# Deprivation as an Outcome Determinant in Emergency Medical Admissions

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Five Key Words: Deprivation, Mortality, Patient Admission, Emergencies, Social Class

Word Count: Main Body 1,659; Abstract 249

# ABSTRACT

**Background:** Deprivation in the general population predicts mortality. We have investigated its relevance to an acute medical admission, using a database of all emergency admissions to St James' Hospital, Dublin, over a ten year period (2002-2011).

**Methods:** All emergency admissions, based on geocoding of residence, were allocated to a Small Area Health Research Unit (SAHRU) division, with a corresponding deprivation index. We then examined this index as a univariate (unadjusted) and independent (adjusted) predictor of 30-day in-hospital mortality.

**Results:** The 30-day in-hospital mortality, over the 10 year period was higher, for those in the upper half of the deprivation distribution (9.6% vs 8.6%: p = 0.002). Indeed, there was a stepwise increase in 30-day mortality over the quintiles of deprivation from 7.3% (Quintile 1) to 8.8%, 10.0%, 10.0% and 9.3% respectively. Univariate logistic regression of the deprivation indices (quintiles) against outcome showed an increased risk (p = 0.002) of a 30-day death with OR's respectively (compared with lowest deprivation quintile) of 1.23 (95% CI 1.07, 1.40), 1.41 (95% CI 1.24, 1.60), 1.41 (95% CI 1.24, 1.61) and 1.30 (95% CI 1.14, 1.48). The deprivation index was an independent predictor of outcome in a model when adjusted for illness severity and co-morbidity. The fully adjusted OR for a 30-day death was increased by 31% (p=0.001) for patients in the upper half of the deprivation index distribution (OR 1.31: 95% CI 1.20, 1.44).

**Conclusion:** Deprivation independently of co-morbidity or acute illness severity is a powerful outcome predictor in acute medical admissions.

# INTRODUCTION

Socioeconomic deprivation has been shown to increase hospital utilization and hence health care costs.[1] The majority of patients admitted as medical emergencies to hospitals are sickest on first presentation. The current hostile economic climate coupled with an expanding and aging population has placed increasing demands on decreasing resources. In this setting it is vital to allocate these resources to where they are most needed both at a national and a hospital level. There is increasing interest in indicators and models that assist in this process and therefore have potential to improve patient care.

Deprivation has been shown to predict mortality in the general population.[2,3] This relationship has been confirmed for a number of individual diseases including myocardial infarction, heart failure and colorectal cancer.[4-6] Socioeconomic deprivation is associated with death from suicide and accidental injury.[7,8] Mortality from alcohol-related diseases also shows a strong association with deprivation.[9] Standardized mortality ratios have been shown to increase in parallel with the increasing deprivation over time of specific occupational groups.[10]

To our knowledge deprivation has not previously been shown to be an outcome determinant in emergency medical admissions. The aim of this study was to investigate the association of deprivation and mortality in emergency medical admissions.

# METHODS

## Background

St James's Hospital (SJH), in addition to national and regional roles, serves as a secondary care centre for emergency admissions for its local Dublin catchment area of 270,000 adults, operating a continuous sectorized acute general 'take' with patients directed towards surgical or medical specialties. All unselected emergency medical admissions are referred to one of nine teams operating a 1:9 24 hr 'on-call' roster; this paper deals with any such patient admitted under any 'on-call' consultant participating in this General Medical roster between 2002 and 2011 inclusive. As part of the establishment of an Acute Admission Units in 2003,

an anonymous patient database of all such emergencies was established. The patient electronic data (EPR – electronic patient record) is separate from the patient chart (clinical paper record); the latter may contain sensitive and confidential patient information and is not accessed. With instutional approval, the hospital informatics deparment provides data and periodic updates that includes the unique identifier (MRN – Hospital Medical Record Number), admitting consultant, date of birth, gender, principal diagnosis, up to nine additional secondary diagnoses, major disease category, procedures (principal and up to nine additional secondary procedures) and admission and discharge dates. Additional information may be available from a 'data warehouse' based on the MRN and episode admission/discharge date. Thereby data from an episode such as haematology, biochemistry or emergency attendance triage category and inital haemodynamic and physiological observations can be retrieved. Access to the database is highly restricted and limited to the principal investigator, the unit statistician or a princial author. The authors can only access the hospital systems indirectly to better protect the confidentiality and integrity of the hospital systems. Data was related to all emergency general medical patients admitted to SJH between 1 January 2002 and 31 December 2011. Where patients were admitted more than once, only the last admission was considered – the analysis was on unique patients and not on episodes.

To classify deprivation, we used the public domain Irish National Deprivation Index for Health and Health Services Reseach, derived by the Small Area Health Research Unit (SAHRU) at Trinity College Dublin.[12] Using the census data from the Central Statistic Office (CSO) (1991, updated in 2002 and 2006), a functional index of deprivation was computed by the TCD group. The Republic of Ireland is divided into 3440 Electoral Divisions (ED); these are the smallest administrative areas for which population statistics are gathered by the Central Statistics Office (CSO). Some ED's are sparsely populated and for reasons of confidentiality their data is merged with neighbouring ED's; therefore the Small Area Populations Statistics (SAPS) was available on 3409 ED's. SAPS contain classifications of census variables; data pertaining to individuals are not available. Using principle components analysis (PCA), a weighted combination (originally five including overcrowding) of four indicators, relating to unemployment, social class, type of housing tenure and car ownership was derived. In this analysis, the PCA is weighted by the population size of the ED – a typical approach for geographically weighted data. Larger populations with this method tend to disproportionately influence the model, so the authors employed an adjusted method ('shrinkage') so that each of the constituent indicators for ED's

within small populations were 'shrunk' towards the respective local area average. With this method, the first principal component retained over 71% of the information content in the constitutent variables. A raw score (SAHRU Index) was derived from the 1st PCA; the Index Scores were ranked from low (least deprived) to high (most deprived) and divided into deciles according to their ranked raw scores. Using an address, data at an individual level was geocoded and matched with the SAHRU Deprivation raw score and decile. This attribute data were joined to the small area polygon geometries based upon their relative geographic positions, using the ArcGIS 10.(c) Geographic Information System software implementation of the well-known Point-in-Polygon algorithm as outlined by Shimrat (Figure 1).[13]

We have shown that derangement of haemodynamic and physiological admission parameters may be utilised to predict clinical outcome, using biochemical or haematology data to compute an age adjusted aggregrate score.[14] This, termed an Acute Illness Severity Score (AISS), used laboratory tests routinely recorded on all medical admissions whilst in the Emergency Department: these were the serum sodium (Na), serum potassium (K), serum urea, haematocrit and white blood cell count (WCC) and the troponin T level. For such aggregate score methods, such as that based on 'lab' data, one may examine several candidate predictor variables that may influence outcome. Assumptions may be made of a linear relationship for continuous predictors, the they may be categorized with postulated step functions. However, we employed an alternative approach as proposed by Royston (ref) and Sauerbrei[15] to derive an accurate age adjusted aggregate score system.[16] The AUROC to predict a death at 30-day in this analysis was 0.88 (95% CI 0.87, 0.88). A structured approach, based on fractional polynomials, can give a satisfactory solution to the problem of simultaneously identifying 'important' predictors and determining the functional relationship for continuous predictors.

**Statistical methods**

Descriptive statistics were calculated for background demographic data, including means/standard deviations (SD), medians/interquartile ranges (IQR), or percentages. Comparisons between categorical variables and mortality were made using chi-square tests. Logistic regression analysis identified potential mortality predictors and then tested those that proved to be significant univariate predictors ($p < 0.01$ by Wald test). We used the margins

command in Stata 12.1 to estimate and interpret adjusted predictions for deprivation quintiles, while controlling for other variables such as illness severity, using computations of average marginal effects. Odds ratios (OR) and 95% confidence intervals (CI) were calculated where appropriate. Statistical significance at P<0.05 was assumed throughout. Stata v.12.1 (Stata Corporation, College Station, Texas) statistical software was used for analysis.

# RESULTS

## Patient Characteristics

A total of 61,578 episodes were recorded among 31,057 patients admitted acutely via ED between 1 January 2002 and 31 December 2011. These episodes represented all emergency medical admissions, admitted under any of the nine 'on-call' medical teams, during these years, including patients admitted to the Intensive Care Unit (ICU) or High Dependency Unit (HDU). There were 15,037 male (48.4%) and 16,020 female (51.9%) patients; their median age (IQR) was 58.0 yr (37.4 – 75.6) with the upper 10% boundary at 84.2 yr. The median (IQR) length of stay (LOS) was 4.5 (1.8, 9.0) days. The major disease categories were respiratory (21.7%), cardiovascular (16.6%), neurological (18.5%), gastrointestinal (10.7%), hepatobilary (5.4%) and kidney (4.4%).

## Deprivation influences (Table I and Fig I)

We divided patients into the top or bottom half of deprivation index (Table I); patients in the top half of deprivation (deciles VI – X) were more likely to be male, be younger, have a higher co-morbidity (Charlson) index with disease weighted towards respiratory and against cardiovascular diease. The majority of patients (64.5%) admitted were in the highest quintile of deprivation index (deciles 9 / 10); 87.2% were in the top half.

The 30-day in-hospital mortality, over the 10 yr period was higher, for those in the upper half of the deprivation distribution (9.6% vs 8.6%: p = 0.002). Indeed, there was a stepwise increase in 30-day mortality over the quintiles of deprivation from 7.3% (Quintile 1) to 8.8%, 10.0%, 10.0% and 9.3% respectively. Univariate logistic regression of the deprivation indices (quintiles) against outcome showed an increased risk (p = 0.002) of a 30-day death with OR's

respectively (compared with lowest deprivation quintile) of 1.23 (95% CI 1.07, 1.40), 1.41 (95% CI 1.24, 1.60), 1.41 (95% CI 1.24, 1.61) and 1.30 (95% CI 1.14, 1.48).

Both illness severity and deprivation were independent predictors of 30-day outcome ($p<0.001$); moreover there was significant interaction between these predictors with outcome being increasingly negative as deprivation quintiles increased (Fig I).

**Full model to predict a death by day 30 (Table II)**

The deprivation index was also an independent predictor of outcome in the full model (Table III below), when adjusted for illness severity and co-morbidity. The model predicted 30-day hospital outcome with a high degree of reliability (AUROC 0.88 (95% CI 0.87, 0.98)). The unadjusted OR was an approximate 14% significant ($p=0.001$) increased risk of a death by day 30 (OR 1.14: 95% CI 1.05, 1.23) for those within the upper half of the deprivation distribution. This appeared to underestimate the true risk, as in the full multivariate model, this risk was amplified (OR 1.31: 95% CI 1.20, 1.44).

# DISCUSSION

Our study has shown deprivation to be an independent predictor of 30-day mortality in acute medical admissions. Patients in the upper half of the deprivation index distribution had a significant 31% increased risk of death by day 30. A trend towards increasing mortality risk with increasing deprivation quintile was also evident.

The association between mortality and socioeconomic deprivation is of considerable interest. Previous studies have shown that socioeconomic deprivation predicts all-cause mortality in the general population.[2,3,17] There is some evidence that this effect is most pronounced in those individuals with baseline good health.[18] Studies have shown an increased risk of mortality from cardiovascular disease in patients from deprived communities.[19,20] This association extends to 30-day mortality from acute myocardial infarction, with a higher mortality in more deprived areas.[4,21] The mortality from some but not all types of cancer is predicted by neighbourhood deprivation.[22] Deprivation has also been shown to predict medium and long-term mortality from bronchiectasis and AIDS.[23,24]

There are a number of potential explanations for the association between deprivation and mortality previously noted in the general population and confirmed for acute medical admissions in our study. A higher rate of health behaviour associated risk factors such as smoking, obesity and low physical activity has been noted in areas with higher deprivation scores.[25] Material disadvantage, childhood conditions and psychosocial factors have also been suggested as possible aetiological factors.[26] Areas with higher deprivation may have limited access to health care, a preponderance of unhealthy food and higher environmental pollution.[27,28] Studies which have attempted to control for these individual risk factors have suggested that neighbourhood socioeconomic deprivation may independently predict mortality in the general population.[17]

Our study has several strengths. We have a large and complete patient dataset with 61,578 admission episodes; this covered all 31,057 patients admitted medically to our institution over a 10 year period. This has enabled us to demonstrate a significant relationship which may not have been evident in smaller studies. Our study also included all patients admitted to the ICU and HDU - ensuring that we have captured the sickest patients in our dataset.

Like any study ours has limitations. We have assessed acute general medical admissions only, our institution has a number of other admitting services, all acute coronary syndromes are admitted under the cardiology service for example. This limits the generalisability of the results to services other than acute general medicine. We have shown that an association exists between mortality and deprivation in acute medical admissions, this does not neccesarily imply causation. We have attempted to account for this in our multivariate model, however we cannot exclude other unmeasured factors being responsible for this association. Similarly the demonstration of this association does not explain the process underlying it, an area which will require future study to unravel.

In conclusion we have demonstrated that deprivation independently of co-morbidity or acute illness severity is a powerful outcome predictor in acute medical admissions. Further exploration of the underlying pathways behind this association may have important public health and policy implications.

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**TABLE I: Patient details of Medical Emergencies, by Deprivation Class (2002 – 2011)**

| **Variable** | Decile I - V | Decile VI - X | P < |
|---|---|---|---|
| **Gender** | | | |
| Male | 7313 (46.9%) | 7724 (49.9%) | 0.001 |
| Female | 8276 (53.1%) | 7744 (50.1%) | |
| Total | 15589 (100%) | 15468 (100%) | |
| **Age (years)** | | | |
| Mean (SD) | 58.4 (21.8) | 54.6 (21.3) | 0.001 |
| **Length stay (days)** | | | |
| Mean (SD) | 6.6 (6.6) | 6.6 (6.6) | 0.08 |
| **Charlson Index** | | | |
| 0 | 9159 (58.8%) | 8747 (56.6%) | 0.001 |
| 1 | 3753 (24.1%) | 3934 (25.4%) | |
| 2 | 2677 (17.2%) | 2787 (18.0%) | |
| **MDC Class** | | | |
| Respiratory | 3189 (20.5%) | 3559 (23.0%) | 0.001 |
| Cardiac | 2643 (17.0%) | 2499 (16.2%) | 0.06 |
| Neurological | 2892 (18.6%) | 2842 (18.4%) | 0.69 |
| GastroIntestinal | 1698 (10.9%) | 1626 (10.5%) | 0.28 |

**Figure 1 Legend:**

Average marginal effect of increasing Illness Severity by Deprivation Quintiles on the predicted 30-day outcome. An increasing risk of poor outcomes with increasing deprivation is evident for the higher grades (top two quintiles) of illness severity.

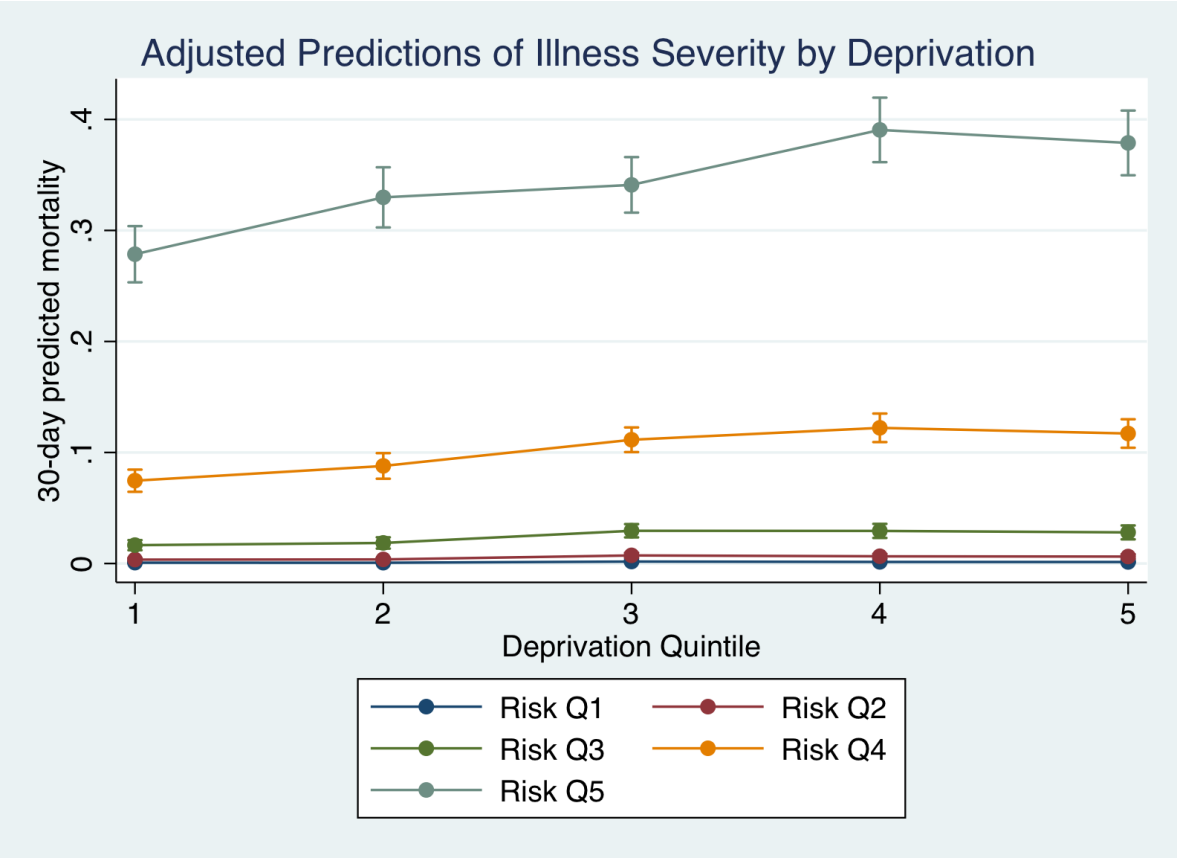

**Table II: Multi-variate logistic regression model for a 30-day in-hospital death**

| Variable | Variable | Odds Ratio | [95% CI] | P>\|z\| |
|---|---|---|---|---|
| Illness Severity Score | Grp 1 vs 2 | 4.03 | 2.1, 7.8 | 0.001 |
| | Grp 1 vs 3 | 11.1 | 6.0, 20.6 | 0.001 |
| | Grp 1 vs 4 | 40.1 | 21.2, 73.1 | 0.001 |
| | Grp 1 vs 5 | 211.1 | 116.8, 385 | 0.001 |
| Charlson Index | Grp 0 vs 1 | 1.22 | 1.08, 1.37 | 0.001 |
| | Grp 0 vs 2 | 1.79 | 1.60, 2.00 | 0.001 |
| Deprivation Quintile | Q 1 vs 2 | 1.25 | 1.07, 1.45 | 0.004 |
| | Q 1 vs 3 | 1.42 | 1.23, 1.64 | 0.001 |
| | Q 1 vs 4 | 1.65 | 1.42, 1.91 | 0.001 |
| | Q 1 vs 5 | 1.58 | 1.36, 1.84 | 0.001 |

**Fig I: Small Areas with Deprivation colour code by Quintiles**