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Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

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Supplementary Material

Contents

Supplementary Methods

Data cleaning and preparation

Amy Mason, Phuong Quan, Sarah Walker and Tim Peto had access to the original Infections in Oxfordshire Research Database (IORD) extract used to create the study analysis dataset which was created as follows. The following data cleaning and data preparation steps were undertaken on an extract of 3,446,864 spells (no date or other restrictions, through 8 April 2015). Each spell included one or more consecutive consultant episodes from initial admission to discharge from the Oxford University Hospitals NHS Foundation Trust. We included transfers in from other NHS Trusts providing these transfers met other inclusion criteria below (in particular, were emergencies based on their admission method code) and adjusted for admission source in all analyses. We did not have information available on the previous admission to the Trust from which they were transferred. First we dropped episodes which were complete duplicates based on variables included in the analysis (n=142) or had missing spellid (n=25); then dropped episodes from spells with admission date before 1 January 2006 or after 31 December 2014 (n=1,449,750 (using the start date of the first episode in the spell as the admission date for 22 spells with missing admission date)); then dropped spells where the first episode in a spell was non-emergency (prefix of the admission method code not equal to 2) (n=1,378,037), regardless of intended or actual length-of-stay (i.e. including day cases); then dropped episodes from external mother and baby units (site codes RTH16 and RTH19 (n=71)); then dropped episodes with missing anonymised patient identifiers (3 records), and finally dropped episodes within a spell that had non-unique episode numbers with admission time of midnight when the other episode with the same episode number had a different time of day (n=6); leaving 618,830 episodes from 505,675 spells. We chose 1 January 2006 as the study start date because this was when secondary diagnosis codes were recorded electronically, increasing the numbers recorded and hence reducing coding depth bias.[1] We chose 31 December 2014 as the study end date to allow for at least 60 days to report a death within 30-days of the last included admission before the data download on 8 April 2015. Following these exclusions/inclusions, the first episode per spell was retained (with associated spell admission and discharge dates). 12 missing discharge dates that were also missing the end date of the final episode were replaced with the start date of the final episode; records showing multiple simultaneous admissions for the same patient were merged to form a single admission with multiple episodes (1112 (0·2%) spells). This left a total of 504,563 spells from 257,885 patients for analysis. 625 (0·1%) admissions with missing age (n=69), negative age (1), missing sex (or intersex) (7), or missing diagnostic codes (548) were excluded from all analyses.

Exposures included all the admission factors adjusted for in the previous NHS studies,[2,3] specifically: age, sex, ethnic group, admission speciality type (medical vs surgical vs other), admission method type, admission source, consultant of first consultant episode, prior admissions (total and in previous year), prior complex admissions (defined as admissions with two or more consultant episodes, both total and in previous year), the Clinical Classifications Software (CCS) group of the primary diagnosis code of the first episode of each admission,[4] Charlson co-morbidity score (defined from all secondary diagnosis codes of the first episode[5]), Index of Multiple Deprivation (IMD) score and admission day of the week, day of the year (1-365) and calendar year. Supplementary Figure 1 shows a conceptual hierarchy of exposures included in multivariable (adjusted) models.

Previous studies also adjusted for the intrinsic risk of admission diagnoses/procedures based on their observed mortality across all English hospitals. As we only had data from the Oxford University Hospitals NHS Foundation Trust, as an alternative intrinsic risk measure, we extracted 30-day mortality by primary diagnosis codes in the linked HES-ONS data statistics for financial years 2006-2009,[6] ranked primary diagnosis codes into five equal sized groups and classified study admissions according to this risk quintile.

For these exposures, missing admission speciality type and admission source was set to “Other” (319 and 22 records respectively). In admissions between 1 October 2014 and 31 December 2014, a local software update changed the drop down menus so that the default admission source was “NHS other – general ward” instead “Usual Place of Residence”, causing the number of “NHS-other general ward” to increase from 2% of the admissions to 56% of the admissions, and “Usual Place of Residence” to decrease from 97% of admissions to 43% of admissions during this quarter. Admission source names of “NHS other – general ward” were therefore replaced with “Usual Place of Residence” for this specific period, affecting 9412 records (1·9%). Ethnicities were regrouped due to changes in definitions between 2006 and 2014: ("Not Asked”, “Not Given", "Not Stated", "") classified with “Unknown”; ("White", "White British", "White Irish", "Any other White background") were classified with “White”, ("African", "Black - African", "Black - Other", "Any other Black background", "Caribbean", "Black - Caribbean") were classified with “Black”; (“Indian”, “Pakistani”, “Bangladeshi”, “Chinese”) were classified with “Asian”, and all other named ethnic groups (including mixed background) as “Other”.

For the mortality outcome, we first generated date of death from known in-hospital deaths, as the discharge date with discharge method 4 or 5 (all had discharge destination 79); or discharge destination 79 alone (4 additional records, 3 with death date confirmed from national registry and one not matched). Where patients were discharged alive, we used death dates from the national registry (via the regularly updated local database), excluding 101 deaths recorded as occurring before admission (all >8 days previously, 92 >90 days previously). For patients not known to have died, we took the date last known to be alive as the maximum of the date the last mortality check was conducted and of any subsequent hospital admissions. We then censored both deaths and follow-up back to 30-days for the primary endpoint, chosen for consistency with previous studies. 5,409 (1%) of admissions could not be matched to the national registry (and were censored at their last hospital contact). All but 884 (0·2%) of the remaining admissions had a vital status check performed after 1 January 2016. Of 479,563 spells where the patient was not known to have died in the last 30-days, 4922 (1%) were censored before 30-days. Patients dying on the day of admission were counted as deaths at 0·5 days.

Mortality was highest during the first 7 days and length-of-stay was short (median 2 calendar days), complicating the interpretation of a time-updated factor reflecting current day of the week at risk (almost all of which were spent outside of hospital). To avoid possible age-period-cohort effects, Poisson regression of 7-day mortality (overall and cause-specific death before discharge) was therefore used to assess whether day of admission was a stronger predictor of mortality than current day of the week (adjusting for days since admission, and using days at risk as the denominator). We estimated the excess hazard associated with admission-day over time from admission using flexible parametric models,[7] using BIC to determine the degrees for freedom for the underlying hazard and a time-varying effect of weekend vs weekday admission, unadjusted and adjusted for all other factors in models 'A' and 'B'. All other regressions used Cox models. Primary analyses included all emergency admissions. Primary analyses did not use a robust variance adjustment by patient since this only changes standard errors (not point estimates) and was considered unlikely to have a large impact due to the size of the dataset and the relatively low percentage of readmissions, taking into account the substantial increase in running time of each model incorporating this variance adjustment, making variable selection and interaction checking infeasible. Sensitivity analyses included patient-level robust variance adjustment for final models.

To improve model stability, categories with <3000 admissions were combined into "other" for CCS group, admission speciality, admission method and admission source; prior to this, CCS categories with <0·5% observed mortality were combined into "low risk" (see Supplementary Table 1 for details). Following Freemantle et al.,[8] sensitivity analyses grouped these CCS categories with <3000 admissions into 15 subgroups based on clinical advice (ML). Number of prior admissions (overall and in the last year) and Charlson scores were truncated at their 95th percentiles (24, 7 and 15 respectively) to improve model stability, and number of prior complex admissions at its 99th percentile (6). As only 11% of patients had had a prior complex admission in the preceding year, this variable was dichotomised as any vs no prior complex admission in the last year. We incorporated the possibility of non-linear effects in continuous factors (age and number of prior admissions) using natural cubic splines[9] (Stata mkspline, cubic); these provide similar overall performance to fractional polynomials[10] but can better recover more complex functions which we hypothesised could be important for the effect of laboratory test results (and their interactions). Natural cubic splines were included where this improved the BIC of the univariable (unadjusted) model, placing knots following recommendations in[11] and choosing the number of knots (up to 6) using BIC. Five knots were chosen for age, but there was no improvement in model fit for other continuous factors in models including administrative factors which were therefore included as linear. Multivariable models used the same number of knots, but all estimated effects were visualised to confirm these were not over-fitting and the spline terms tested to confirm non-linearity remained significant (Supplementary Table 2). Day of the year was modelled using a sin() + cos() function (2df) to ensure a smooth transition in risk from year to year. 36360 (7·2%) of admissions had missing IMD score (due to missing postcode in the underlying data source) and were excluded from analyses considering this factor.

Number of prior admissions overall and in the last year (spearman rho=0·66) and number of complex prior admissions overall and in the last year (spearman rho=0·63) demonstrated evidence of co-linearity (effects with opposite signs including both factors in one model, one in the opposite direction to univariable (unadjusted) models). One factor from each pair was chosen based on minimising the BIC.

Variation in illness severity at presentation

To investigate the potential for residual confounding by severity of the presenting illness, we considered additional independent effects of 15 haematology/biochemistry blood test results: haemoglobin, platelets, lymphocytes, neutrophils, eosinophils, monocytes, C-reactive protein (CRP), urea, bilirubin, creatinine,

albumin, alanine aminotransferase (ALT), alkaline phosphatase (ALP), sodium and potassium. White cell count and the ratio between neutrophils and lymphocytes were highly correlated with neutrophils (spearman rho 0·92 and 0·74 respectively) and thus were not considered in models. The choice of included tests was primarily based on completeness (see below). Several of these tests reflect the presence of underlying infection (particularly CRP, neutrophils, lymphocytes, eosinophils). Others reflect liver and renal function, that is, are markers of physiological dysfunction. Albumin is a marker of chronic under-nutrition, and sodium and phosphate reflect fluid balance. We considered creatinine rather than estimates of glomerular function or creatinine clearance based on creatinine levels because weight was not available; we were therefore not able to use the Cockcroft Gault formula (which includes an explicit term for weight) nor were we able to adjust the Modification of Diet in Renal Disease formula for body surface area (based on weight and height) as is recommended to avoid underestimating glomerular filtration for heavy individuals and overestimating it for underweight individuals. Our primary goal was to estimate the impact of adjusting for these test results on the weekend effect, rather than to directly estimate the impact of these test results on mortality.

We used the closest values (comparing collection time of blood sample to the time of admission) within [-2,+2] calendar days of admission; the 15 tests were primarily chosen based on completeness which varied from 66·6% for CRP to 69·2-72·4% for albumin/ALP/ALT/bilirubin, 75·6% for urea and 81·4-82·9% for all other tests. 571,465 (53·9%) of admissions had all 15 results (varying across admission days from a minimum of 53·0% (41,579/78,394) on Friday to a maximum of 54·5% (40,867/74,975) on Thursdays). 74·8% (18,244/24,383) of those dying within 30-days of admission had complete test results vs 52·8% (253,221/479,555) of those not dying within 30-days (see Supplementary Table 1 for covariate distribution in full dataset vs complete cases). 92·2% (250,274) of the 271,465 admissions with all 15 test results available had all their tests within [-24,24] hours from the recorded time of admission, the majority (56·4%, 153167) having all tests within [-3,+3] hours (Supplementary Figure 12). 1·5% (4001) had at least one test more than 24 hours before admission (1·4% on weekdays, 1·6% on weekends). 6·4% (17499) had at least one test more than 24 hours after admission (6·4% on weekdays, 6·7% on weekends). If anything, blood tests were taken very slightly earlier with respect to admission time at weekends (Supplementary Figure 12). Results such as "<5" or ">5" were set to the numeric value only e.g. "5" (81556 (24·3%) of values for C-reactive protein (almost all ">160" where 160 was the upper limit used in truncation), 3942 (1·1%) of alanine aminotransferase, all others <1%). We truncated values at the 1st and 95th percentiles to avoid undue influence from outliers. All models allowed the effects of test results to be non-linear (eg J-shaped or U-shaped) using natural cubic splines as for age above and choosing the number of knots based on univariable (unadjusted) models (3 knots for urea, eosinophils; 4 knots for neutrophils, haemoglobin, lymphocytes, platelets, CRP, albumin, ALT, bilirubin, potassium, sodium, monocytes; 5 knots for alkaline phosphatase, creatinine).

271,465 (53·9%) of admissions had all test results. All laboratory tests performed in the hospitals were processed by the single pathology laboratory, so (other than for a small number of failed assays) missing laboratory data reflects the fact that a test was not requested by the managing clinician. Two approaches to analysis with missing data are to restrict to complete cases without missing data, or to impute the missing data. Imputation is well-recognised to have major pitfalls, as well as potential.[12] In particular, great care has to be paid to non-linearity and normality of continuous predictors being imputed, and also to including appropriate interactions in every imputation model, otherwise erroneous results can be obtained. Supplementary Figures 6(a)-6(f) and 7(a)-7(m) present the non-linear associations between continuous test results and 30-day mortality, and interactions between different pairs of factors in model 'B' (including test results), respectively. These non-linearities and interactions are just for one outcome (mortality), and appropriate imputation would require similar levels of complexity for each of the 15 test results being imputed. Imputation has greatest potential in the context of limited power and data which are missing at random (i.e. missing values depend only on other measured covariates considered for inclusion in multivariable (adjusted) models and the outcome, following the standard terminology of Rubin). In this situation, complete case analysis will provide unbiased inference, but with larger standard errors due to smaller numbers included. Given the size of our dataset, and our focus on the impact of adjustment on estimates of the 'weekend effect' rather than 'statistical significance' per se, our judgement was that there was more danger in mis-specifying complex imputation models, rather than restricting to complete cases, which comprised 53·9% of the dataset. Our concern was particularly about correct specification of potentially large numbers of interactions (since, for example, the final model for mortality including 15 test results also included 19 interaction terms), also making imputation extremely computationally intensive (as multiple different interaction models cannot be fitted with existing software).

Supplementary Table 1 shows the distribution of covariates in the full (model 'A'; N=503,938) dataset and complete cases for test results (model 'B'; N=271,465): given the very large numbers, many of these comparisons reach traditional levels of significance (e.g. p<0·05), but the differences in distributions are not

large, even for those factors which would be anticipated to most strongly affect test result missingness (e.g. medical vs surgical vs other admission speciality, quintile risk). Across the primary exposure (admission day-of-the-week), the percentage with complete data only varied between 53·0% (Friday) and 54·5% (Thursday). Therefore, complete cases were broadly representative of the full dataset.

Both imputation and complete case analysis may produce biased estimates if data are not missing at random (i.e. the unobserved value is more likely to take particular values by virtue of it being unobserved even after adjusting for other covariates). This is particularly problematic when there is missing data in the outcome, which is not the case for this analysis. Of the 24,383 admissions followed by death in the next 30-days (included in model 'A'), test results were complete in 18,244 (74·8%), compared to 253,221 (52·8%) of the 479,555 admissions not known to have died within 30-days. Given the strong prognostic importance of the test results for 30-day mortality, it is plausible that missing test result values were predominantly less abnormal. Supporting this, Supplementary Table 1 demonstrates that somewhat more, rather than less, patients admitted from GPs had complete test results. However, there was no evidence that those with all 15 test results available had higher mortality adjusting for all factors in model 'A' (adjusted relative risk vs those without all test results=1·01 (95% CI 0·98-1·04) p=0·40). Whilst we therefore cannot rule out some bias (similarly to residual confounding in standard modelling), if anything, we may have relatively modestly over-sampled more severe cases in the complete cases. Over-sampling more severe cases with more abnormal test results, and under-sampling less severe cases with normal test results is, if anything, likely to lead to dilution bias in our estimated effects – that is, the genuine effect of test results is plausibly larger than we estimate. Adjusting for this larger effect than we are able to estimate could potentially lead to an even greater attenuation in the 'weekend effect'.

Including only main effects of each test result, there was some evidence of co-linearity between urea and creatinine (spearman rho=0·67) and albumin and haemoglobin (spearman rho=0·48) (as evidenced by effects with opposite signs when both factors were included in one model, one in the opposite direction to that obtained from univariable (unadjusted) models). Including interactions between each pair of test results produced clinically plausible results (see Supplementary Figure 7) and therefore each pair of factors and their interaction were retained in final model 'B', regardless of impact on BIC.

Other outcomes

In order to assess robustness of our findings to our choice of 30-day mortality as the primary outcome (following previous studies), we also fitted final models 'A' and 'B' to mortality to 7-, 14- and 21-days after emergency admission. In order to investigate a different adverse patient outcome which could be hypothesised to be similarly affected by differing service provision and/or staffing levels at weekends, we considered being admitted directly or transferred to an intensive care unit (ICU) as a secondary time-to-event outcome. We estimated model 'A' for both cause-specific hazards (conditional on remaining alive in hospital) and competing risks subdistribution hazards (to reflect overall probability of moving to an ICU).[13]

Sensitivity analyses

We also conducted sensitivity analyses adjusting for several different alternative exposures. These were considered sensitivity analyses as they were identified as potential exposures after original models 'A' and 'B' had been fitted. As alternative severity measures, we considered whether admission blood cultures were performed or blood gases tested (closest result to admission time within [-2,+2] calendar days of admission; done in 94,815 (18·8%) and 125,210 (24·8%) respectively). We also considered additional effects of time since last inpatient admission and duration of last inpatient admission.

Other sensitivity analyses explored the robustness of our findings to specific decisions about categorisation of variables. Our primary exposure was calendar day-of-the-week, following previous studies which used hospital episode statistics data which does not include admission time, only admission day. However, this does not reflect hospital shift patterns. If service provision/staffing were a major driver of excess mortality risks associated with weekend admission, categorisation reflecting actual shift patterns would be expected to strengthen associations. To account for hospital shift patterns, sensitivity analyses therefore defined 'day-of-the-week' starting at 7am or 8am rather than midnight.

Other sensitivity analyses explored the robustness of our findings to specific decisions about the included population. Our primary analyses included all emergency admissions, but this group covered a wide range of presenting complaints and treatment specialities, with potentially varying levels of service provision (Supplementary Table 1). We therefore also fitted model 'A' to only the largest speciality group (General Medicine, treatment speciality code 300) which has always had a single service providing cover 24 hours a day, 7 days a week in the Oxford hospitals. 6,448 (26·4%) of deaths occurred within 3 days of admission; these early

could theoretically be less affected by admission day if they can be considered unpreventable despite intervention, or more affected by admission day if they provide a key opportunity for intervention. We therefore repeated model 'A' from 3 days following admission (excluding deaths and time at risk before 3 days as[7]) to assess robustness of our findings to inclusion or exclusion of this early period at risk. Finally, a number of patients were re-admitted within 30-days of a previous admission. To assess whether including these re-admissions in our primary analysis had had an important effect on our results, we considered final models either excluding readmissions within 30-days of a previous admission or incorporating patient-level robust variance adjustment.

Hospital workload

If the 'weekend effect' were due to under-staffing or lack of services, increased mortality would also be expected when the hospital was busier or fuller than average for any specific given day of the week; that is, we would expect mortality to be greater on Mondays when the hospital was busier or fuller than average compared to other Mondays when busy-ness and/or fullness was either average or lower than average. Staffing levels in OUH are not adjusted on a day-by-day or even week-by-week basis depending on specific numbers of patients in the hospital and dependency levels (that is, rotas are fixed in advance), and the hospital runs at continuously high bed-occupancy (Supplementary Figure 10(i)). Changes may happen periodically, for example when wards are re-assigned speciality.

Staffing information was not available, so to test this hypothesis we considered several normalised measures of hospital workload (based on inpatient admission data) as proxies for under-staffing/lack of services, where the normalisation was performed to compare workload on a specific calendar day to what was typical or expected for that day-of-the-week in that calendar year.

First we estimated relative hospital occupancy, by calculating the difference between the number of patients admitted and discharged each day (overall and for emergency admissions separately), and compared the value to the typical value for that day-of-the-week and calendar year by normalising against all the values for that day-of-the-week and calendar year (using a trimmed mean at the 5^{th} and 95^{th} percentiles). Given that staffing levels and equipment are similar for any given day-of-the-week, increased net patients versus average for each day-of-the-week/calendar year should decrease patient: doctor, patient: nurse, patient: equipment ratios (and vice versa). If staffing or service provision were the driver of the weekend effect, we would therefore expect to see an association between this relative hospital workload factor and overall mortality (although it would not be expected to alter the estimated effect of admission day-of-the-week on mortality). We normalised by calendar year as well as day-of-the-week given the trends towards increasing hospital workload over time (Supplementary Figure 10) which could be confounded with calendar year effects without normalisation. We constructed a similar relative measure of the total and emergency admissions compared to normal for each day-of-the-week and calendar year. Third, we combined the official hospital statistics on the number of beds available each quarter together with the total duration of inpatient admissions from the admission database across the whole Trust (emergency, elective and other) to create a percentage bed-occupancy variable for each day, and normalised this by calendar year and day-of-the-week as above; and then did the same for emergency admissions and acute beds available.

Delays in appropriate management

An alternative explanation for the 'weekend effect' is that patients are more likely to initially be admitted under the incorrect consultant team at the weekend, and therefore take longer to receive appropriate management. We therefore considered having a second consultant episode in the current admission as a secondary time-to-event outcome, estimating model 'A' and 'B' for both the cause-specific hazard of moving to a second consultant conditional on remaining alive in hospital and the competing risks sub-distribution hazard for the overall probability of moving to a second consultant.[13]

Oversight of the Infections in Oxfordshire Research Database

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Supplementary Results

Of the 503,938 emergency admissions included in primary analyses, 347,199 (68.9%) were to the John Radcliffe Hospital, Oxford, 98,341 (19.5%) were to the Horton General Hospital, Banbury (a district hospital in a town 35 miles north of Oxford, but part of the same hospital Trust), and 48,963 (9.7%) were to the Churchill Hospital, Oxford.

Within 30-days of admission, 24,383 (4·8%) patients admitted as an emergency died. 18,313/385,647 (4·7%) patients admitted on a weekday died, versus 6,070/118,291 (5·1%) admitted at the weekend. 12,647 (3·3%) and 5666 (1·5%) patients admitted on a weekday died in-hospital and out-of-hospital respectively, versus 4,318 (3·7%) and 1752 (1·5%) patients admitted at the weekend, respectively.

Additional results from model 'A'

All the factors adjusted for in previous analyses of administrative datasets had an independent effect on 30-day mortality. 30-day mortality was independently higher in men; Caucasians; older patients; several CCS groups; non-surgical admission specialties; patients admitted via the accident and emergency department or their family doctor, or from anywhere other than their place of residence; and in patients admitted in the winter, in earlier calendar years, with higher Charlson score, higher intrinsic mortality risk, and with more admissions or any complex admission in the last year. IMD score did not improve the model fit (Supplementary Table 1).

Within the main model 'A' based on factors available in previous analyses of administrative datasets, the effect of age was not linear (i.e. risk did not increase consistently with age over the entire age range), but rather mortality risk increased most per year below 30 years.

Model fit was significantly improved (Supplementary Table 2) by including ten interactions; between age and Charlson (very similar to those presented for model 'B' in Supplementary Figure 7(j)), age and number of prior admissions (Supplementary Figure 7(k)), Charlson and number of prior admissions (Supplementary Figure 7(l)), Charlson and intrinsic risk (Supplementary Figure 7(m)), Charlson and admission specialty (Supplementary Table 1), Charlson and any prior complex admission (Supplementary Table 1), calendar year and admission method (Supplementary Table 1), admission specialty and number of admissions in the last year (Supplementary Table 1), admission method and number of admissions in the last year (Supplementary Table 1), and number of admissions in the last year and any complex admission in the last year (Supplementary Table 1). All these interactions were quantitative, rather than qualitative, i.e. associations between factors and 30-day mortality were slightly more or less pronounced in particular subgroups, but the general overall direct of association persisted in all subgroups.

These interactions generally reflected a reduced effect of increasing Charlson score and more admissions in the last year on mortality risk in patients who were either younger or older; with a more pronounced increase in risk with increasing Charlson score in patients at generally lower risk (surgical versus medical emergency inpatients, lowest quintile risk score, no previous complex admissions in the last year). While mortality decreased year on year for every admission method, this effect was more pronounced in those coming from consultant clinics and less pronounced in those coming in by other methods. Increased risk associated with increasing number of prior admissions in the last year was more pronounced for those coming from and the A&E or GPs, admitted to Medical specialities, and those with no complex admissions in the last year. Of note, estimated reductions in mortality in later calendar years plausibly reflect continued improvements in completeness of secondary codes over time, meaning that Charlson score is more accurately estimated in later periods, and thus underestimated in earlier periods (so-called coding depth bias[1]).

Of note, the excess risk associated with weekend admission was a similar magnitude to that in men versus women (Supplementary Table 1), and the winter versus the summer (Supplementary Figure 13: day 0 of the year corresponding to 1 January and day 365 to 31 December).

There was no evidence that the excess mortality risk associated with weekend admission varied across patient subgroups defined by these factors, including calendar year (interaction p>0·2; Supplementary Table 3).

Sensitivity analyses for model 'A'

Excess mortality risks associated with admission at the weekend were similar fitting the same final model 'A' to the largest speciality group (General Medicine), defining 'days of week' starting at 7am and 8am (reflecting hospital shifts and changeovers) compared to midnight, censoring patients who died during the first 3 days of admission, dividing the original 'Other' CCS group into 15 smaller subgroups based on clinical advice,

adjusting for time since last discharge or duration of last admission, excluding readmissions within 30-days of a previous admission or incorporating patient-level robust variance adjustment (Supplementary Table 4(a)).

Adding an indicator to model 'A' as to whether blood was taken either for culture (as a marker for when doctors suspected bacterial infections) or for blood gases each improved the model BIC (both factors also p<0·0001), but did not change the 'weekend effect' (main Figure 2(a)). Adding an indicator for whether admissions had complete vs incomplete admission test results did not improve model fit (adjusted relative risk(complete vs incomplete)=1·01 (95% CI 0·98-1·04) p=0·40) or change the 'weekend effect' (main Figure 2(a)).

Additional results from model 'B'

All model 'A' factors remained associated with 30-day mortality adjusting for test results (Supplementary Table 2). Model 'A' included the ten interactions between factors assessed in previous administrative analyses, see above. All these interactions were retained in model 'B', regardless of impact on BIC. Three were no longer statistically significant at conventional levels; admission method and number of admissions in the last year (interaction p=0·08), number of admissions in the last year and any complex admission in the last year (interaction p=0·07) and Charlson and any prior complex admission (interaction p=0·14) (Supplementary Table 2). Other interactions were of similar magnitude in model 'A' and 'B'. There were five additional interactions between test results included in model 'B' (Supplementary Figure 7(a)-(e)) (one between haemoglobin and albumin to address co-linearity issues, Supplementary Figure 7(e)) and four additional interactions between test results and previous administrative factors (Supplementary Figure 7(f)-(g)) (Supplementary Table 2), that is, model 'B' included 19 interactions in total. For neutrophils and eosinophils (Supplementary Figure 7(a)), mortality risk was reduced only with neutrophils below the upper limit of normal and eosinophils above the lower limit of normal. Similarly, for neutrophils and CRP (Supplementary Figure 7(b)), mortality risk was reduced only when both neutrophils and CRP were below the upper limit of normal; once neutrophils were above the upper limit of normal there was little variation in risk associated with varying CRP. For lymphocytes and platelets, broadly mortality risk was increased only for platelets below the lower limit of normal and lymphocytes towards the upper end of the normal range (see Supplementary Figure 7(c)). For urea and creatinine (Supplementary Figure 7(d)), risk increased sharply with increasing bilirubin if creatinine was below the lower limit of normal, but remained low, more slowly for creatinine within the normal range, and was high regardless of bilirubin levels for creatinine above the upper limit of normal. For albumin and Charlson Score (Supplementary Figure 7(f)), the reduced mortality with higher albumin was attenuated in individuals with higher Charlson scores. For creatinine and number of admissions in the last year (Supplementary Figure 7(g)), increases in risk associated with increasing number of recent admissions were more pronounced when creatinine was below the lower limit of normal. For neutrophils/CRP and number of admissions in the last year (Supplementary Figure 7(h), 7(i)), increases in risk associated with increasing number of recent admissions were more pronounced at higher neutrophil/CRP values.

The final model 'B' including test results and their interaction terms substantially improved the model fit compared to a model including only terms (main effects and interactions) from model 'A' fitted to the subgroup of emergency admissions with all 15 test results (BIC change=14,799).

Using flexible parametric models to model the daily risk of death, and the excess risk associated with having been admitted at the weekend, over the number of days since admission, showed that the largest mortality difference was on the first two days following admission (main Figure 3).

Adjusting for time-updated current day of the week as well as day of admission

Length-of-stay was relatively short (median 2 calendar days, IQR 1-6), and therefore most time at risk through 30-days was spent outside the hospital. Risk of early mortality through 7 days, overall and before discharge, was most strongly related to day of admission (both Poisson p<0·0001); there were small or no independent effects of current day of week (p=0·02 and p=0·20 respectively adjusting for day of admission and days since admission). However, for 7-day mortality there was no evidence of any excess mortality risk associated with it currently being a Saturday (p=0·34) or a Sunday (p=0·65); rather only Mondays were associated with an excess risk (p=0·001). Results were similar in Poisson models including time up to 30-days from admission, and in time-dependent Cox models adjusted for current day of admission and all factors in model 'A' or model 'B' (Supplementary Table 4(b)).

Can the `weekend effect' be explained by delays in appropriate management?

The proportions of admissions with multiple consultants varied across day of the week in unadjusted analyses (p<0·0001; Supplementary Figure 2). After adjusting for all the factors influencing 30-day mortality in model 'A', rather than an increase in second consultant referrals on the weekend, in fact there was a reduced risk of

moving to a second consultant for admissions on Thursday (cause-specific hazard only), Friday or Saturday (Supplementary Figure 14). This may be because patients already in hospital are less likely to move consultant over the weekend. However, since we found no evidence of an increase in mortality due to actually being in hospital at the weekend (as opposed to be admitted at the weekend), reduced movement between consultants for those admitted Thursday-Saturday does not appear to have a significant adverse effect on patient care. The mismatch of timing of reduction in referrals with weekend admission shows it cannot be the dominant factor behind excess mortality associated with admission at the weekend.

Other outcomes

Our primary outcome was pre-specified as mortality within the 30-days following emergency admission, as used in previous studies. In unadjusted models, excess risks associated with weekend admission were greater at shorter timescales; however, after adjusting for administrative factors excess risks associated with emergency admission on Saturdays or Sundays vs Wednesdays were similar for 7-day to 30-day mortality (Supplementary Figure 9(a)). Similarly, adjusting for test results attenuated these excess risks, regardless of timescale over which the mortality outcome was assessed (Supplementary Figure 9(a)).

Results for the risk of moving to an ICU were also similar to those observed for 30-day mortality. In particular, the excess risk of moving to an ICU was greater in those admitted as emergencies at weekends in model 'A' before and after adjusting for other administrative factors, regardless of analysis method (Supplementary Figure 15(a)). Adjusting for laboratory test results in model 'B' significantly attenuated these excess risks regardless of analysis method (Supplementary Figure 15(b)).

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562 **Supplementary Table 1 Impact of exposures on 30-day mortality in univariable (unadjusted) and multivariable (adjusted) models**

		All emergency admissions (503,938*)	Deaths within 30-days (24,383)	Emergency admissions with full test results (271,465)	Univariable (unadjusted) model (503,938)			Multivariable (adjusted) model 'A' (503,938)			Multivariable (adjusted) model 'A' in those with all test results (271,465)			Multivariable (adjusted) model 'B' including test results (271,465)		
		N (col %) or median (IQR)	N dead (row %)	N (col %) or median (IQR)	aRR	95% CI		aRR	95% CI		aRR	95% CI		aRR	95% CI	
Day of admission	Monday	80950 (16·1%)	3900 (4·8%)	43662 (16·1%)	1·01	0·97	1·06	0·99	0·95	1·04	1·03	0·97	1·08	1·01	0·95	1·06
	Tuesday	75596 (15·0%)	3611 (4·8%)	41101 (15·1%)	1·00	0·96	1·05	1·00	0·95	1·04	1·01	0·96	1·06	0·99	0·94	1·05
	Wednesday	75732 (15·0%)	3607 (4·8%)	41059 (15·1%)	1·00			1·00			1·00			1·00		
	Thursday	74975 (14·9%)	3541 (4·7%)	40867 (15·1%)	0·99	0·95	1·04	0·97	0·92	1·01	0·98	0·93	1·03	0·96	0·91	1·02
	Friday	78394 (15·6%)	3654 (4·7%)	41579 (15·3%)	0·98	0·93	1·02	0·96	0·92	1·01	0·97	0·92	1·03	0·96	0·91	1·01
	Saturday	59242 (11·8%)	3100 (5·2%)	31469 (11·6%)	1·11	1·05	1·16	1·08	1·03	1·14	1·11	1·05	1·17	1·07	1·01	1·13
	Sunday	59049 (11·7%)	2970 (5·0%)	31728 (11·7%)	1·06	1·01	1·11	1·09	1·03	1·14	1·11	1·05	1·18	1·05	1·00	1·11
Calendar year †	(per year later) †	2010 (2008,2013)	2010 (2008,2012)	2010 (2008,2013)	0·97	0·97	0·98	0·93	0·92	0·93	0·93	0·92	0·94	0·93	0·92	0·94
Admission method †	A&E †	268193 (53·2%)	12085 (4·5%)	135893 (50·1%)	1·00			1·00			1·00			1·00		
	Consultant clinic †	28506 (5·7%)	603 (2·1%)	8515 (3·1%)	0·46	0·42	0·50	0·70	0·59	0·83	0·83	0·67	1·02	0·90	0·73	1·12
	GP †	134521 (26·7%)	8813 (6·6%)	92846 (34·2%)	1·45	1·41	1·49	0·88	0·83	0·93	0·88	0·83	0·94	0·84	0·78	0·89
	Other ** †	72718 (14·4%)	2882 (4·0%)	34211 (12·6%)	0·87	0·83	0·90	0·63	0·57	0·70	0·64	0·57	0·73	0·58	0·51	0·66
Admission source	NHS general ward	9181 (1·8%)	535 (5·8%)	5558 (2·0%)	1·23	1·12	1·33	1·11	1·02	1·21	1·16	1·05	1·27	1·03	0·93	1·14
	Other	2860 (0·6%)	376 (13·1%)	1782 (0·7%)	2·97	2·68	3·29	1·70	1·54	1·89	1·71	1·52	1·92	1·44	1·28	1·62
	Temporary place of residence	3723 (0·7%)	148 (4·0%)	2120 (0·8%)	1·00	0·85	1·17	1·10	0·93	1·29	1·13	0·94	1·35	0·97	0·81	1·16
	Usual place of residence	488174 (96·9%)	23324 (4·8%)	262005 (96·5%)	1·00			1·00			1·00			1·00		
Admission speciality †	Medical †	286705 (56·9%)	19542 (6·8%)	173117 (63·8%)	1·00			1·00			1·00			1·00		
	Surgical †	205289 (40·7%)	4272 (2·1%)	94903 (35·0%)	0·30	0·29	0·31	0·60	0·56	0·64	0·70	0·65	0·76	0·82	0·76	0·88
	Other ** †	11944 (2·4%)	569 (4·8%)	3445 (1·3%)	0·69	0·63	0·75	1·56	1·26	1·94	2·09	1·58	2·77	1·96	1·49	2·58
Charlson Comorbidity Index (CCI) †	(per unit higher) †	0 (0,4)	10 (0,14)	0 (0,7)	1·17	1·17	1·18	1·50	1·31	1·71	1·58	1·31	1·91	1·46	1·21	1·75
Number of prior admissions ‡	Per additional admission	3 (1,7)	5 (2,10)	3 (1,8)	1·04	1·04	1·04	NA‡	NA	NA	NA	NA	NA	NA	NA	NA
Number of admissions in the past year †	Per additional admission †	0 (0,2)	1 (0,3)	1 (0,2)	1·17	1·17	1·18	1·20	1·04	1·39	1·12	0·92	1·36	1·11	0·92	1·35
Any prior complex admission ‡		125929 (25·0%)	9955 (7·9%)	81685 (30·1%)	2·09	2·04	2·15	NA‡	NA	NA	NA	NA	NA	NA	NA	NA
Any complex admissions in the past year †		56491 (11·2%)	5555 (9·8%)	38589 (14·2%)	2·38	2·31	2·45	1·43	1·33	1·54	1·22	1·23	1·45	1·12	1·03	1·22
Intrinsic risk quintile †	1 (lowest risk) †	21379 (4·2%)	9 (0·04%)	5184 (1·9%)	1·00			1·00			1·00			1·00		
	2 †	57272 (11·4%)	139 (0·2%)	20679 (7·6%)	5·78	2·95	11·3	6·10	1·63	22·8	4·65	0·56	38·8	4·72	0·58	38·7
	3 †	115507 (22·9%)	931 (0·8%)	51448 (19·0%)	19·2	9·98	37·1	11·1	3·02	41·0	14·0	1·73	114	13·8	1·73	110
	4 †	135055 (26·8%)	3152 (2·3%)	73960 (27·2%)	56·1	29·2	108	18·7	5·09	69·0	21·9	2·70	177	20·4	2·55	162
	5 (Highest Risk) †	174725 (34·7%)	20152 (11·5%)	120194 (44·3%)	290	150	557	60·2	16·4	222	63·3	7·82	512	43·3	5·43	345
Sex	Female	255330 (50·7%)	11918 (4·7%)	140123 (51·6%)	1·00			1·00			1·00			1·00		

		All emergency admissions (503,938*)	Deaths within 30-days (24,383)	Emergency admissions with full test results (271,465)	Univariable (unadjusted) model (503,938)			Multivariable (adjusted) model 'A' (503,938)			Multivariable (adjusted) model 'A' in those with all test results (271,465)			Multivariable (adjusted) model 'B' including test results (271,465)		
		N (col %) or median (IQR)	N dead (row %)	N (col %) or median (IQR)	aRR	95% CI		aRR	95% CI		aRR	95% CI		aRR	95% CI	
	Male	248608 (49·3%)	12465 (5·0%)	131342 (48·4%)	1·08	1·05	1·11	1·12	1·09	1·15	1·11	1·08	1·14	1·04	1·01	1·07
Ethnicity	White	410814 (81·5%)	21472 (5·2%)	228714 (84·3%)	1·00			1·00			1·00			1·00		
	Black	5501 (1·1%)	90 (1·6%)	2657 (1·0%)	0·31	0·25	0·38	0·83	0·68	1·02	0·78	0·61	1·00	0·84	0·65	1·08
	Asian	14347 (2·8%)	221 (1·5%)	6637 (2·4%)	0·29	0·26	0·33	0·72	0·63	0·82	0·71	0·61	0·83	0·78	0·67	0·91
	Other **	9386 (1·9%)	148 (1·6%)	3927 (1·4%)	0·30	0·26	0·36	0·90	0·77	1·06	0·98	0·82	1·18	0·98	0·82	1·18
	Unknown	63890 (12·7%)	2452 (3·8%)	29530 (10·9%)	0·74	0·71	0·77	1·18	1·13	1·23	1·15	1·09	1·21	1·11	1·05	1·16
Age at last birthday (years) †	Per additional year	55 (29,76)	80 (69-87)	64 (42,79)	1·05	1·05	1·05	††			††			††		
IMD score‡	Per unit higher	11 (7,18)	10 (7,16)	11 (7,17)	0·99	0·99	0·99	NA‡	NA	NA	NA	NA	NA	NA	NA	NA
CCS group	Abdominal Pain	18486 (3·7%)	158 (0·9%)	13659 (5·0%)	1·00			1·00			1·00			1·00		
	Acute and unspecified renal failure	3042 (0·6%)	517 (17·0%)	2615 (1·0%)	21·6	18·0	25·8	1·47	1·22	1·77	1·76	1·42	2·19	0·89	0·72	1·11
	Acute bronchitis	11675 (2·3%)	771 (6·6%)	6759 (2·5%)	7·88	6·64	9·35	0·82	0·68	0·98	0·99	0·80	1·23	0·76	0·61	0·94
	Acute cerebrovascular disease	7511 (1·5%)	1506 (20·1%)	5143 (1·9%)	26·2	22·3	30·9	1·91	1·61	2·28	2·30	1·87	2·83	3·43	2·79	4·21
	Acute myocardial infarction	6363 (1·3%)	631 (9·9%)	4541 (1·7%)	12·3	10·3	14·6	1·10	0·92	1·33	1·40	1·13	1·74	1·61	1·29	1·99
	Biliary tract disease	6248 (1·2%)	147 (2·4%)	5564 (2·0%)	2·75	2·20	3·44	0·99	0·79	1·25	1·08	0·84	1·40	0·46	0·36	0·60
	Cardiac dysrhythmias	8799 (1·7%)	196 (2·2%)	5391 (2·0%)	2·61	2·12	3·22	0·66	0·53	0·81	0·88	0·69	1·12	0·98	0·77	1·25
	Chronic obstructive pulmonary disease and bronchiectasis	9055 (1·8%)	758 (8·4%)	7087 (2·6%)	10·1	8·50	12·0	0·82	0·68	0·98	1·03	0·83	1·27	0·98	0·79	1·21
	Chronic renal failure	3032 (0·6%)	116 (3·8%)	1635 (0·6%)	4·50	3·54	5·72	2·76	2·17	3·52	3·49	2·61	4·67	1·74	1·29	2·33
	Complication of device; implant or graft	8009 (1·6%)	157 (2·0%)	3461 (1·3%)	2·28	1·83	2·84	0·61	0·48	0·76	0·94	0·72	1·24	0·65	0·50	0·86
	Complications of surgical procedures or medical care	7765 (1·5%)	62 (0·8%)	4071 (1·5%)	0·92	0·69	1·24	0·71	0·53	0·96	0·81	0·57	1·16	0·49	0·34	0·69
	Congestive heart failure; nonhypertensive	4528 (0·9%)	736 (16·3%)	3632 (1·3%)	20·4	17·2	24·2	1·15	0·96	1·38	1·48	1·20	1·83	1·33	1·07	1·64
	Coronary atherosclerosis and other heart disease	7757 (1·5%)	209 (2·7%)	4517 (1·7%)	3·20	2·61	3·94	0·61	0·49	0·75	0·90	0·70	1·14	1·38	1·08	1·76
	Crushing injury or internal injury	5028 (1·0%)	89 (1·8%)	1374 (0·5%)	2·08	1·61	2·70	0·70	0·54	0·91	1·03	0·75	1·42	0·88	0·64	1·22
	Deficiency and other anemia	4658 (0·9%)	173 (3·7%)	2031 (0·7%)	4·34	3·50	5·39	0·61	0·49	0·76	0·82	0·63	1·07	0·81	0·61	1·06
	Epilepsy; convulsions	7173 (1·4%)	120 (1·7%)	3635 (1·3%)	1·96	1·55	2·49	0·82	0·64	1·04	0·98	0·74	1·30	1·18	0·89	1·56
	Fracture of lower limb	6244 (1·2%)	76 (1·2%)	1572 (0·6%)	1·42	1·08	1·87	0·85	0·64	1·12	1·31	0·94	1·83	1·04	0·75	1·45
	Fracture of neck of femur (hip)	6412 (1·3%)	513 (8·0%)	3550 (1·3%)	9·59	8·02	11·5	0·73	0·61	0·89	0·92	0·73	1·15	0·93	0·74	1·16

		All emergency admissions (503,938*)	Deaths within 30-days (24,383)	Emergency admissions with full test results (271,465)	Univariable (unadjusted) model (503,938)			Multivariable (adjusted) model 'A' (503,938)			Multivariable (adjusted) model 'A' in those with all test results (271,465)			Multivariable (adjusted) model 'B' including test results (271,465)		
		N (col %) or median (IQR)	N dead (row %)	N (col %) or median (IQR)	aRR	95% CI		aRR	95% CI		aRR	95% CI		aRR	95% CI	
	Fracture of upper limb	10194 (2·0%)	87 (0·9%)	1354 (0·5%)	1·00	0·77	1·30	1·08	0·83	1·41	1·70	1·21	2·37	1·23	0·88	1·72
	Gastrointestinal haemorrhage	4698 (0·9%)	446 (9·5%)	3804 (1·4%)	11·6	9·71	14·0	1·30	1·08	1·57	1·53	1·23	1·90	1·02	0·82	1·27
	Genitourinary symptoms and ill-defined conditions	3790 (0·8%)	81 (2·1%)	1944 (0·7%)	2·50	1·91	3·27	0·90	0·68	1·17	1·07	0·77	1·49	0·71	0·51	0·99
	Intestinal infection	5958 (1·2%)	185 (3·1%)	3864 (1·4%)	3·66	2·96	4·52	1·03	0·83	1·27	1·21	0·94	1·54	0·65	0·51	0·83
	Low Risk	85321 (16·9%)	203 (0·2%)	30580 (11·3%)	0·28	0·22	0·34	0·65	0·53	0·81	0·85	0·66	1·11	0·84	0·64	1·09
	Nausea and vomiting	3421 (0·7%)	91 (2·7%)	1990 (0·7%)	3·11	2·40	4·03	0·48	0·37	0·62	0·58	0·43	0·79	0·50	0·37	0·68
	Non-infectious gastroenteritis	3793 (0·8%)	134 (3·5%)	2470 (0·9%)	4·18	3·32	5·27	1·32	1·05	1·67	1·67	1·29	2·17	1·10	0·85	1·42
	Non-specific chest pain	20802 (4·1%)	119 (0·6%)	11103 (4·1%)	0·67	0·53	0·85	0·43	0·34	0·56	0·52	0·39	0·71	0·85	0·63	1·16
	Open wounds of head; neck; and trunk	7141 (1·4%)	107 (1·5%)	1522 (0·6%)	1·77	1·39	2·27	0·81	0·63	1·03	1·31	0·97	1·76	1·30	0·97	1·76
	Other	127254 (25·3%)	10850 (8·5%)	77521 (28·6%)	10·3	8·80	2·1	1·70	1·44	2·01	2·00	1·65	2·42	1·42	1·17	1·72
	Other connective tissue disease	5078 (1·0%)	64 (1·3%)	2509 (0·9%)	1·47	1·10	1·96	0·64	0·48	0·86	0·76	0·53	1·09	0·73	0·51	1·04
	Other fractures	4526 (0·9%)	147 (3·2%)	1895 (0·7%)	3·83	3·06	4·80	0·56	0·45	0·71	0·83	0·63	1·09	0·76	0·58	1·00
	Other gastrointestinal disorders	4881 (1·0%)	220 (4·5%)	3481 (1·3%)	5·33	4·34	6·54	1·54	1·25	1·89	1·94	1·54	2·46	1·53	1·21	1·94
	Other nervous system disorders	4395 (0·9%)	132 (3·0%)	2194 (0·8%)	3·51	2·79	4·42	0·73	0·58	0·93	0·87	0·66	1·16	1·01	0·76	1·34
	Other non-traumatic joint disorders	3302 (0·7%)	41 (1·2%)	1286 (0·5%)	1·44	1·02	2·04	0·81	0·57	1·15	0·93	0·50	1·47	0·84	0·54	1·32
	Other upper respiratory disease	7990 (1·6%)	232 (2·9%)	3483 (1·3%)	3·40	2·78	4·17	0·61	0·49	0·75	0·72	0·56	0·93	0·88	0·69	1·14
	Pleurisy, pneumothorax; pulmonary collapse	3310 (0·7%)	321 (9·7%)	2131 (0·8%)	11·7	9·70	14·2	1·19	0·97	1·45	1·50	1·19	1·90	1·20	0·95	1·52
	Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	12582 (2·5%)	2567 (20·4%)	10109 (3·7%)	26·7	22·7	31·4	2·05	1·73	2·43	2·50	2·05	3·05	1·47	1·21	1·80
	Poisoning by psychotropic agents	4943 (1·0%)	41 (0·8%)	1459 (0·5%)	0·97	0·69	1·37	2·05	1·44	2·90	3·04	2·02	4·59	2·06	1·37	3·10
	Senility and organic mental disorders	3295 (0·9%)	251 (7·6%)	2407 (0·9%)	9·04	7·41	11·0	0·49	0·40	0·60	0·58	0·46	0·75	0·68	0·53	0·87
	Skin and subcutaneous tissue infections	9874 (2·0%)	127 (1·3%)	6223 (2·3%)	1·50	1·19	1·90	0·71	0·56	0·90	0·87	0·67	1·14	0·56	0·43	0·73
	Spondylosis; intervertebral disc	5326 (1·1%)	48 (0·9%)	2085 (0·8%)	1·05	0·76	1·45	1·00	0·72	1·40	1·35	0·92	1·99	1·30	0·89	1·92

		All emergency admissions (503,938*)	Deaths within 30-days (24,383)	Emergency admissions with full test results (271,465)	Univariable (unadjusted) model (503,938)			Multivariable (adjusted) model 'A' (503,938)			Multivariable (adjusted) model 'A' in those with all test results (271,465)			Multivariable (adjusted) model 'B' including test results (271,465)		
		N (col %) or median (IQR)	N dead (row %)	N (col %) or median (IQR)	aRR	95% CI		aRR	95% CI		aRR	95% CI		aRR	95% CI	
	disorders; other back problems															
	Superficial injury; contusion	11236 (2·2%)	173 (1·5%)	2801 (1·0%)	1·81	1·46	2·25	0·54	0·43	0·67	0·76	0·58	1·00	0·76	0·58	1·00
	Syncope	7863 (1·6%)	210 (2·7%)	4391 (1·6%)	3·16	2·57	3·88	0·31	0·25	0·38	0·40	0·31	0·51	0·55	0·42	0·70
	Urinary tract infections	11182 (2·2%)	571 (5·1%)	8622 (3·2%)	6·02	5·05	7·18	0·45	0·37	0·54	0·55	0·45	0·69	0·42	0·34	0·52
Calendar year admission method Interaction, per year	Consultant clinic	NA	NA	NA	NA	NA	NA	0·99	0·96	1·02	0·98	0·95	1·02	0·98	0·94	1·01
	GP	NA	NA	NA	NA	NA	NA	1·01	1·00	1·02	1·00	0·99	1·01	1·01	0·99	1·02
	Other **	NA	NA	NA	NA	NA	NA	1·05	1·04	1·07	1·05	1·03	1·07	1·05	1·03	1·08
Admission method Interaction with number of admissions in the last year, per year	Consultant clinic	NA	NA	NA	NA	NA	NA	0·95	0·92	0·98	0·97	0·93	1·01	0·98	0·94	1·02
	GP	NA	NA	NA	NA	NA	NA	1·03	1·02	1·05	1·02	1·01	1·04	1·01	0·99	1·02
	Other **	NA	NA	NA	NA	NA	NA	0·95	0·94	0·97	0·96	0·95	0·98	0·98	0·96	1·00
Admission speciality Interaction with number of admissions in the last year, per year	Surgical	NA	NA	NA	NA	NA	NA	0·97	0·96	0·99	0·97	0·95	0·99	0·98	0·96	1·00
	Other **	NA	NA	NA	NA	NA	NA	0·93	0·90	0·96	0·81	0·89	0·96	0·93	0·90	0·97
Admission speciality interaction with Charlson Index, per unit higher	Surgical	NA	NA	NA	NA	NA	NA	1·03	1·02	1·03	1·02	1·01	1·03	1·02	1·01	1·03
	Other **	NA	NA	NA	NA	NA	NA	1·00	0·98	1·02	0·99	0·97	1·01	0·98	0·96	1·00
Intrinsic risk quintile interaction with Charlson, per unit higher Charlson	2 †	NA	NA	NA	NA	NA	NA	0·85	0·76	0·95	0·87	0·74	1·03	0·86	0·73	1·01
	3 †	NA	NA	NA	NA	NA	NA	0·85	0·76	0·94	0·83	0·70	0·98	0·82	0·69	0·96
	4 †	NA	NA	NA	NA	NA	NA	0·84	0·75	0·93	0·82	0·70	0·97	0·81	0·69	0·95
	5 (Highest Risk) †	NA	NA	NA	NA	NA	NA	0·81	0·72	0·90	0·80	0·68	0·94	0·79	0·68	0·93
Any prior complex admission in the last year interaction with Charlson	(per unit higher Charlson)	NA	NA	NA	NA	NA	NA	0·99	0·98	0·99	0·99	0·98	0·99	1·00	0·99	1·00
Any prior complex admission in the last year interaction with any prior admission in the last year	(per extra admission)	NA	NA	NA	NA	NA	NA	0·97	0·95	0·98	0·98	0·96	0·99	0·99	0·97	1·00

* 625 (0·1%) admissions with missing age, sex (or intersex), or diagnostic codes were excluded from all analyses.

** Other admission method included Bed Bureau and Other means. Other admission speciality included Paediatric and other specialities (first digit of treatment function code 2, 6, 7 or 8); Surgical specialities had first digit of treatment function code=1, and Medical 3, 4,5. Other ethnicity included any mixed background and "Any other" ethnic group.

† Final model ‘A’ included 10 interactions, which were also included in model ‘B’. These interactions were between admission method and each of number of admissions in the last year and calendar year; between admission speciality and each of number of admissions in the last year and Charlson; between Charlson and each of age, number of prioradmissions in the last year, any complex admission in the last year and quintile risk; and between number of admissions in the last year and each of age and any complex admission in the last year. The table shows the main effects for each variable at the reference category of categorical variables and the median of continuous variables. Interactions between continuous variables are shown in Supplementary Figure 7 for model ‘B’ (very similar to results from model ‘A’). Final model ‘B’ included an additional 9 interactions shown in Supplementary Figure 7. These were between number of admissions in the last year and each of creatinine, neutrophils and C-reactive protein, between Charlson and albumin, and between 5 pairs of test results (urea/creatinine, haemoglobin/albumin, eosinophils/neutrophils, C-reactive protein/neutrophils and lymphocytes/platelets). The table shows the main effects for each variable at the median value of each test result.

‡ Not selected for inclusion in main model ‘A’.

†† Included with a non-linear effect; that is the impact of being 10 years older has an effect on mortality risk that varies according to age, and was further modified by Charlson comorbidity score and number of prior admissions (see Supplementary Figure 7(j) and 7(k) for fitted effects).

Note: aRR=adjusted relative risk. effects of test results, age and day of the year which had non-linear effects on mortality risk (natural cubic splines and combination sin/cos function respectively), and/or interactions between continuous variables, are shown in Supplementary Figures 6 and 7 respectively. Consultant of the first episode was a significant predictor univariably, but was not selected in any multivariable (adjusted) model and so is not shown. All relative risks (or hazard ratios) are from Cox models which adjust for days since admission through the non-parametric baseline hazard, but do not adjust for time-updated day of week at risk; estimates from model ‘A’ and model ‘B’ were similar additionally adjusting for time-updated day of week at risk (see Supplementary Table 4(b)).

586 **Supplementary Table 2 Strength of association between factors and 30-day mortality**

	Model 'A' (excluding test results) on the full dataset C-statistic=0·88			**Model 'A' on patients with complete test results C-statistic=0·84**			**Model 'B' including test results C-statistic=0·89**		
Factor (main effects)	Df	ChiSq	P	Df	ChiSq	P	Df	ChiSq	P
Admission day of week	6	46·5	<0·0001	6	45·1	<0·0001	6	26·2	0·0002
Admission calendar year	1	437·8	<0·0001	1	276·4	<0·0001	1	267·5	<0·0001
Admission day of the year	2	80·0	<0·0001	2	68·8	<0·0001	2	13·3	0·001
Admission method	3	90·0	<0·0001	3	52·2	<0·0001	3	80·8	<0·0001
Admission source	3	108·7	<0·0001	3	97·8	<0·0001	3	38·5	<0·0001
Admission speciality	2	287·4	<0·0001	2	123·3	<0·0001	2	55·2	<0·0001
Charlson co-morbidity index	1	36·3	<0·0001	1	22·8	<0·0001	1	16·4	0·0001
Number of admissions in the last year	1	5·9	0·015*	1	1·22	0·27*	1	1·2	0·28*
Any complex admissions in the last year	1	99·6	<0·0001	1	46·1	<0·0001	1	7·7	0·006
Intrinsic risk quintile	4	1820·3	<0·0001	4	1051·3	<0·0001	4	591·7	<0·0001
Sex	1	71·7	<0·0001	1	46·4	<0·0001	1	5·3	0·02
Ethnicity	4	88·2	<0·0001	4	53·5	<0·0001	4	27·3	<0·0001
Age (5 knots, 4df)	4	4518·1	<0·0001	4	2839·6	<0·0001	4	1314·9	<0·0001
CCS group	42	4529·9	<0·0001	42	3067·2	<0·0001	42	2754·7	<0·0001
Interactions									
Admission method#calendar year	3	41·7	<0·0001	3	27·2	<0·0001	3	31·5	<0·0001
Admission method#admissions in the last year	3	109	<0·0001	3	40·8	<0·0001	3	6·8	0·08
Admission speciality#admissions in the last year	2	28·8	<0·0001	2	24·2	<0·0001	2	16·3	0·0003
Admission speciality#Charlson	2	100·1	<0·0001	2	39·2	<0·0001	2	35·8	<0·0001
Quintile risk#Charlson	4	199·9	<0·0001	4	112·9	<0·0001	4	71·1	<0·0001
Admissions in the last year#Charlson	1	75·8	<0·0001	1	30·7	<0·0001	1	19·9	<0·0001
Any complex admissions in the last year#Charlson	1	23·2	<0·0001	1	14·9	0·0001	1	2·16	0·14
Age#Charlson	4	807	<0·0001	4	596·3	<0·0001	4	240·0	<0·0001
Admissions in the last year#any complex admissions in the last year	1	24·5	<0·0001	1	7·1	0·008	1	3·2	0·07
Age#admissions in the last year	4	181·5	<0·0001	4	76·6	<0·0001	4	56·2	<0·0001
Main effects test results									
Albumin							3	291·8	<0·0001
Alanine aminotransferase							3	177·0	<0·0001
Alkaline phosphatase							4	411·7	<0·0001
Bilrubin							3	26·3	<0·0001
Creatinine							4	136·1	<0·0001
C-reactive Protein							3	178·9	<0·0001
Eosinophils							2	249·8	<0·0001
Haemoglobin							3	50·3	<0·0001
Lymphocytes							3	45·0	<0·0001
Monocytes							3	19·1	0·0003
Neutrophils							3	33·1	<0·0001
Platelets							3	5·1	0·17*
Sodium							3	343·8	<0·0001
Potassium							3	221·1	<0·0001
Urea							2	50·7	<0·0001
Interactions with test results									

	Model 'A' (excluding test results) on the full dataset C-statistic=0·88			Model 'A' on patients with complete test results C-statistic=0·84			Model 'B' including test results C-statistic=0·89		
Albumin#Charlson							3	88·5	<0·0001
Admissions in the last year#creatinine							4	125·5	<0·0001
Admissions in the last year#neutrophils							3	71·7	<0·0001
Admissions in the last year#CRP							3	68·3	<0·0001
Urea#creatinine							8	53·1	<0·0001
Albumin#haemoglobin							9	13·1	0·16**
Eosinophils#neutrophils							4†	170·4	<0·0001
CRP#neutrophils							6†	158·7	<0·0001
Lymphocytes#plateltes							9	124·8	<0·0001

* significant interactions with other factors included in the model, and therefore main effect included regardless of impact on BIC.

** included to address co-linearity issues, see Supplementary Figure 7.

† interactions including a 4 knot spline for neutrophils with either eosinophils or CRP had very large standard errors for the final spline term, and therefore a 3 knot spline was used for these neutrophil interactions.

Note: DF=degrees of freedom. Df include spline terms (so df=3 is a natural cubic spline with 4 knots; selected using BIC for continuous variables). CRP=C-reactive protein. BIC=Bayesian Information Criteria.

Supplementary Table 3 Strength of association of interaction between weekend admission (binary) and model factors with 30-day mortality

	Model 'A' (excluding test results) on the full dataset			Model 'B' including test results		
	Df	**ChiSq**	**Interaction P**	**Df**	**ChiSq**	**Interaction P**
Admission calendar year	1	0·29	0·59	1	0·01	0·93
Admission day of the year	2	2·53	0·28	2	6·04	0·05
Admission method	3	4·63	0·20	3	1·87	0·60
Admission source	3	4·25	0·24	3	4·31	0·23
Admission speciality	2	0·77	0·68	2	1·02	0·60
Charlson co-morbidity index	1	0·30	0·58	1	0·04	0·84
Number of admissions in the last year	1	0·71	0·40	1	0·00	0·99
Any complex admissions in the last year	1	0·40	0·53	1	0·22	0·64
Intrinsic risk quintile	4	0·31	0·99	4	1·72	0·79
Sex	1	0·55	0·46	1	0·04	0·84
Ethnicity	4	3·02	0·55	4	6·95	0·14
Age (5 knots, 4df)	4	4·32	0·36	4	1·47	0·83
CCS group	42	47·1	0·27	42	32·46	0·86
Albumin				3	1·24	0·74
Alanine aminotransferase				**3**	**13·42**	**0·004***
Alkaline phosphatase				4	3·16	0·53
Bilirubin				**3**	**15·4**	**0·002†**
Creatinine				4	4·51	0·34
C-reactive Protein				3	0·54	0·91
Eosinophils				2	0·60	0·74
Haemoglobin				3	3·82	0·28
Lymphocytes				3	1·74	0·63
Monocytes				3	4·71	0·19
Neutrophils				3	3·97	0·26
Platelets				3	4·40	0·22
Sodium				3	0·99	0·80
Potassium				3	5·81	0·12
Urea				2	0·44	0·80

* For alanine aminotransferase, increases in mortality risk with higher alanine aminotransferase remained present but were slightly attenuated at the weekend. See Supplementary Figure 8(a). Interaction between ALT and admission day of week p=0·10 and hence this interaction was not included in the main model 'B'.

† For bilirubin, mortality risk did not depend strongly on bilirubin for admissions at the weekend, whereas lower values within the normal range were associated with lower mortality risks for admissions on weekdays. See Supplementary Figure 8(b). Interaction between bilirubin and admission day of week p=0·08 and hence this interaction was not included in the main model 'B'.

Supplementary Table 4(a) Impact of day of week of admission in multivariable (adjusted) models in specific subgroups and sensitivity analyses based on model 'A'

	General Medicine (167449 admissions)			Days start at 7am rather than midnight			Days start at 8am rather than midnight			Censoring patients who died during the first 3 days from admission			Using alternative clinical classification for small CCS groups			Adjusting for days since last discharge* (3 knot spline)			Adjusting for duration of last inpatient admission** (3 knot spline)			Excluding readmissions			Including patient-level robust variance adjustment		
Day of admission	aRR	95% CI		aRR	95% CI		aRR	95% CI		aRR	95% CI		aRR	95% CI		aRR	95% CI		aRR	95% CI		aRR	95% CI		aRR	95% CI	
Monday	1·01	0·95	1·07	1·00	0·95	1·04	1·00	0·96	1·05	1·01	0·96	1·06	0·98	0·94	1·03	0·99	0·95	1·04	1·00	0·95	1·04	0·99	0·94	1·04	0·99	0·95	1·04
Tuesday	0·97	0·92	1·03	1·01	0·96	1·05	1·02	0·97	1·07	1·02	0·96	1·07	1·00	0·95	1·04	1·00	0·95	1·04	1·00	0·95	1·04	0·98	0·93	1·03	1·00	0·95	1·04
Wednesday	1·00			1·00			1·00			1·00			1·00			1·00			1·00			1·00			1·00		
Thursday	0·96	0·91	1·02	0·97	0·93	1·02	0·97	0·93	1·02	0·99	0·93	1·04	0·97	0·92	1·01	0·97	0·92	1·01	0·97	0·93	1·02	0·97	0·92	1·02	0·97	0·92	1·01
Friday	0·96	0·90	1·02	0·98	0·93	1·02	0·98	0·94	1·03	0·99	0·93	1·04	0·97	0·93	1·01	0·96	0·92	1·01	0·96	0·92	1·01	0·96	0·91	1·01	0·96	0·92	1·01
Saturday	1·08	1·02	1·15	1·11	1·06	1·17	1·11	1·06	1·17	1·11	1·05	1·17	1·09	1·04	1·15	1·08	1·03	1·14	1·08	1·03	1·13	1·07	1·02	1·13	1·08	1·03	1·14
Sunday	1·09	1·03	1·16	1·07	1·02	1·13	1·08	1·03	1·13	1·09	1·03	1·16	1·09	1·04	1·14	1·09	1·03	1·14	1·09	1·03	1·14	1·08	1·02	1·14	1·09	1·03	1·14

* Wald chi-squared for time since last discharge=77·4, df=3, p<0·0001.

** Wald chi-squared for duration of last inpatient admission=271·1, df=3, p<0·0001.

Note: all models also adjusted for all factors in final model 'A'. RR=adjusted relative risk.

Supplementary Table 4(b) Impact of day of week of admission in multivariable (adjusted) models also adjusting for time-updated current day of the week

	Main Model 'A' (as Supplementary Table 1)			Model 'A' adjusting for current day of the week using time-dependent Cox			Main Model 'B' (as Supplementary Table 1)			Model 'B' adjusting for current day of the week using time-dependent Cox		
	aRR	95% CI		aRR	95% CI		aRR	95% CI		aRR	95% CI	
Day of admission												
Monday	0·99	0·95	1·04	0·98	0·94	1·03	1·01	0·95	1·00	1·00	0·95	1·05
Tuesday	1·00	0·95	1·04	0·99	0·95	1·04	0·99	0·94	0·99	0·99	0·94	1·04
Wednesday	1·00			1·00			1·00		1·00	1·00		
Thursday	0·97	0·92	1·01	0·97	0·92	1·01	0·96	0·91	0·96	0·96	0·91	1·02
Friday	0·96	0·92	1·01	0·96	0·92	1·01	0·96	0·91	0·95	0·95	0·99	1·01
Saturday	1·08	1·03	1·14	1·08	1·02	1·13	1·07	1·01	1·07	1·07	1·01	1·13
Sunday	1·09	1·03	1·14	1·07	1·02	1·13	1·05	1·00	1·04	1·04	0·99	1·11
Current day at risk												
Monday	-			1·11	1·06	1·16	-			1·06	1·01	1·12
Tuesday	-			1·05	1·00	1·10	-			1·04	0·98	1·10
Wednesday	-			1·00			-			1·00		
Thursday	-			0·98	0·95	1·05	-			1·00	0·95	1·05
Friday	-			1·02	0·94	1·03	-			0·96	0·91	1·01
Saturday	-			0·99	0·97	1·07	-			1·01	0·96	1·07
Sunday	-			0·99	0·95	1·04	-			0·97	0·92	1·03

Note: all models also adjusted for all factors in final model 'A' and 'B' respectively. aRR=adjusted relative risk.

Supplementary Table 5(a) Impact of normalised measures of hospital workload on mortality risk and estimates of the effect of day of week of admission in model 'A'

	Model 'A' plus normalised number of admissions			Model 'A' plus normalised number of emergency admissions			Model 'A' plus normalised net admissions minus discharges			Model 'A' plus normalised net emergency admissions minus discharges			Model 'A' plus normalised bed occupancy			Model 'A' plus normalised emergency bed occupancy		
	aRR	**95% CI**		**aRR**	**95% CI**		**aRR**	**95% CI**		**aRR**	**95% CI**		**aRR**	**95% CI**		**aRR**	**95% CI**	
Day of admission																		
Monday	0·99	0·95	1·04	0·99	0·95	1·04	0·99	0·95	1·04	0·99	0·95	1·04	0·99	0·95	1·04	0·99	0·95	1·04
Tuesday	1·00	0·95	1·04	1·00	0·95	1·04	1·00	0·95	1·04	1·00	0·95	1·04	1·00	0·95	1·04	1·00	0·95	1·04
Wednesday	1·00			1·00			1·00			1·00						1·00		
Thursday	0·97	0·92	1·01	0·97	0·92	1·01	0·97	0·92	1·01	0·97	0·92	1·01	0·97	0·92	1·01	0·97	0·92	1·01
Friday	0·96	0·92	1·01	0·96	0·92	1·01	0·96	0·92	1·01	0·96	0·92	1·01	0·96	0·92	1·01	0·96	0·92	1·01
Saturday	1·08	1·03	1·14	1·08	1·03	1·14	1·08	1·03	1·14	1·08	1·03	1·14	1·08	1·03	1·14	1·08	1·03	1·14
Sunday	1·09	1·04	1·14	1·09	1·03	1·14	1·09	1·03	1·14	1·09	1·03	1·14	1·09	1·03	1·14	1·09	1·03	1·14
Per unit higher workload measure	0·99	0·98	1·00	1·00	0·98	1·01	1·00	0·98	1·01	1·01	0·99	1·02	1·00	0·99	1·02	1·01	0·99	1·02
p	P=0·06			P=0·61			P=0·59			P=0·47			P=0·82			P=0·38		

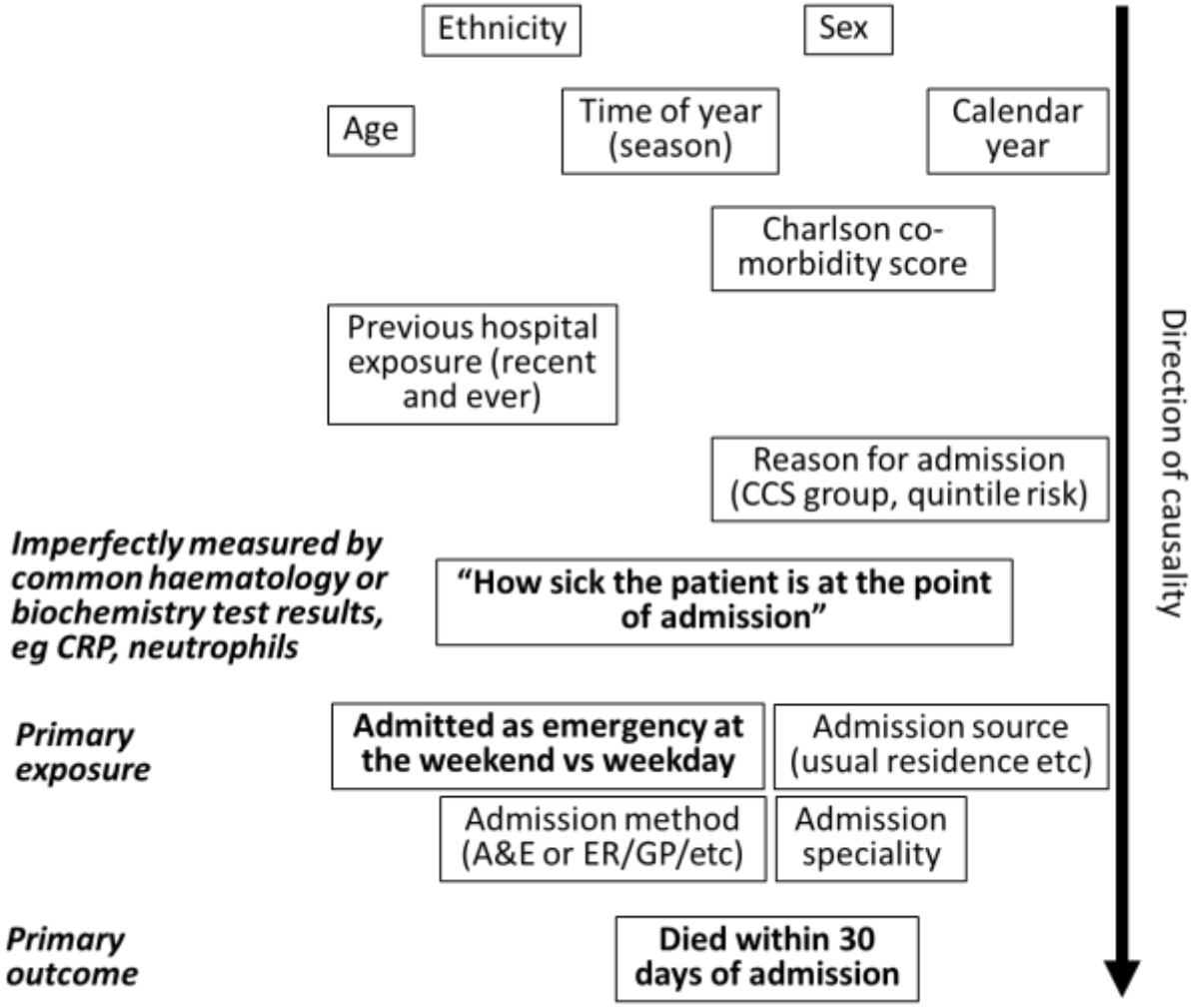
Note: all models also adjusted for all factors in final model 'A'. aRR=adjusted relative risk.

Supplementary Table 5(b) Impact of normalised measures of hospital workload on mortality risk and estimates of the effect of day of week of admission in model 'B'

	Model 'B' plus normalised number of admissions			Model 'B' plus normalised number of emergency admissions			Model 'B' plus normalised net admissions minus discharges			Model 'B' plus normalised net emergency admissions minus discharges			Model 'B' plus normalised bed occupancy			Model 'B' plus normalised emergency bed occupancy		
	aRR	**95% CI**		**aRR**	**95% CI**		**aRR**	**95% CI**		**aRR**	**95% CI**		**aRR**	**95% CI**		**aRR**	**95% CI**	
Day of admission																		
Monday	1·01	0·95	1·06	1·01	0·95	1·06	1·01	0·95	1·06	1·01	0·95	1·06	1·01	0·95	1·06	1·01	0·95	1·06
Tuesday	0·99	0·94	1·04	0·99	0·94	1·04	0·99	0·94	1·04	0·99	0·94	1·05	0·99	0·94	1·05	0·99	0·94	1·05
Wednesday	1·00			1·00			1·00			1·00			1·00					
Thursday	0·96	0·91	1·02	0·96	0·91	1·02	0·96	0·91	1·02	0·95	0·91	1·02	0·96	0·91	1·02	0·96	0·91	1·02
Friday	0·96	0·91	1·01	0·96	0·91	1·01	0·96	0·91	1·01	0·96	0·91	1·01	0·96	0·91	1·01	0·96	0·91	1·01
Saturday	1·07	1·01	1·13	1·07	1·01	1·13	1·07	1·01	1·13	1·07	1·01	1·13	1·07	1·01	1·13	1·07	1·01	1·13
Sunday	1·05	1·00	1·11	1·05	1·00	1·11	1·06	1·00	1·11	1·05	1·00	1·11	1·05	1·00	1·11	1·05	1·00	1·11
Per unit higher workload measure	0·99	0·98	1·01	0·99	0·98	1·01	1·00	0·99	1·02	1·01	0·99	1·02	1·01	1·00	1·03	1·01	1·00	1·03
p	P=0·39			P=0·37			P=0·83			P=0·57			P=0·18			P=0·17		

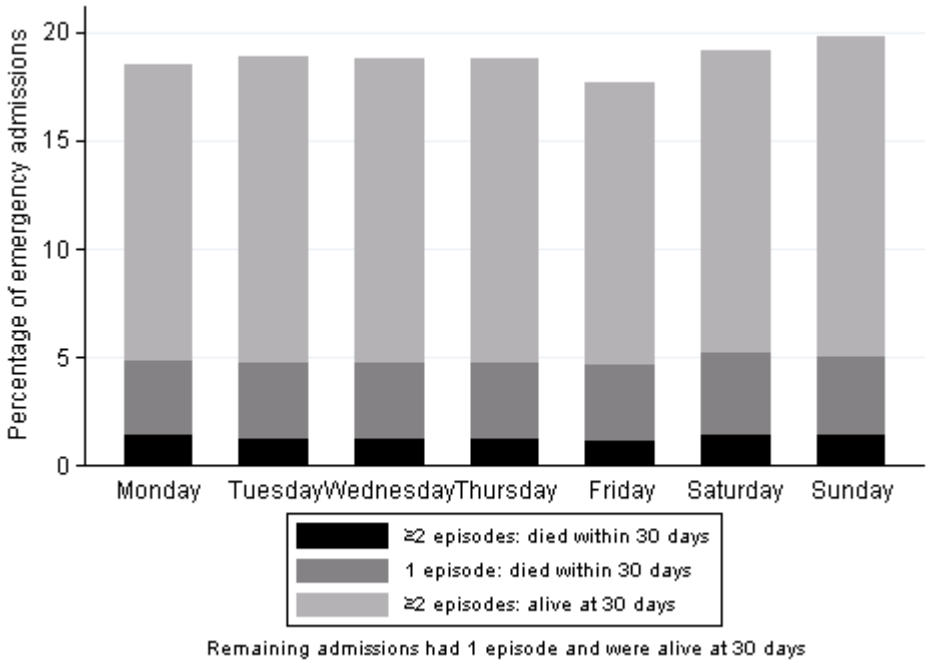
Note: all models also adjusted for all factors in final model 'B'. aRR=adjusted relative risk.

Supplementary Figure 1: Conceptual hierarchy of exposures and outcome



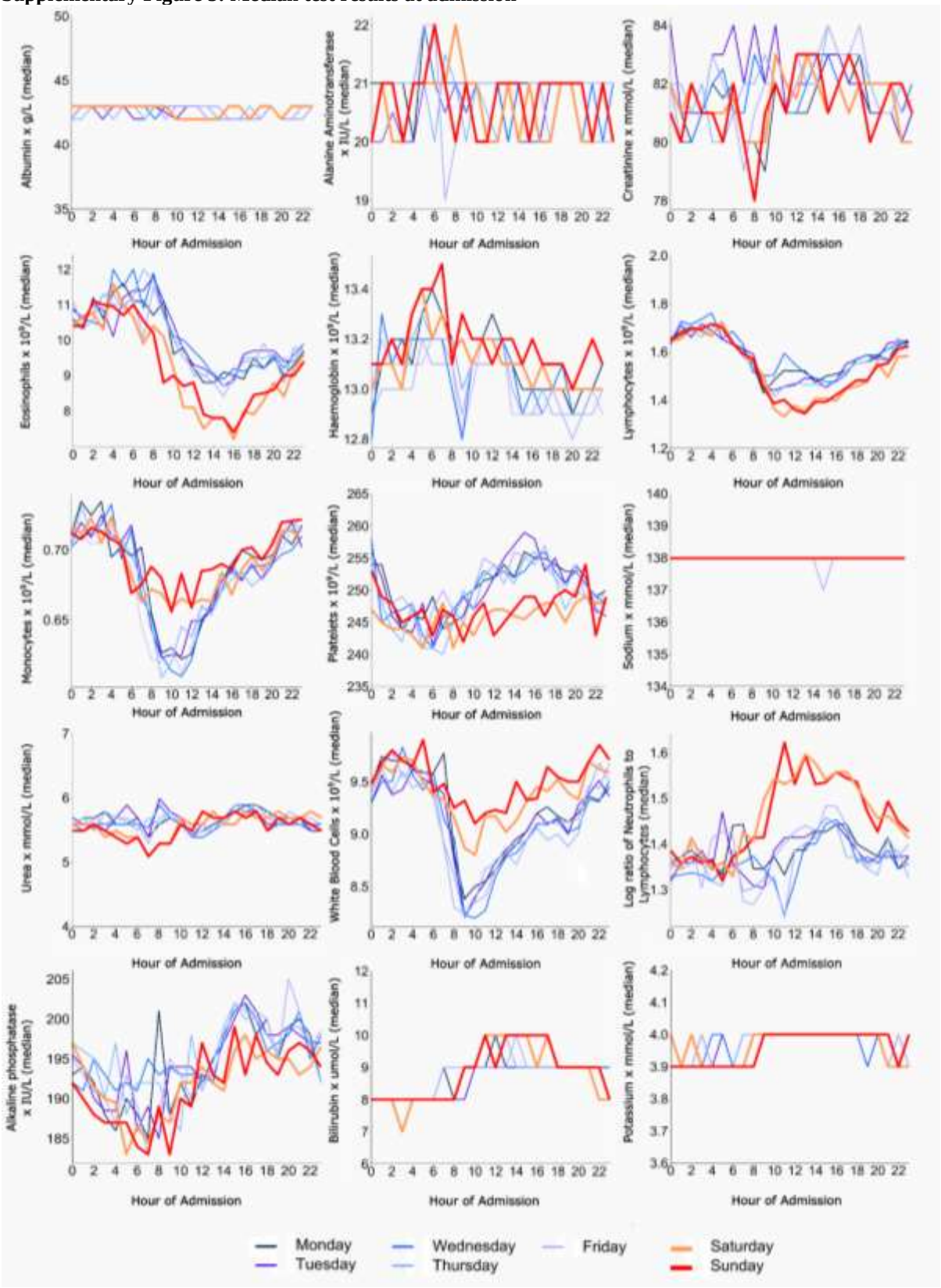
Note: arrows constructing a Directed Acyclic Graph not shown for clarity (e·g. age plausibly affects everything below it in the conceptual hierarchy); however, arrows can only go down. Haematology/biochemistry test results are used as imperfect measures of severity of illness at the point of admission.

628 **Supplementary Figure 2: Mortality following emergency admission by day of the week (N=503,938)**



629
630 The proportion of complex admissions differs by day of the week (p <0·0001)
631
632

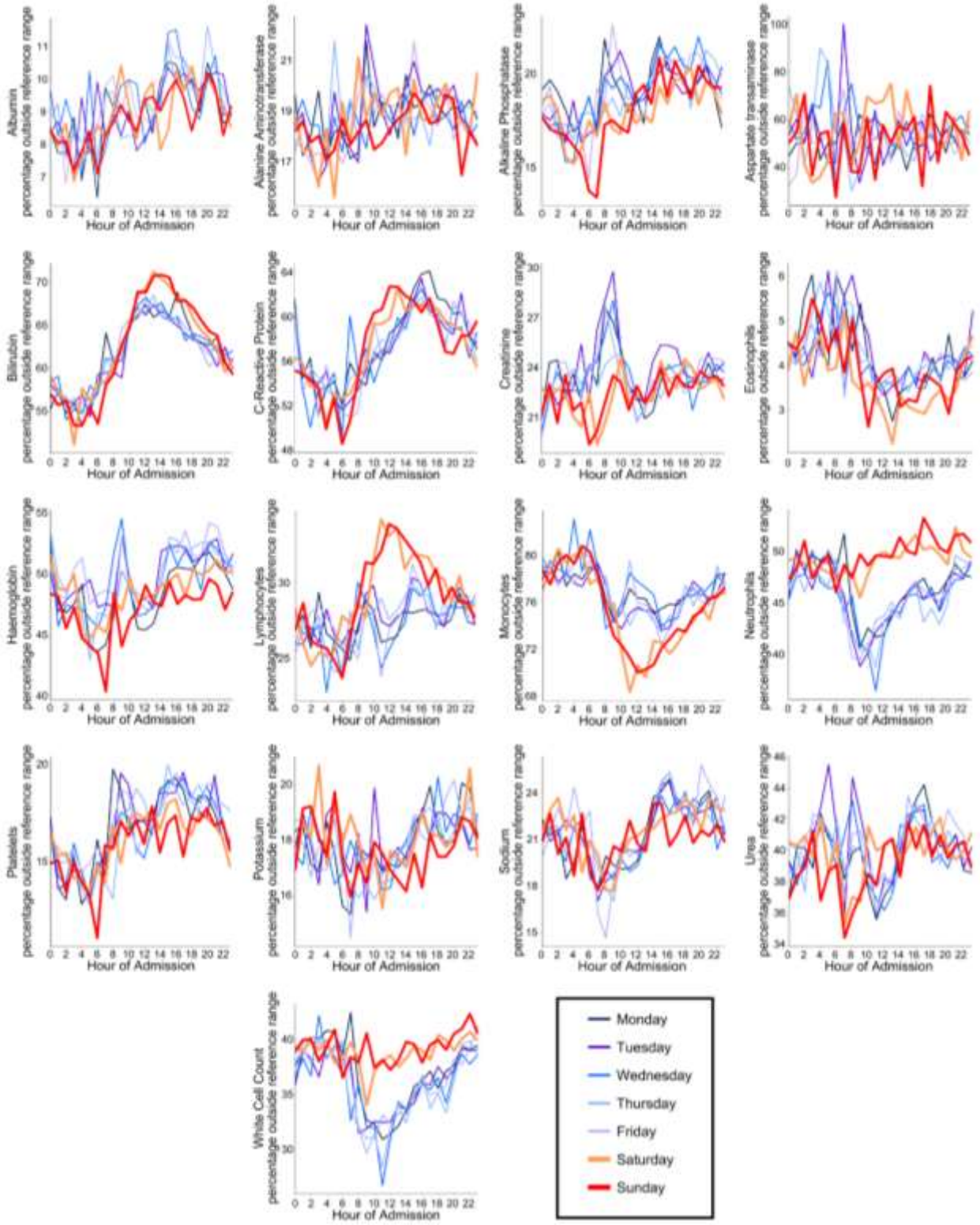
633 **Supplementary Figure 3: Median test results at admission**



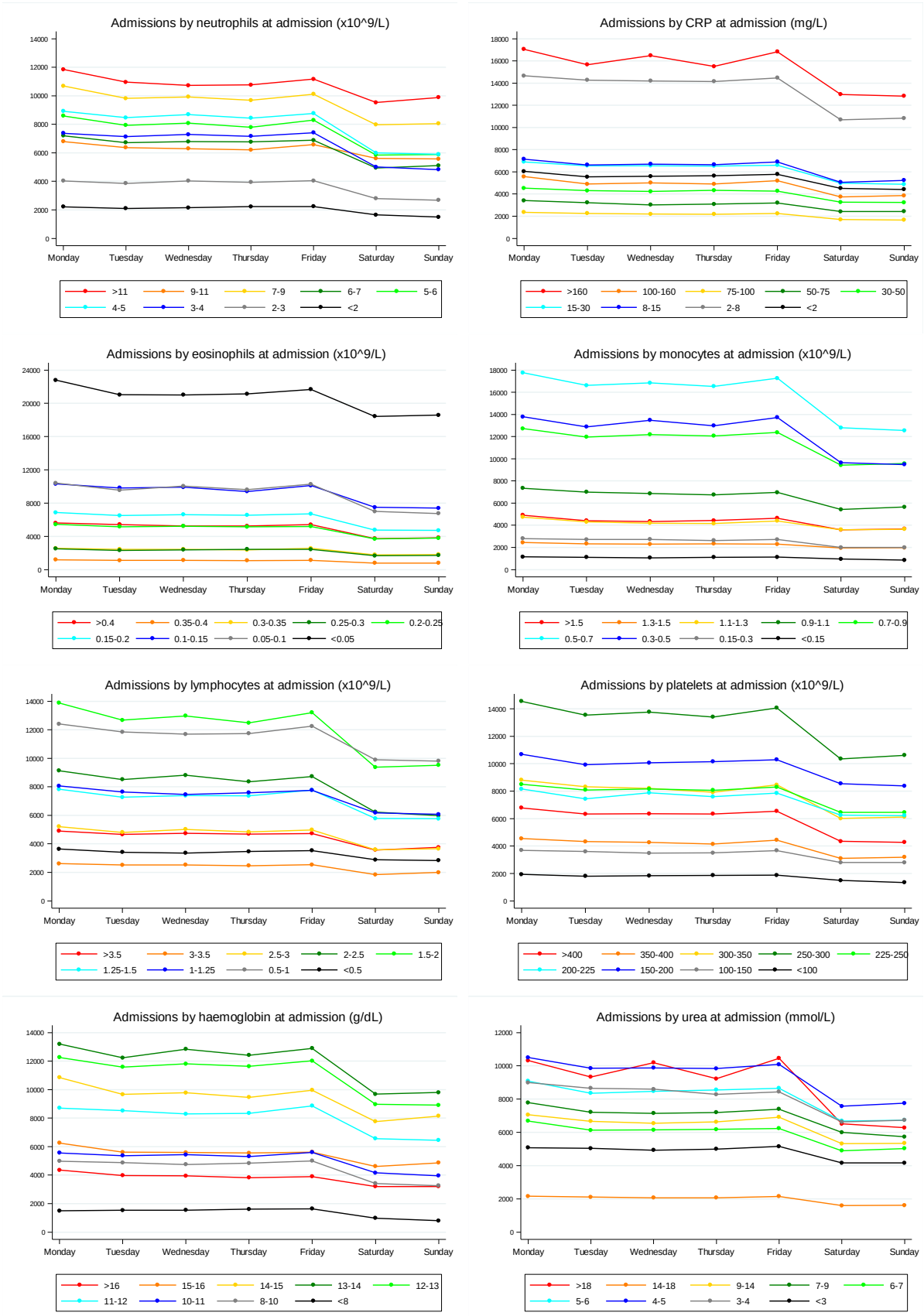
634

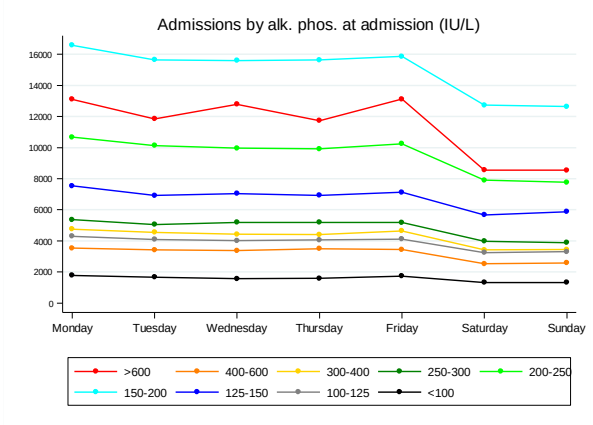
Supplementary Figure 4: Proportions of test results at admission outside normal ranges

Note: normal ranges shown on plots in Supplementary Figures 6-7



Supplementary Figure 5: Absolute number of admissions according to laboratory test results and day of the week



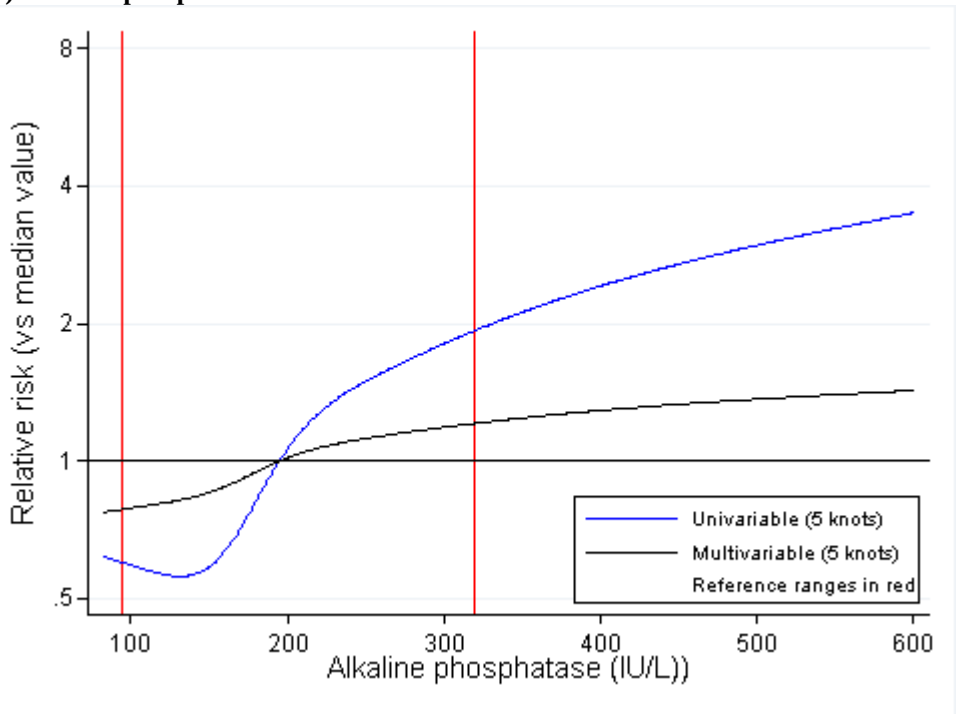

Admissions by alk. phos. at admission (IU/L)
16000
14000
12000
10000
8000
6000
4000
2000
0
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
>600
400-600
300-400
250-300
200-250
150-200
125-150
100-125
<100

641
642

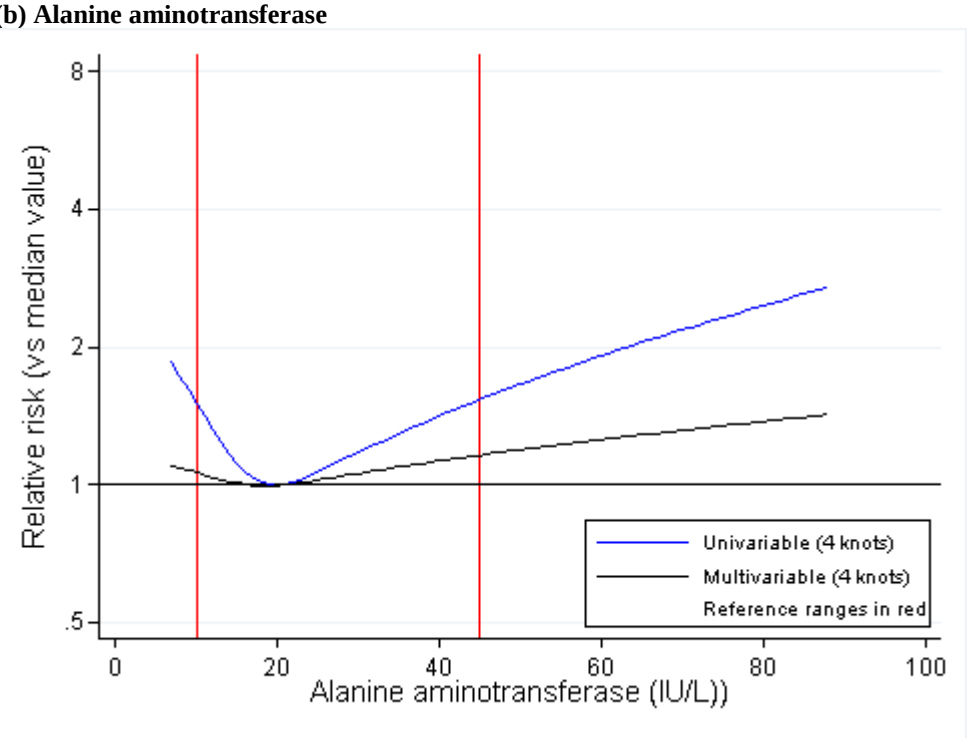
Supplementary Figure 6: Unadjusted and adjusted (model 'B') associations between haematology/biochemistry test results and 30-day mortality (for test results without interactions with other factors in model 'B') (N=271,465)

In all panels, red lines indicate reference ranges for laboratory test results. Risks are presented compared to an rounded value close to the median.

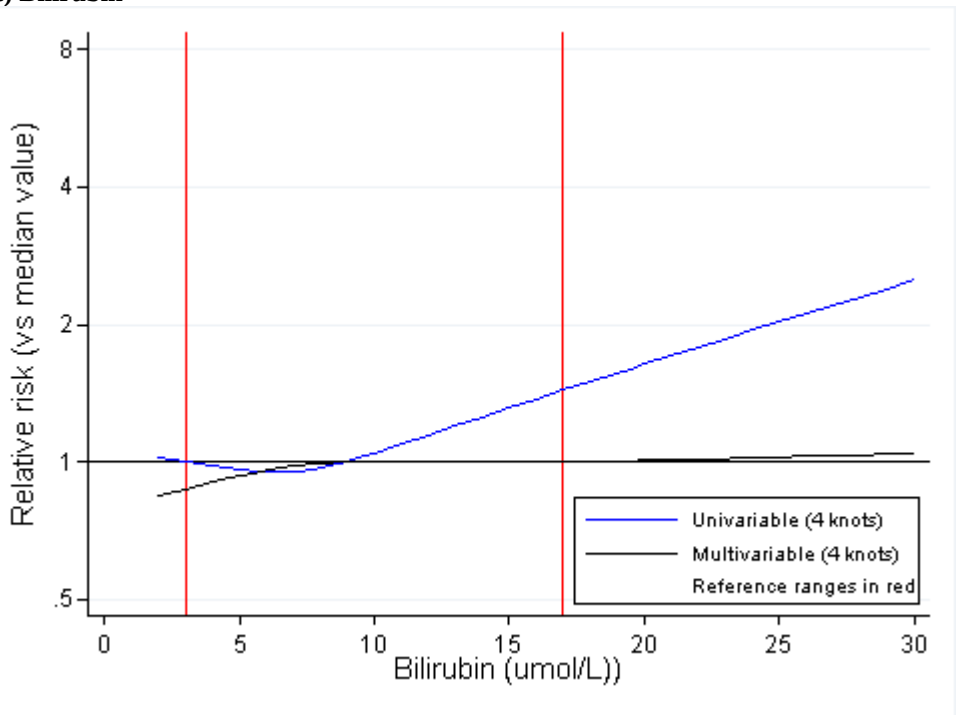
(a) Alkaline phosphatase



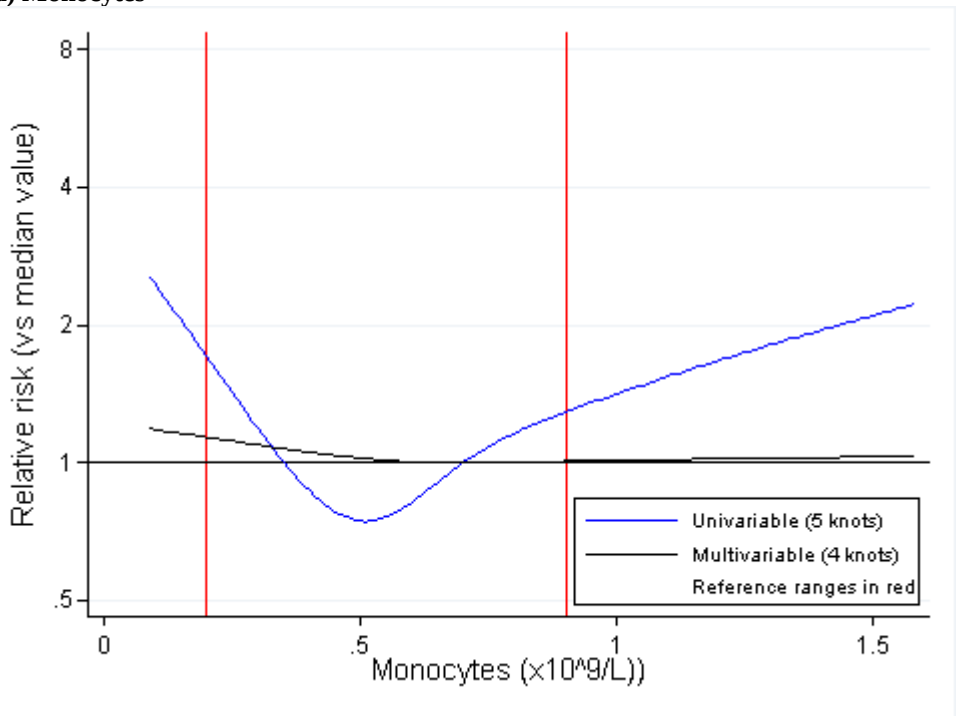
(b) Alanine aminotransferase



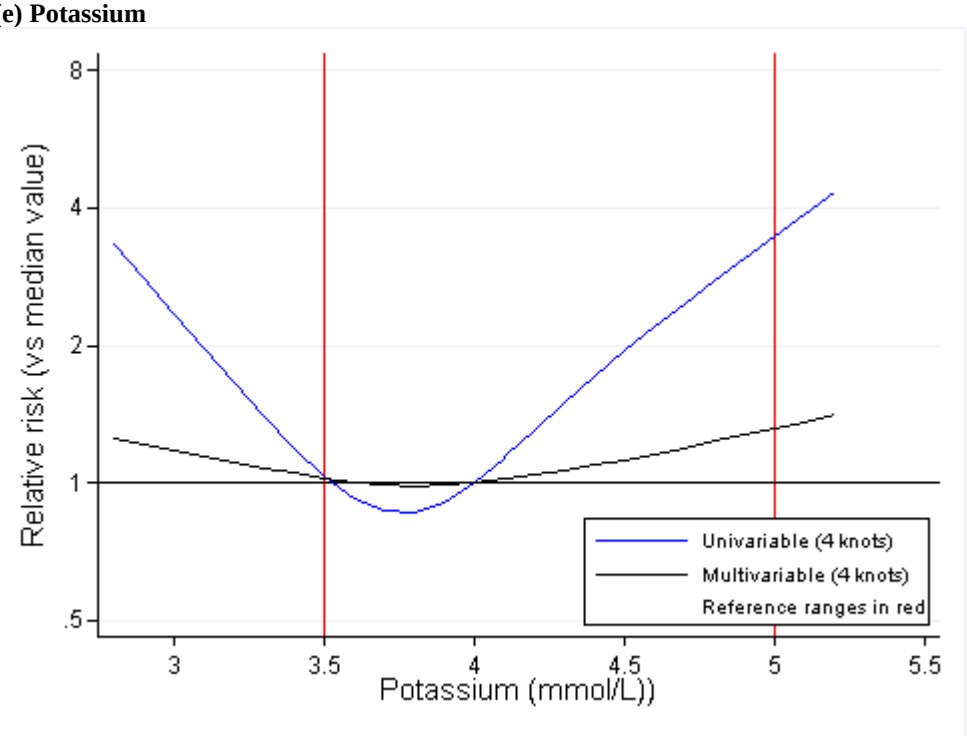
(c) Bilirubin



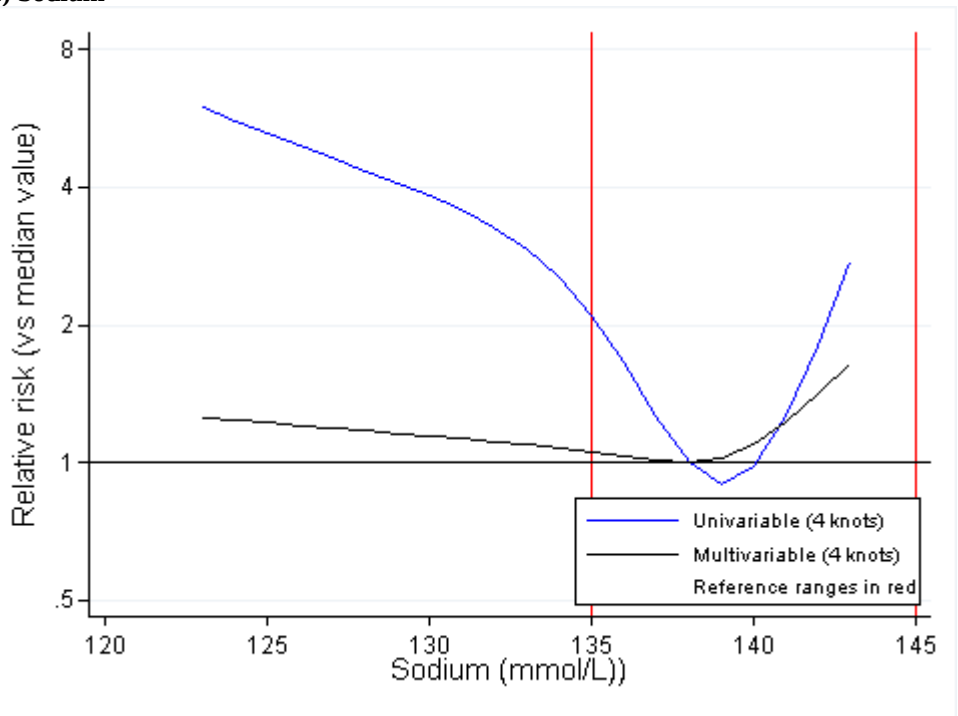
(d) Monocytes



(e) Potassium



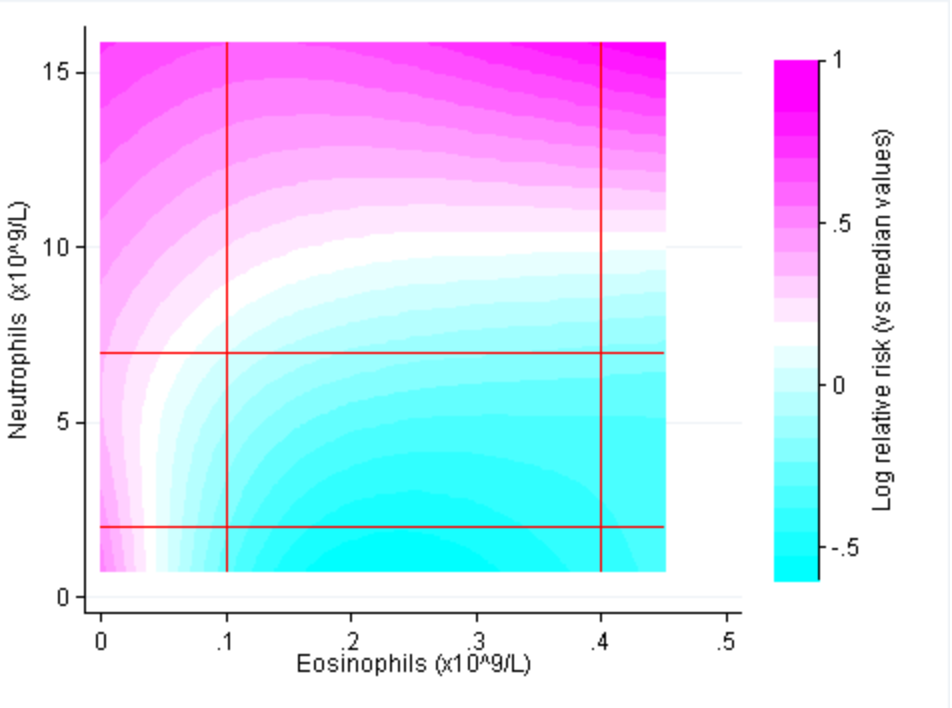
(f) Sodium



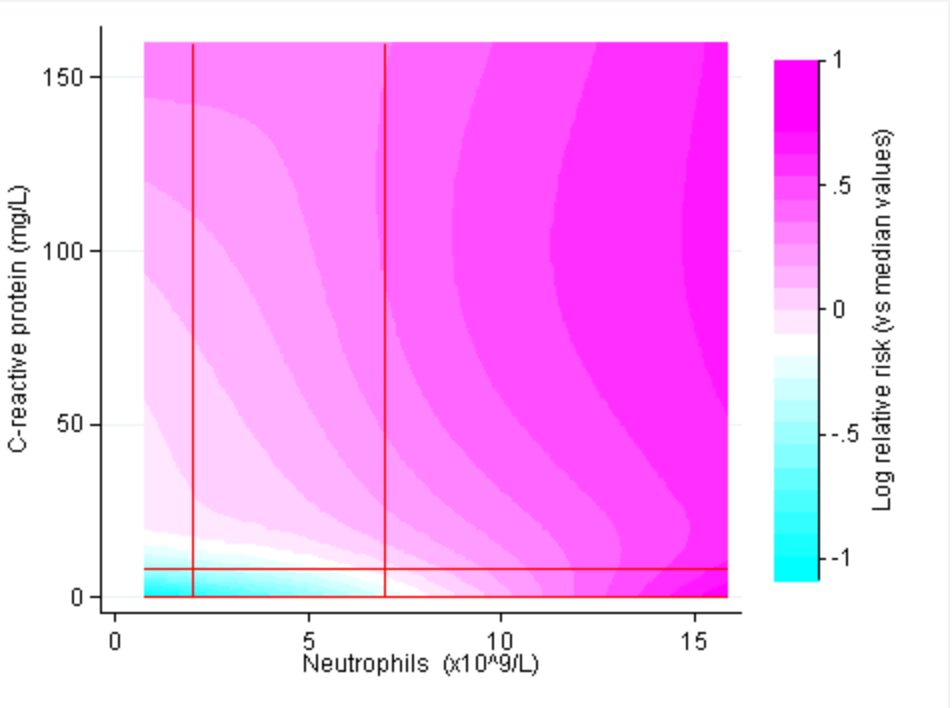
Supplementary Figure 7: Associations with 30-day mortality including interaction terms in model 'B' (N=271,465)

In all panels, red lines indicate reference ranges for laboratory test results. Interactions also in model 'A' similar.

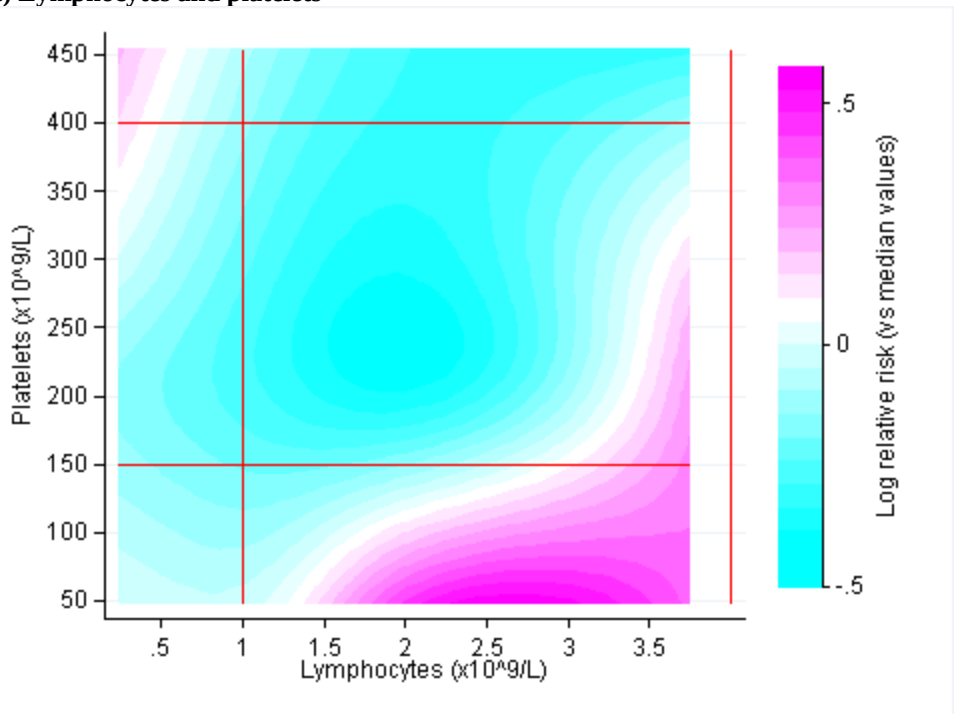
(a) Neutrophils and eosinophils



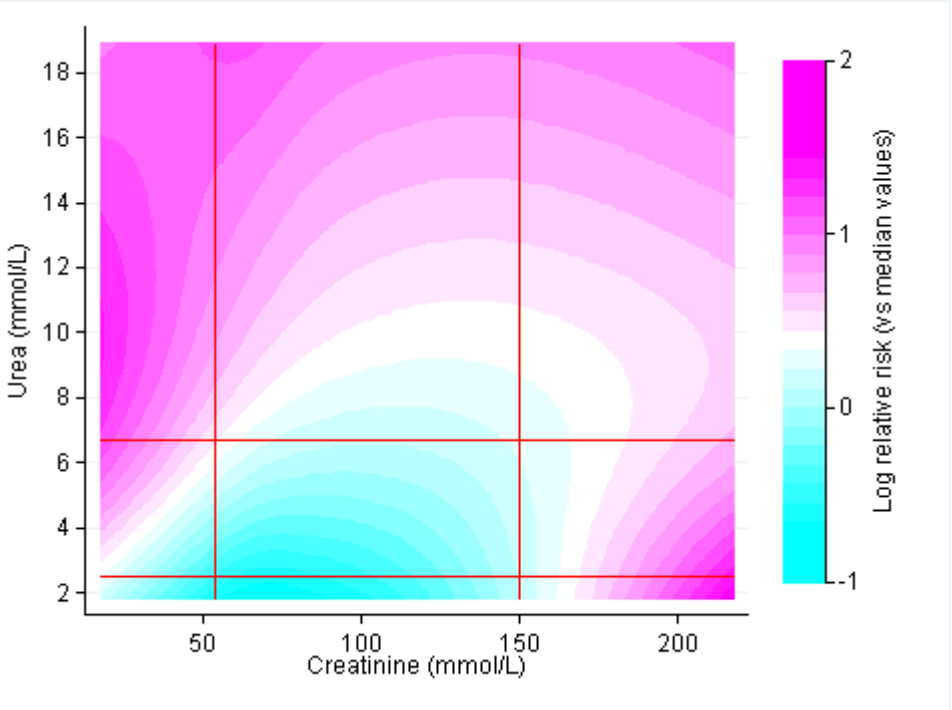
(b) Neutrophils and C-reactive protein



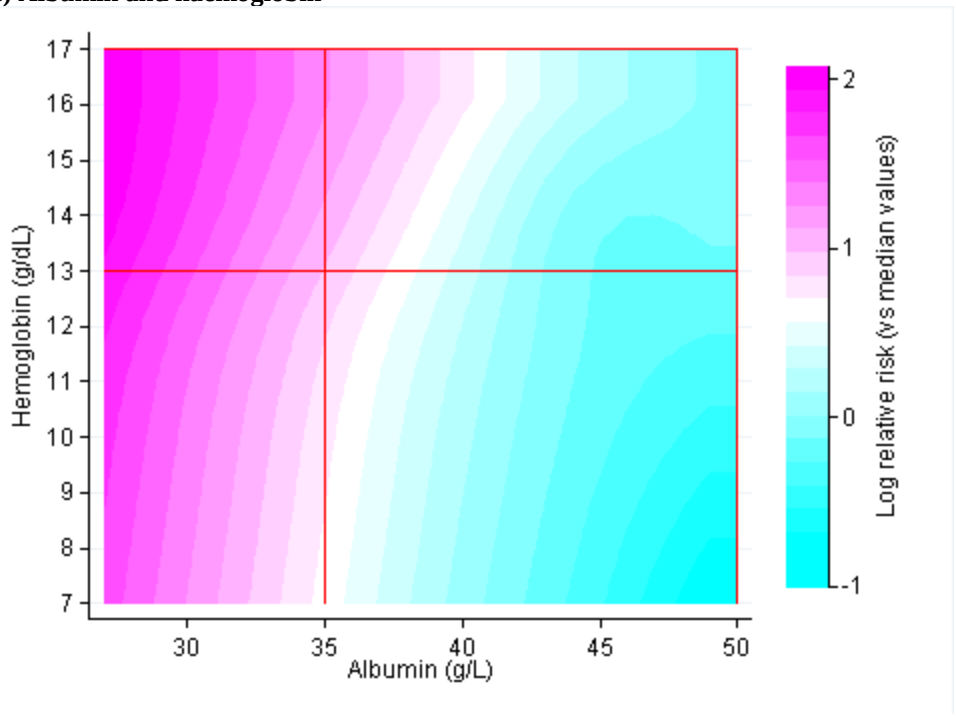
(c) Lymphocytes and platelets



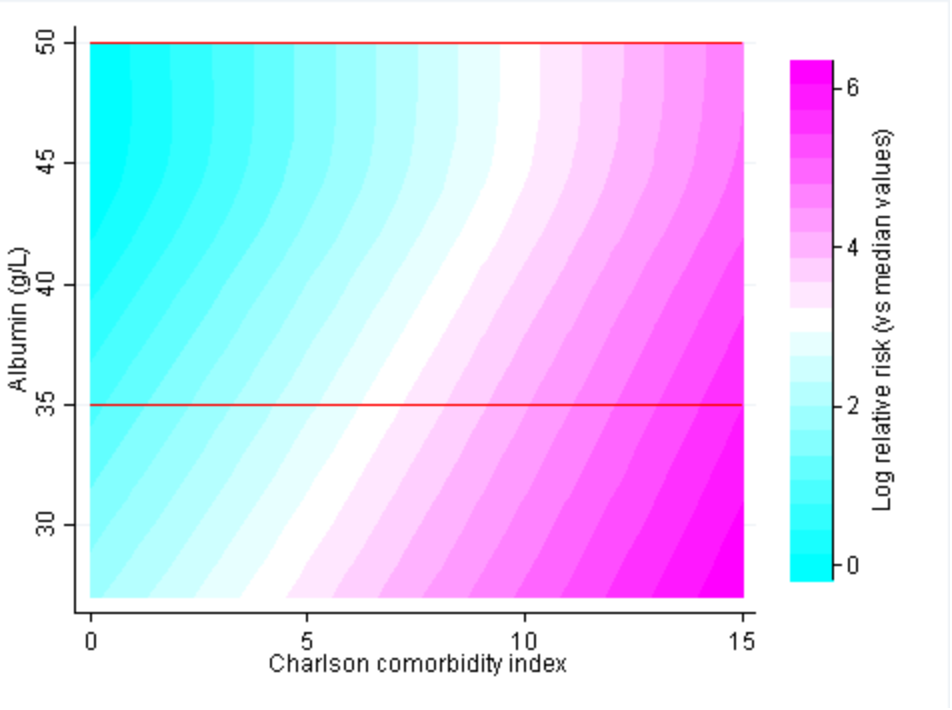
(d) Urea and creatinine



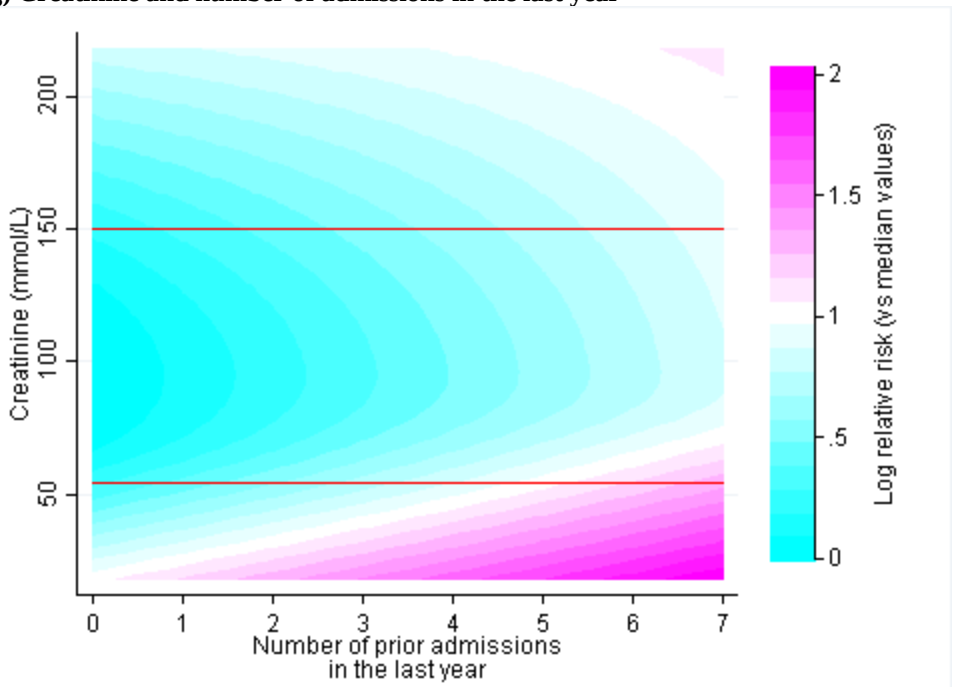
(e) Albumin and haemoglobin



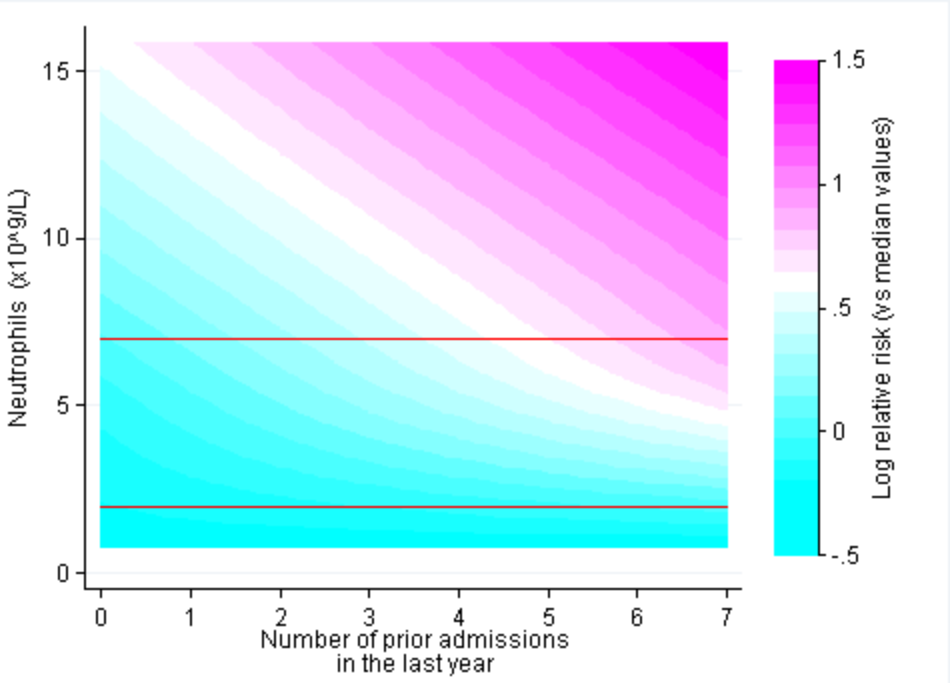
(f) Albumin and Charlson Comorbidity Index



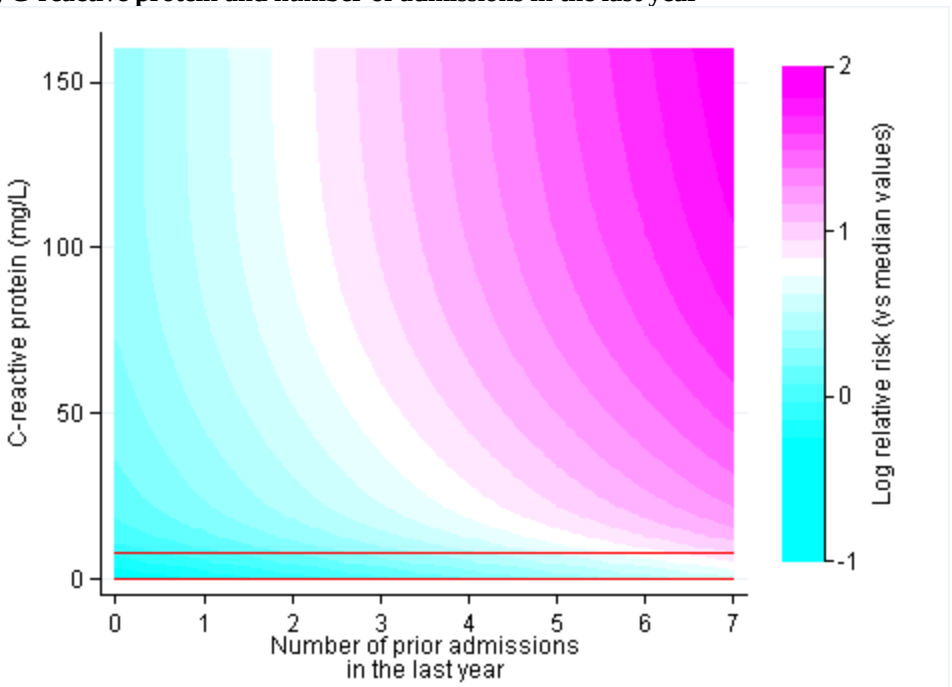
(g) Creatinine and number of admissions in the last year



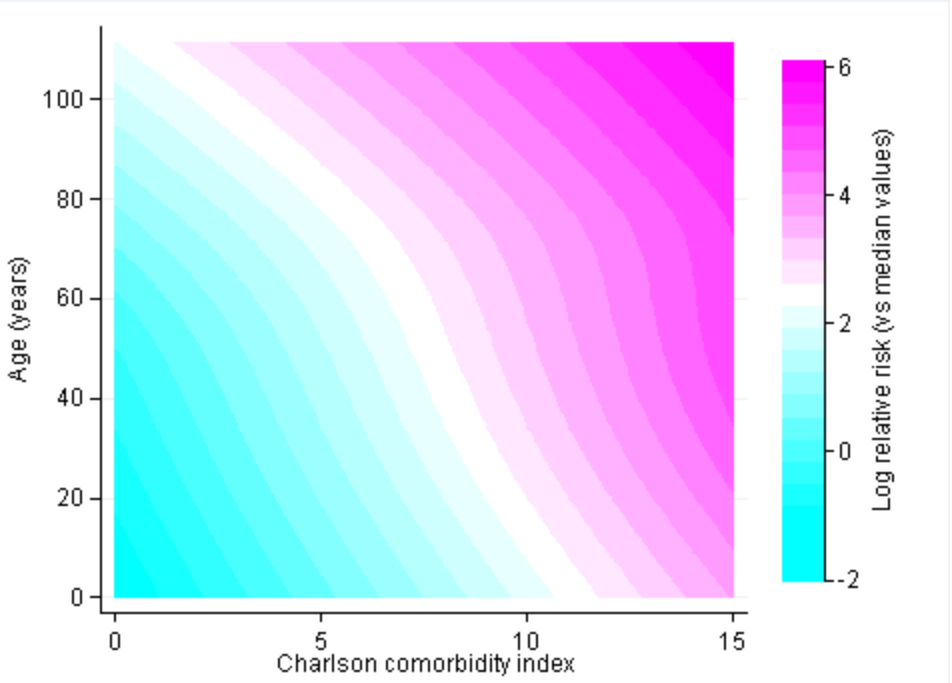
(h) Neutrophils and number of admissions in the last year



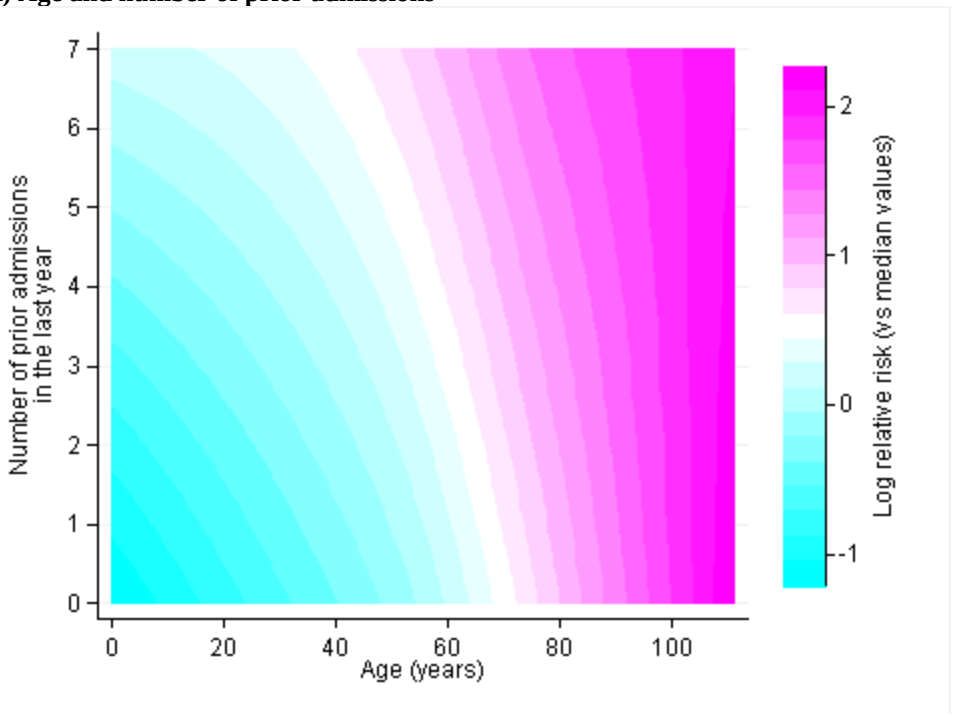
(i) C-reactive protein and number of admissions in the last year



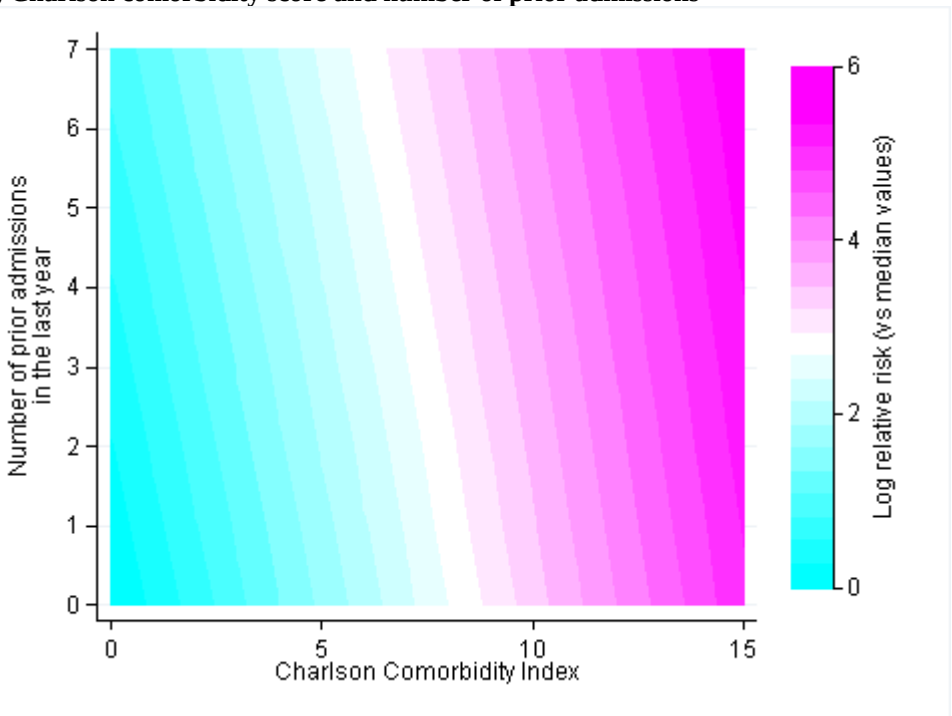
(j) Age and Charlson comorbidity index



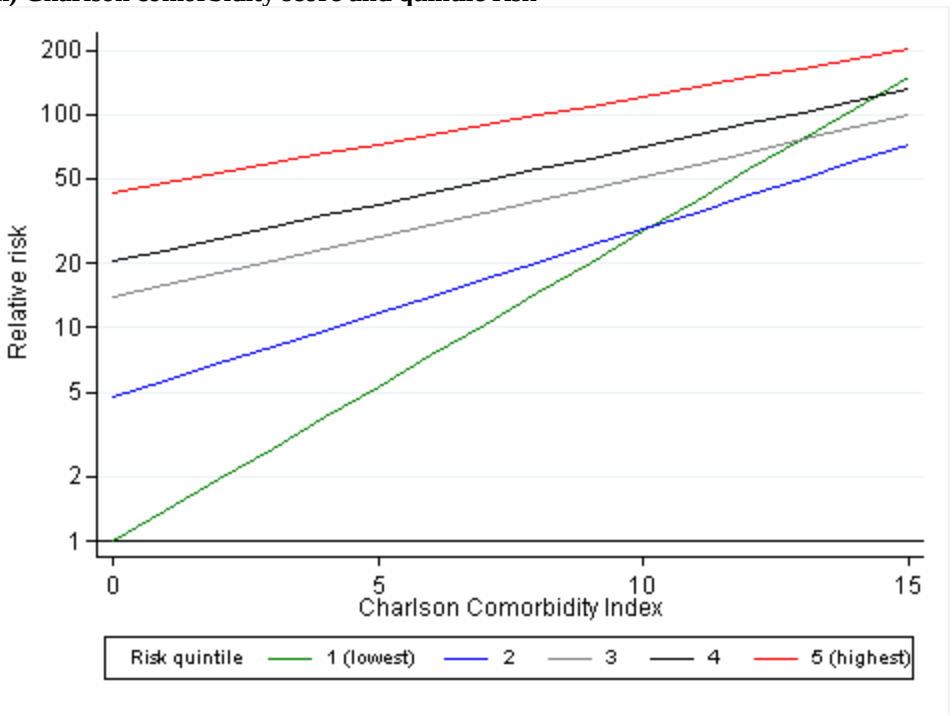
(k) Age and number of prior admissions



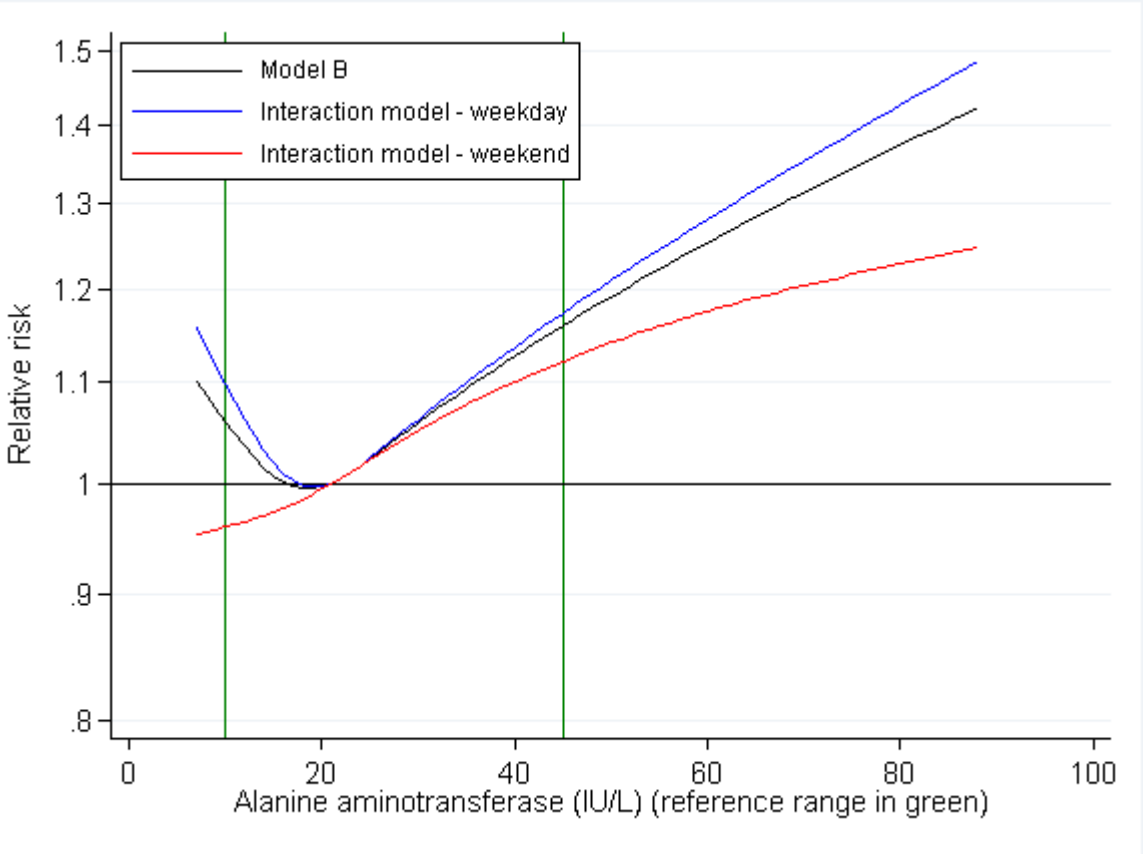
(l) Charlson comorbidity score and number of prior admissions



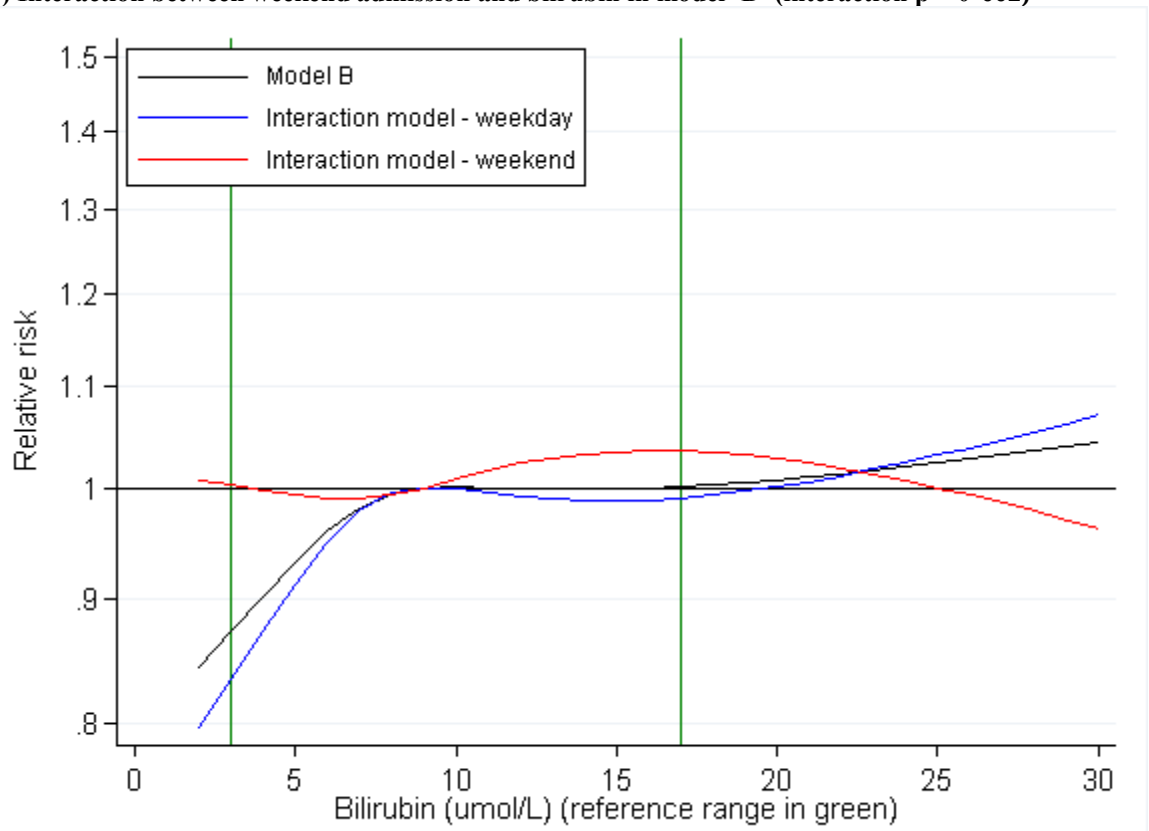
(m) Charlson comorbidity score and quintile risk



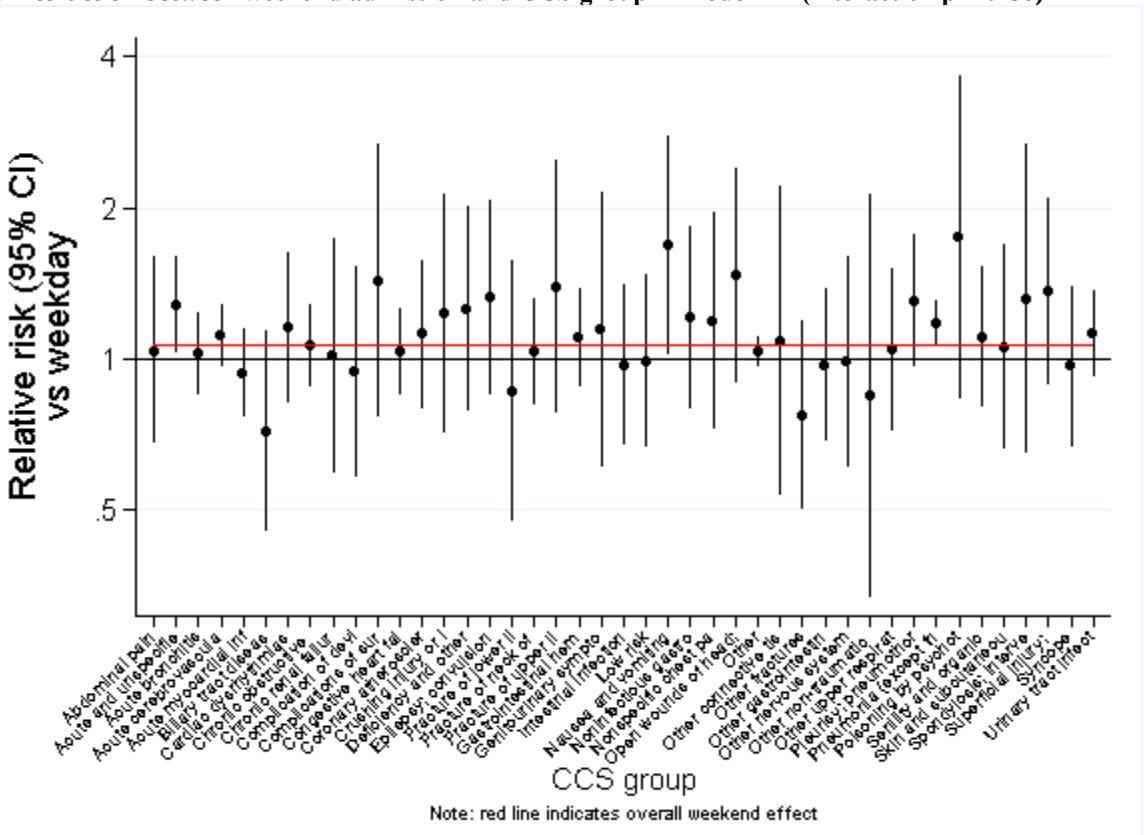
Supplementary Figure 8: Interactions between factors and weekend admission on effect on 30-day mortality in model 'B' (N=271,465)
(a) Interaction between weekend admission and alanine aminotransferase in model 'B' (interaction p = 0·004)



(b) Interaction between weekend admission and bilrubin in model 'B' (interaction p = 0·002)



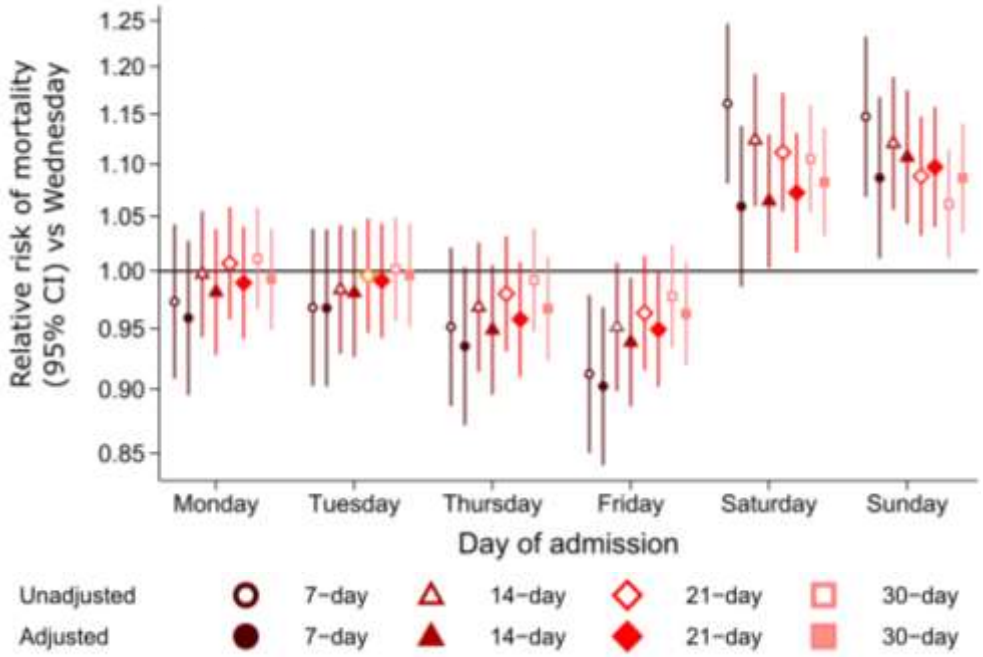
(c) Interaction between weekend admission and CCS group in model 'B' (interaction p = 0·86)



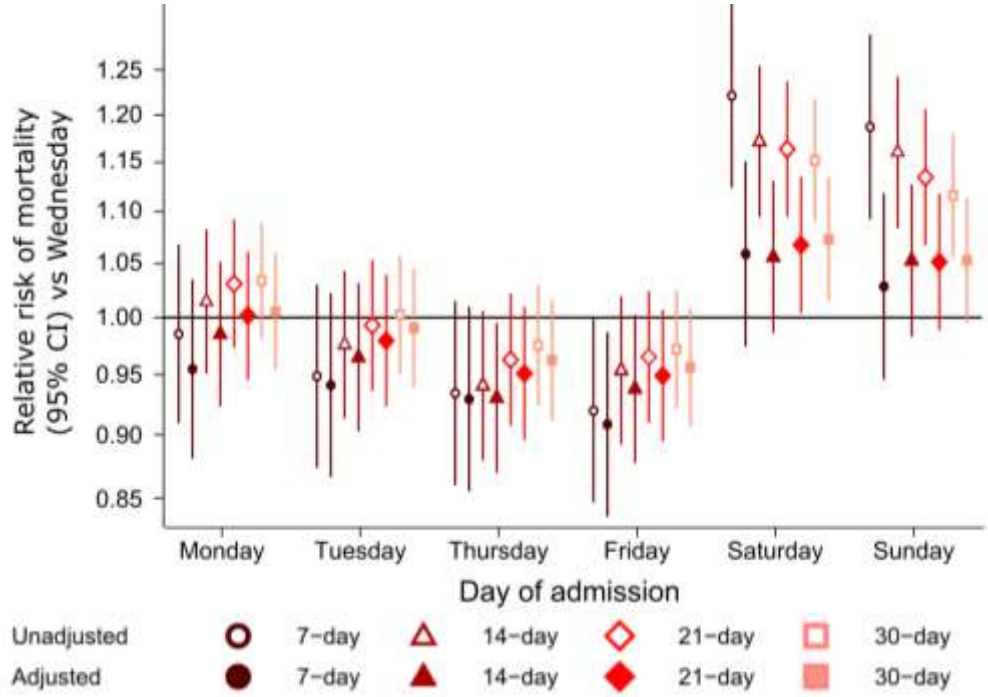
Red line indicates the relative risk of weekend to weekday in model 'B'.

Supplementary Figure 9: Risk of mortality 7-, 14-, 21- and 30-days after admission by day of admission

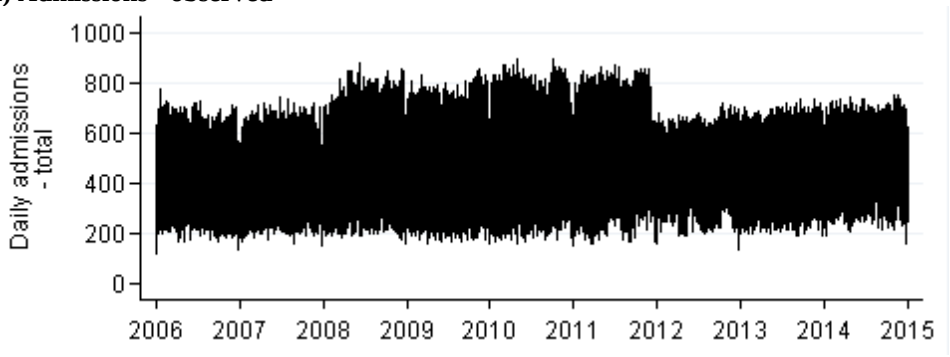
(a) Model 'A' (N=503,938)



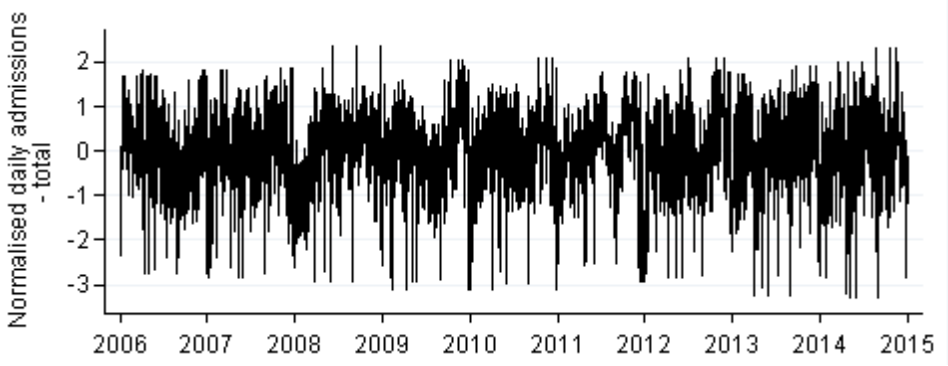
(b) Model 'B' (N=271,465)



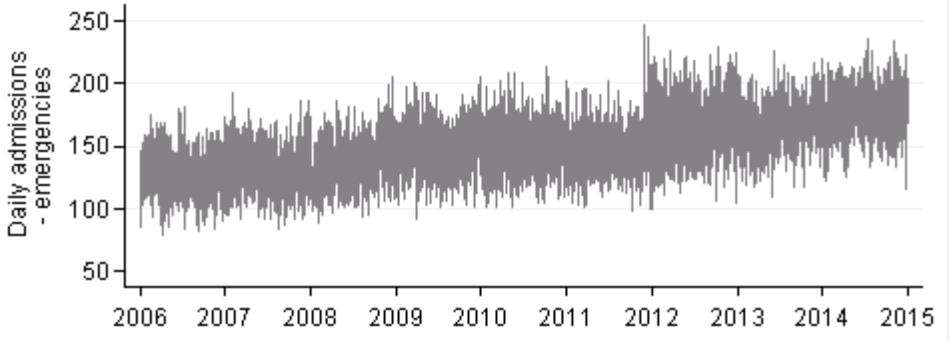
Supplementary Figure 10: Observed and normalised measures of hospital workload over time
Note: each measure is normalised to the trimmed mean (standard deviation) values for that day of the week and calendar year
(a) Admissions - observed



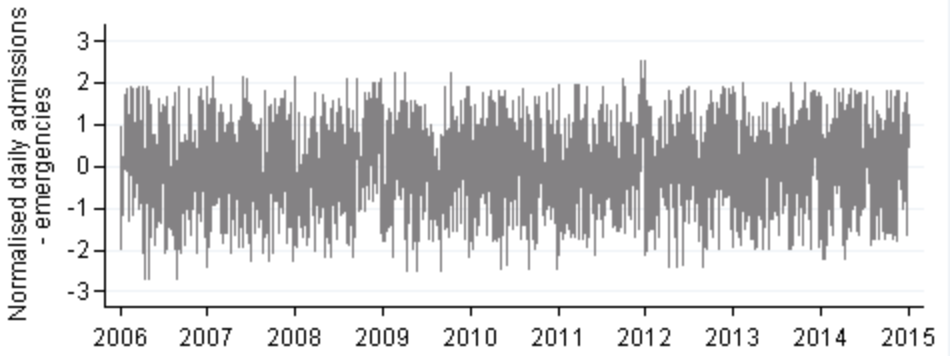
(b) Admissions – normalised



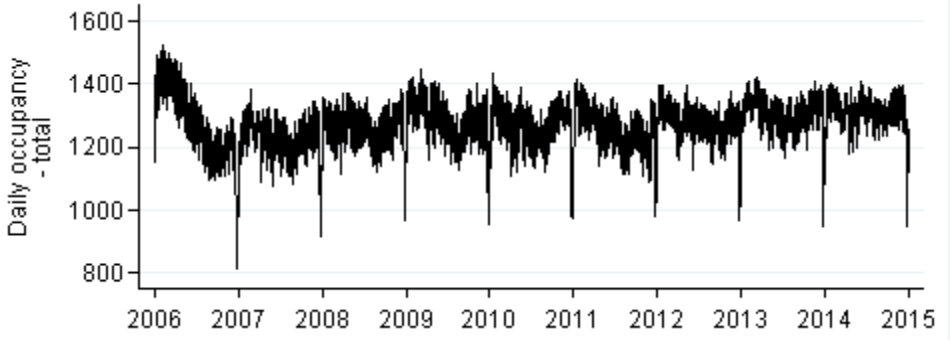
(c) Emergency admissions – observed



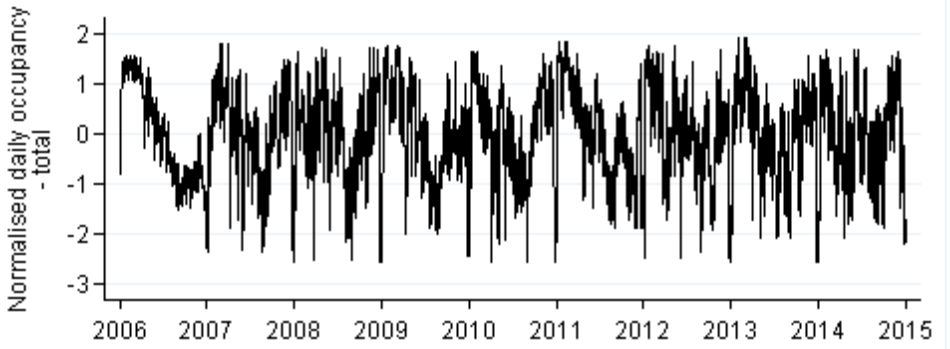
(d) Emergency admissions – normalised



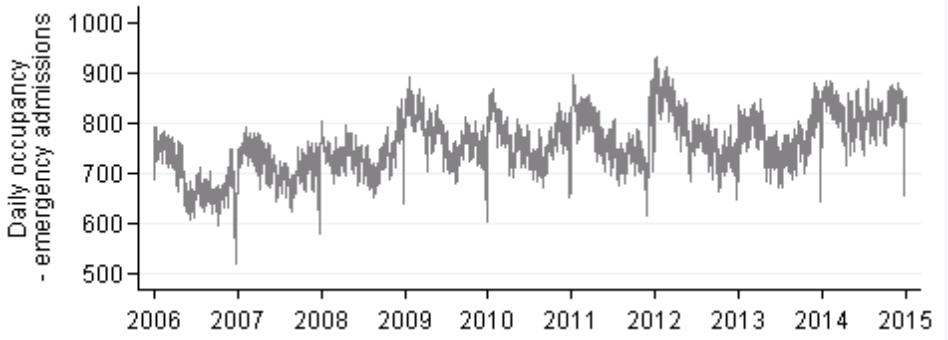
(e) Net admissions minus discharges – observed



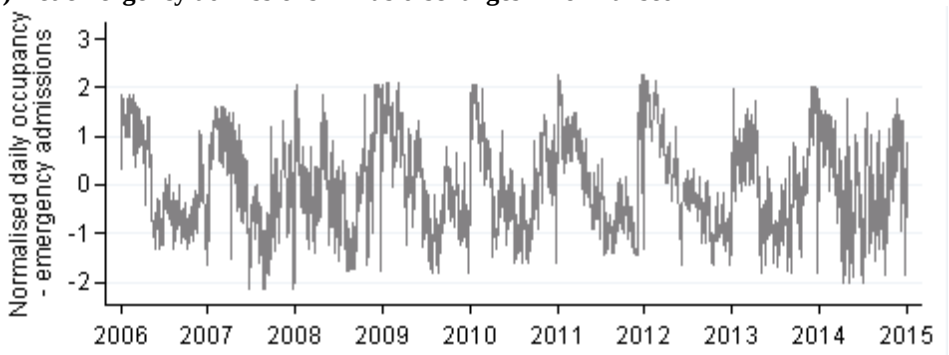
(f) Net admissions minus discharges – normalised



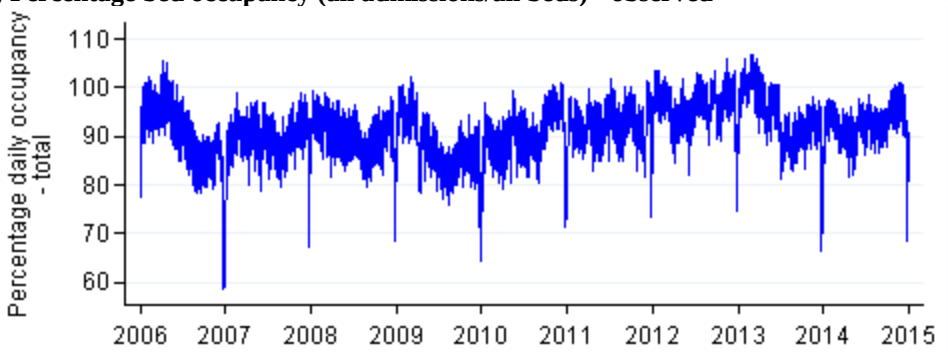
(g) Net emergency admissions minus discharges – observed



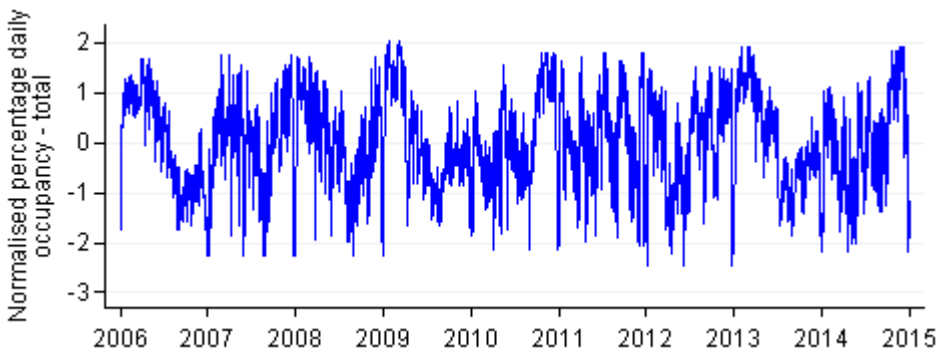
(h) Net emergency admissions minus discharges – normalised



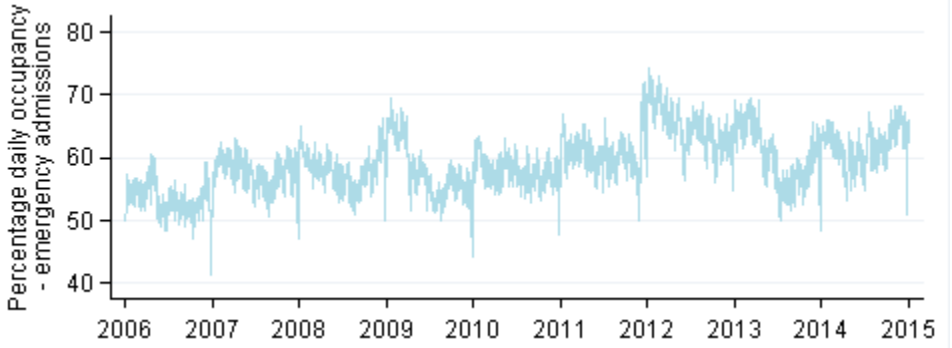
(i) Percentage bed occupancy (all admissions/all beds) - observed



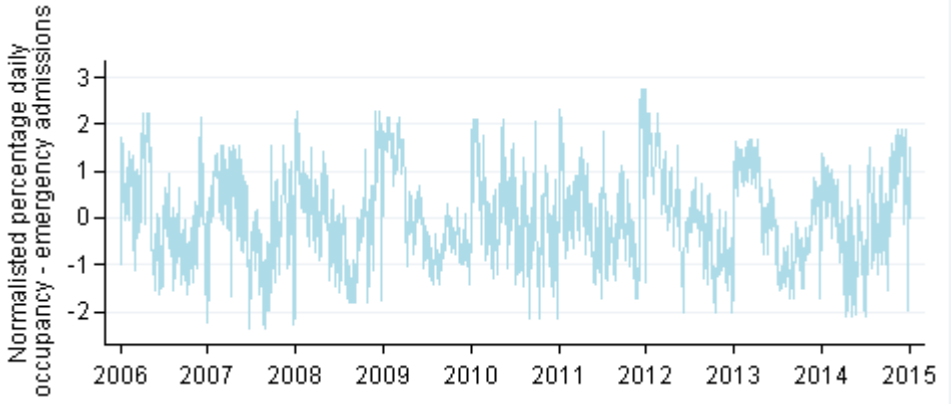
(j) Percentage bed occupancy (all admissions/all beds) - normalised



(k) Percentage emergency bed occupancy (emergency admissions/acute beds) - observed

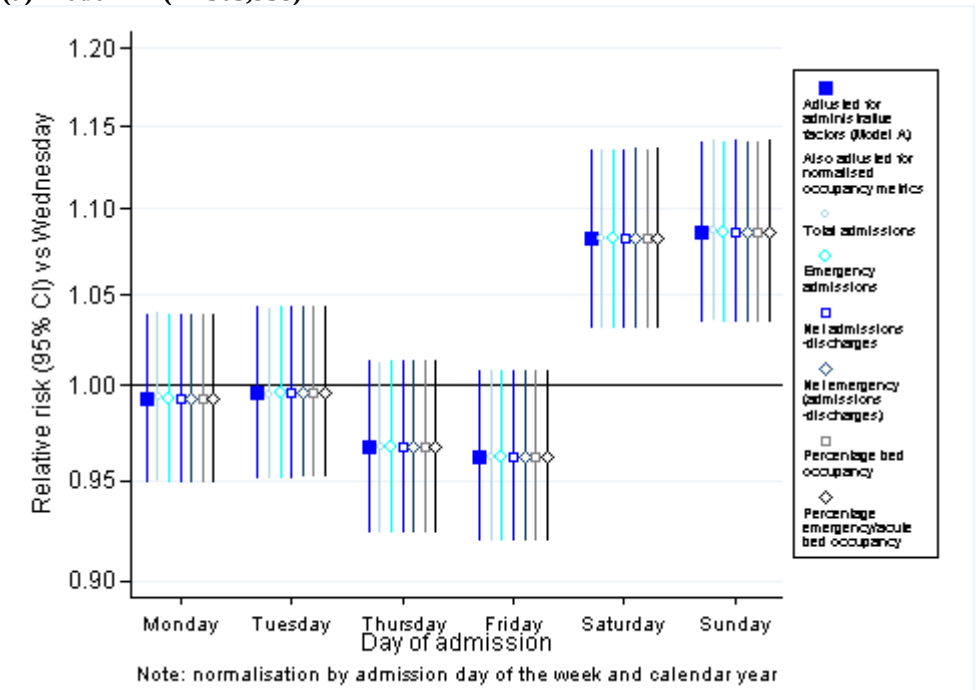


(l) Percentage emergency bed occupancy (emergency admissions/acute beds) – normalised

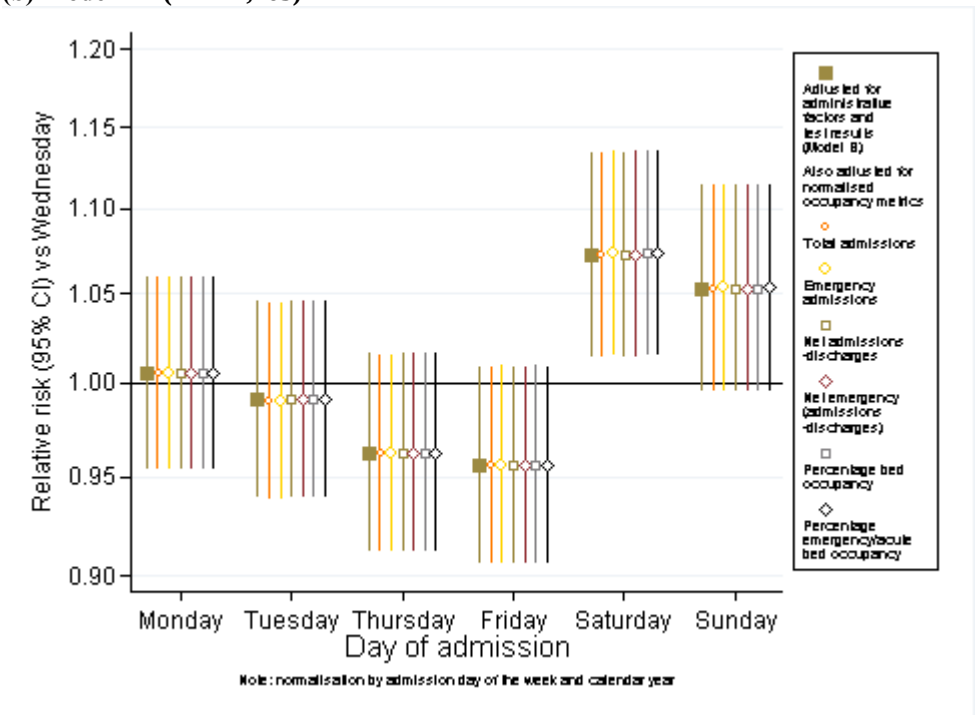


Supplementary Figure 11: Mortality risk associated with day of admission with and without adjustment for normalised measures of hospital workload

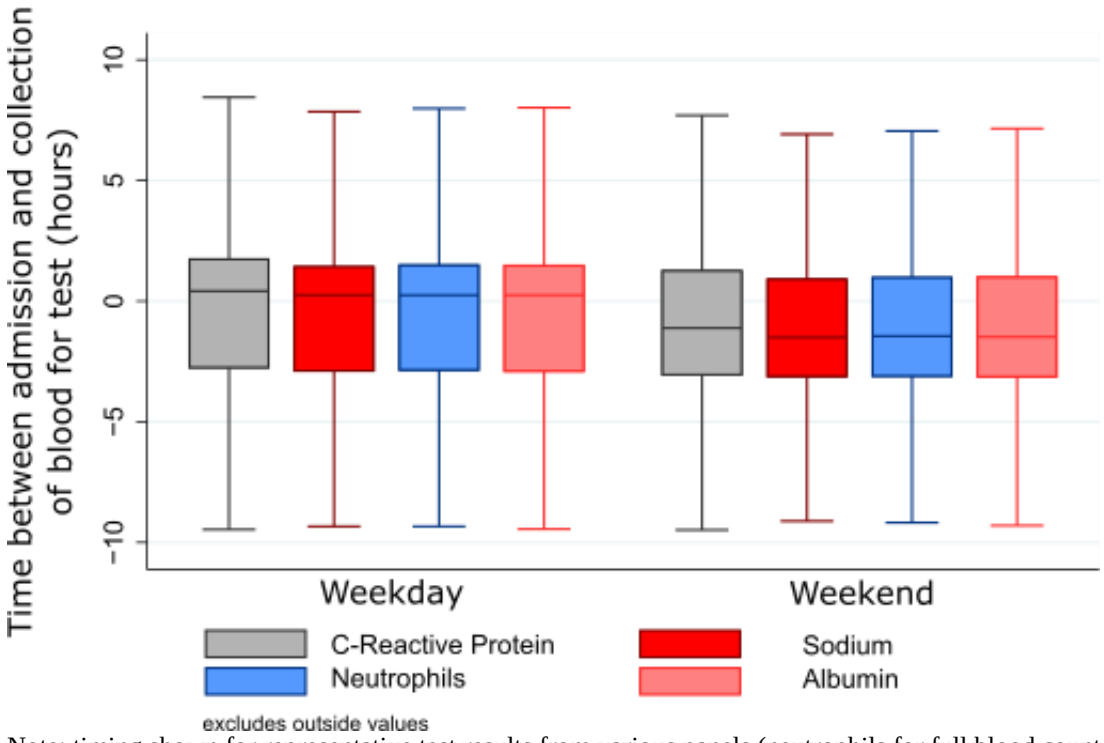
(a) Model 'A' (N=503,938)



(b) Model 'B' (N=271,465)

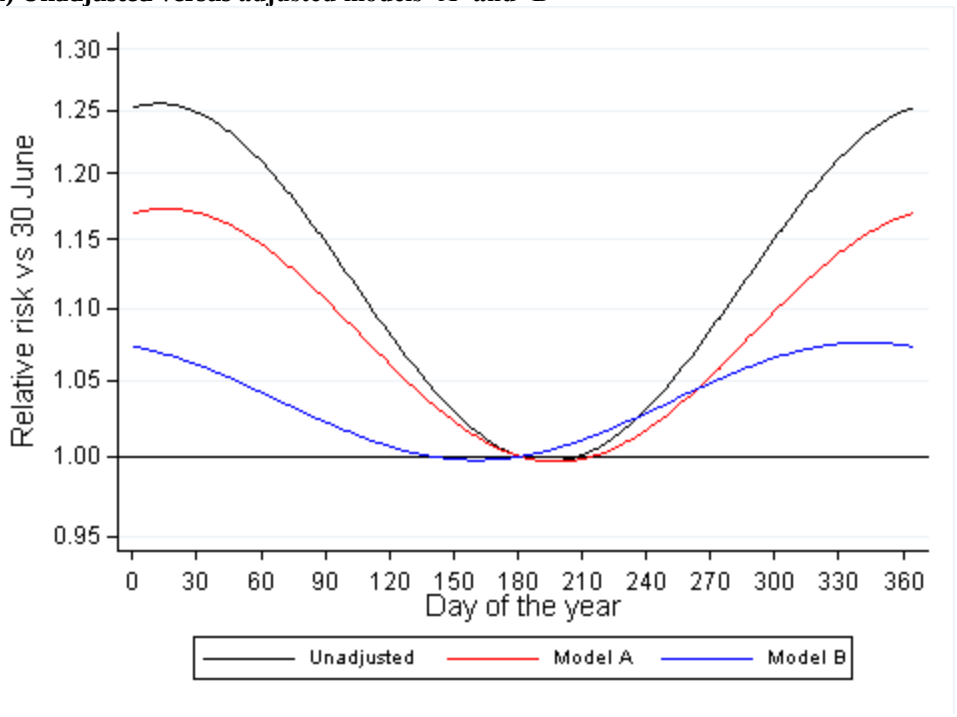


Supplementary Figure 12: Difference between time of admission and time of blood test collection

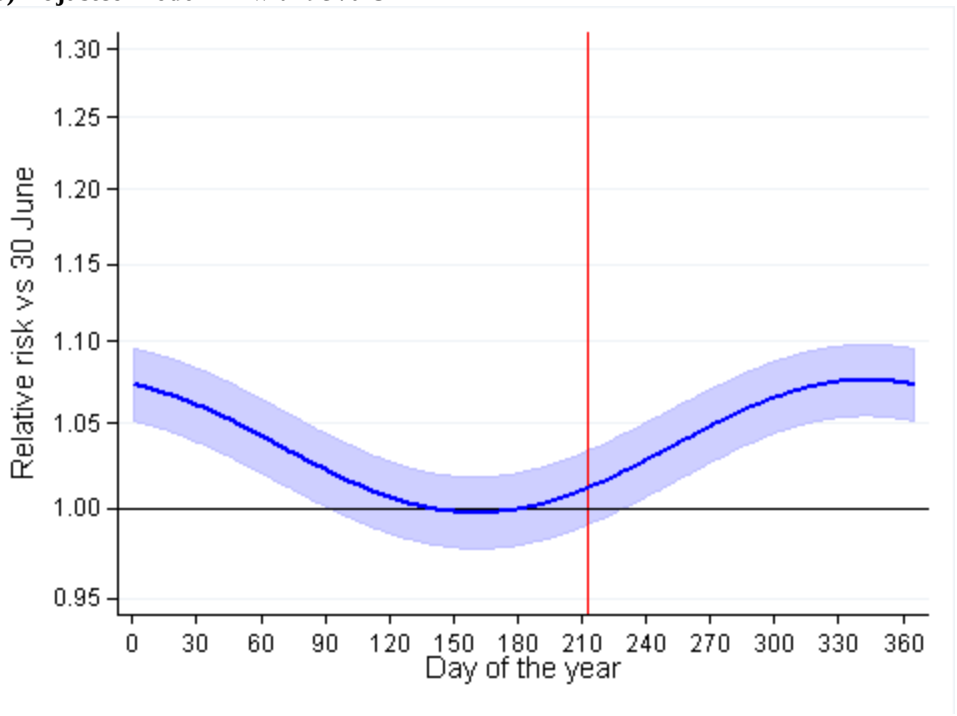


Note: timing shown for representative test results from various panels (neutrophils for full blood count, sodium for electrolytes, albumin for biochemistry)

Supplementary Figure 13: Association between day of the year and 30-day mortality
(a) Unadjusted versus adjusted models 'A' and 'B'

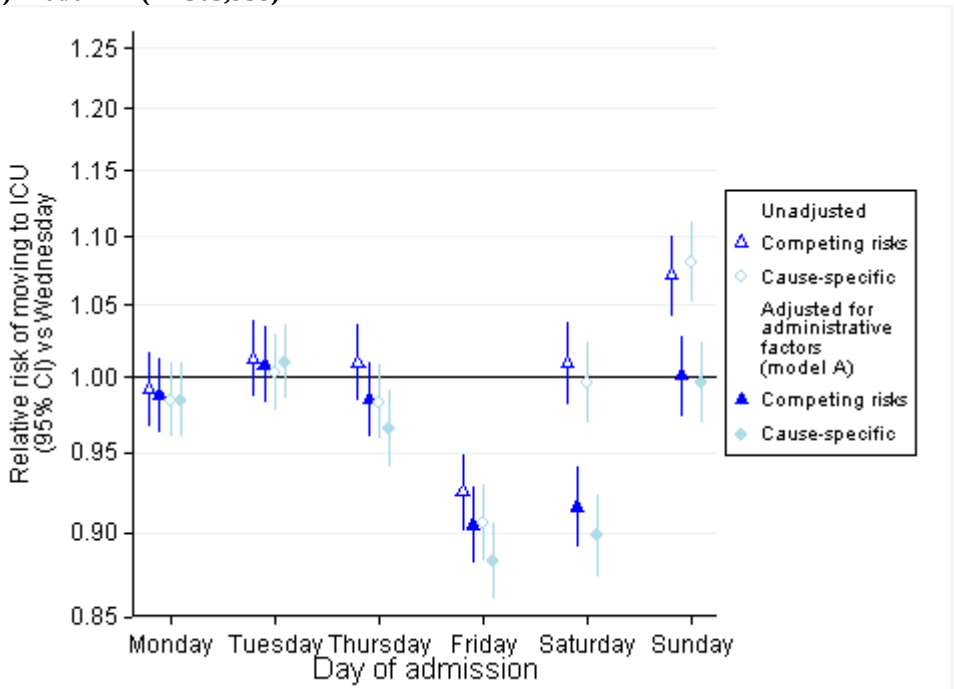


(b) Adjusted model 'B' with 95% CI

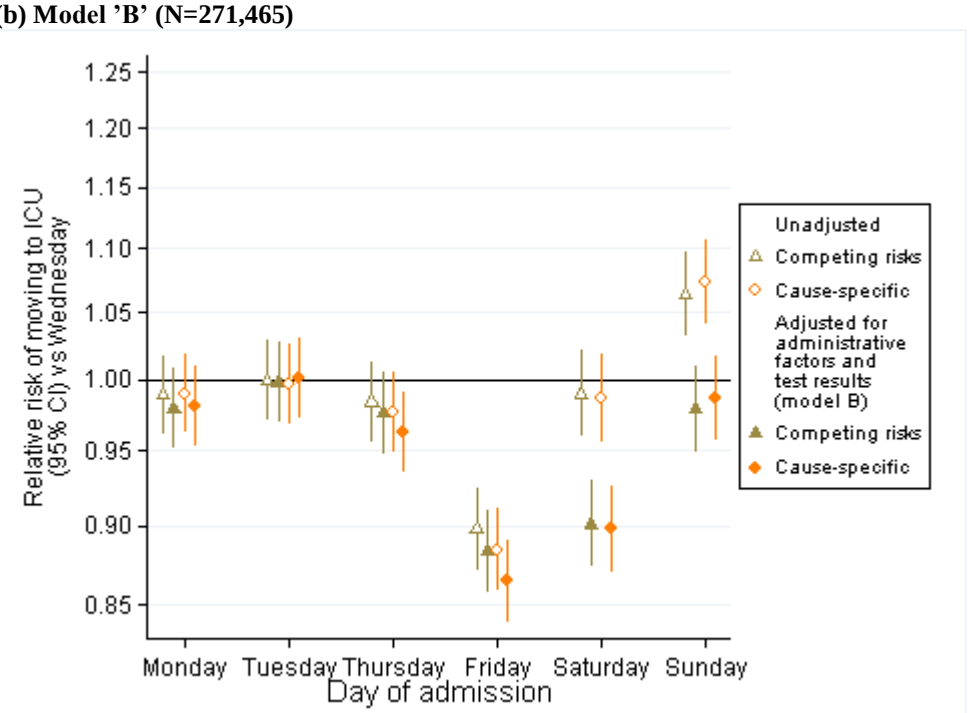


Supplementary Figure 14: Risk of moving to a second consultant by day of admission

(a) Model 'A' (N=503,938)

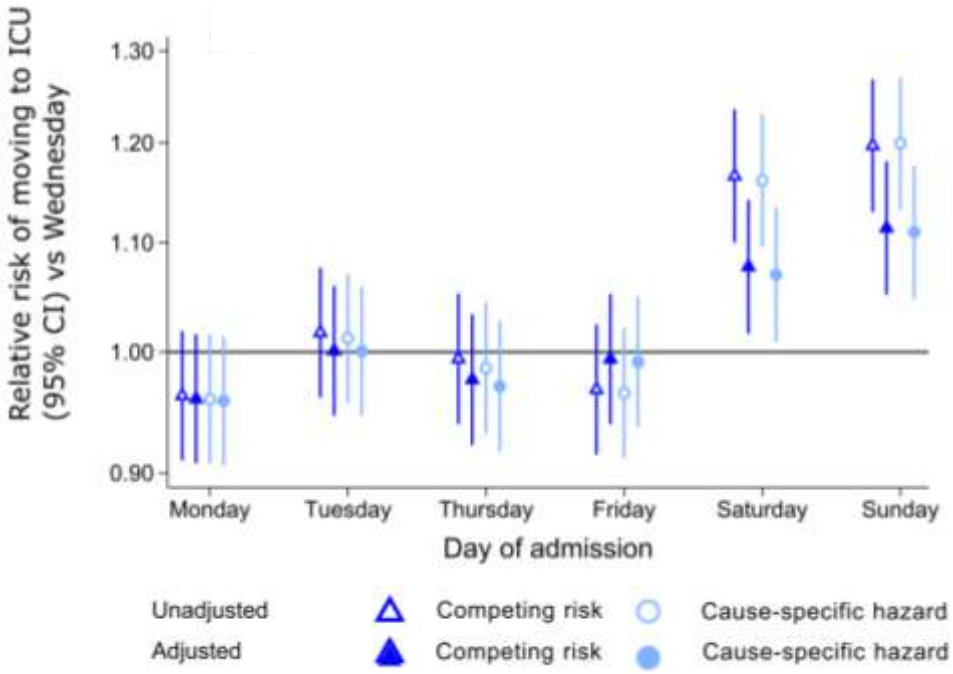


(b) Model 'B' (N=271,465)



Supplementary Figure 15: Risk of moving to ICU by day of admission

(a) Model 'A' (N=503,938)



(b) Model 'B' (N=271,465)