Increased mortality associated with week-end hospital admission: a case for expanded seven-day services?

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Introduction

Any modern, effective health care system should prevent premature deaths from treatable causes, improve quality of life for people with long-term conditions, aid recovery from acute conditions and ensure safe care, whilst achieving as positive an experience for patients as reasonably possible. Intuitively, reduced provision of healthcare at weekends has an adverse impact on all of these domains. Defining the relationship between service organisation across the week and excess mortality cannot readily be addressed using a randomised controlled design, so the evidence base for healthcare service design relies necessarily on an observational approach. Our previous study of all NHS England hospital admissions during the financial year 2009-10, indicated that admission at the weekend (Saturday and Sunday) was associated with a significantly increased risk of in-hospital death when compared to mid-week, but being in hospital at the weekend was associated with reduced risk of death.[1] These findings were replicated in an analysis of 254 leading hospitals in the US.[1]

Because 6 years have elapsed since our last assessment of weekend mortality [1] we have updated our analysis using data from NHS English hospitals and related deaths in 2013/2014. The methods are identical apart from incremental improvements in modelling strategy which are described below. The original analysis was built on our previous work developing the QUORUM metric for comparing hospital mortality rates,[2]. This metric identified that the risk of death is highly predictable in NHS admissions.

The three main objectives of the current analysis were to: 1) characterise the patient population admitted at weekend; 2) address whether or not, following robust case-mix adjustment, weekend admission carries an increased 30-day mortality risk compared to mid-week; 3) estimate whether there is a difference in mortality risk between hospital stay at weekends and during the week days.

In this paper we discuss the main findings of our updated analysis, their potential interpretation and implications for service design.

Survivorship Models to Address Weekend Effects

We applied our previously developed survivorship models,[1] which accounted separately for day of admission and day of the week of hospital stay, following patients for the first 30 days after admission. These analyses used a time-dependent covariate to estimate the effect of day of the week of hospital stay, identifying the day of the week for each death as it occurred and the corresponding day of the week for each patient still alive and in follow up. We utilised very similar case mix adjustment to our previous analyses [1] albeit with some incremental advances due to the developments in the Hospital Episode Statistic (HES) data set and methodological developments in the area - for example in the grouping of diagnostic categories where we applied the Summary Hospital Mortality Index (SHMI) approach which achieves greater statistical efficiency.[3]

One change of note was that we adopted time to death either in or out of hospital as our principal outcome as this is not subject to bias, with time to in-hospital death relegated to a secondary outcome, as the latter is somewhat biased by informative censorship.

Full description of our methods has been previously published,[1] and we include only a brief synopsis here. Case mix adjustment included Diagnosis (SHMI [3] Grouped CCS category); Age; Position in the year; Trust; Deprivation; number of previous emergency admissions; number of previous complex admissions; admission source; admission urgency; gender; ethnicity; Charlson Comorbidity Index. Age, and position in the year were accounted for as non-linear predictors using restricted cubic splines.[4]. These explanatory variables collectively had a C-statistic of 0.92 when used to predict mortality.

The principal analysis included 14818374 admissions and 280788 deaths for the year 2013-2014. Only 6.6% of all admissions in the period had to be excluded because of missing data where at least one of the case-mix items was missing, highlighting the high percentage of data completeness.

Principal Analysis Results

Characteristics of patients admitted

The number of patients admitted to hospital during the working week (Mon – Fri) averaged 2.7m per day, while 1.2m patients were admitted on Saturday and 1m patients were admitted on a Sunday. This translates to 17% of all admissions per day during the week, 8% on Saturday and 6% on Sunday. A

higher proportion of patients were admitted to hospital as emergencies on Saturday (635020/1261085; 50%) and Sunday (621356/952375; 65%) than weekdays (3951971/13646048; 29%).

The cohort admitted at weekend included a greater prevalence of patients with higher predicted mortality risk than those admitted during the week according to our case-adjustment (Figure 1). This was derived from a survival model which included all our identified risk factors except day of admission and day of death, and dividing the patients into five strata (quintiles) by predicted risk of death. For patients admitted on Saturday, 24.6% were in the highest risk quintile (without a weekend effect we would expect 20%), which carries a predicted 30-day mortality of 7.88%, and for Sunday admissions 29.2% were in the highest risk quintile. By contrast, for admissions on weekdays, fewer than 20% were in the highest risk quintile. The 30 day mortality for all admission was 1.8% (292277/15859508), 57% of deaths (166360) occurred in-hospital.

Risks Associated With Day of Admission and Hospital Stay

The analysis based on day of admission, showed that the relative risk of 30-day mortality compared with Wednesday was increased by 2% for admission on a Friday, 10% for admission on Saturday, 15% for admissions on a Sunday and 5% for admission on a Monday (Figure 2a).

With regards to the risk of death on specific days of the week, having accounted for case mix and day of admission (Figure 2b), Friday and

Saturday were modestly statistically different from Wednesday, with Friday associated with a 2% increase in the relative risk of death compared with Wednesday, and Saturday associated with a 2% reduction in the relative risk of death compared to Wednesday. These findings were qualitatively similar but not identical to the corresponding results from our previous analyses of 2009/10 data.[1]

The cause of death by day of the week on which death occurred was broadly similar by day, and is described in Table 1. There was also no qualitatively important difference in mortality by age through the week.

Censoring Early Deaths

As a greater proportion of patients are in the highest risk quintile at the weekend and at a higher risk of an early event, we confirmed the robustness of the model by censoring (excluding) those patients who died within 3 days of admission.

63355 deaths (22.6%) occurred within the first 3 days of admission to hospital. The increased mortality risk associated with weekend admission was still present, although numerically attenuated, with Sunday admissions associated with a 10% increase in risk, and Saturday admissions associated with a 7% increase in the risk of death.

Analysis for disease groups

Separate supportive analyses including either admission for Cardiovascular Disease (CVD) or for Oncology conditions derived from the principal diagnosis

according the International Classification for Disease version 10 codes for diagnosis provided similar results (Figure 3a 3b; Figure 4a 4b). These two groups were chosen on the basis that they are high prevalence and associated with substantial mortality. In both cases the weekend admission days were associated with markedly increased risk of death, and with cancer admissions this was manifest for admissions occurring on Monday and Friday. However, for both CVD and Oncology admissions, the risks associated with particular hospital days was similar, with the exception of Fridays which were associated in both cases with a 5% increase in risk of death compared with Wednesday.

Length of Stay

In supportive analyses we examined the length of stay in hospital for all patients and for those in the highest risk quintile who were admitted on different days.

For all admissions (discharged alive or dead), the median length of stay is 1 day (IQR 0, 2) for Monday through Friday, for Saturday it is 2 days (IQR 1, 3) and for Sunday it is 2 days (IQR 1, 4). Among those who died in hospital, the median length of stay was 5 days on Monday, and 6 days on all other days of admission. The IQR for each day was similar (IQR (2, 12) except Tuesday and Wednesday when the 75th Percentile was 13, and Saturday and Sunday when the 25% Percentile was 3.

Median length of stay for the highest risk quintile patients on Saturday was 4 days, Inter Quartile Range (IQR 0, 11) and 5 (IQR 0, 11) on Sunday. This contrasts with a median length of stay on Monday through Friday of 3 days (IQR 0, 8). For admissions which ended in death, the median length of stay for both Saturday and Sunday was 7 days (IQR 3, 16) while for weekdays it was 8 days (IQR 4, 18).

Discussion

Our analyses show that, while fewer hospital admissions occur at the weekend, patients admitted on Saturday and Sunday are sicker and face an increased likelihood of death within 30 days even when severity of illness is taken into account – a finding similar to our previous analysis.[1]

In the current analysis a smaller increased risk of 30 day mortality is also detected for admissions occurring on Friday and Monday, suggesting a more generalised "weekend effect". This analysis of 2013/14 data suggests that around 11,000 more people die each year within 30 days of admission to hospital on Friday, Saturday, Sunday or Monday compared with other days of the week (Tuesday, Wednesday, Thursday).

We should be clear that it is not possible to ascertain the extent to which these excess deaths may be preventable; to assume that they are avoidable would be rash and misleading.[5] But, from an epidemiological perspective, this statistic is *'not otherwise ignorable'* as a source of information on risk of death and it raises challenging questions about reduced weekend service

provision. Similar to our previous analysis [1], we have found that patients already in hospital over the weekend do not have an increased risk of death. An advantage of the statistical methodology used in this analysis is that it is not subject to bias caused by systematic differences in coding practices between hospitals. Further, any differences in coding practice between the weekend and week days within all hospitals are captured in our estimate of the additional severity of weekend admissions and thus does not affect interpretation of the results. In our previous study [1] we found no systematic hospital weekend effect differences.

Patients in the highest quintile of predicted mortality risk admitted at weekends who survive the in-hospital episode have a longer length of stay than similar patients admitted during the working week.

For patients from this higher risk group who die, the time to death is shorter for those admitted at weekend. This raises questions regarding the relative impact of reduced hospital or out-of-hospital services on length of stay.

These observations are not unique to the NHS in England, but as the largest and most comprehensive health service in the world, the NHS may be the best equipped to understand and address them.

Appropriate support services in hospitals are usually reduced from late Friday through the weekend, leading to disruption on Monday morning. This could go some way towards explaining our finding of a "week-end effect" extending into these Friday and Monday.

We have demonstrated a clear association between weekend admission and worse patient outcomes. Our analyses show that an increased proportion of

higher risk patients are admitted on Saturday and Sunday when services inside and outside the hospital are reduced. There is evidence that junior hospital doctors feel clinically exposed during the weekend [6] and that hospital chief executives are concerned about levels of weekend cover [7]. This has led to calls for reviewing the way services are provided in hospitals at weekend by the Academy of Medical Royal Colleges, Medical Education England, the Royal College of Physicians and the Royal College of Surgeons,[6-12] with a particular focus on urgent care.

In starting to address these concerns, NHS England incorporated a set of clinical standards - building on work originally undertaken by the London Clinical Senate and endorsed by the Academy of Medical Royal Colleges - into the national NHS acute contract. [13]

In view of the current analysis, it is necessary to determine exactly which services need to be improved at the weekend, to address the increased risk of mortality and also to ensure, for example, that frail elderly patients and patients needing end of life care receive appropriate treatment in the right place every day of the week.

Patients generally accept the risks associated with their condition and with any necessary treatment, but they should never have to accept an increased risk because of the way healthcare services are designed and delivered.

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Keogh and Bennett are employed by NHS England. Ray, McNulty, Rosser and Pagano are employed by University Hospitals Birmingham NHS Trust, and Freemantle has an honorary appointment with University Hospitals Birmingham NHS Trust

Keogh requested that our earlier analyses be updated with more recent data. Freemantle and McNulty ran the analyses. Freemantle wrote the first draft of the paper which all authors reviewed and revised.

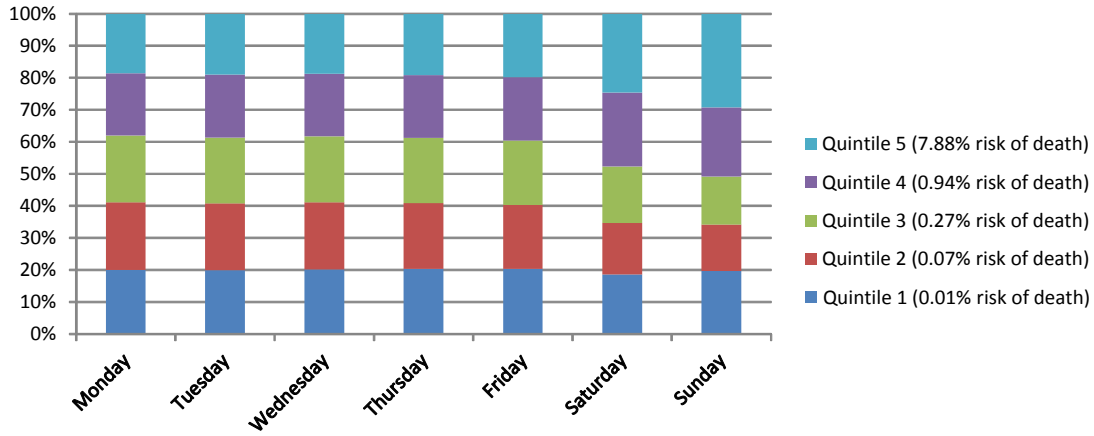
This work was registered as an audit with University Hospitals Birmingham NHS Trust

Table 1. Cause of Death by Day of the Week, where cause of death has at least 1% of deaths.

Cause of Death	Monday	Monday %	Tuesday	Tuesday %	Wednesday	Wednesday %	Thursday	Thursday %	Friday	Friday %	Saturday	Saturday %	Sunday	Sunday %	Grand Total	% total
Certain Infectious and Parasitic Diseases	594	1.49	552	1.38	501	1.24	540	1.34	531	1.28	526	1.33	566	1.45	3810	1.36
Diseases of the Circulatory System	10001	25.04	10032	25.02	9815	24.30	9912	24.57	10128	24.42	9577	24.28	9318	23.82	68783	24.50
Diseases of the Digestive System	2470	6.18	2550	6.36	2527	6.26	2555	6.33	2615	6.31	2530	6.42	2488	6.36	17735	6.32
Diseases of the Genitourinary System	967	2.42	965	2.41	940	2.33	926	2.30	959	2.31	883	2.24	959	2.45	6599	2.35
Diseases of the Nervous System	1029	2.58	1083	2.70	1027	2.54	1027	2.55	1106	2.67	1074	2.72	1064	2.72	7410	2.64
Diseases of the Respiratory System	5846	14.64	5914	14.75	6127	15.17	5978	14.82	6074	14.65	5807	14.72	5921	15.14	41667	14.84
Endocrine, Nutritional and Metabolic Diseases	608	1.52	659	1.64	586	1.45	550	1.36	675	1.63	506	1.28	654	1.67	4238	1.51
External Causes of Morbidity and Mortality	757	1.90	665	1.66	772	1.91	727	1.80	741	1.79	703	1.78	691	1.77	5056	1.80
Mental and Behavioural Disorders	1660	4.16	1679	4.19	1601	3.96	1633	4.05	1733	4.18	1681	4.26	1734	4.43	11721	4.17
Neoplasms	13995	35.04	13940	34.77	14456	35.79	14461	35.85	14819	35.73	14118	35.80	13731	35.10	99520	35.44
Other causes	1006	2.52	1050	2.62	950	2.35	980	2.43	1045	2.52	1029	2.61	1066	2.73	7126	2.54
Unknown	1010	2.53	1005	2.51	1091	2.70	1050	2.60	1046	2.52	1003	2.54	923	2.36	7128	2.54
Grand Total	39943		40094		40393		40339		41472		39437		39115		280793	

Notes, Percentages are of deaths on that day

Figure 1 Quintiles of risk of mortality over 30 days, by day of admission.



Note Derived from a survival model including risk adjustment but not including day of admission or day of hospital stay

Figure 2a

Day of Admission vs Wednesday: Hazard Ratio and 95% Confidence Interval

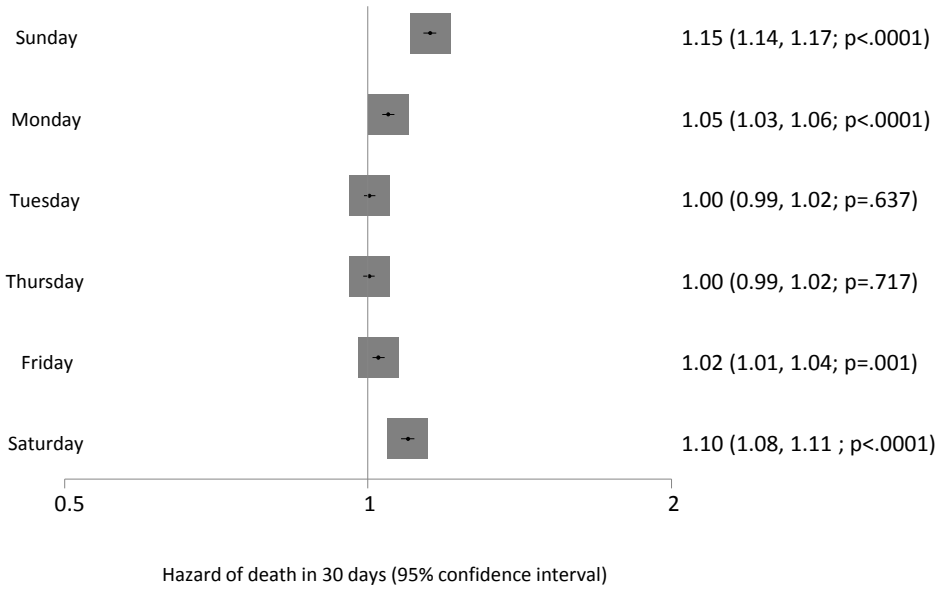


Figure 2b

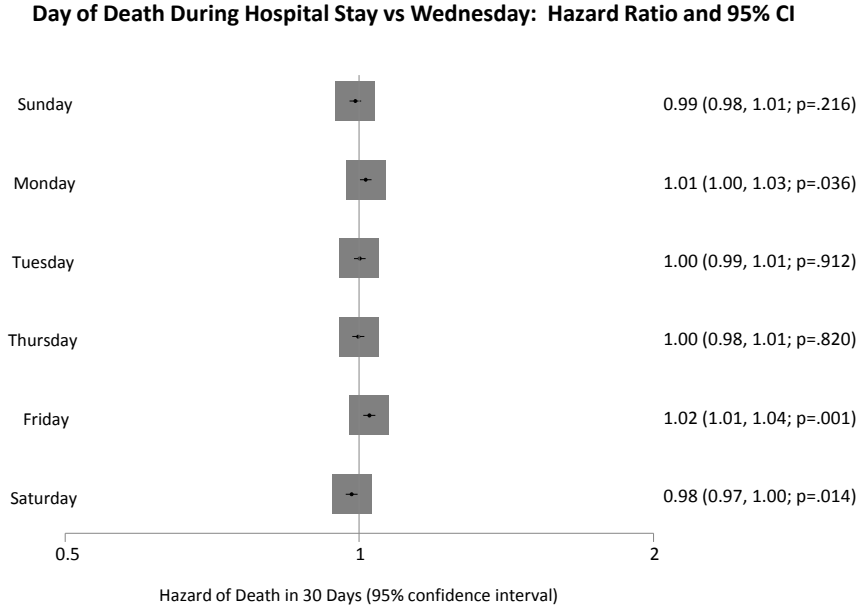

Day of Death During Hospital Stay vs Wednesday: Hazard Ratio and 95% CI
Sunday
Monday
Tuesday
Thursday
Friday
Saturday
0.99 (0.98, 1.01; p=.216)
1.01 (1.00, 1.03; p=.036)
1.00 (0.99, 1.01; p=.912)
1.00 (0.98, 1.01; p=.820)
1.02 (1.01, 1.04; p=.001)
0.98 (0.97, 1.00; p=.014)
0.5
1
2
Hazard of Death in 30 Days (95% confidence interval)

Figure 3a

Day of Admission vs Wednesday in Oncology Patients: Hazard Ratio and 95% Confidence Interval

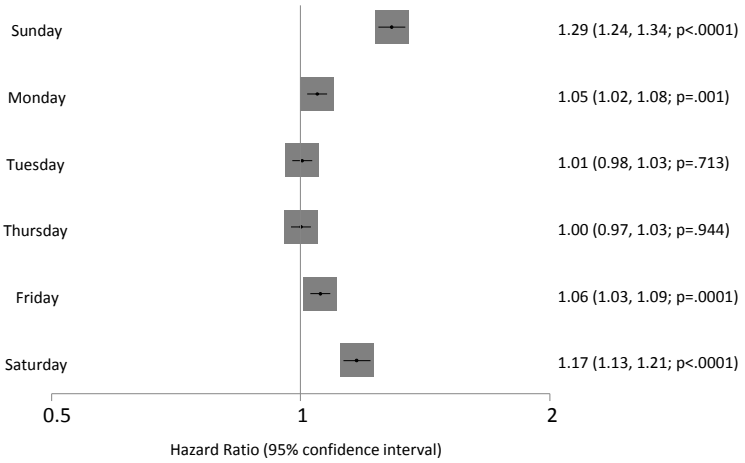


Figure 3b

Day of Death During Hospital Stay vs Wednesday in Oncology Patients: Hazard Ratio and 95% CI

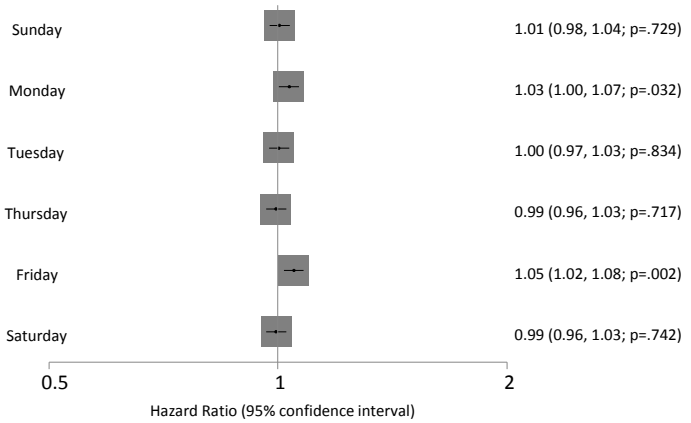


Figure 4a

Day of Admission vs Wednesday in CVD Patients: Hazard Ratio and 95% Confidence Interval

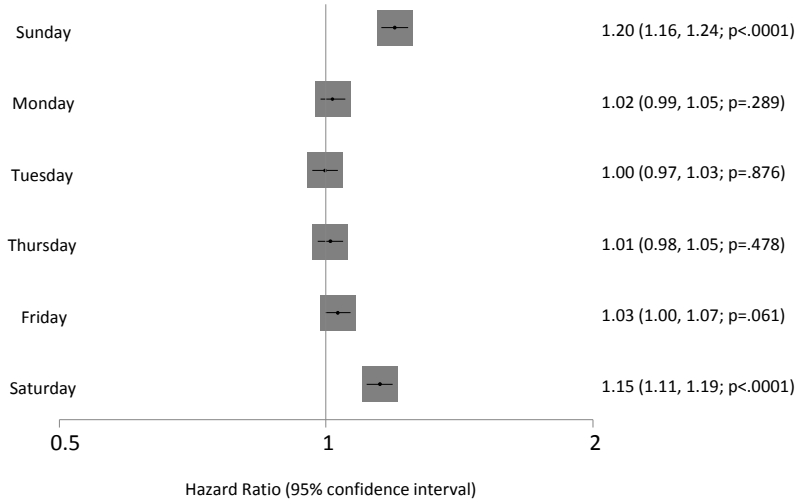
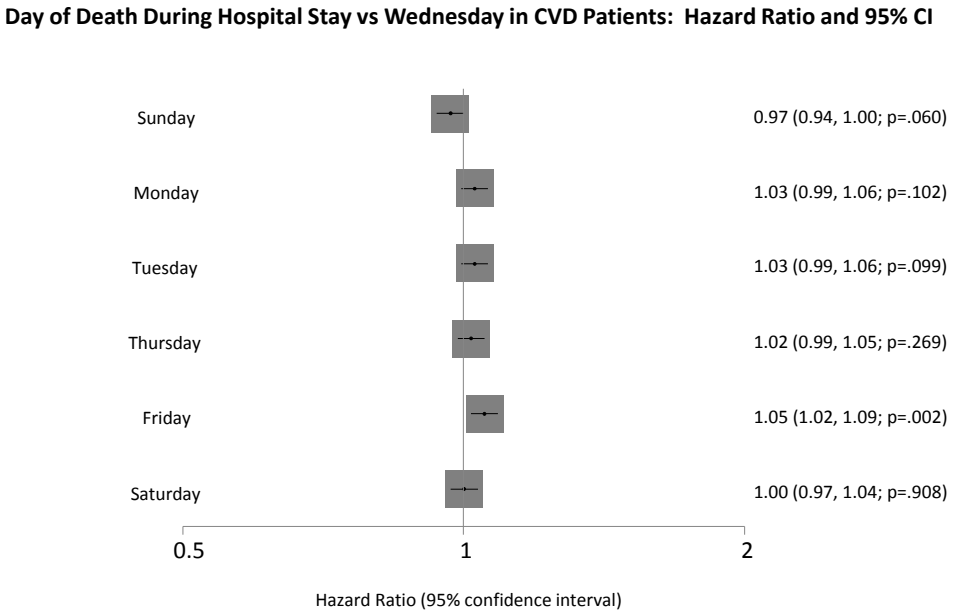


Figure 4b


Day of Death During Hospital Stay vs Wednesday in CVD Patients: Hazard Ratio and 95% CI
Sunday
Monday
Tuesday
Thursday
Friday
Saturday
0.97 (0.94, 1.00; p=.060)
1.03 (0.99, 1.06; p=.102)
1.03 (0.99, 1.06; p=.099)
1.02 (0.99, 1.05; p=.269)
1.05 (1.02, 1.09; p=.002)
1.00 (0.97, 1.04; p=.908)
0.5
1
2
Hazard Ratio (95% confidence interval)