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Socioeconomic Status and Outcome From Intensive Care in England and Wales

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Objective: The objective of this study was to estimate the association between socioeconomic status (SES) and outcome for admissions to intensive care.

Research Design: Retrospective cohort study.

Subjects: We studied 51,572 admissions to 99 intensive-care units in England and Wales between 1995 and 2000.

Measures: The SES of admissions was measured using Carstairs deprivation scores. Outcome was hospital mortality after adjustment for case mix using the APACHE II method.

Results: Admissions of lower SES were, on average, younger and less likely to be following surgery. There was evidence of a SES gradient for hospital mortality in admissions after elective surgery after adjusting for case mix (test for trend $P < 0.001$), with higher SES associated with lower mortality. In the least-deprived quintile of SES, the odds ratio for hospital mortality was 0.70 (95% confidence interval, 0.58–0.84) compared with the most deprived quintile. There was no evidence of a SES gradient for hospital mortality in nonsurgical or emergency surgical admissions, and the decision to withdraw active treatment did not differ by SES.

Conclusions: There is a SES gradient for hospital mortality in elective surgical admissions that is not explained by differences in case mix or the withdrawal of active treatment. Further research is required to establish if this finding can be explained by unmeasured differences in health status at admission to an intensive-care unit or differences in care and to establish the potential impact these results may have on interpreting comparative surgical performance data.

Key Words: socioeconomic status, intensive care, hospital mortality, APACHE

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In the United Kingdom, almost all intensive care is provided by the National Health Service (NHS). In common with other universal healthcare systems, the NHS aims to provide health services solely on the basis of clinical need.[1] This means that the U.K. government is concerned that factors such as disease severity and the ability to benefit from treatment should determine healthcare use rather than, for example, patients' ages, ethnicity, or socioeconomic status.

The association between lower socioeconomic status (SES) and poorer health has been established for a wide range of diseases.[2] Studies have shown this association has a gradient across the entire range of SES rather than below a poverty threshold.[3,4]

There is growing recognition that the unfair provision or use of health care has an impact on health inequalities.[5,6] Assessing the fairness (or equity) of healthcare use is dependent on accurate identification of the population in need of care and accurate measurement of that need. Differences in the use of health care are not unfair if they can be explained by differences in clinical and social need. Much of the work on SES and health care has examined cardiac interventions and has identified differences in the use of, and outcome from, health care.

Internationally, SES differences have been demonstrated in the use of coronary artery bypass grafts (CABG),[7,8] cardiac rehabilitation,[9,10] access to angiography,[11] hospital treatment after myocardial infarction,[12,13] and waiting times for specialist treatment.[11,14] There is also evidence of SES differences in the outcome of health care for patients with myocardial infarction, which remains after adjusting for other risk factors. Higher levels of median income were associated with lower risk-adjusted mortality after allowing for differences in insurance status.[15] Lower SES was associated with higher case mix-adjusted mortality after 1 year[11] and increased 30-day event recurrence and mortality after adjusting for treatment and prognostic factors.[16] Worse outcomes after CABG have also been reported.[17,18]

There has been less research undertaken on SES differences in other conditions. The evaluation of SES differences in intensive care allows outcomes to be examined across a wide range of conditions, not just cardiovascular patients, using a common method for adjusting for case mix. Two studies have examined the relationship between SES and outcome from intensive care in adults.[19,20] Neither study reported a significant association, but the small sample sizes resulted in wide confidence intervals that did not exclude an association of increased mortality with lower SES.

Differences in outcome after intensive care may be associated with differences in the treatment given in the intensive-care unit (ICU). In England and Wales, there are limited data collected routinely on treatment provided in the ICU, although data are collected on active treatment withdrawal. Active treatment withdrawal commonly precedes death in intensive care, although there is wide variation in approaches to end-of-life care.[21] It has been hypothesized that withdrawal of active treatment in intensive care may be influenced by a patient's SES.[22] A survey of healthcare workers' opinions found no evidence that SES was a determinant of decisions to withdraw active treatment in intensive care,[23] although no studies have evaluated this in practice.

The aim of our study was to test whether there is an association between SES and outcome for patients admitted to intensive care after adjusting for case mix, whether any association differs by surgical status and whether any differences in hospital mortality can be explained by differences in the withdrawal of active treatment.

METHODS

Data on admissions to intensive care were collected as part of the Intensive Care National Audit & Research Centre's (ICNARC) Case Mix Programme, a national comparative audit of patient outcomes from intensive care.[24] Participation in the Case Mix Programme is voluntary, and at the time of the study, 42% of ICUs in England and Wales were participating.[25] Participation includes tertiary and secondary care ICUs from all health regions in England and Wales. Case mix, outcome, and ICU and hospital length of stay in the Programme have been shown to be nationally representative.[26,27]

We measured SES using Carstairs deprivation scores,[28] an indicator based on male unemployment, overcrowding, social class, and car ownership using data from the 1991 U.K. census. Carstairs scores are calculated at the enumeration district (ED) level with each ED containing, on average, around 170 households and a median population of 410 (interquartile range 159–519, 90th percentile 598). The score for each admission was derived from residential postcode and categorized by national population quintile.

We adjusted for case mix using the individual components of the UK APACHE II model.[29,30] The components were the APACHE II Acute Physiology Score, age in years, a weighting for severe medical history, surgical status (nonsurgical, elective surgical, or emergency surgical) and underlying condition (the primary reason for admission adapted from the original APACHE II model[31]). Individual components were used because of the possibility of residual confounding resulting from miscalibration of the UK APACHE II model in the current data. Using individual components of the APACHE II model as predictor variables in a regression analysis is akin to classic epidemiologic approaches to adjustment for confounding.[32] The Acute Physiology Score was defined by derangement from the normal range for 12 physiological variables in the first 24 hours in the ICU. A severe medical history was defined as the presence of 1 or more of 16 predefined severe chronic conditions. A surgical admission was defined as direct admission to the ICU from the operating room or recovery. Underlying condition was defined by the ICNARC Coding Method[33] and mapped to the original APACHE II diagnostic categories.[31] Valid APACHE II exclusions were applied (age less than 16 years, staying in ICU for less than 8 hours, admissions for burns or after CABG). Readmissions to ICU during the same hospital stay were also excluded to prevent double counting.

Differences in age and Acute Physiology Score by population quintile of SES were estimated using least-squares regression after adjusting for other case mix variables. We also adjusted for ICU because we were interested in the association between SES and these characteristics rather than exploring differences between ICUs.

We estimated the relationship between SES and hospital mortality (including deaths of patients transferred to other hospitals after discharge from ICU) using multivariable logistic regression. Odds ratios of hospital mortality for each quintile of SES compared with the most deprived quintile and the statistical significance for a trend across quintiles (the SES gradient) were calculated after adjusting for case mix and ICU. We adjusted for each ICU to take account any differences in hospital mortality between ICUs and the effect these might have on the relationship between SES and mortality. For example, it is possible that lower SES admissions are more likely to be in ICUs with higher overall mortality. To assess whether the association between SES and outcome differed by surgical status, we tested for an interaction between the SES gradient and surgical status using the likelihood ratio test. Quintile of SES was modeled as a continuous variable, and interactions with dummy variables for the 3 categories of surgical status were used to estimate the significance of the SES gradient for each category. The odds ratios (for a 1-quintile increase in SES) produced from this interaction model were compared with those produced by modeling each category of surgical status in separate regression analyses.

To assess whether different SES gradients between ICUs explained differences in outcome, we tested interactions between quintile of SES measured as a continuous variable and dummy variables for each ICU in the logistic regression model using a likelihood ratio test. We also fitted a random slopes and intercepts model using multilevel logistic regression.[34] In the multilevel model, we adjusted for each ICU's average SES using the median of the Carstairs scores for their admissions. The advantage of the multilevel modeling approach is that it allows us to treat the SES gradient for hospital mortality as a random coefficient, that is, the SES gradient can vary randomly between ICUs. It is then possible to test whether there is evidence for variation in the gradients. We did not include other ICU-level factors in the multilevel model because we wanted to adjust for, rather than explain, differences in mortality between ICUs.

We checked the effect sizes and standard errors of the relationship between SES and hospital mortality between the single and multilevel models, and between the surgical status interaction model and separate logistic regression models for each category of surgical status. We also checked the impact of alternative ways of including age in our adjustment for case mix. Combinations of age in years, age squared, and APACHE II age weights[29] were checked with respect to the distribution of residuals and impact on effect sizes. Finally, we added year of admission to the model to check whether the effect of SES on hospital mortality changed.

Treatment withdrawal was defined as the decision to withdraw active treatment except for comfort measures and is documented with time and date as part of the Case Mix Programme. The definition excludes placing an upper limit on treatment, that is, withholding certain treatments or failing to intensify treatment of a deteriorating patient. The association between treatment withdrawal and SES was estimated using logistic regression after adjusting for case mix and ICU. The likelihood ratio test was used to assess whether the association differed by surgical status.

RESULTS

From December 1995 to February 2000, the Case Mix Programme prospectively collected data on 74,243 admissions to 100 ICUs in England and Wales. There were 15,215 (20.5%) excluded admissions applying the APACHE II criteria along with 2876 (3.9%) readmissions during the same hospital stay. Invalid or missing postcodes accounted for 3912 (5.3%) exclusions, including 1 ICU that only collected partial postcodes. A further 668 (0.9%) admissions with no data on hospital mortality were excluded, leaving 51,572 admissions to 99 ICUs included in the analysis.

Admissions were not evenly distributed by population quintile of SES and fewer admissions were seen in the most and least deprived quintiles (Table 1). Overall, admissions in the most-deprived quintile of SES were, on average, younger than those in less-deprived quintiles, although they reported similar mean Acute Physiology Scores and percentage of patients with a severe medical history.

We found a strong association between SES and surgical status. The percentage of surgical admissions ranged from 39.7% in the most-deprived quintile of SES compared with over 50% in the 3 highest quintiles. However, elective surgical admissions, as a percentage of all surgical admissions, was lowest in the most-deprived quintile (55.1%) and highest in the least-deprived quintile (60.9%.) More-deprived SES was associated with a higher percentage of admissions with conditions related to the respiratory and metabolic systems, and a lower percentage related to the cardiovascular and gastrointestinal systems.

When age, Acute Physiology Score, and severe medical history were examined separately by surgical status, we found the trend of more deprived admissions being younger was consistent across each category of surgical status (Table 2). Lower SES was associated with worse Acute Physiology Scores in elective surgical admissions, but no such relationship was found for emergency surgical and nonsurgical admissions. A severe medical history was less likely in nonsurgical admissions of lower SES, although not for emergency surgical admissions. The higher percentage of low SES admissions with a severe medical history disappeared in the adjusted analysis.

Overall, there were 15,258 (29.6%) deaths in the hospital and the highest hospital mortality (32.2%) was observed in the most-deprived quintile of SES (Table 3). After adjusting for case mix and ICU, there was a trend of lower hospital mortality associated with higher SES (test for trend $P = 0.008$). There was evidence that the SES gradient in hospital mortality was different according to surgical status (test of interaction $P = 0.002$). In elective surgical admissions, there was a trend of lower mortality associated with higher SES (test for trend $P < 0.001$), whereas there was no evidence of an association for nonsurgical or emergency surgical admissions. The multilevel analysis produced identical results (to 2 decimal places for odds ratios and 95% confidence limits) and are not reported here. Fitting separate logistic regression models for each category of surgical status showed a small increase in the odds ratios (0.02–0.03 larger) for elective surgical admissions, although strong evidence ($P = 0.001$) for a trend of lower mortality with higher SES remained. Including alternative variables for age and year of admission did not alter the association between SES and hospital mortality.

There was no evidence to suggest that different SES gradients between ICUs explained differences in outcome (test of interaction $P = 0.68$) after adjusting for case mix. This was confirmed in the multilevel analysis, which examined the effect of allowing the slope and the intercept of the SES gradient to differ for each ICU ($P = 0.50$).

The decision to withdraw active treatment was made in 4965 (9.6%) admissions (Table 4) and was more common in nonsurgical and emergency surgical admissions compared

TABLE 1. Case Mix by Population Quintile of SES for Admissions to Intensive Care

	Population Quintile of SES					
	Most Deprived	2nd	3rd	4th	Least Deprived	All Admissions
Number of admissions (%)	9428 (18.3)	11,121 (21.6)	11,377 (22.1)	10,703 (20.8)	8943 (17.3)	51,572
Sex: % male	58.1	57.4	57.7	60.2	60.3	58.7
Mean age in years (standard deviation)	55.8 (18.4)	59.4 (18.0)	60.6 (17.7)	61.6 (17.6)	61.3 (17.4)	59.8 (18.0)
Adjusted* difference in mean age (95% CI)	reference	2.0 (1.5 to 2.4)	2.4 (2.0 to 2.9)	3.1 (2.7 to 3.6)	3.1 (2.6 to 3.6)	
Mean APACHE II Acute Physiology Score (APS)	13.0	12.5	12.2	12.0	12.1	12.3
Adjusted† difference in mean APACHE II APS (95% CI)	reference	−0.03 (−0.20 to 0.14)	−0.15 (−0.32 to 0.02)	−0.10 (−0.27 to 0.07)	−0.05 (−0.23 to 0.13)	
Severe medical history: n (%)	1328 (14.1)	1644 (14.8)	1711 (15.0)	1491 (13.9)	1263 (14.1)	7437 (14.4)
Surgical status: n (%)						
Nonsurgical	5687 (60.3)	5835 (52.5)	5607 (49.3)	4837 (45.2)	4132 (46.2)	26,098 (50.6)
Surgical	3741 (39.7)	5286 (47.5)	5770 (50.7)	5866 (54.8)	4811 (53.8)	25,474 (49.4)
Elective	2061 (55.1)	3112 (58.9)	3326 (57.6)	3518 (60.0)	2932 (60.9)	14,949 (58.7)
Emergency	1680 (44.9)	2174 (41.1)	2444 (42.4)	2348 (40.0)	1879 (39.1)	10,525 (41.3)
Primary body system: n (%)‡						
Respiratory	2112 (22.4)	2293 (20.6)	2150 (18.9)	1859 (17.4)	1588 (17.8)	10,002 (19.4)
Cardiovascular	2703 (28.7)	3385 (30.4)	3559 (31.3)	3518 (32.9)	2871 (32.1)	16,036 (31.1)
Gastrointestinal	1972 (20.9)	2611 (23.5)	2814 (24.7)	2694 (25.2)	2241 (25.1)	12,332 (23.9)
Neurological	1280 (13.6)	1457 (13.1)	1564 (13.7)	1498 (14.0)	1260 (14.1)	7059 (13.7)
Renal	411 (4.4)	555 (5.0)	602 (5.3)	579 (5.4)	507 (5.7)	2654 (5.1)
Metabolic	845 (9.0)	726 (6.5)	582 (5.1)	441 (4.1)	367 (4.1)	2961 (5.7)
Hematological	105 (1.1)	94 (0.8)	106 (0.9)	114 (1.1)	109 (1.2)	528 (1.0)

*Adjusted for case mix variables (APS, severe medical history, surgical status, and underlying condition) and ICU.
†Adjusted for case mix variables (age, severe medical history, surgical status, and underlying condition) and ICU.
‡Derived from the underlying condition.

with elective surgical admissions. After adjusting for case mix and ICU, there was no association between SES and treatment withdrawal (test for trend $P = 0.69$) and no evidence of different associations between SES and treatment withdrawal according to surgical status (test of interaction $P = 0.54$).

DISCUSSION

We found that SES was associated with differences in admission to, and outcome from, intensive care. There was a trend of lower hospital mortality associated with higher SES in admissions after elective surgery, although no evidence of an association in nonsurgical and emergency surgical admissions.

Our study has 3 main strengths. First, the size of the study, which is based on data from 99 ICUs and represents approximately 42% of all tertiary and secondary-care ICUs in England and Wales.[25] Second, quality control of the Case Mix Programme Database ensures that the prospectively collected data are standard, complete, and accurate. Finally, the APACHE II method has been validated in the United Kingdom and shown to be a good method of case mix adjustment for comparing outcomes.[35]

There are 2 potential weaknesses of the study design: exclusions from the analysis and the measurement of SES. There were 1018 elective surgical admissions who spent less than 8 hours in ICU and were otherwise valid for APACHE II. The addition of these excluded admissions to the analysis did not alter our findings. The 20.5% of admissions excluded under the APACHE II criteria was similar across quintiles of SES (range, 20.0–20.8%; $P = 0.45$). Overall mortality (36.9%) was higher in these exclusions but did not differ by SES. In excluded elective surgical admissions, mortality was 11.4% and did not differ by SES ($P = 0.87$, 12.2% in lowest quintile of SES). The 3912 (5.3%) admissions excluded with invalid or missing postcodes represent a similar percentage to other studies linking postcodes with SES data.[16] The second potential weakness is the measurement of SES using Carstairs

TABLE 2. Case Mix by Population Quintile of SES and Surgical Status

	Population Quintile of SES					Test for Trend Across Quintiles
	Most Deprived	2nd	3rd	4th	Least Deprived	
Mean Age (SD) in Years						
Nonsurgical admissions	52.3 (18.7)	55.5 (18.6)	56.3 (18.5)	57.4 (18.7)	57.5 (18.6)	$P < 0.001$
Elective surgical admissions	62.2 (15.1)	64.3 (15.0)	65.3 (14.2)	65.7 (14.5)	65.2 (13.9)	$P < 0.001$
Emergency surgical admissions	59.8 (18.5)	62.9 (18.0)	64.1 (18.0)	64.2 (17.6)	64.0 (17.4)	$P < 0.001$
Adjusted* difference in mean age (95% CI)						
Nonsurgical admissions	reference	2.1 (1.5 to 2.6)	2.4 (1.8 to 3.0)	3.6 (3.0 to 4.2)	3.6 (3.0 to 4.2)	$P < 0.001$
Elective surgical admissions	reference	1.4 (0.5 to 2.2)	2.1 (1.3 to 2.9)	2.3 (1.5 to 3.2)	2.0 (1.2 to 2.9)	$P < 0.001$
Emergency surgical admissions	reference	2.3 (1.3 to 3.2)	2.9 (2.0 to 3.9)	3.1 (2.2 to 4.1)	3.4 (2.4 to 4.4)	$P < 0.001$
Mean APACHE II Acute Physiology Score (APS)						
Nonsurgical admissions	14.3	14.3	14.2	14.3	14.2	$P = 0.50$
Elective surgical admissions	9.9	9.4	9.1	9.1	9.2	$P < 0.001$
Emergency surgical admissions	12.1	11.9	11.8	11.7	11.8	$P = 0.10$
Adjusted† difference in mean APACHE II APS (95% CI)						
Nonsurgical admissions	reference	0.02 (−0.20 to 0.24)	−0.14 (−0.36 to 0.08)	−0.01 (−0.24 to 0.23)	0.02 (−0.22 to 0.26)	$P = 1.0$
Elective surgical admissions	reference	−0.41 (−0.73 to −0.48)	−0.53 (−0.85 to −0.20)	−0.51 (−0.83 to −0.18)	−0.49 (−0.82 to 0.15)	$P = 0.012$
Emergency surgical admissions	reference	−0.04 (−0.42 to 0.33)	−0.13 (−0.50 to 0.23)	−0.29 (−0.66 to 0.08)	−0.17 (−0.56 to 0.22)	$P = 0.17$
Severe medical history: n (%)						
Nonsurgical admissions	810 (14.2)	904 (15.5)	929 (16.6)	778 (16.1)	650 (15.7)	$P = 0.016$
Elective surgical admissions	292 (14.2)	437 (14.0)	436 (13.1)	415 (11.8)	387 (13.2)	$P = 0.037$
Emergency surgical admissions	226 (13.5)	303 (13.9)	346 (14.2)	298 (12.7)	226 (12.0)	$P = 0.081$
Adjusted‡ odds ratio for a severe medical history (95% CI)						
Nonsurgical admissions	reference	1.06 (0.95 to 1.19)	1.13 (1.01 to 1.26)	1.09 (0.97 to 1.22)	1.14 (1.00 to 1.29)	$P = 0.046$
Elective surgical admissions	reference	1.05 (0.89 to 1.24)	1.00 (0.85 to 1.19)	0.92 (0.78 to 1.09)	1.07 (0.90 to 1.27)	$P = 0.90$
Emergency surgical admissions	reference	1.10 (0.91 to 1.34)	1.08 (0.89 to 1.30)	0.99 (0.81 to 1.20)	0.97 (0.79 to 1.20)	$P = 0.38$

*Adjusted for case mix variables (APS, severe medical history, and underlying condition) and ICU.
†Adjusted for case mix variables (age, severe medical history, and underlying condition) and ICU.
‡Adjusted for case mix variables (age, APS, and underlying condition) and ICU.

deprivation scores, a small area measure of SES. The classification of SES using Carstairs scores at the enumeration district level is an established method for classifying socioeconomic deprivation.[28] Empiric studies have found that area-based measures provide smaller effects than individual-based measures of deprivation[36] so our use of Carstairs scores

TABLE 3. Association Between SES and Hospital Mortality for Admissions to Intensive Care

	Population Quintile of SES					
	Most Deprived	2nd	3rd	4th	Least Deprived	All Admissions
Hospital mortality: n (%)	3033 (32.2)	3879 (30.4)	3812 (29.1)	2990 (27.9)	2544 (28.4)	15,258 (29.6)
Hospital mortality by surgical status: n (%)						
Nonsurgical	2165 (38.1)	2299 (39.4)	2146 (38.3)	1934 (40.0)	1665 (40.3)	10,209 (39.1)
Elective surgical	297 (14.4)	376 (12.1)	379 (11.4)	350 (9.9)	281 (9.6)	1683 (11.3)
Emergency surgical	571 (34.0)	704 (32.4)	787 (32.2)	706 (30.1)	598 (31.8)	3366 (32.0)
	Odds Ratio for Hospital Mortality (95% Confidence Interval)					Test for Trend Across Quintiles
Unadjusted	reference	0.92 (0.87 to 0.98)	0.87 (0.82 to 0.92)	0.82 (0.77 to 0.87)	0.84 (0.79 to 0.89)	$P < 0.001$
Adjusted for case mix and ICU	reference	1.00 (0.92 to 1.07)	0.96 (0.89 to 1.04)	0.94 (0.87 to 1.02)	0.91 (0.84 to 0.99)	$P = 0.008$
By surgical status (adjusted for case mix and ICU)						
Nonsurgical	reference	1.02 (0.93 to 1.12)	0.96 (0.88 to 1.06)	1.01 (0.91 to 1.11)	0.96 (0.87 to 1.07)	$P = 0.45$
Elective surgical	reference	0.91 (0.76 to 1.09)	0.87 (0.73 to 1.05)	0.76 (0.64 to 0.92)	0.70 (0.58 to 0.84)	$P < 0.001$
Emergency surgical	reference	0.99 (0.84 to 1.15)	1.00 (0.86 to 1.16)	0.93 (0.80 to 1.09)	0.98 (0.83 to 1.15)	$P = 0.55$

TABLE 4. Active Treatment Withdrawal by SES

	Population Quintile of SES					
	Most Deprived (n = 9428)	2nd (n = 11,121)	3rd (n = 11,377)	4th (n = 10,703)	Least Deprived (n = 8943)	All Admissions (n = 51,572)
Treatment withdrawn: n (%)	960 (10.2)	1077 (9.7)	1081 (9.5)	1002 (9.4)	845 (9.4)	4965 (9.6)
Treatment withdrawn by surgical status: n (%)						
Nonsurgical	708 (12.4)	785 (13.5)	750 (13.4)	686 (14.2)	591 (14.3)	3,520 (13.5)
Elective surgical	53 (2.6)	78 (2.5)	84 (2.5)	73 (2.1)	59 (2.0)	347 (2.3)
Emergency surgical	199 (11.8)	214 (9.8)	247 (10.1)	243 (10.3)	195 (10.4)	1098 (10.4)
Adjusted* odds ratio for treatment withdrawal (95% CI)	reference	0.99 (0.89 to 1.10)	0.98 (0.88 to 1.09)	0.98 (0.87 to 1.09)	0.98 (0.87 to 1.10)	Test for trend $P = 0.69$

*Adjusted for case mix and ICU.

may underestimate the SES gradient in admissions after elective surgery.

Our finding of SES differences in the outcome of intensive care is consistent with the effect sizes reported in previous studies, although the small sample sizes in these studies resulted in wide confidence intervals that did not exclude an odds ratio of 1. A study of 774 admissions to 1 ICU in Scotland estimated an odds ratio of approximately 0.8 (95% confidence interval [CI], 0.6–1.1) for hospital mortality in high compared with low SES admissions after adjusting for case mix using APACHE II probabilities of mortality.[19] Another study of 847 admissions to 3 ICUs in Spain estimated an odds ratio of 0.75 (95% CI, 0.49–1.15) for ICU mortality in high versus low SES admissions after adjustment using the Simplified Acute Physiology Score.[20]

In addition to issues of study design, our findings may be the result of unmeasured differences in the health status of patients on admission to intensive care. It is known that there is an association between lower SES and poorer health[2] which, it is suggested, may be mediated through individual and contextual factors such as the physical and social environment and health behavior. These include smoking, diet, lack of exercise, and stress as well as the presence of local amenities and the quality of social support.[4] The influence of these factors on health status may not be adequately measured by the APACHE II method.

It has been suggested that the inclusion of detailed comorbidity information could improve the prediction of mortality in critically ill patients[37] because APACHE II only includes information on the most severe chronic conditions. One study found that 7 of 34 potential measures of comorbidity and physiological reserve were associated with hospital outcome.[38] All 7 were rare in elective surgical admissions and are therefore not used for mortality prediction in these admissions. A subsequent study of ICU admissions in U.S. Veterans Affairs hospitals found several comorbidities were independently associated with hospital mortality after adjusting for case mix, with comorbidities being associated with outcome for surgical and nonsurgical admissions in different ways.[39] This study was based on a highly selective group of admissions and some of the findings were counterintuitive, for example, the presence of diabetes and hypertension, more common with deprived SES, were associated with reduced mortality, although this may have been the result of coding biases such as a failure to record comorbidities in more severely ill admissions.

If unmeasured differences in health status contribute to the observed association between SES and outcome in elective surgical admissions, then why is there no such association in nonsurgical and emergency surgical admissions? One reason may be that comorbidities have different effects depending on the surgical status of the admission.[38] The association between SES and the presence of comorbidities not included in our adjustment for case mix may also be weaker in nonsurgical and emergency surgical admissions. Although higher SES is associated with better health in the general population, there may be a larger proportion of high SES nonsurgical and emergency surgical admissions to intensive care who are "atypical" with respect to comorbidities.

A final explanation for differences in the outcome of intensive care is that patients may receive different care according to their SES. Such differences could arise in deciding who is admitted to intensive care, the treatment given in intensive care, discharge from intensive care, and subsequent treatment and discharge from the hospital. When measuring the influence of clinical judgment about the treatment a patient should receive, it is important to positively demonstrate that clinical decision-making is guided by prejudice before concluding that bias is present.[40] Decisions on withholding and withdrawing treatment may vary by SES as a result of clinical decision-making, patient or family attitudes to these decisions, or as a result of mutual decision-making. We found no evidence that active treatment withdrawal differed by SES or that it explained SES differences in hospital mortality in elective surgical admissions. However, our data on treatment withdrawal do not indicate patient or family preferences for care or other factors involved in decisions to withdraw active treatment.[21] We did not have data on, and therefore could not look at, other potentially important factors such as withholding treatment or differences in therapeutic effort.

For patients admitted to intensive care, we found that a smaller percentage of patients of low SES were admitted after elective surgery compared with high SES patients. This may be the result of issues of study design discussed here, patient-related factors such as the clinical need for intensive care, or clinical judgment. There is some evidence to suggest that our findings may be because low SES patients are less likely to have access to, and undergo, elective surgery than high SES patients,[7,8] which would reduce their need for postoperative intensive care. Our findings of more severe Acute Physiology Scores in elective surgical admissions of low SES support this hypothesis because they suggest that low SES patients who undergo elective surgery are sicker than their high SES counterparts. It is unlikely that the difference in Acute Physiology Scores is the result of clinical decisions about admissions to intensive care, because elective surgical patients are rarely refused admission to intensive care.[41] In the event of an intensive-care bed being unavailable, elective surgery tends to be delayed. This would imply that our findings can be explained by differences in who gets surgery rather than unfair access to intensive care.

To directly investigate the equity of admission to intensive care, it is necessary to have data on clinical need for intensive care on patients who were not admitted to intensive care. Case mix can be used as a crude indicator of clinical need but data are not available on patients who are not admitted. An indirect method for investigating whether use of intensive care is equitable is to compare case mix severity in patients who are admitted.[42] Our finding of no evidence for a difference in mean Acute Physiology Score across quintiles of SES for emergency surgical and nonsurgical admissions therefore provides some assurance that admission to intensive care is not influenced by SES. However, for nonsurgical admissions, there was some evidence that low SES admissions to intensive care were less likely to have a severe medical history compared with high SES admissions. This raises the possibility that low SES patients with a severe medical history were less likely to be admitted to intensive care than their high SES counterparts.

We have shown that lower SES is associated with higher hospital mortality for admissions to intensive care after elective surgery. This result has important implications for admission to intensive care and the provision of intensive care. Decisions to admit patients to intensive care should be based on the concept of potential benefit.[43] Determining the potential to benefit is not straightforward because severity of illness scoring systems such as APACHE are intended for use in groups of patients admitted to intensive care, and not for making admission decisions for individual patients.[43] Furthermore, the worse outcomes seen in lower SES admissions after elective surgery should not be interpreted as indicating a lower potential to benefit. It is possible this indicates a greater need for intensive care instead. Further research is needed to establish if our findings for elective surgical admissions can be explained by the existence of additional risk factors not included in our measure of case mix or by differences in treatment. If there are specific additional risk factors, then we need to understand how these are, or might be used, in determining who has the potential to benefit from admission to intensive care.

Our findings also need to be taken into account in relation to increasing demands for the publication of comparative performance data on outcomes after surgery. Despite intensive care having some of the most sophisticated methods for measuring and adjusting for case mix, there is an unexplained reduction of 30% in the odds of hospital mortality between the most- and least-deprived elective surgical admissions. We do not recommend including SES in individual case mix adjustment in intensive care without a clearer understanding of why SES disparities in outcome exist. However, in view of the large SES disparity in outcomes for elective surgical admissions, stratifying by SES should be done when comparing outcomes between ICUs. Stratification should also be done when comparing surgical performance for procedures in which admission to intensive care is common.

REFERENCES

1. Department of Health. *The New NHS Modern and Dependable: A National Framework for Assessing Performance*. London: Department of Health; 1998.
2. Adler NE, Ostrove JM. Socioeconomic status and health: what we know and what we don't. *Ann NY Acad Sci*. 1999;896:3–15.
3. Marmot MG, Shipley MJ, Rose G. Inequalities in death: specific explanations of a general pattern? *Lancet*. 1984;1:1003–1006.
4. Adler NE, Boyce T, Chesney MA, et al. Socioeconomic status and health: the challenge of the gradient. *Am Psychol*. 1994;49:15–24.
5. Fiscella K, Franks P, Gold MR, et al. Inequality in health: addressing socioeconomic, racial and ethnic disparities in health care. *JAMA*. 2000;283:2579–2584.
6. Stewart AL, Nápoles-Springer AM. Advancing health disparities research: can we afford to ignore measurement issues? *Med Care*. 2003; 41:1207–1220.
7. Ancona C, Agabiti N, Forastiere F, et al. Coronary artery bypass graft surgery: socioeconomic inequalities in access and in 30 day mortality: a population-based study in Rome. *J Epidemiol Community Health*. 2000; 54:930–935.
8. Ben-Shlomo Y, Chaturvedi N. Assessing equity in access to health care provision in the UK: does where you live affect your chances of getting a coronary artery bypass graft? *J Epidemiol Community Health*. 1995; 49:200–204.
9. Melville MR, Packham C, Brown N, et al. Cardiac rehabilitation: socially deprived patients are less likely to attend but patients ineligible for thrombolysis are less likely to be invited. *Heart*. 1999;82:373–377.
10. Taylor F, Angelini G, Victory J. Uptake of cardiac rehabilitation among patients following cardiac bypass surgery. *Heart*. 2001;86:92–93.
11. Alter DA, Naylor CD, Austin P, et al. Effects of socioeconomic status on access to invasive cardiac procedures and on mortality after acute myocardial infarction. *N Engl J Med*. 1999;341:1359–1367.
12. Morrison C, Woodward M, Leslie W, et al. Effect of socioeconomic group on incidence of, management of, and survival after myocardial infarction and coronary death: analysis of coronary event register. *BMJ*. 1997;314:541–546.
13. Salomaa V, Miettinen H, Niemela M, et al. Relation of socioeconomic position to the case fatality, prognosis and treatment of myocardial infarction events: the FINMONICA MI register study. *J Epidemiol Community Health*. 2001;55:475–482.
14. Pell JP, Pell AC, Norrie J, et al. Effect of socioeconomic deprivation on waiting time for cardiac surgery: retrospective cohort study. *BMJ*. 2000;320:15–19.
15. Shen JJ, Wan TT, Perlin JB. An exploration of the complex relationship between socioecologic factors in the treatment and outcomes of acute myocardial infarction in disadvantaged populations. *Health Serv Res*. 2001;36:711–732.
16. Barakat K, Stevenson S, Wilkinson P, et al. Socioeconomic differentials in recurrent ischaemia and mortality after acute myocardial infarction. *Heart*. 2001;85:390–394.
17. Taylor FC, Ascione R, Rees K, et al. Socioeconomic deprivation is a predictor of poor postoperative cardiovascular outcomes in patients undergoing coronary artery bypass grafting. *Heart*. 2003;89:1062–1066.
18. Boscarino JA, Chang J. Survival after coronary bypass graft surgery and community socioeconomic status: clinical and research implications. *Med Care*. 1999;37:210–216.
19. Findlay JY, Plenderleith JL, Schroeder DR. Influence of social deprivation on intensive care outcome. *Intensive Care Med*. 2000;26:929–933.
20. Latour J, Lopez V, Rodriguez M, et al. Inequalities in health in intensive care patients. *J Clin Epidemiol*. 1991;44:889–894.
21. Way J, Back AL, Curtis JR. Withdrawing life support and resolution of conflict with families. *BMJ*. 2002;325:1342–1345.
22. Crane D. Decisions to treat critically ill patients: a comparison of social versus medical considerations. *Milbank Mem Fund Q Health Soc*. 1975;53:1–33.
23. Cook DJ, Guyatt GH, Jaeschke R, et al. Determinants in Canadian health care workers of the decision to withdraw life support from the critically ill. *JAMA*. 1995;273:703–708.
24. Rowan KM, Black N. A bottom-up approach to performance indicators through clinician networks. In: Appleby J, Harrison A, eds. *Health Care UK Spring 2000: the King's Fund Review of Health Policy*. London: King's Fund; 2000:42–46.
25. Audit Commission. *Critical to Success: The Place of Efficient and Effective Critical Care Services Within the Acute Hospital*. London: Audit Commission; 1999.
26. Harrison DA, Brady AR, Rowan K. Case mix, outcome and length of stay for admissions to adult, general critical care units in England, Wales and Northern Ireland: the Intensive Care National Audit & Research Centre Case Mix Programme Database. *Crit Care*. 2004;8:R99–R111.
27. Black N, Payne M. Directory of clinical databases: improving and promoting their use. *Qual Saf Health Care*. 2003;12:348–352.
28. Carstairs V, Morris R. *Deprivation and Health in Scotland*. Aberdeen: Aberdeen University Press; 1991.
29. Rowan KM, Kerr JH, Major E, et al. Intensive Care Society's APACHE II study in Britain and Ireland II: outcome comparisons of intensive care units after adjustment for case mix by the American APACHE II method. *BMJ*. 1993;307:977–981.
30. Rowan KM. Outcome comparisons of intensive care units in Great Britain and Ireland using the APACHE II method [PhD thesis]. Oxford: University of Oxford; 1993.
31. Knaus WA, Draper EA, Wagner DP, et al. APACHE II: a severity of disease classification system. *Crit Care Med*. 1985;13:818–829.
32. Rothman KJ, Greenland S. *Modern Epidemiology*. Philadelphia: Lippin-

cott Williams & Wilkins; 1998.
33. Young JD, Goldfrad C, Rowan K. Development and testing of a hierarchical method to code the reason for admission to intensive care units: the ICNARC Coding Method. *Br J Anaesth*. 2001;87:543–548.
34. Goldstein H. *Multilevel Statistical Models*. London: Arnold; 1995.
35. Rowan K. Risk adjustment for intensive care outcomes. In: Goldhill D, Withingston S, eds. *Textbook of Intensive Care*. London: Chapman and Hall; 1997:787–798.
36. Krieger N, Gordon D. Use of census-based aggregate variables to proxy for socioeconomic group: evidence from national samples. *Am J Epidemiol*. 1999;150:892–894.
37. Poses RM, McClish DK, Smith WR, et al. Prediction of survival of critically ill patients by admission comorbidity. *J Clin Epidemiol*. 1996;49:743–747.
38. Knaus WA, Wagner DP, Draper EA, et al. The APACHE III prognostic system: risk prediction of hospital mortality for critically ill hospitalized adults. *Chest*. 1991;100:1619–1636.
39. Johnston JA, Wagner DP, Timmons S, et al. Impact of different measures of comorbid disease on predicted mortality of intensive care unit patients. *Med Care*. 2002;40:929–940.
40. Raine R. Bias measuring bias. *J Health Serv Res Policy*. 2002;7:65–67.
41. Metcalfe MA, Sloggett A, McPherson K. Mortality among appropriately referred patients refused admission to intensive-care units. *Lancet*. 1997;350:7–11.
42. Raine R, Goldfrad C, Black N, et al. Gender differences in admission to intensive care. *J Epidemiol Community Health*. 2002;56:418–423.
43. Smith G, Nielsen M. ABC of intensive care: criteria for admission. *BMJ*. 1999;318:1544–1547.