European Journal of Internal Medicine 24 (2013) 546–551

Contents lists available at ScienceDirect

European Journal of Internal Medicine

journal homepage: www.elsevier.com/locate/ejim

Original article

Increased winter mortality: The effect of season, temperature and deprivation in the acutely ill medical patient

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ARTICLE INFO

Article history:
Received 21 November 2012
Received in revised form 8 February 2013
Accepted 9 February 2013
Available online 6 March 2013

Keywords:
Winter
Mortality
Deprivation
Co-morbidity
Season

ABSTRACT

Background: Studies examining seasonal mortality have found excess winter mortality, particularly in the elderly. We examined the seasonal mortality variations for all emergency medical admissions to St James' Hospital, Dublin, over 10 years (2002–2011). We explored the effects of ambient temperature, deprivation markers, case-mix, co-morbidity and illness severity on seasonal mortality.

Methods: All emergency admissions to an acute hospital were categorised by season. We examined season as a predictor of 30-day hospital mortality.

Results: 30-day in-hospital mortality was lowest in autumn (7.5%) and highest in winter (9.6%). Winter admission had 17% ($p = 0.009$) increased unadjusted risk of a death by day 30 (OR 1.17: 95% CI 1.07, 1.28). A clinical classification system identified that chronic obstructive disease, pneumonia, epilepsy/seizures and congestive heart failure had more presentations in the winter. Multivariate analysis found that winter was not an independent predictor (OR 1.08: 95% CI 0.97, 1.19). Predictors including illness severity and the Charlson Index accounted for the increased risk of winter admission. The minimum daily temperature independently predicted outcome; there was a 20% increased in-hospital death rate when it was colder (OR 1.20: 95% CI 1.09, 1.33; $p < 0.001$). Deprivation was a univariate and multivariate (OR 1.22 95%CI 1.07, 1.39; $p = 0.002$) predictor of mortality, but did not show marked seasonal variation.

Conclusion: Patients admitted in the winter have an approximate 17% increased risk of an in-hospital death by 30 days; this is related to cold along with increased illness severity and co-morbidity burden. The disease profile is different with winter admissions.

1. Introduction

Excess winter mortality (EWM) remains an important public health issue particularly across southern and Western Europe [1–4]. Despite this, the etiology of EWM remains a topic of debate in the literature. [4–13]. As a substantial increase in winter mortality has been found in patients aged ≥75 years (up to 30%) [4,6] excess winter mortality is likely to become an increasing concern with an ageing population.

In the search for a cause of EWM seasonal fluctuations in mortality have been linked to changes in ambient temperature [14–16]. But, EWM has been shown to occur to a lesser extent in some colder countries, suggesting that those living in warmer countries take fewer precautions against cold [4]. Other links have included social deprivation, [4,6,8], influenza [5,9] and air pollutants [10].

Physiological changes in winter have been examined [11–13]. The Euro winter group noted that cold causes changes in haemoconcentration, thrombosis and immune resistance [17]. Whilst Woodhouse et al. found that colder home temperature was associated with increased blood pressure in older people [11]. These changes may provide the link particularly with cardiac death, a common cause of winter death [18,19].

The effect of season on mortality is multifaceted. Ambient temperature has been linked with cardio respiratory morbidity [20] whilst certain illnesses are more common in Winter months including respiratory disease [10,21], influenza [22], viral illnesses [9], cardiac disease [23], stroke [24] and gastrointestinal disease [25,26]. There is an increase in mortality causes by myocardial illness [19,27], stroke [28] and respiratory illness [29]. In addition, EWM has been reported in association with substance abuse [30], the post-operative period [31] and MRSA infection [32].

Winter peaks in occupancy of acute hospital beds in winter months (including intensive care and critical care bed utilisation) are recognised with associated challenges. It has been suggested that changes in illness severity in winter months contribute to the problem [33,34]. Allder et al. [34] found little seasonality in demand for bed occupancy, but proposed that a change in the operational flow of acute hospital beds during the crucial Christmas period accounted for much of the Winter demand.

The aim of this study was to examine seasonal (especially winter) variations of in-hospital mortality in patients admitted to an acute

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http://dx.doi.org/10.1016/j.ejim.2013.02.004

hospital using a ten year database (2002–2011) of 62,184 episodes in 31,057 patients. In particular, we sought to determine the extent to which variations in risk predictors such as ambient temperature, deprivation markers, case-mix, co-morbidity and illness severity could be held responsible for any observed differences in mortality.

2. Methods

2.1. Patients and definitions

A dedicated anonymysed patient database was uploaded by cross-linking the computerized patient administration system (PAS) to the hospital in-patient enquiry (HIPE) scheme using a unique patient identifier. HIPE is a national database of coded discharge summaries from acute public hospitals in Ireland, run by the Economic and Social Research Institute [35]. Ireland used the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) for both diagnosis and procedure coding from 1990 to 2005 and has used ICD-10-CM since then.

We used the Clinical Classifications System (CCS) for ICD-9-CM – a diagnosis and procedure categorization scheme – to collapse the ICD-9-CM's multitude of codes (>14,000 diagnosis codes) into a smaller number (approx 240) of clinically meaningful categories that are more useful for presenting descriptive statistics than are individual ICD-9-CM codes. The CCS for ICD-9 was collapsed and restricted for the principal codes [36] which have been shown to have an almost homogenous relationship with clinical pathways and risk of mortality (ROM).

Every admission in the hospital is recorded within the HIPE dataset as an admission 'episode'. Linking the HIPE dataset with the PAS dataset permits interrogation of routinely collected data for the purposes of research, planning and quality control. Data held on the database includes the unique identifier, admitting consultant, date of birth, gender, area of residence by county, principal diagnosis, up to nine additional secondary diagnoses, procedures (principal and up to nine additional secondary procedures) and admission and discharge dates (including length of stay, LOS). Additional information cross-linked and automatically uploaded to the database includes physiological, haematological and biochemical datasets along with emergency attendance triage category and basic haemodynamic and physiological observations. All emergency medical admission episodes under any of the nine 'on-call' medical teams, including patients admitted to the Intensive Care (ICU) or High Dependency Units (HDU) between 1 January 2002 and 31 December 2011 were included for analysis. Surgical admissions and medical admissions requiring coronary care intervention were not admitted under the nine medical 'on call' teams and so were not included.

The HIPE dataset of all coded diseases at the time of discharge/death, together with procedures and investigations undertaken during the hospital stay, was examined. Data was related to all emergency general medical patients admitted to SJH between 1 January 2002 and 31 December 2011.

2.2. Seasonal divisions

Winter was taken as November, December, January and each successive 3 month interval class as spring, summer and autumn respectively. Daily temperatures were calculated from the Automatic Weather Station, located at Dún Laoghaire Harbor. Recordings are at least every 10 min; these data were first averaged for each hour and then a single daily minimum value calculated for each day of the 10 yr period.

2.3. Deprivation index

We used the Irish National Deprivation Index for Health and Health Services Research derived by the Small Area Health Research Unit (SAHRU) at Trinity College Dublin [37]. Using the census data from the Central Statistic Office (CSO) (2002 and 2006) and the nearly three and a half thousand electoral divisions in Ireland, the Trinity College group derived (principle components analysis) a functional index of deprivation, using a weighted combination of four indicators (unemployment, social class, type of housing tenure and car ownership). This deprivation score for each small area, we then ranked by quintile and docile — to allow its relationship with outcome to be evaluated.

2.4. Outcome definitions

We have previously demonstrated that derangement of hemodynamic and physiological admission parameters may be utilised to predict clinical outcomes [38]. We have applied an Acute Illness Severity Score (AISS) to predict in-hospital mortality from seven laboratory tests that are routinely recorded in the Emergency Department [39]. The AISS groups patients into 5 groups divided by a log of 30-day in-hospital mortality ($\leq$1%, $>$1$\leq$2%, $>$2, $\leq$4%, $>$4, $\leq$8%, $>$8%) and is calculated using serum sodium (Na), serum potassium (K), serum urea, haematocrit and white blood cell count (WCC); together with albumin and cardiac troponin. Thereby, an age adjusted aggregate score system predicts clinical outcome over a 5, 7 or 30 day timespan to be reliably computed, using the method proposed by Sauerbrei [40] and the goodness-of-fit test [41]. To examine seasonal variations in mortality, addition putative predictive variables (approximately forty: $p<0.10$ from the univariate analysis) were entered into a multivariate logistic regression analysis to examine their utility in predicting 30-day in hospital mortality. In addition we examined the effect of the Charlson co-morbidity index on seasonal mortality. The Charlson Index is a validated indicator of morbidity derived from a large extended 10 yr database and uses a weighted score based on a total of 22 conditions [42] to categorise patients into three risk groups.

2.5. 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. Bivariate logistic regression was used to identify statistically significant variables including season and temperature associated with 30-day mortality. Statistically significant variables ($p<0.01$ by Wald test) were then added sequentially into a multivariable logistic regression model together with season to identify predictors of 30-day mortality. The AUROC (area under the receiver operating curve) was calculated to test the probability of the multivariable model used to assess season and temperature as a predictor of 30-day mortality. Odds ratios (OR) and 95% confidence intervals (CI) were calculated where appropriate. Analysis of season was carried out for Winter vs. other seasons to examine the effect of Winter on mortality. Statistical significance at $P<0.05$ was assumed throughout. Stata v.12.2 (Stata Corporation, College Station, Texas) statistical software was used for all analyses, with significance accepted with $p<0.05$.

3. Results

3.1. Patient characteristics

A total of 62,184 episodes were recorded among 31,057 patients admitted acutely via ED between 1 January 2002 and 31 December 2011. There were 15,037 male (48.4%) and 16,020 female (51.9%) patients; their median age (IQR) was 58.0 years (37.4–75.6) with the upper 10% boundary at 84.2 years. The median (IQR) length of stay (LOS) was 4.5 (1.8, 9.0) days. The major disease categories were