

The effect of socioeconomic status on outcomes for seriously ill patients: a linked data cohort study

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Socioeconomic status (SES), as measured by either individual-level indicators (such as education, income and occupation) or disadvantaged area-level indicators, is a determinant of outcomes for many diseases.¹⁻⁵ In a number of developed countries, patients with a lower SES have significantly worse health outcomes.^{1,2,4,5} Despite overall improvements in population health, the differences in health outcomes between patients with different SES have in fact increased over time in many countries.³

Many seriously ill patients are admitted to an intensive care unit (ICU) only after other layers of the health care system have failed to prevent or reverse the critical illness. SES may have a significant effect on outcomes of critical illness. For instance, patients in the United Kingdom and the United States who come from socioeconomically disadvantaged areas have been found to have significantly more pre-existing comorbidities and worse long-term survival after acute myocardial infarction.^{6,7} Other studies investigating the effects of SES on short-term outcomes of critical illness have shown that seriously ill patients from socioeconomically disadvantaged areas have higher-acuity critical illnesses and worse hospital outcomes.⁸⁻¹⁰

Because acuity of acute illness and pre-existing comorbidities are important risk factors for poor health outcomes, and SES is associated with poor health outcomes as well as comorbidities and acuity of acute illness, SES may only be a "confounder" for poor health outcomes. In other words, a lower SES may be associated with poor health outcomes purely because of its associations with other risk factors for poor health outcomes, and SES may not have an independent effect on health outcomes.

We hypothesised that SES has an attributable effect on mortality of seriously ill patients over and above the background effects of usual biological explanations such as comorbidities, acuity of acute illness, and geographical access to essential services. The potential independent effects of SES on in-hospital and long-term mortality of seriously ill patients have not been thoroughly investigated.^{11,12} In a linked data cohort study, we investigated whether low SES was an independent risk factor for in-hospital and long-

ABSTRACT

Objective: To investigate the association between socioeconomic status (SES) and outcomes for seriously ill patients.

Design and setting: A retrospective cohort study based on data from an intensive care unit clinical database linked with data from the Western Australian hospital morbidity and mortality databases over a 16-year period (1987–2002).

Main outcome measures: In-hospital and long-term mortality.

Results: Data on 15 619 seriously ill patients were analysed. The in-hospital mortality rate for all seriously ill patients was 14.8%, and the incidence of death after critical illness was 7.4 per 100 person-years (4.8 per 100 person-years after hospital discharge). Patients from the most socioeconomically disadvantaged areas were more likely to be younger, to be Indigenous, to live in a remote area, to be admitted non-electively, and to have more severe acute disease and comorbidities. SES was not significantly associated with in-hospital mortality, but long-term mortality was significantly higher in patients from the lowest SES group than in those from the highest SES group, after adjusting for age, ethnicity, comorbidities, severity of acute illness, and geographical accessibility to essential services (hazard ratio for death in lowest SES group v highest SES group was 1.21 [95% CI, 1.04–1.41]; $P=0.014$). The attributable incidence of death after hospital discharge between patients from the lowest and highest SES groups was 1.0 per 100 person-years (95% CI, 0.3–1.6 per 100 person-years).

Conclusion: Lower SES was associated with worse long-term survival after critical illness over and above the background effects of age, acuity of acute illness, comorbidities, Indigenous status and geographical access to essential services.

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term mortality in a diverse group of seriously ill patients.

METHODS

Data source

Our data source was the clinical database of the ICU at Royal Perth Hospital. Royal Perth Hospital is the largest tertiary referral hospital in Western Australia, with all medical and surgical specialties except liver transplantation represented. From the ICU clinical database we extracted de-identified details of all ICU admissions over a 16-year period (1987 to 2002), including demographics, admission diagnosis, severity of acute illness (measured by the Acute Physiology and Chronic Health Evaluation [APACHE] II score), and in-hospital mortality.¹² The data were reviewed annually for internal consistency, and no patients were lost to follow-up or had missing in-hospital mortality data. Patients in the cohort had experienced a wide range of acute diseases

or conditions, including sepsis, respiratory failure, cardiogenic shock, cardiac arrest, drug overdose, intracranial haemorrhage, acute surgical emergencies and cardiothoracic surgery. Some details of this cohort have been described in our previous publications.^{13,14}

The ICU clinical database was linked with WA hospital morbidity and mortality databases to provide information on patients' long-term survival outcomes as at 31 December 2003 and on all pre-existing comorbidities recorded on admission to private or public hospitals up to 5 years before their ICU index admission.^{14,15} For each patient, we extracted the presence of pre-existing comorbidities, as defined by the Charlson Comorbidity Index, using ICD-9-CM (International classification of diseases, 9th revision, clinical modification) coding algorithms.^{14,16,17} The WA hospital morbidity database also provided each patient's residential postcode at the time of ICU admission.

RESEARCH

To categorise patients into SES groups, we used the Index of Relative Socioeconomic Disadvantage (IRSD) developed by the Australian Bureau of Statistics from data collected in the 1986, 1991, 1996 and 2001 censuses. After a census, each postcode in Australia is allocated an IRSD value based on a combination of factors that includes residents' educational level, employment status, income, motor vehicle ownership and fluency in English.¹⁸ Patients in our study cohort were allocated to one of six SES groups according to the IRSD of their residential postcode, mapped to the census data of the year nearest to the year of ICU admission. Because the IRSD of each postcode changes over time, one postcode could represent patients from different socioeconomic areas, depending on the year of ICU admission and the IRSD of the postcode of the nearest census year.

SES groups were defined as follows: group I, comprised of patients from areas with the highest IRSD in the WA population (>90th percentile, least disadvantaged); group II (75th to 90th percentile); group III (50th to 75th percentile); group IV (25th to 50th percentile); group V (10th to 25th percentile); and group VI (<10th percentile, most disadvantaged).

Using the Accessibility/Remoteness Index of Australia (ARIA) developed by the

Australian Institute of Health and Welfare,¹⁹ we classified patients' geographical accessibility to essential services into one of five categories based on patients' residential postcodes.

Patients were excluded from our analysis if they had a diagnosis not included in the APACHE II prognostic model (eg, coronary artery bypass graft surgery, burns, snake bite) ($n = 8265$); if they were living outside WA at the time of ICU admission ($n = 425$); or if we could not ascertain a linkage between the hospital morbidity database and the ICU clinical database for that patient ($n = 45$).

Patients were followed up for an average of 6 years (range, 1–17 years).

Statistical analyses

Continuous variables with near-normal distribution were analysed by *t* test; categorical variables and continuous variables with skewed distribution were analysed by the χ^2 test and Mann–Whitney test, respectively. Multiple logistic regression was used to assess the independent effect of SES on in-hospital mortality after adjusting for predictors of in-hospital mortality. Cox proportional hazards regression analysis was used to assess the independent effect of SES on long-term mortality after adjusting for other potential predictors of long-term mortality.

APACHE II-predicted mortality and the Charlson Comorbidity Index were used to adjust for differences in severity of acute illness and comorbidities, respectively.^{12,16}

Interaction terms were confined to the interaction between SES and Indigenous status, as they were mostly likely to be significant. Subgroup or sensitivity analysis was confined to non-Indigenous patients to assess whether SES had an adverse effect on outcomes among non-Indigenous patients.

A *P* value of less than 0.05 was regarded as significant, all tests were two-tailed tests, and no adjustment was made for multiple comparisons during the progressive inclusion of predictors in the analyses.

All statistical analyses were performed using SPSS statistical software, version 14.0 for Windows (SPSS Inc, Chicago, Ill, USA).

Ethics approval

Our study was approved by the Royal Perth Hospital Ethics Committee, the Confidentiality of Health Information Committee and the WA Aboriginal Health Information and Ethics Committee.

RESULTS

After exclusions, data on 15 619 patients were available for analysis. Patients from the most socioeconomically disadvantaged areas

1 Relationship between socioeconomic status (SES) and other characteristics of seriously ill patients

| Patient characteristic | SES group* | | | | | | <i>P</i> [†] |
|---|-----------------|-------------------|--------------------|-------------------|------------------|-------------------|-----------------------|
| | I ($n = 926$) | II ($n = 2501$) | III ($n = 3906$) | IV ($n = 4426$) | V ($n = 2726$) | VI ($n = 1134$) | |
| Mean age in years (SD) | 56.7 (20.5) | 53.9 (20.0) | 52.5 (19.7) | 54.6 (18.9) | 54.3 (19.3) | 51.7 (18.9) | 0.001 |
| Number (%) of males | 600 (64.8%) | 1556 (62.2%) | 2433 (62.3%) | 2805 (63.4%) | 1748 (64.1%) | 699 (61.6%) | 0.366 |
| Number (%) of elective admissions | 377 (40.7%) | 871 (34.8%) | 1226 (31.4%) | 1543 (34.9%) | 968 (35.5%) | 314 (27.7%) | 0.001 |
| Number (%) of Indigenous patients | 4 (0.4%) | 77 (3.1%) | 209 (5.4%) | 239 (5.4%) | 204 (7.5%) | 263 (23.2%) | 0.001 |
| Acute Physiology Score (SD) | 10.9 (6.6) | 11.0 (7.1) | 11.4 (7.1) | 11.1 (7.4) | 11.1 (7.1) | 11.9 (7.3) | 0.001 [‡] |
| Number (%) of patients with one or more comorbidities included in the Charlson Comorbidity Index [§] | 348 (42.9%) | 884 (39.5%) | 1468 (40.0%) | 1721 (43.0%) | 1023 (41.6%) | 404 (39.2%) | 0.022 |
| Charlson Comorbidity Index (SD) | 1.1 (1.9) | 1.0 (1.7) | 1.0 (1.7) | 0.9 (1.5) | 1.0 (1.7) | 1.0 (1.8) | 0.315 [‡] |
| Number (%) of patients with one or more APACHE II-defined severe comorbidities | 86 (9.3%) | 294 (11.8%) | 373 (9.5%) | 464 (10.5%) | 312 (11.4%) | 116 (10.2%) | 0.034 |
| Accessibility/Remoteness Index of Australia category | | | | | | | 0.001 |
| 1 (metropolitan) | 921 | 2227 | 2821 | 3205 | 2195 | 830 | |
| 2 | 0 | 69 | 356 | 542 | 206 | 13 | |
| 3 | 1 | 102 | 429 | 426 | 96 | 13 | |
| 4 | 0 | 55 | 116 | 111 | 97 | 31 | |
| 5 (most remote) | 3 | 34 | 129 | 128 | 169 | 246 | |
| Number of postcode areas included | 26 | 88 | 175 | 154 | 76 | 38 | |

APACHE = Acute Physiology and Chronic Health Evaluation. *SES group I (least disadvantaged); SES group VI (most disadvantaged). † *P* values were generated by comparing all SES groups. ‡ Non-parametric test. § Denominator used to derive percentage ($n = 14\ 065$) was smaller than total number of patients, as analysis was confined to patients' first admission to intensive care unit.

2 Crude death rate among seriously ill patients, by socioeconomic group

| SES group | No. of patients | Hospital person-years of follow-up | Total person-years of follow-up | No. (%) of in-hospital deaths | No. of in-hospital deaths per 100 person-years | Incidence of death per 100 person-years after hospital discharge | Overall incidence of death per 100 person-years* |
|-------------------------|-----------------|------------------------------------|---------------------------------|-------------------------------|--|--|--|
| I (least disadvantaged) | 926 | 50 | 4 082 | 115 (12.4%) | 230 | 5.2 | 8.0 |
| II | 2 501 | 127 | 12 046 | 352 (14.1%) | 277 | 5.0 | 8.0 |
| III | 3 906 | 202 | 21 097 | 598 (15.3%) | 296 | 4.4 | 7.2 |
| IV | 4 426 | 235 | 30 038 | 648 (14.6%) | 276 | 4.8 | 7.0 |
| V | 2 726 | 132 | 17 135 | 411 (15.1%) | 311 | 5.0 | 7.4 |
| VI (most disadvantaged) | 1 134 | 63 | 6 960 | 183 (16.1%) | 290 | 5.1 | 7.6 |
| All patients | 15 619 | 809 | 91 358 | 2 307 (14.8%) | 285 | 4.8 | 7.4 |

SES = socioeconomic status. *Includes in-hospital deaths.

were more likely to be younger, to be Indigenous, to live in a remote area, to be admitted non-electively, and to have more severe acute disease and comorbidities (Box 1). The in-hospital mortality rate for all seriously ill patients was 14.8%, and the overall incidence of death after critical illness was 7.4 per 100 person-years (4.8 per 100 person-years after hospital discharge) (Box 2).

SES was significantly associated with in-hospital mortality after adjusting for age alone, but this association was no longer significant after further adjustments for comorbidities, severity of acute illness, ARIA category and Indigenous status (Box 3).

SES was not significantly associated with long-term mortality in the univariate analysis, but a significant association was seen

after adjustment for age, comorbidities, severity of acute illness, ARIA category and Indigenous status (Box 4, Box 5). The hazard ratio (HR) for long-term mortality progressively increased from SES group I to group VI (II v I: HR, 1.11, $P = 0.143$; III v I: HR, 1.13, $P = 0.071$; IV v I: HR, 1.17, $P = 0.021$; V v I: HR, 1.23, $P = 0.003$; VI v I: HR, 1.21, $P = 0.014$ [overall $P = 0.030$]). The attributable incidence of death after hospital discharge between patients from the lowest and highest socioeconomic areas was 1.0 per 100 person-years (95% CI, 0.3–1.6 per 100 person-years). The difference in estimated survival probability at 16-year follow-up between the highest and the lowest SES group was close to 10% (45% v 35%) (Box 5).

The other significant predictors of long-term mortality in the final Cox model included age (HR, 1.03 [95% CI, 1.02–1.04]; $P < 0.001$), Charlson Comorbidity Index (HR, 1.11 [95% CI, 1.09–1.12]; $P < 0.001$), severity of acute illness (HR for a 10% increment in APACHE II-predicted mortality, 1.33 [95% CI, 1.31–1.34]; $P < 0.001$), and Indigenous status (HR, 1.36 [95% CI, 1.19–1.54]; $P < 0.001$). The interaction term between Indigenous status and SES grouping was not significant and was not retained in the final model (Box 4).

Sensitivity or subgroup analysis

After excluding Indigenous patients ($n = 996$) from the analysis, the association between

3 Relationship between socioeconomic status (SES) and in-hospital mortality, after adjusting for potential predictors of in-hospital mortality*

| | Odds ratio (95% CI) for in-hospital mortality, by SES group [†] | | | | | | P |
|---|--|---------------------|---------------------|---------------------|---------------------|---------------------|-------|
| | I (n = 926) | II (n = 2501) | III (n = 3906) | IV (n = 4426) | V (n = 2726) | VI (n = 1134) | |
| SES alone | 1 | 1.16 (0.92–1.45) | 1.28 (1.03–1.58) | 1.21 (0.98–1.50) | 1.25 (1.00–1.56) | 1.36 (1.06–1.75) | 0.164 |
| SES + age | 1 | 1.22 (0.97–1.53) | 1.38 (1.11–1.71) | 1.26 (1.02–1.56) | 1.31 (1.05–1.64) | 1.49 (1.16–1.92) | 0.024 |
| SES + age + APACHE II-predicted mortality | 1 | 1.06 (0.82–1.39) | 1.20 (0.93–1.54) | 1.10 (0.86–1.41) | 1.26 (0.97–1.63) | 1.17 (0.87–1.58) | 0.310 |
| SES + age + APACHE II-predicted mortality + Charlson Comorbidity Index | 1 | 1.03 (0.78–1.36) | 1.11 (0.85–1.44) | 1.06 (0.81–1.37) | 1.24 (0.94–1.62) | 1.16 (0.85–1.59) | 0.375 |
| SES + age + APACHE II-predicted mortality + Charlson Comorbidity Index + ARIA category | 1 | 1.02 (0.77–1.34) | 1.09 (0.84–1.43) | 1.04 (0.80–1.35) | 1.21 (0.92–1.60) | 1.12 (0.81–1.54) | 0.455 |
| SES + age + APACHE II-predicted mortality + Charlson Comorbidity Index + ARIA category + Indigenous status (yes/no) | 1 | 1.01 (0.76–1.34) | 1.10 (0.84–1.43) | 1.03 (0.79–1.35) | 1.22 (0.93–1.61) | 1.15 (0.83–1.58) | 0.372 |

APACHE = Acute Physiology and Chronic Health Evaluation. ARIA = Accessibility/Remoteness Index of Australia. *Age ($P < 0.001$) and APACHE II-predicted mortality ($P < 0.001$) were significant covariates in the final model. ARIA category ($P = 0.099$), Charlson Comorbidity Index ($P = 0.922$), and Indigenous status ($P = 0.104$) were not significant in the final model. [†] SES group I (least disadvantaged); SES group VI (most disadvantaged).

4 Relationship between socioeconomic status (SES) and long-term mortality, after adjusting for potential predictors of long-term mortality*

| | Hazard ratio (95% CI) for long-term mortality, by SES group [†] | | | | | | P |
|---|--|---------------------|---------------------|---------------------|---------------------|---------------------|-------|
| | I (n = 926) | II (n = 2501) | III (n = 3906) | IV (n = 4426) | V (n = 2726) | VI (n = 1134) | |
| SES alone | 1 | 1.04 (0.92–1.18) | 1.00 (0.89–1.13) | 1.06 (0.94–1.19) | 1.09 (0.97–1.24) | 1.11 (0.97–1.28) | 0.145 |
| SES + age | 1 | 1.15 (1.02–1.31) | 1.17 (1.03–1.31) | 1.16 (1.03–1.31) | 1.21 (1.07–1.37) | 1.34 (1.17–1.54) | 0.002 |
| SES + age + APACHE II-predicted mortality | 1 | 1.07 (0.94–1.21) | 1.09 (0.97–1.23) | 1.09 (0.97–1.23) | 1.15 (1.02–1.30) | 1.18 (1.03–1.35) | 0.093 |
| SES + age + APACHE II-predicted mortality + Charlson Comorbidity Index | 1 | 1.12 (0.98–1.28) | 1.13 (0.99–1.29) | 1.18 (1.04–1.34) | 1.25 (1.09–1.42) | 1.25 (1.08–1.46) | 0.006 |
| SES + age + APACHE II-predicted mortality + Charlson Comorbidity Index + ARIA category | 1 | 1.12 (0.97–1.28) | 1.14 (0.99–1.30) | 1.17 (1.03–1.34) | 1.24 (1.08–1.41) | 1.24 (1.07–1.45) | 0.012 |
| SES + age + APACHE II-predicted mortality + Charlson Comorbidity Index + ARIA category + Indigenous status (yes/no) | 1 | 1.11 (0.97–1.27) | 1.13 (0.99–1.29) | 1.17 (1.02–1.33) | 1.23 (1.07–1.40) | 1.21 (1.04–1.41) | 0.030 |

APACHE = Acute Physiology and Chronic Health Evaluation. ARIA = Accessibility/Remoteness Index of Australia. * Age ($P < 0.001$), APACHE II-predicted mortality ($P < 0.001$), Charlson Comorbidity Index ($P < 0.001$) and Indigenous status ($P < 0.001$) were significant covariates in the final model. ARIA category ($P = 0.205$) was not significant in the final model. † SES group I (least disadvantaged); SES group VI (most disadvantaged). ◆

SES and in-hospital mortality remained non-significant ($P = 0.381$) and the association between SES and long-term mortality remained largely unchanged, with the HR for long-term mortality progressively increasing from SES group I to group VI (II v I: HR, 1.11, $P = 0.134$; III v I: HR, 1.14, $P = 0.055$; IV v I: HR, 1.16, $P = 0.026$; V v I: HR, 1.23, $P = 0.003$; VI v I: HR, 1.17, $P = 0.018$ [overall $P = 0.059$]).

DISCUSSION

Our study shows that seriously ill patients from socioeconomically disadvantaged areas have significantly higher long-term mortality than patients from the most socioeconomically advantaged areas, over and above the background effects of age, comorbidities, severity of acute illness, Indigenous status, and geographical accessibility to essential services.

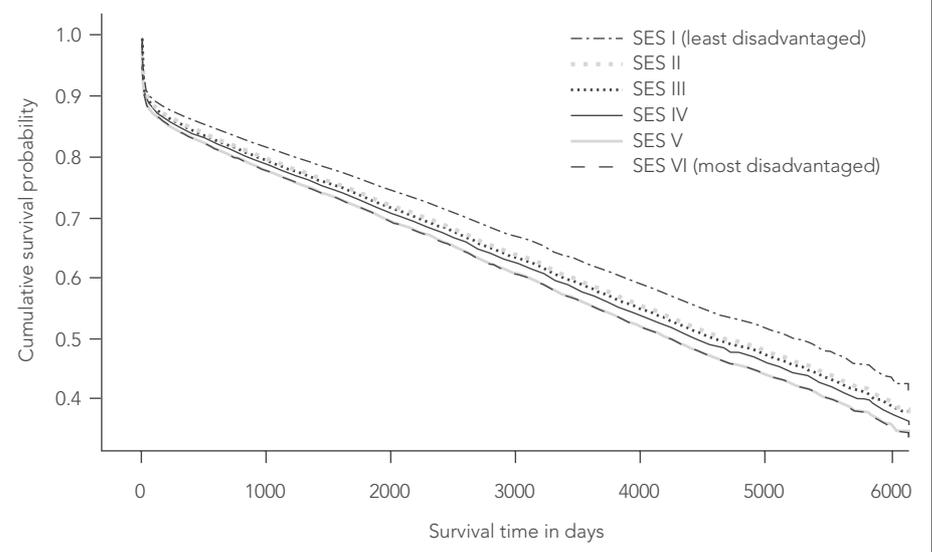
As far as we are aware, ours is the first study to investigate the effect of SES on long-term outcomes for a heterogeneous group of seriously ill patients. The final Cox model confirmed some of the known risk factors for long-term patient mortality, such as comorbidities and Indigenous status,^{20,21} but also showed that lower SES was independently associated with poorer health outcomes. There are at least two possible explanations. First, although we adjusted for geographical accessibility of essential services, financial and cultural barriers to some services (especially specialist medical services) may have a significant effect on

rehabilitation and long-term survival after critical illness.^{22–24} The role of specialist medical services in reducing the long-term mortality of seriously ill patients may be particularly important for patients who are recovering from a life-threatening illness, especially if they also have significant comorbidities. Second, lower SES is associated with some risk factors for poor health outcomes that we did not adjust for in our study. These include smoking, alcohol mis-

use, poor nutrition, overcrowded accommodation and inadequate physical activity. More intensive targeting of such preventable or reversible risk factors in lower-SES patients could potentially improve long-term outcomes for these patients.

Intensive care services are expensive, and it would be a waste of resources if the aim of treatment were only to discharge patients alive from the hospital without optimising their long-term outcome. The death rate in

5 Difference in long-term survival of patients of different socioeconomic status (SES) after adjusting for age, APACHE II-predicted mortality, Charlson Comorbidity Index, Accessibility/Remoteness Index of Australia and Indigenous status



our cohort (7.4 per 100 person-years) was much higher than the crude death rate in WA (0.58 and 0.57 per 100 person-years in 1991 and 2001, respectively) and more comparable to the death rate of WA men aged between 75 and 84 years (7.6 and 5.7 per 100 person-years in 1991 and 2001, respectively).²⁵

The fact that crude and fully adjusted in-hospital mortality rates were similar in patients with the highest and lowest SES is reassuring and suggests equity of access to acute care services in the public health care system in Australia. SES was significantly associated with in-hospital mortality after adjusting for age alone (most likely due to the younger age profile of patients with lower SES), but the association was no longer significant after adjusting for other predictors. This result is consistent with a recent cohort study evaluating mortality after acute myocardial infarction, which showed the crude difference in 30-day mortality rates between patients with different household incomes disappeared after adjustment for comorbidities and cardiac risk factors.⁵ Thus our findings confirm that the relationship between SES and in-hospital mortality can be largely explained by differences in the usual biological risk factors for in-hospital mortality.

Strengths of our study were the long time period (16 years) and the large cohort of seriously ill patients included. There were also a number of limitations. Firstly, it was a single-centre observational study and the results may not be generalisable to Australia as a whole or to other countries. Secondly, the use of IRSD at the aggregated level of postcode to estimate SES at the individual level may have meant that the SES classification of some patients was inaccurate. Thus, the effects of SES on health outcomes may potentially have been under- or overestimated.²⁶ Finally, we assigned the Charlson Comorbidity Index as zero in patients with no prior hospitalisation before the index ICU admission. Some of these patients may have had significant comorbidities at the time of ICU admission that were not recorded in the hospital morbidity database.

In conclusion, lower SES was associated with higher long-term mortality after critical illness over and above the background effects of acuity of acute illness, comorbidities, Indigenous status and geographical access to essential services. It remains to be seen whether targeting seriously ill patients from socioeconomically disadvantaged areas

for more intensive health care follow-up will improve their long-term survival.

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COMPETING INTERESTS

None identified.

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