing' was included as a separate group for each categorical variable.

Table 1. Distribution of missing data for cases of severe maternal morbidity and controls

Variable	Number of cases with missing information (% of total cases)	Number of controls with missing information (% of total controls)
Socioeconomic Group	193 (16.9)	303 (13.4)
Ethnicity	18 (1.6)	78 (3.5)
Age	3 (0.3)	18 (0.8)
Smoking	28 (2.5)	61 (2.7)
Pre-existing medical condition(s)	6 (0.5)	27 (1.2)
Body mass index	128 (11.2)	219 (9.7)
Parity	3 (0.3)	22 (1.0)
Multiple pregnancy	2 (0.2)	18 (0.8)
Past pregnancy complication(s)	9 (0.8)	31 (1.4)

Variables likely to confound the relationship between socioeconomic position and severe maternal morbidity were identified *a priori* based on evidence from the published literature and

the results of univariable analysis. These included ethnicity, maternal age, smoking, pre-existing medical conditions and body mass index (BMI)[1 7 10 23-36]. Other variables included in the analysis as possible confounders were parity, multiple pregnancy and past pregnancy complications.

Model building using unconditional logistic regression proceeded by the inclusion of severe maternal morbidity (outcome) and socio-economic position, with each of the potential confounders added in turn one-by-one. The individual effect of each variable on the fit of the data was assessed using the likelihood ratio test. The variables with *a priori* evidence of effect were included in the final model. Of the additional three variables examined (parity, multiple pregnancy and past pregnancy conditions) only those demonstrating a statistically significant effect ($p<0.05$) on the fit of the data were retained; parity was thus excluded.

Age, included as a continuous variable, was tested for departure from linearity; the results are for ease of presentation, shown as categorical. BMI was included as a categorical variable due to the high proportion of missing data and the concern that by including it as continuous, women with missing data would be excluded. There was no evidence of a significant interaction between socioeconomic position and any of the other variables included in the final model ($p<0.01$).

Sensitivity analyses were conducted to explore the effect of missing data for socioeconomic position and BMI. The final multivariable regression model was re-run after redistributing missing values into the lowest and highest categories for each of these variables.

The findings demonstrated that the distribution and impact of missing data was substantial and that the pattern of missing data was unlikely to be 'missing at random'.

The results of multivariable analysis were therefore likely to be biased by the high proportion and non-random pattern of missing data if the missing observations were not accounted for. Due to the evidence against a 'missing at random' assumption, Multiple Imputation was not an appropriate solution to deal with the effects of missing data. We therefore included the missing data as a separate category for the relevant variables, treating them as 'proxy indicators' in the subsequent model-building processes.

Study Power

The analysis included a fixed number of cases and controls derived from specified UKOSS studies. Based on 1,144 cases and 2,256 controls, and with a prevalence of 13% for the lowest (unemployed) socioeconomic group, the analysis had 80% power to detect as statistically significant ($p<0.05$) an odds of 1.32 or greater and 90% power to detect as statistically significant ($p<0.05$) an odds of 1.37 or greater, for comparisons with the highest (managerial/professional) socioeconomic group.

RESULTS

The analysis included a total of 1,144 cases of severe maternal morbidity and 2,256 controls. Compared with the controls cases were more likely to be older, multiparous, of non-white ethnicity, to have missing socio-economic position and BMI information, to be non-smokers, to have a pre-existing medical condition, a history of past pregnancy complications and a multiple pregnancy in the index pregnancy (Table 2).

Table 2. Maternal characteristics associated with severe maternal morbidity

Characteristic	Cases n= (%) N= 1,144	Controls n= (%) N=2,256	Unadjusted OR (95% CI)	Adjusted* OR (95%CI)
Socioeconomic group				
Managerial/ Professional	292 (25.5)	567 (25.1)	1.0	1.0
Intermediate	244 (21.3)	482 (21.4)	0.98 (0.80 – 1.21)	1.17 (0.94 – 1.45)
Routine/Manual	273 (28.7)	595 (26.4)	0.89 (0.73 – 1.09)	1.16 (0.93 – 1.45)
Unemployed	142 (14.9)	309 (13.7)	0.89 (0.70 – 1.14)	1.22 (0.92 – 1.61)
Missing	*193 (16.9)*	*303 (13.4)*	*1.24 (0.98 – 1.56)*	*1.51 (1.18 – 1.94)*
Ethnic group				
White	827 (72.3)	1796 (79.6)	1.0	1.0
Asian	139 (12.2)	197 (8.7)	1.53 (1.22 – 1.93)	1.57 (1.23 – 2.00)
Black	108 (9.4)	116 (5.1)	2.02 (1.54 – 2.66)	1.77 (1.32 – 2.36)
Other	52 (4.6)	69 (3.1)	1.64 (1.13 – 2.37)	1.50 (1.02 – 2.19)
Missing	*18 (1.6)*	*78 (3.5)*	*0.50 (0.30 – 0.84)*	*0.51 (0.28 – 0.91)*
Age				
Age <20	56 (4.9)	139 (6.2)	0.98 (0.70 – 1.39)	1.08 (0.75 – 1.56)
Age 20 – 24	127 (11.1)	449 (19.9)	0.69 (0.54 – 0.89)	0.71 (0.55 – 0.92)
Age 25 – 29	225 (19.7)	549 (24.3)	1.0	1.0
Age 30 – 34	341 (29.8)	622 (27.6)	1.34 (1.09 – 1.64)	1.33 (1.08 – 1.64)
Age ≥35	392 (34.3)	479 (21.2)	2.00 (1.63 – 2.45)	1.98 (1.60 – 2.45)
Missing	*3 (0.3)*	*18 (0.8)*	*0.41 (0.12 – 1.39)*	*2.66 (0.22 – 26.00)*
Smoking status				
Non-Smokers	899 (78.6)	1,642 (72.8)	1.0	1.0
Smokers	217 (19.0)	553 (24.5)	0.72 (0.60 – 0.86)	0.89 (0.73 – 1.08)
Missing	*28 (2.5)*	*61 (2.7)*	*0.84 (0.53 – 1.32)*	*0.95 (0.54 – 1.67)*
BMI				
Continuous (per kg/m^2 increase in BMI)			1.01 (1.00 – 1.03)	
< 25 kg/m^2	513 (44.8)	1,121 (49.7)	1.0	1.0
25-29.9 kg/m^2	297 (26.0)	545 (24.2)	1.19 (1.00 – 1.42)	1.10 (0.92 – 1.32)
≥ 30 kg/m^2	206 (18.0)	371 (16.5)	1.21 (0.99 – 1.48)	1.09 (0.88 – 1.34)
Missing	*128 (11.2)*	*219 (9.7)*	*1.28 (1.00 – 1.63)*	*1.24 (0.95 – 1.61)*
Co-existing medical conditions**				
No	1,045 (91.4)	2,126 (94.2)	1.0	1.0
Yes	93 (8.1)	103 (4.6)	1.84 (1.38 – 2.46)	1.60 (1.18 – 2.17)
Missing	*6 (0.5)*	*27 (1.2)*	*0.45 (1.18 – 1.10)*	*0.76 (0.17 – 3.41)*
Parity				
Nulliparous	403 (35.2)	984 (43.6)	1.0	No significant effect on fit of model (excluded)
Multiparous	738 (64.5)	1,250 (55.4)	1.44 (1.24 – 1.67)	
Missing	*3 (0.3)*	*22 (1.0)*	*0.33 (0.10 – 1.12)*	
Multiple pregnancy				
No	1,083 (94.7)	2,211 (98.0)	1.0	1.0
Yes	59 (5.2)	27 (1.2)	4.46 (2.81 – 7.08)	3.88 (2.42 – 6.22)
Missing	*2 (0.2)*	*18 (0.8)*	*0.23 (0.53 – 0.98)*	*0.20 (0.02 – 2.54)*
Past pregnancy conditions***				
No	1,041 (91.0)	2,121 (94.0)	1.0	1.0
Yes	94 (8.2)	104 (4.6)	1.81 (1.38 – 2.46)	1.58 (1.16 – 2.14)
Missing	*9 (0.8)*	*31 (1.4)*	*0.59 (0.28 – 1.25)*	*1.12 (0.36 – 3.54)*

*All variables adjusted for all other variables in the table

**Cardiac disease, diabetes mellitus, epilepsy, essential hypertension, haematological disorders, past thrombotic event, recent/current anticoagulation, IV drug use and/or alcohol abuse

***Amniotic fluid embolism, gestational diabetes, pregnancy-induced hypertension, pre-eclampsia, eclampsia, thrombotic event, acute fatty liver of pregnancy, manual removal of placenta, placenta accreta, past classical caesarean section

Following adjustment, compared with the controls, cases were 1.17 (95%CI 0.94-1.45) times more likely to be in the 'intermediate' socioeconomic group than the 'managerial/professional' group, 1.16 (95%CI: 0.93 – 1.45) times more likely to be in the 'routine/manual' group, 1.22 (95%CI: 0.92 – 1.61) times more likely to be unemployed, noting that these were not statistically significant increases. Cases were statistically significantly1.51 (95%CI: 1.18 – 1.94) times more likely to have missing socioeconomic information than controls. Compared with controls cases were 1.77 (95%CI 1.32-2.36) times more likely to be black than white, 1.57 (95%CI 1.23-2.00) times more likely to be Asian and 1.50 (95%CI 1.02-2.19) times more likely to be from another minority ethnic group, all statistically significant associations. The relationship between the odds severe maternal morbidity and maternal age was J-shaped with cases having significantly raised adjusted odds of being 30-34yrs (aOR 1.33; 95%CI 1.08-1.64) or 35+yrs (aOR 1.98; 95%CI 1.60-2.45). After adjustment, cases had a non-significant 10% increase in the odds of having a BMI of 25 or over and a 24% increase in the odds of having missing BMI data which was similarly non-significant. Cases were significantly more likely than controls to have a history of pre-existing medical conditions (aOR 1.60; 95%CI 1.18-2.17), past pregnancy complications (aOR 1.58; 95%CI 1.16-2.14) and to have a multiple pregnancy (aOR 3.54; 95%CI 2.18-5.76).

Sensitivity analysis

Redistributing all the missing socioeconomic observations into the managerial/professional group reduced the aOR associated with unemployment to 1.02 (95%CI 0.79-1.32), a non-significant association, whereas, redistribution of all the missing socioeconomic observations into the unemployed group produced an aOR of 1.38 (95%CI 1.11–1.72) associated with unemployment (Table 3), a statistically significant increase.

Table 3. Sensitivity analysis for missing observations

Missing values	Sub-category	Cases (%)	Controls (%)	Adjusted OR (95% CI)
Socioeconomic group				

Missing SEP values recoded to 'Managerial/ Professional' (best case)	Managerial Intermediate Routine/Manual Unemployed	485 (42.4) 244 (21.3) 273 (23.9) 142 (12.4)	870 (38.6) 482 (21.4) 595 (26.4) 309 (13.7)	1.0 1.01 (0.83 – 1.23) 0.99 (0.82 – 1.21) 1.02 (0.79 – 1.32)
Missing SEP values recoded to 'unemployed' (worst case)	Managerial Intermediate Routine/Manual Unemployed	292 (25.5) 244 (21.3) 273 (23.9) 335 (29.3)	567 (25.1) 482 (21.37) 595 (26.4) 612 (27.1)	1.0 1.17 (0.94 – 1.46) 1.17 (0.94 – 1.46) 1.38 (1.11 – 1.72)

Re-running the multivariable model including only those cases and controls with complete information for every variable generated an aOR of 1.31 (95%CI 0.97–1.77) associated with unemployment, an aOR of 1.13 (95%CI 0.89-1.43) for the routine/manual group and 1.19 (95%CI 0.94-1.49) for the intermediate group. These results are very similar to the estimates from the analysis using proxy indicators.

DISCUSSION

Findings

The results of this study suggest that there may be an independent association between socioeconomic position and severe maternal morbidity. We found that, compared to women from the highest managerial/professional socioeconomic group, unemployed status was associated with a 22% increase in the odds of severe morbidity. However, this was not a statistically significant association and may therefore represent a chance finding. Women with missing socioeconomic information had a more than 50% increase in the odds of severe morbidity and this finding was unlikely to be due to chance. The women with missing socioeconomic information were clearly different in a range of characteristics than the women with complete information, and we hypothesised that these women were more likely to be unemployed. To explore what the impact of this might be in our analysis if this hypothesis were correct, we undertook a sensitivity analysis which suggested that if all the women with missing socioeconomic data were unemployed, the estimate of the odds of severe morbidity increased to 38%; with a result unlikely to be due to chance. It is important to note, however, that as

information about the covariates was obtained by an obstetrician knowing the outcome status of the women, the missing values and/or potential misclassification might be differential according to outcome. We are unable to assess any further whether our hypothesis about those with missing information is correct; nevertheless, we believe this potential association is worthy of further investigation amongst different populations and using different methodologies to determine whether it can be reproduced.

Despite universal health care which is free at the point of delivery, and significant investment in researching social inequalities in health in the UK, socially-marginalised groups continue to fare poorly as compared with more affluent sections of society, across a range of health outcomes including, as suggested by our analysis, maternal health. The reasons for the social gradient in maternal health in the UK have not yet been thoroughly explored. It is therefore unclear whether the observed potential association is as a result of differences in the underlying risk of disease, including, but not limited to, lifestyle factors, differences in health-seeking behaviour, or differences in access to, or provision and quality of services during pregnancy, delivery and the post-partum period.

In addition to finding an association between severe morbidity and factors such as pre-existing medical conditions, multiple pregnancy and past pregnancy complications, this study also reflected the findings of past studies in France and the Netherlands[6 26 32] which have demonstrated a significantly increased risk of severe morbidity amongst women from minority ethnic groups. The suggested association with socioeconomic position was, however, independent of these associations.

Implications of the Study Findings

Health research in various settings worldwide has illuminated the ongoing existence of the 'inverse care law', first described in 1971 by Tudor Hart as the tendency for the "availability of good medical care to vary inversely with the need for it in the population served"[37].

Since the global financial crisis in 2008, the World Health Organisation has stressed that "as standards of living decrease in many countries, and government revenues are tightened, [we would argue that] it is even more urgent that the distributional effects on all policies are taken into account in policy decision making"[38]. In a paper that argues that social welfare spending is as important as protecting health through safeguarding the healthcare budget, Stuckler et al have proposed that the economic crisis presents the opportunity to reorganise the provision of services to those most in need[39]. Our findings identify one such group who may be in need.

'Maternity Matters' guidance for service commissioning in England released in 2007 emphasised the Government's commitment to providing choice guarantees for women regarding type of antenatal care and place of birth and also highlighted the need for future maternity services to address disproportionately higher rates of maternal morbidity amongst disadvantaged women[40]. Although it described a comprehensive approach to delivering improved maternity care the guidance did not provide any specific recommendations as to how to improve services for women from socially disadvantaged backgrounds. Our study emphasises the need for developing such recommendations within the currently changing structure of health service commissioning in England.

Strengths and Limitations of the Study

UKOSS, the first system of its kind in obstetrics worldwide, has provided an invaluable wealth of information on uncommon but serious disorders of pregnancy. The active, negative surveillance approach has ensured robust case ascertainment, and many of the UKOSS studies are the largest-scale studies of rare disorders of pregnancy worldwide.

By studying disorders of pregnancy and childbirth in separate studies, UKOSS provided the means by which to explore 'severe maternal morbidity' due to direct pregnancy causes as an aggregate of multiple conditions, thereby avoiding the challenges encountered by previous

studies which have used combined clinical and intervention criteria. It also avoids the perennial difficulty that there is no universally agreed definition of what constitutes 'severe maternal morbidity'. One disadvantage of this approach is that 'indirect causes' of maternal morbidity were excluded from our analysis, including several major contributors to maternal mortality in the UK such as cardiac disease, thromboembolic disease and puerperal psychosis/suicide[41].

The design of UKOSS studies ensures that sampling bias is minimised by recruiting cases from all obstetric units across the UK, thus including women from all different ethnic, age and socioeconomic groups. Selection of controls is also aimed at attaining a representative sample of the general population of women giving birth by recruiting women from the same obstetric units as cases throughout the UK during the same time period. Comparison between UKOSS controls and national maternity data suggests that the controls recruited for UKOSS studies are closely representative of the general, child-bearing population[19].

A universal challenge for studies that seek to explore the impact of social disadvantage in society is how to best capture the concept of 'social disadvantage' and define socioeconomic position. There are multiple dimensions to social disadvantage and there are many different approaches to defining a person's position in the social structure of society. The retrospective collection of data for UKOSS from patient records limited the definition of socioeconomic position to maternal occupation (or paternal where maternal was not available). Using the national classification of socioeconomic position (NS-SEC) ensured the study population was categorised using a system that is used nationally. However, the collection of other socioeconomic indicators such as level of education, years of schooling, residential location or income was not possible although this would have allowed further analysis of social disadvantage by using composite measures of disadvantage such as the Index of Multiple Deprivation. There is thus a place for further research using other indicators of socioeconomic position to see whether the results of this study are replicated.

The results of this study clearly apply only to high resource countries with well-developed healthcare systems. However, other high resource countries have different models of health care, such that pregnancy and delivery care may not be free at the point of access, as is the case in the UK. This study used only UK data and the results may therefore not be generalisable to women giving birth in other countries. Further research using information from other settings is therefore important to investigate whether socioeconomic position is associated with severe maternal morbidity in countries with differing health systems as this may give insights into the causes and where modifiable risks might lie. The use of data collected through the International Network of Obstetric Surveillance Systems[42], which use similar definitions and methodologies, may be a route to achieve this.

Conclusions

This study suggests that socioeconomic position may be associated with an increased risk of severe maternal morbidity, independent of risks associated with maternal age, ethnic group or known medical and pregnancy complications, although the association we observed was not statistically significant. However, the reasons for this possible association remain unclear, suggesting a need, not only to see if the observed association can be reproduced in other populations or settings, but also for further research to investigate whether there are differences in disease risks, lifestyle and health-seeking behaviour, access to care or the quality of care received by women from different socioeconomic groups. Further information about these differences would allow development of specific recommendations for the care of women from socially disadvantaged backgrounds in order to minimise future risks.

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Variation in severe maternal morbidity according to socioeconomic position: a UK national case-control study.

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ARTICLE SUMMARY

Article Focus

- To explore the relationship between socioeconomic position, defined by occupation, and severe maternal morbidity using data obtained from a series of UKOSS studies
- To estimate the risk of severe morbidity by socioeconomic group, independent of ethnicity, maternal age, smoking, pre-existing medical condition, BMI, multiple pregnancy and past pregnancy complications

Key Messages

- The results suggested that women from the lowest socioeconomic group are 1.22 times (95%CI: 0.92 – 1.61) more likely than women from the highest group to experience severe maternal morbidity
- The results also showed that other risk factors for severe maternal morbidity include non-white ethnicity, older maternal age (≥35 years), BMI ≥25 kg/m^2, pre-existing medical condition/s, multiple pregnancy or previous pregnancy complications

Strengths and Limitations

- Study strengths include the robust case ascertainment, minimisation of sampling bias through collection of data from all consultant-led obstetric units in the UK and the clear definition of severe maternal morbidity
- Limitations relate to the data available to define socioeconomic position and the application of the findings to other non-UK setting

ABSTRACT

Objectives: This study aimed to explore the independent association between socioeconomic position, defined by occupation, and severe maternal morbidity amongst women in the UK. **Design:** Case-control study. **Setting:** The analysis was conducted as a case-control analysis, using data from a series of studies of direct causes of severe maternal morbidity undertaken through the UK Obstetric Surveillance System (UKOSS), with data collected throughout all consultant-let obstetric units in the UK. **Participants:** The analysis included 1,144 cases and 2,256 comparison women (controls). UKOSS studies from which data on case women were obtained included amniotic fluid embolism, acute fatty liver of pregnancy, eclampsia, peripartum hysterectomy, therapies for peripartum haemorrhage and uterine rupture. **Primary outcome measure:** Odds of severe maternal morbidity by socioeconomic group, independent of ethnicity, maternal age, smoking, pre-existing medical condition, BMI, multiple pregnancy and past pregnancy complications. Occupation was used to classify different socioeconomic groups. **Secondary outcome measure:** Odds of morbidity related to ethnic group, maternal age, smoking, pre-existing medical condition, BMI, multiple pregnancy and past pregnancy complications. **Results**: Across the socioeconomic groups, compared to the 'managerial/professional' group, adjusted odds ratios were 1.17 (95%CI: 0.94 – 1.45) for the 'intermediate group', 1.16 (95%CI: 0.93 – 1.45) for 'routine/manual', 1.22 (95%CI: 0.92 – 1.61) for 'unemployed' women, and 1.51 (95%CI: 1.18 – 1.94) for women with missing socioeconomic information. Women of non-white ethnicity, older maternal age (≥35 years), BMI ≥25 kg/m^2 and those with pre-existing medical condition/s, multiple pregnancy or past pregnancy complications were shown to have a significantly increased odds of severe maternal morbidity. **Conclusion**: This study suggests that socioeconomic position may be independently associated with an increased risk of severe maternal morbidity, although the observed association was not statistically significant. Further research is warranted to confirm this and investigate why this

association might exist in a country where healthcare is universal and free at the point of access.

INTRODUCTION

Maternal morbidity is of major public health concern with some estimates suggesting that as many as ten million women worldwide suffer from pregnancy-related complications each year[1]. In countries where maternal deaths are infrequent, the information that mortality audits provide cannot be generalised readily across the general population of pregnant women, nor can it necessarily accurately predict which women are at increased risk of adverse outcomes[2]. In these circumstances, additional focus on maternal morbidity is now widely recognised as a robust approach to improving maternal health and the quality of healthcare provision[3-6].

Identifying high-risk women is imperative to prevent adverse outcomes, since it allows more intensive clinical management to be directed towards these women and is the fundamental purpose of antenatal care. Extensive research has demonstrated convincing links between severe maternal morbidity and advanced maternal age, pre-existing medical conditions and obesity[1 7 8]. However, these factors are unable to explain entirely the differences in maternal morbidity found between different populations of women both within and between countries. Other evidence suggests that ethnicity and social disadvantage may have a significant role to play, with UK data suggesting that women from ethnic minority groups and from socially disadvantaged groups are more likely to experience severe maternal morbidity than white women, and also to be at higher risk of dying from specific maternal morbidities[9-11]. However, as highlighted by several studies exploring ethnic differences in maternal health, it is unclear whether ethnicity itself is directly related to poor outcomes or, more likely, whether it is a marker for factors such as low socioeconomic position and lower levels of education[12]. Because minority ethnic groups are often disproportionately represented in lower socioeconomic groups, results attributed to ethnic differences are likely to be confounded by socioeconomic differences[13]. The aim of the analysis reported here was to explore whether there is an independent risk of severe maternal morbidity associated with socioeconomic position in the UK.

METHODS

Data Collection and Definitions

A case-control analysis was performed using data derived from a series of UK-wide studies of direct causes of maternal morbidity undertaken through the UK Obstetric Surveillance System (UKOSS)[14]. These studies were of amniotic fluid embolism (AFE), acute fatty liver of pregnancy (AFLP), eclampsia, peripartum hysterectomy, therapies for peripartum haemorrhage and uterine rupture[15-21]. For the purpose of this analysis, these cases are collectively referred to as 'severe maternal morbidity' (Box 1).

Box 1. Criteria used to define cases of severe maternal morbidity used in the UKOSS studies included in the analysis

Condition	Definition	UKOSS Study Timeframe
Amniotic fluid embolism	EITHER a clinical diagnosis of AFE (acute hypotension or cardiac arrest, acute hypoxia or coagulopathy in the absence of any other potential explanation for the symptoms and signs observed) OR a pathological diagnosis (presence of fetal squames or hair in the lungs)	01/02/2005 – 31/01/2010
Acute fatty liver of pregnancy	EITHER AFLP confirmed by biopsy or post-mortem examination OR a clinician has made a diagnosis of AFLP with signs and symptoms consistent with AFLP	01/02/2005 – 30/04/2006
Eclampsia	The occurrence of convulsions during pregnancy or in the first ten days postpartum, together with at least two of the following features within 24 hours after the convulsions: 1) Hypertension (a booking diastolic pressure of <90mmHg, a maximum diastolic of ≥90mmHg, and a diastolic increment of ≥25mmHg) 2) Proteinuria (at least + protein in a random urine sample or ≥0.3g in a 24hr collection) 3) Thrombocytopenia (platelet count of $<100X10^9/l$)	01/02/2005 – 29/02/2006

	4) An increased plasma alanine aminotransferase (ALT) concentration (≥42 iu/l) or an increased plasma aspartate transaminase aminotransferase (AST) concentration (≥42iu/l)	
Peripartum hysterectomy	Any woman giving birth to an infant and having a hysterectomy during the same clinical episode	01/02/2005 – 29/02/2006
Therapies for major peripartum haemorrhage	All women in the UK treated therapeutically or prophylactically for major peripartum haemorrhage with: EITHER Activated factor VIIa OR B-lynch suture or other brace suture OR Arterial ligation or embolisation	01/09/2007 – 30/09/2008
Uterine rupture	Any woman in the UK identified as having a uterine rupture using the following definition: A complete separation of the wall of the pregnant uterus, with or without expulsion of the fetus, involving rupture of the membranes at the site of the uterine rupture or extension into the uterine muscle separate from any previous scar, and endangering the life of the mother or fetus Excluded: any asymptomatic palpable or visualised defect (for example dehiscence noted incidentally at caesarean delivery)	01/04/2009 – 30/04/2010

The UKOSS methodology used to carry out a rolling programme of studies has been described in detail elsewhere[14]. In brief, monthly mailing of notification cards to all obstetric-led maternity units in the UK enables identification of all cases under study. Data collection forms despatched in response to a case notification are used by the clinician responsible for care to report de-identified information from the woman's medical notes. Follow-up of non-responders maximises the completeness of data collection and confirms denominator numbers for incidence estimates.

For many of the UKOSS studies, data about a representative sample of women without the specific condition under study were obtained by collecting information on the two women

delivering immediately prior to each case in the same obstetric unit; these were defined as controls. The same information was collected about the controls as for case women. Data were thus available for analysis on 1,144 cases of severe maternal morbidity and 2,256 controls.

Maternal occupation was used to classify cases and controls by socioeconomic group, where this was not available her husband's/partner's occupation was used. Using the National Statistics Socio-Economic Classification (NS-SEC)[22], occupation was coded into three categories plus an additional group for unemployed women.

Statistical Analysis

All analyses were carried out using STATA version 11.0. Following univariable analysis multivariable unconditional logistic regression was used to examine the independent relationship between socioeconomic position and severe maternal morbidity and to generate adjusted odds ratios (aORs) with their 95% confidence intervals (95%CIs). Due to the high proportion and distribution of missing data for some variables, particularly for socio-economic position (Table 1), 'missing' was included as a separate group for each categorical variable.

Table 1. Distribution of missing data for cases of severe maternal morbidity and controls

Variable	Number of cases with missing information (% of total cases)	Number of controls with missing information (% of total controls)
Socioeconomic Group	193 (16.9)	303 (13.4)
Ethnicity	18 (1.6)	78 (3.5)
Age	3 (0.3)	18 (0.8)
Smoking	28 (2.5)	61 (2.7)
Pre-existing medical condition(s)	6 (0.5)	27 (1.2)
Body mass index	128 (11.2)	219 (9.7)
Parity	3 (0.3)	22 (1.0)
Multiple pregnancy	2 (0.2)	18 (0.8)
Past pregnancy complication(s)	9 (0.8)	31 (1.4)

Variables likely to confound the relationship between socioeconomic position and severe maternal morbidity were identified *a priori* based on evidence from the published literature and

the results of univariable analysis. These included ethnicity, maternal age, smoking, pre-existing medical conditions and body mass index (BMI)[1 7 10 23-36]. Other variables included in the analysis as possible confounders were parity, multiple pregnancy and past pregnancy complications.

Model building using unconditional logistic regression proceeded by the inclusion of severe maternal morbidity (outcome) and socio-economic position, with each of the potential confounders added in turn one-by-one. The individual effect of each variable on the fit of the data was assessed using the likelihood ratio test. The variables with *a priori* evidence of effect were included in the final model. Of the additional three variables examined (parity, multiple pregnancy and past pregnancy conditions) only those demonstrating a statistically significant effect ($p<0.05$) on the fit of the data were retained; parity was thus excluded.

Age, included as a continuous variable, was tested for departure from linearity; the results are for ease of presentation, shown as categorical. BMI was included as a categorical variable due to the high proportion of missing data and the concern that by including it as continuous, women with missing data would be excluded. There was no evidence of a significant interaction between socioeconomic position and any of the other variables included in the final model ($p<0.01$).

Sensitivity analyses were conducted to explore the effect of missing data for socioeconomic position and BMI. The final multivariable regression model was re-run after redistributing missing values into the lowest and highest categories for each of these variables.

The findings demonstrated that the distribution and impact of missing data was substantial and that the pattern of missing data was unlikely to be 'missing at random'.

The results of multivariable analysis were therefore likely to be biased by the high proportion and non-random pattern of missing data if the missing observations were not accounted for. Due to the evidence against a 'missing at random' assumption, Multiple Imputation was not an appropriate solution to deal with the effects of missing data. We therefore included the missing data as a separate category for the relevant variables, treating them as 'proxy indicators' in the subsequent model-building processes.

Study Power

The analysis included a fixed number of cases and controls derived from specified UKOSS studies. Based on 1,144 cases and 2,256 controls, and with a prevalence of 13% for the lowest (unemployed) socioeconomic group, the analysis had 80% power to detect as statistically significant ($p<0.05$) an odds of 1.32 or greater and 90% power to detect as statistically significant ($p<0.05$) an odds of 1.37 or greater, for comparisons with the highest (managerial/professional) socioeconomic group.

RESULTS

The analysis included a total of 1,144 cases of severe maternal morbidity and 2,256 controls. Compared with the controls cases were more likely to be older, multiparous, of non-white ethnicity, to have missing socio-economic position and BMI information, to be non-smokers, to have a pre-existing medical condition, a history of past pregnancy complications and a multiple pregnancy in the index pregnancy (Table 2).

Table 2. Maternal characteristics associated with severe maternal morbidity

Characteristic	Cases n= (%) N= 1,144	Controls n= (%) N=2,256	Unadjusted OR (95% CI)	Adjusted* OR (95%CI)
Socioeconomic group				
Managerial/ Professional	292 (25.5)	567 (25.1)	1.0	1.0
Intermediate	244 (21.3)	482 (21.4)	0.98 (0.80 – 1.21)	1.17 (0.94 – 1.45)
Routine/Manual	273 (28.7)	595 (26.4)	0.89 (0.73 – 1.09)	1.16 (0.93 – 1.45)
Unemployed	142 (14.9)	309 (13.7)	0.89 (0.70 – 1.14)	1.22 (0.92 – 1.61)
Missing	*193 (16.9)*	*303 (13.4)*	*1.24 (0.98 – 1.56)*	*1.51 (1.18 – 1.94)*
Ethnic group				
White	827 (72.3)	1796 (79.6)	1.0	1.0
Asian	139 (12.2)	197 (8.7)	1.53 (1.22 – 1.93)	1.57 (1.23 – 2.00)
Black	108 (9.4)	116 (5.1)	2.02 (1.54 – 2.66)	1.77 (1.32 – 2.36)
Other	52 (4.6)	69 (3.1)	1.64 (1.13 – 2.37)	1.50 (1.02 – 2.19)
Missing	*18 (1.6)*	*78 (3.5)*	*0.50 (0.30 – 0.84)*	*0.51 (0.28 – 0.91)*
Age				
Age <20	56 (4.9)	139 (6.2)	0.98 (0.70 – 1.39)	1.08 (0.75 – 1.56)
Age 20 – 24	127 (11.1)	449 (19.9)	0.69 (0.54 – 0.89)	0.71 (0.55 – 0.92)
Age 25 – 29	225 (19.7)	549 (24.3)	1.0	1.0
Age 30 – 34	341 (29.8)	622 (27.6)	1.34 (1.09 – 1.64)	1.33 (1.08 – 1.64)
Age ≥35	392 (34.3)	479 (21.2)	2.00 (1.63 – 2.45)	1.98 (1.60 – 2.45)
Missing	*3 (0.3)*	*18 (0.8)*	*0.41 (0.12 – 1.39)*	*2.66 (0.22 – 26.00)*
Smoking status				
Non-Smokers	899 (78.6)	1,642 (72.8)	1.0	1.0
Smokers	217 (19.0)	553 (24.5)	0.72 (0.60 – 0.86)	0.89 (0.73 – 1.08)
Missing	*28 (2.5)*	*61 (2.7)*	*0.84 (0.53 – 1.32)*	*0.95 (0.54 – 1.67)*
BMI				
Continuous (per kg/m^2 increase in BMI)			1.01 (1.00 – 1.03)	
< 25 kg/m^2	513 (44.8)	1,121 (49.7)	1.0	1.0
25-29.9 kg/m^2	297 (26.0)	545 (24.2)	1.19 (1.00 – 1.42)	1.10 (0.92 – 1.32)
≥ 30 kg/m^2	206 (18.0)	371 (16.5)	1.21 (0.99 – 1.48)	1.09 (0.88 – 1.34)
Missing	*128 (11.2)*	*219 (9.7)*	*1.28 (1.00 – 1.63)*	*1.24 (0.95 – 1.61)*
Co-existing medical conditions**				
No	1,045 (91.4)	2,126 (94.2)	1.0	1.0
Yes	93 (8.1)	103 (4.6)	1.84 (1.38 – 2.46)	1.60 (1.18 – 2.17)
Missing	*6 (0.5)*	*27 (1.2)*	*0.45 (1.18 – 1.10)*	*0.76 (0.17 – 3.41)*
Parity				
Nulliparous	403 (35.2)	984 (43.6)	1.0	No significant effect on fit of model (excluded)
Multiparous	738 (64.5)	1,250 (55.4)	1.44 (1.24 – 1.67)	
Missing	*3 (0.3)*	*22 (1.0)*	*0.33 (0.10 – 1.12)*	
Multiple pregnancy				
No	1,083 (94.7)	2,211 (98.0)	1.0	1.0
Yes	59 (5.2)	27 (1.2)	4.46 (2.81 – 7.08)	3.88 (2.42 – 6.22)
Missing	*2 (0.2)*	*18 (0.8)*	*0.23 (0.53 – 0.98)*	*0.20 (0.02 – 2.54)*
Past pregnancy conditions***				
No	1,041 (91.0)	2,121 (94.0)	1.0	1.0
Yes	94 (8.2)	104 (4.6)	1.81 (1.38 – 2.46)	1.58 (1.16 – 2.14)
Missing	*9 (0.8)*	*31 (1.4)*	*0.59 (0.28 – 1.25)*	*1.12 (0.36 – 3.54)*

*All variables adjusted for all other variables in the table

**Cardiac disease, diabetes mellitus, epilepsy, essential hypertension, haematological disorders, past thrombotic event, recent/current anticoagulation, IV drug use and/or alcohol abuse

***Amniotic fluid embolism, gestational diabetes, pregnancy-induced hypertension, pre-eclampsia, eclampsia, thrombotic event, acute fatty liver of pregnancy, manual removal of placenta, placenta accreta, past classical caesarean section

Following adjustment, compared with the controls, cases were 1.17 (95%CI 0.94-1.45) times more likely to be in the 'intermediate' socioeconomic group than the 'managerial/professional' group, 1.16 (95%CI: 0.93 – 1.45) times more likely to be in the 'routine/manual' group, 1.22 (95%CI: 0.92 – 1.61) times more likely to be unemployed, noting that these were not statistically significant increases. Cases were statistically significantly1.51 (95%CI: 1.18 – 1.94) times more likely to have missing socioeconomic information than controls. Compared with controls cases were 1.77 (95%CI 1.32-2.36) times more likely to be black than white, 1.57 (95%CI 1.23-2.00) times more likely to be Asian and 1.50 (95%CI 1.02-2.19) times more likely to be from another minority ethnic group, all statistically significant associations. The relationship between the odds severe maternal morbidity and maternal age was J-shaped with cases having significantly raised adjusted odds of being 30-34yrs (aOR 1.33; 95%CI 1.08-1.64) or 35+yrs (aOR 1.98; 95%CI 1.60-2.45). After adjustment, cases had a non-significant 10% increase in the odds of having a BMI of 25 or over and a 24% increase in the odds of having missing BMI data which was similarly non-significant. Cases were significantly more likely than controls to have a history of pre-existing medical conditions (aOR 1.60; 95%CI 1.18-2.17), past pregnancy complications (aOR 1.58; 95%CI 1.16-2.14) and to have a multiple pregnancy (aOR 3.54; 95%CI 2.18-5.76).

Sensitivity analysis

Redistributing all the missing socioeconomic observations into the managerial/professional group reduced the aOR associated with unemployment to 1.02 (95%CI 0.79-1.32), a non-significant association, whereas, redistribution of all the missing socioeconomic observations into the unemployed group produced an aOR of 1.38 (95%CI 1.11–1.72) associated with unemployment (Table 3), a statistically significant increase.

Table 3. Sensitivity analysis for missing observations

Missing values	Sub-category	Cases (%)	Controls (%)	Adjusted OR (95% CI)
Socioeconomic group				

Missing SEP values recoded to 'Managerial/ Professional' (best case)	Managerial Intermediate Routine/Manual Unemployed	485 (42.4) 244 (21.3) 273 (23.9) 142 (12.4)	870 (38.6) 482 (21.4) 595 (26.4) 309 (13.7)	1.0 1.01 (0.83 – 1.23) 0.99 (0.82 – 1.21) 1.02 (0.79 – 1.32)
Missing SEP values recoded to 'unemployed' (worst case)	Managerial Intermediate Routine/Manual Unemployed	292 (25.5) 244 (21.3) 273 (23.9) 335 (29.3)	567 (25.1) 482 (21.37) 595 (26.4) 612 (27.1)	1.0 1.17 (0.94 – 1.46) 1.17 (0.94 – 1.46) 1.38 (1.11 – 1.72)

Re-running the multivariable model including only those cases and controls with complete information for every variable generated an aOR of 1.31 (95%CI 0.97–1.77) associated with unemployment, an aOR of 1.13 (95%CI 0.89-1.43) for the routine/manual group and 1.19 (95%CI 0.94-1.49) for the intermediate group. These results are very similar to the estimates from the analysis using proxy indicators.

DISCUSSION

Findings

The results of this study suggest that there may be an independent association between socioeconomic position and severe maternal morbidity. We found that, compared to women from the highest managerial/professional socioeconomic group, unemployed status was associated with a 22% increase in the odds of severe morbidity. However, this was not a statistically significant association and may therefore represent a chance finding. Women with missing socioeconomic information had a more than 50% increase in the odds of severe morbidity and this finding was unlikely to be due to chance. The women with missing socioeconomic information were clearly different in a range of characteristics than the women with complete information, and we hypothesised that these women were more likely to be unemployed. To explore what the impact of this might be in our analysis if this hypothesis were correct, we undertook a sensitivity analysis which suggested that if all the women with missing socioeconomic data were unemployed, the estimate of the odds of severe morbidity increased to 38%; with a result unlikely to be due to chance. It is important to note, however, that as

information about the covariates was obtained by an obstetrician knowing the outcome status of the women, the missing values and/or potential misclassification might be differential according to outcome. We are unable to assess any further whether our hypothesis about those with missing information is correct; nevertheless, we believe this potential association is worthy of further investigation amongst different populations and using different methodologies to determine whether it can be reproduced.

Despite universal health care which is free at the point of delivery, and significant investment in researching social inequalities in health in the UK, socially-marginalised groups continue to fare poorly as compared with more affluent sections of society, across a range of health outcomes including, as suggested by our analysis, maternal health. The reasons for the social gradient in maternal health in the UK have not yet been thoroughly explored. It is therefore unclear whether the observed potential association is as a result of differences in the underlying risk of disease, including, but not limited to, lifestyle factors, differences in health-seeking behaviour, or differences in access to, or provision and quality of services during pregnancy, delivery and the post-partum period.

In addition to finding an association between severe morbidity and factors such as pre-existing medical conditions, multiple pregnancy and past pregnancy complications, this study also reflected the findings of past studies in France and the Netherlands[6 26 32] which have demonstrated a significantly increased risk of severe morbidity amongst women from minority ethnic groups. The suggested association with socioeconomic position was, however, independent of these associations.

Implications of the Study Findings

Health research in various settings worldwide has illuminated the ongoing existence of the 'inverse care law', first described in 1971 by Tudor Hart as the tendency for the "availability of good medical care to vary inversely with the need for it in the population served"[37].

Since the global financial crisis in 2008, the World Health Organisation has stressed that "as standards of living decrease in many countries, and government revenues are tightened, [we would argue that] it is even more urgent that the distributional effects on all policies are taken into account in policy decision making"[38]. In a paper that argues that social welfare spending is as important as protecting health through safeguarding the healthcare budget, Stuckler et al have proposed that the economic crisis presents the opportunity to reorganise the provision of services to those most in need[39]. Our findings identify one such group who may be in need.

'Maternity Matters' guidance for service commissioning in England released in 2007 emphasised the Government's commitment to providing choice guarantees for women regarding type of antenatal care and place of birth and also highlighted the need for future maternity services to address disproportionately higher rates of maternal morbidity amongst disadvantaged women[40]. Although it described a comprehensive approach to delivering improved maternity care the guidance did not provide any specific recommendations as to how to improve services for women from socially disadvantaged backgrounds. Our study emphasises the need for developing such recommendations within the currently changing structure of health service commissioning in England.

Strengths and Limitations of the Study

UKOSS, the first system of its kind in obstetrics worldwide, has provided an invaluable wealth of information on uncommon but serious disorders of pregnancy. The active, negative surveillance approach has ensured robust case ascertainment, and many of the UKOSS studies are the largest-scale studies of rare disorders of pregnancy worldwide.

By studying disorders of pregnancy and childbirth in separate studies, UKOSS provided the means by which to explore 'severe maternal morbidity' due to direct pregnancy causes as an aggregate of multiple conditions, thereby avoiding the challenges encountered by previous

studies which have used combined clinical and intervention criteria. It also avoids the perennial difficulty that there is no universally agreed definition of what constitutes 'severe maternal morbidity'. One disadvantage of this approach is that 'indirect causes' of maternal morbidity were excluded from our analysis, including several major contributors to maternal mortality in the UK such as cardiac disease, thromboembolic disease and puerperal psychosis/suicide[41].

The design of UKOSS studies ensures that sampling bias is minimised by recruiting cases from all obstetric units across the UK, thus including women from all different ethnic, age and socioeconomic groups. Selection of controls is also aimed at attaining a representative sample of the general population of women giving birth by recruiting women from the same obstetric units as cases throughout the UK during the same time period. Comparison between UKOSS controls and national maternity data suggests that the controls recruited for UKOSS studies are closely representative of the general, child-bearing population[19].

A universal challenge for studies that seek to explore the impact of social disadvantage in society is how to best capture the concept of 'social disadvantage' and define socioeconomic position. There are multiple dimensions to social disadvantage and there are many different approaches to defining a person's position in the social structure of society. The retrospective collection of data for UKOSS from patient records limited the definition of socioeconomic position to maternal occupation (or paternal where maternal was not available). Using the national classification of socioeconomic position (NS-SEC) ensured the study population was categorised using a system that is used nationally. However, the collection of other socioeconomic indicators such as level of education, years of schooling, residential location or income was not possible although this would have allowed further analysis of social disadvantage by using composite measures of disadvantage such as the Index of Multiple Deprivation. There is thus a place for further research using other indicators of socioeconomic position to see whether the results of this study are replicated.

The results of this study clearly apply only to high resource countries with well-developed healthcare systems. However, other high resource countries have different models of health care, such that pregnancy and delivery care may not be free at the point of access, as is the case in the UK. This study used only UK data and the results may therefore not be generalisable to women giving birth in other countries. Further research using information from other settings is therefore important to investigate whether socioeconomic position is associated with severe maternal morbidity in countries with differing health systems as this may give insights into the causes and where modifiable risks might lie. The use of data collected through the International Network of Obstetric Surveillance Systems[42], which use similar definitions and methodologies, may be a route to achieve this.

Conclusions

This study suggests that socioeconomic position may be associated with an increased risk of severe maternal morbidity, independent of risks associated with maternal age, ethnic group or known medical and pregnancy complications, although the association we observed was not statistically significant. However, the reasons for this possible association remain unclear, suggesting a need, not only to see if the observed association can be reproduced in other populations or settings, but also for further research to investigate whether there are differences in disease risks, lifestyle and health-seeking behaviour, access to care or the quality of care received by women from different socioeconomic groups. Further information about these differences would allow development of specific recommendations for the care of women from socially disadvantaged backgrounds in order to minimise future risks.

Competing interests: None declared

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STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			**4**
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5-6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	6 & 8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	11
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-10
		(b) Indicate number of participants with missing data for each variable of interest	9-10
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	9-10
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-10
		(*b*) Report category boundaries when continuous variables were categorized	9-10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	11-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	14-15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Correction

Lindquist A, Knight M, Kurinczuk JJ. Variation in severe maternal morbidity according to socioeconomic position: a UK national case–control study. *BMJ Open* 2013;**3**:e002742. The order of author names is incorrect. It should be Lindquist A, Kurinczuk JJ, Knight M.

BMJ Open 2013;**3**:e002742corr1. doi:10.1136/bmjopen-2013-002742corr1