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### 81 ABSTRACT

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Using observational data and variation in hospital admissions across days of the week, we examined 83 the association between ED boarding time and development of delirium within 72 hours of admission 84 85 among patients aged 65+ years admitted to an inpatient neurology ward. We exploited a natural experiment created by potentially exogenous variation in boarding time across days of the week 86 because of competition for the neurology floor beds. Using proportional hazard models adjusting for 87 socio-demographic and clinical characteristics in a propensity score, we examined the time to 88 89 delirium onset among 858 patients: 2/3 were admitted for stroke, with the remaining admitted for 90 another acute neurologic event. Among all patients, 81.2% had at least one delirium risk factor in addition to age. All eligible patients received delirium prevention protocols upon admission to the floor 91 and received at least one delirium screening event. While the clinical and social-demographic 92 93 characteristics of admitted patients were comparable across days of the week, patients with ED arrival on Sunday or Tuesday were more likely to have had delayed floor admission (waiting time 94 greater than 13 hours) and delirium (adjusted HR=1.54, 95%CI:1.37-1.75). Delayed initiation of 95 delirium prevention protocol appeared to be associated with greater risk of delirium within the initial 96 72 hours of a hospital admission. 97

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Keywords: Quality of Care/Patient Safety, Mental Health, Hospitals, Integrated Delivery Systems,
 Health Care Organizations and Systems, Clinical Practice Patterns, Aging,

101 Access/Demand/Utilization of Services, Geriatrics

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#### 106 INTRODUCTION

107 Delirium is an acute cognitive disorder characterized by altered awareness, attentional deficits,

108 confusion, and disorientation (Sachdev et al., 2014). Current estimates of new-onset delirium

109 underscore the sobering fact that delirium overwhelmingly develops in medical settings (as high as

110 82% in intensive care settings) compared to the community at large (approximately 1%-2%)

111 (Dharmarajan et al., 2017). Critically, research has demonstrated that 30%-40% of all delirium cases

are preventable (Dharmarajan et al., 2017, Inouye et al., 2014, Inouye et al., 1999, Neurology, 2016).

113

Although delirium reverberates through all age populations, older adults (≥65 years of age) are at greater risk of developing delirium during an acute illness, as are individuals with an underlying neurocognitive disorder (mild cognitive impairment and dementia). New-onset delirium in older patients alone translates to a high financial burden on the health care system (Dittrich et al., 2016, Lundstrom et al., 2005). Despite known efficacy of inpatient delirium preventative strategies and predictive models to identify at-risk patients, new-onset delirium occurrence and the associated expenditures remain unchanged (Davis et al., 2013).

121

Delirium represents a global challenge for healthcare managers, healthcare providers, and payors because it increases hospital costs (i.e., prolonged utilization of services and hospital stay) and also decreases hospital revenue (e.g., reimbursement penalties in value-based payment models) (Mate and Compton-Phillips, 2014, Haas et al., 2015, Porter and Kaplan, 2016, Collier, 2012). With the COVID-19 pandemic, administrators have faced several challenges with respect to managing hospital capacity (Eriksson et al., 2017, Bravata et al., 2021). As a result, multiple stakeholders began to review their hospital admission processes with the ultimate goal of improving patient outcomes.

However, ongoing endeavors to assess the efficacy of delirium prevention strategies have overlooked 130 the key contributing factors, such as the healthcare experience prior to receiving preventive measures 131 on the inpatient wards (e.g., ED experience and bed transfer processes). Therefore, individuals that 132 experience a delay between initial ED arrival and transfer to an inpatient bed (i.e., "delayed bed-flow," 133 "boarding") may have delayed access to preventative care. Unfortunately, traditional estimates of the 134 association between ED boarding and delirium have been confounded by baseline disease severity 135 and other unmeasured variables. For instance, greater disease severity might reduce the ED 136 boarding time while increase delirium risk. 137

138

We exploited a natural experiment created by exogenous bed competition to examine the impact of prolonged ED boarding (certain days of the week) on the risk of delirium within 72 hours of admission.

#### 142 METHODS

### 143 Study design

We conducted a retrospective study using data abstracted from routine clinical care documented in 144 electronic health records (EHRs) of a large academic medical center between 01/2016 and 12/2018. 145 Our hypothesis was that prolonged ED boarding (i.e., waiting time at the fourth guartile) increases the 146 147 risk of delirium during an urgent inpatient admission. In our conceptual framework (Figure 1), the association between ED boarding and delirium might be confounded by disease severity and other 148 variables. However, based on the assumption that no one can choose the day of the week they will 149 have a neurological emergency (i.e., strokes are unpredictable), one could putatively exploit the 150 exogenous variation in neurology floor bed competition to indirectly examine the association between 151 ED boarding time and delirium risk. 152

153

154 [Insert Figure 1]

156

#### 157 Source of participants and data

Between 01/2016 and 12/2018, 79,467 older patients ( $\geq$ 65+ years) were evaluated in our emergency department (ED). From this population, we identified all patients who were subsequently transferred to a specific study neurology hospital floor (n=1,725), which had implemented a systematic program for delirium prevention and screening. We excluded those who did not have at least one delirium assessment completed during the inpatient stay (n=867 out of 1,725), resulting in a final analytical sample of 858 patients (Figure 2).

164

166

165 [Insert Figure 2]

Delirium prophylactic protocol and screening: In accordance with national guidelines, the study 167 neurology hospital floor has a delirium screening and prevention program (Neurology, 2016). The 168 prevention program is based on multimodal, nonpharmacologic delirium prevention programs such as 169 the "The Hospital Elder Life Program" (HELP) and incorporates several preventive measures, 170 including redirection, review of medications, avoidance of restraints (Inouye et al., 2006, Inouye et al., 171 1999). Delirium screening assessments are performed by registered nurses using the modified 172 Confusion Assessment Method (CAM) and documented in the electronic medical record. Previous 173 controlled studies found that these interventions are effective in preventing delirium, cognitive, and 174 functional decline (Inouye et al., 1990, Mitasova et al., 2012). We further detail the program in 175 Supplementary Text 1. 176

177

#### 178 Variables

179 This study combines demographic (A), clinical (B), process (C), and outcome (D) information:

A: Demographic Information: We acquired basic demographic information (e.g., age, gender, race) and enriched it with measures of socio-economic status (e.g., insurance type) and other pertinent data (e.g., community dwelling vs not) (Table 1, Supplementary Table 1).

183 [Insert Table 1]

184

*B. Clinical Information:* We obtained data on presence of known delirium risk factors, such as stroke,
 visual impairment, and fall, from a validated Clinical Classifications Software (ACUP-AHRQ-CCS) for
 inpatient stays, which utilizes an ICD-10 diagnosis and procedure categorization scheme

188 (Supplementary Table 2, Supplementary Table 3).

189

190 *C: Process Information*: We abstracted the date and time in which patients arrived at the emergency 191 department. From these variables, we categorized ED arrival date according to days of the week

192 (Monday-Sunday). Second, we created an indicator variable for "Delay", time from ED arrival-to-

neurology bed transfer and categorized in quartiles (Delay, yes  $\geq$  13.4 hours vs. no  $\leq$  5.97 hours).

194

D: Outcome Information: Delirium was assessed using the modified Confusion Assessment Method 195 (CAM), which have been validated in post-stroke populations (94-100% sensitivity, 89-95% 196 197 specificity, and high inter-rater reliability). At least 49.7% of the study neurology ward patients were assessed (Figure 2). Some patients could be reevaluated the same day as needed. We captured all 198 CAM assessments for each patient and created our primary outcome variable: time from ED arrival to 199 first CAM positive within a 72h observation period (CAM positive indicated delirium). For sensitivity 200 analysis, we also derived a binary indicator variable for delirium (yes vs no within 72h of admission, 201 Supplementary Table 4). 202

203

204 Data analytic approach

To address potential confounders for the primary analysis, we estimated the probability (propensity score) of arriving on each day of the week (Monday-Sunday). We used a categorical logisticregression to predict the odds of arriving on each day of the week. We examined the distribution of propensity scores across different days of the week, examined for normality assumptions, and compared propensity score means across each day of the week and examined how well the propensity score balanced for potential confounders.

211

The potential confounders were obtained from linked encounter-level electronic medical record data, and included age, gender, race, site of origin (community dwelling vs not), insurance type, and known comorbidity (e.g., presence of known delirium risk factors such as stroke, visual impairment)). The percentage of patients with missing data for these variables was low (<1%). For missing data, we assumed missingness at random and conducted a complete case analysis.

217

218 We compared time from ED door arrival to first documentation of delirium (CAM positive) within a 72h period among those who arrived on different days of the week using a cox proportional hazards 219 model, with propensity score adjustment (as a continuous linear term). To reduce the potential bias 220 from differential follow-up times and the impact the inpatient care and drugs might have on delirium 221 risk overtime that is unrelated to arrival conditions, we limited the maximal follow-up time to 72h. 222 Censored observations included death, transfer, or discharge before 72h. We examined Schoenfeld 223 residuals to examine for potential violation of the proportional-hazards assumption. We reported 224 hazard ratios and 95% confidence intervals for unadjusted and stepwise adjusted analysis. We 225 estimated at least 90% power to detect a 50% higher hazard of delirium, using an estimated sample 226 of at least 100 patients per day of the week (exponential test, hazard difference, alpha 0.5). 227

229 *Sensitivity analysis:* We conducted additional prespecified sensitivity analysis and examined the 230 robustness and validity of our findings in several ways:

231

Statistical assumptions: First, we avoided the use of the propensity score and compared time from 232 233 ED door arrival to first delirium (CAM+) documented within a 72h period among those who arrived on early days of the week (Sunday-Wed = high demand) versus late days of the week (Thursday-234 Saturday = low demand) using cox proportional hazards models, with and without adjustment for the 235 potential confounders used in the main analysis; Second, we avoided the use of survival analysis 236 (cox proportional hazards assumption might be unrealistic) and estimated the 72h odds of delirium 237 using logistic regression models, assuming no loss to follow-up (given very short follow-up time), with 238 239 and without adjustment for the potential confounders listed in the main analysis. Third, we observed that the care experience of those who arrive to the ED during day might be different than the care 240 experience of those who arrive at night. We hypothesized that "shift" could explain the effect of ED 241 242 boarding on delirium risk (e.g., more severe cases arriving at night). Delirium screening was implemented at every shift (day and night). We compared time from ED door arrival to first delirium 243 (CAM+) documented within a 72h period among those who arrived on different days of the week 244 245 using cox proportional hazards models, with propensity score adjustment plus additional adjustment for time of the day (i.e., using "shift" as a binary predictor, meaning arrival to the ED during day vs 246 night hospital shift). 247

248

Screening effect: Systematic delirium screening is hypothesized to naturally increase its detection rate. If ED boarding time increases the 72h delirium risk independent of the destination floor, we expect replication of the results in other samples and settings where delirium prevention protocol was either not done or done differently. For instance, more severe cases (as opposed to systematic screening as in the study floor) are more likely to be screened in a neurological intensive care unit. To

examine this assumption, we repeated the analysis expanding the sample to all neurology inpatients (the study floor, one neurological intensive care unit, and one additional neurology floor).

256

Face validity: We exploited two potential reasons for competing demands for the neurology floor 257 258 beds: a) On certain days of the week (e.g., week days), neurosurgeons place holds on floor beds to accommodate the post-operative needs of their scheduled patients, whereas there are fewer bed 259 holds on weekends (Supplementary Table 5); and b) On certain days of the week (e.g., Sundays), 260 discharges from hospital to another institution (e.g., skilled nursing facilities) are systematically 261 delayed until Monday morning (Supplementary Table 6). With high demand for beds, patients 262 263 admitted from the ED frequently "board" in the ED on Sunday night or Tuesday night until a floor bed 264 opens. The nursing responsibility transfers from ED nurses to neurology ward nurses when the patient arrives on the inpatient ward. 265

266

#### 267 RESULTS

Of the 858 patients who presented to the ED with a neurological emergency, 697 (81.2%) had at least one delirium risk factor in addition to age (e.g., stroke, visual impairment, fall, dementia), with mean age 78 ± 9 years, 51.2% men, and 84.7% white. Patients arriving on different days of the week with neurological emergencies were comparable with respect to age, gender, race, site of origin, insurance type, and comorbidities. Delirium was documented in 234 (30%) patients within the first 72h from ED arrival. Table 1 summarizes the demographic characteristics of the patients upon ED arrival.

275

This study demonstrated an association between days of the week and delirium. ED arrival on Sundays and Tuesdays were associated with shorter time to delirium onset (Sunday: propensity score adjusted HR= 1.54 for delirium onset, 95%CI:1.36-1.75; Tuesday: propensity score adjusted HR=1.39 for delirium onset, 95%CI:1.22-1.58) in a 72-study follow-up time-frame, using Friday as
reference day. These results were similar using different days of the week as reference, and also
after adjusting for time of the day (i.e., day vs night shift) (Supplementary Table 7 and 8). For
illustrative purposes, we provided unadjusted delirium survival curves (Figures 3A to 3C and
Supplementary Figure 1). Findings were similar using the sample of all neurology inpatients (each
with different protocols for use/screening for delirium).

285 [Insert Figure 3A]

287 [Insert Figure 3B]

288

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289 [Insert Figure 3C]

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*This study was Sensitivity analysis*: ED arrival on early days of the week (binary, early meaning
Sunday to Wednesday vs late meaning Thursday to Saturday) was still associated with a shorter time
from ED arrival to delirium onset using covariate adjustment (covariate adjusted HR: 1.242, 95% CI
1.04-1.48), Supplementary Table 9. The adjusted 72h odds of delirium was 1.95-fold greater (95% CI
1.05- 3.64) for those arriving to ED on Sunday compared to Saturday, for instance (Supplementary
Table 10).

297

ED arrival on Sundays was associated with delayed floor admission (waiting time greater than 13.4

hours = time from ED arrival to transfer to inpatient bed, p<0.001, Supplementary Table 11) and with

lowest proportion of hospital to skilled nursing facility discharges (p<0.001, Supplementary Table 6).

301 Similarly, ED arrival on Tuesdays was associated with delayed floor admission (p<0.001,

302 Supplementary table 11) and with greater proportion of elective pre-surgical admissions on

303 Wednesday morning, p<0.001, Supplementary table 5).

Figure 4 illustrates the measures of bed competition (i.e., elective pre-surgical admissions and discharges to nursing homes or alike), the overtime proportion of patients who had prolonged ED boarding time (i.e., >13h), and the various 72h-delirium hazard ratios in relation to days of the week. In summary: a) the ED boarding time followed the trends in the measures of bed competition, and b) ED boarding time was associated with the 72h-delirium hazard ratio.

310 [Insert Figure 4]

311

#### 312 DISCUSSION

Older patients admitted from the ED with neurological emergencies have a substantial risk of developing delirium early in their hospitalization. Our study also reveals that increased "boarding time" (or delayed transfer to the hospital floor) is associated with greater short-term risk of delirium in this natural experiment. While risk factors for delirium are multi-dimensional and time-varying, our study identified areas for process improvement that could have a real link with outcomes leading to improved patient care and decreased health care spending.

319

Our study has several strengths including our very large sample size and its reasonably high rate of delirium, making our comparisons robust. By demonstrating an association between prolonged ED lengths of stay and elevated risk of delirium onset during admission, our results are consistent with the evolving literature suggesting that delirium prophylaxis is critical to prevention and that delays in this process increase the risk of the development of delirium.

325

Specifically, our study demonstrates that risk of developing delirium during hospitalization is greatest for older patients with acute neurologic conditions who present to the ED on days with higher risk of prolonged ED lengths of stay. One prior study that evaluated the association between ED length of stay and incident delirium, also showed a prolonged ED length of stay (10 hours or greater) prior to admission doubled the risk for delirium onset (Bo et al., 2016); this study, however, excluded patients with acute stroke which is one of the major risk factors for delirium among older adults. Delirium is a frequent complication of stroke (10-42%) (Mitasova et al., 2012, Dahl et al., 2010).

333

We theorized that the increased risk of delirium is related to a combination of the care experienced at the ED department and the delayed implementation of delirium prevention measures. For instance, it is also possible that the physical environment of, care limitations of, and/or therapeutics administered in the ED contribute to this short-term increased risk. The physical environment of the ED, with bright lights and high ambient noise level 24 hours a day, is potentially deliriogenic and contrary to the sleep hygiene measures recommended by national delirium prevention guidelines (Grover and Avasthi, 2018, Inouve et al., 2000, NICE, 2003).

341

This study's results are intuitively and quantitatively valid. Presenting to the hospital earlier in the 342 343 week, e.g., Sunday and Tuesday, conveyed higher risk of delirium than presenting later in the week. e.g., Saturday. Some delays in admission have been attributable to exogenous factors. For example, 344 we know that during weekends neurological floors have fewer discharges to skilled nursing facilities 345 (SNF), which, in turn, influences the number of beds available for new admissions on those floors. 346 With respect to mid-week days, we recognized that elective admission to neurological floors, medical 347 or surgical, may impact the number of available beds and cause further delays in admission (McHugh 348 et al., 2008). In this study, we exploited the fact that acute emergencies (e.g., stroke) are largely 349 350 unpredictable, and will continue to occur independent of human's ancient Greek calendar scheme 351 (days of week), surgeon's schedule, or SNF's opening policies.

352

In this study, we tested different categorization assumptions for the predictor variable (individual days of the week vs binary), different modeling assumptions (cox proportional hazard vs steady state assumptions), as well as different samples (more homogeneous study floor with high screening rate
vs all study floors with low screening rate and a heterogeneous population). The association was
stronger with increasing effective sample size (e.g., all samples) and increasing number of
assumptions (e.g., propensity score, binary predictor categorization). Overall, our study conclusions
about differential short-term delirium risk according to days of the week remained robust across all
methods.

361

Our face validity exploratory analysis, while hypothesis-generating in our work, creates avenues for further study in optimizing communication paths between ED and Neurology department providers. Prioritizing ED arrivals over elective surgery admissions could improve patient care delivery regardless of baseline medical condition. This further adds to the discussion for multidisciplinary neurological care to use large and real-care data analysis to cross departmental boundaries and rethink in-hospital processes. More importantly, it provides an opportunity to make targeted interventions for high risk patients in a high-volume and critical care environment.

369

370 This study has several limitations. First, it was conducted at a single tertiary academic center with 371 which may limit its generalizability. This center is known for providing excellent guality care in the emergency room, which suggests that our results could represent a conservative estimation of the 372 impact of ED boarding on delirium risk. Because our center is a tertiary academic center, we may 373 have received a greater share of severe cases when compared to community hospitals. In addition, 374 we also limited our main analysis to patients with neurological emergencies. In fact, roughly two thirds 375 376 of the patients that were included had stroke as a primary diagnosis and this study did not include details of their stroke type, severity at initial presentation in the ED, which would include 377 378 hemodynamics, cardiac and pulmonary status, and whether or not they had significant altered 379 mentation or level of consciousness. Because number, type, and severity of medical conditions are

known risk factors for delirium, our study may have overestimated the general 72h in-hospital delirium
 prevalence.

382

Second, the delirium screening (CAM protocol) was not implemented consistently among the older 383 patients admitted through the ED, with only 50% of patients being screened within the 72h study 384 period. In our main analysis, we chose the study floor that had implemented a systematic protocol for 385 screening at least twice per day to attempt to eliminate the variable of staff judgment when screening. 386 However, the well-trained nurses still used their best judgement about who could have deferred 387 screening in a large proportion of cases. Therefore, it is possible that those at higher risk for delirium 388 (e.g., older age) were more likely to have a documented delirium screening. In a worst-case scenario, 389 390 if we assume that the in-hospital unconscious selection of patients to screen for delirium was driven by a nurses' judgment (prior probability of potential risk for delirium), we expect that the analytical 391 sample would systematically exclude those healthier patients. However, the nurses' judgment is 392 393 expected to be independent of the day of the week surgeon's schedule, and SNF's opening policies. In this scenario (extreme case of independent differential misclassification of the outcome), the 394 395 results could represent an over or underestimate of the true rates of delirium. In this scenario of 396 independent non-differential misclassification of a binary outcome, the estimates are still valid (preserves type I error, alpha set) but is likely conservative (towards the null). Therefore, our results 397 are likely conservative in the main analysis, and potentially biased in an unpredictable direction in the 398 all sample analysis. Further, one could use the reported CAM specificity (95.9%) to obtain the 399 adjusted estimate of the risk (Gusmao-Flores et al., 2012). 400

401

Another common potential source of bias is the misclassification of covariates (e.g., diagnoses). As outlined before, we attempted to mitigate misclassification bias with careful and conservative sensitivity analysis and face validity checks. One additional source of potential misclassification is our

405 use of "elective presurgical admissions" as a proxy for "bed-holds" for surgery. We measured the 406 volume of neurology admissions coming from the elective surgical admission department (as 407 opposed to the ED department or else). An ideal measure of bed competition would actually be the 408 volume of "bed holds" placed by surgeons each day (some eventually become an elective surgical 409 admission while others are canceled for several reasons).

410

Our study could not differentiate the effect of prolonged lengths of stay in the ED environment (e.g., noisy and disruptive day and night) from the effect of delayed initiation of delirium prevention protocol on the neurology floor. Though some EDs do have volunteer-based programs similar to the HELP delirium prevention program (Sanon et al., 2014), there are no studies evaluating the impact of EDinitiated delirium prevention programs on incident delirium.

416

The specific or long-term impact of preventive strategies for delirium is an area for further study. Physicians in training have reported delirium prevention education is often sparse and disproportionate to their exposure to high risk patients (Pickett et al., 2019). In addition to enhanced awareness, electronic delirium risk alerts and targeted deployment of hospital resources are all avenues by which delirium screening rates could improve, and thereby outcomes for high risk patients, can be immediately improved.

423

Finally, our study was not designed to demonstrate causation (cause-and-effect). A randomized controlled clinical trial would not be feasible or ethical in this vulnerable population of patients with neurological emergencies. Therefore, we conducted this rigorous observational study that identified an association between ED boarding time and the documentation of delirium in the first 72 hours of admission.

In a healthcare management framework, common factors associated with ED boarding could be grouped into four main categories: a) how primary care and continuity are organized, b) the existence and effectiveness of organizational models and clinical pathways for chronic patients, c) the presence of bottlenecks related to ED's personnel or equipment endowment, and d) how the ED is organized and its connection with the rest of the hospital (Vainieri et al., 2020). Our study may help healthcare managers to identify feasible targets for process improvement in the connection between ED and the rest of the hospital (e.g., a sensible elective surgery's schedule).

437

This study design did not seek to determine whether it is prolonged ED boarding time or the delayed 438 Neurology transfer arrival that increased the risk of delirium. Some argue that the ED boarding is 439 "delirium-genic" (i.e., the extra hours in the ED extends the patient's exposure to noisy, cold, stressful, 440 and unwelcoming environment without direct exposure to external light). In contrast, the delirium 441 prevention protocols include steps to minimize potential environmental insults. Nevertheless, this 442 443 study provides some feasible suggestions for process improvement that are still within the scope of healthcare managers, such as better alignment between discharge volume needs and SNF's 444 445 admitting hours. This represents a new category for process improvement in the healthcare management framework: relationships between hospitals and post-acute care facilities. 446

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448

#### 449 CONCLUSION

Older patients admitted from the ED with neurologic conditions have a substantial risk of developing delirium early in their hospitalization. Prolonged wait for transfer to the hospital floor appear to be associated with increased risk of delirium in this natural experiment. Hospital complications such as delirium might be prevented by early initiation of prophylaxis protocols and transfer from the ED to the hospital bed. Healthcare managers may improve outcomes and reduce spending by removing bottlenecks in the clinical pathways across primary care, emergency rooms, operating rooms, and

456 post-acute services.

457

### 458 **Declaration of Conflicting Interests**

- 459 The Authors declare that there is no conflict of interest.
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## 537 SUPPLEMENTAL MATERIALS

### **Supplementary Figure 1: Delirium Free Survival Probability (High Demand Days).**

541 [Insert Supplementary Figure 1]

#### **Supplementary Table 1 - Demographic Information Details**

| Variable          | Source | Туре    | Description   |
|-------------------|--------|---------|---|
| Age at Admission  | EHR    | Integer | Calculated using the date of birth and date of admission to the Emergency<br>Department (ED).   |
| Gender            | EHR    | Binary  | Recorded gender of the patient.<br>(Male=1, Female=0)   |
| Race              | EHR    | Text    | Recorded race reclassified as:<br>White= White or Caucasian.<br>Black= Black or African America.<br>Other= Asian; Hispanic or Latino; American Indian or Alaska Native.<br>NA = Unavailable or Declined.  |
| Admission Source  | EHR    | Text    | Recorded source of admission reclassified as:<br><u>Home or Self Care</u> = Self-referral or Physician or Clinic Referral.<br><u>Institutionalized</u> = Skilled Nursing Facility; Psych, Substance Abuse, or Rehab<br>Hospital; Outside Health Care Facility; Outside Hospital or Ambulatory Surgery<br>Center.                                |
| Primary Insurance | EHR    | Text    | Recorded primary insurance, reclassified as: <u>Medicare</u> = Medicare. <u>Commercial</u> = Blue Cross Blue Shield; Tufts Health Plan; Harvard Pilgrim;         Neighborhood Health Plan and AllWays Health Partners. <u>Others</u> : Medicaid, Free Care; Workers Comp / Motor Vehicle; Other Government;         Self-pay and International. |

**Legend:** EHR = Electronic Health Record. 

#### 

## 578 Supplementary Table 2 – Clinical Information (diagnosis) – Delirium Risk Factors

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|---|----|--|
| J | 00 |  |

| Suppl   | lementary T | able 2 - Cli | nical Inforn | nation (Day | of the Weel | K)        |           |           |       |
|---|-------------|--------------|--------------|-------------|-------------|-----------|-----------|-----------|-------|
|   | Overall     | Sunday       | Monday       | Tuesday     | Wednesday   | Thursday  | Friday    | Saturday  | р     |
|   | 858         | 132          | 116          | 119         | 125         | 123       | 130       | 113       |       |
| Stroke = Yes (%)                                    | 536 (62.5)  | 88 (66.7)    | 69 (60.0)    | 65 (54.6)   | 76 (60.8)   | 74 (60.2) | 86 (66.2) | 78 (69.0) | 0.263 |
| Acute Cerebrovascular disease = Yes (%)             | 496 (57.9)  | 82 (62.1)    | 65 (56.5)    | 61 (51.3)   | 66 (52.8)   | 70 (56.9) | 80 (61.5) | 72 (63.7) | 0.334 |
| Epilepsy = Yes $(\%)$                               | 59 (6.9)    | 9 (6.8)      | 8 (7.0)      | 9 (7.6)     | 15 (12.0)   | 4 (3.3)   | 7 (5.4)   | 7 (6.2)   | 0.22  |
| Dementia* = Yes (%)                                 | 2 (0.2)     | 0 (0.0)      | 1 (0.9)      | 0 (0.0)     | 1 (0.8)     | 0 (0.0)   | 0 (0.0)   | 0 (0.0)   | 0.523 |
| Fall = Yes(%)                                       | 18 (2.1)    | 2 (1.5)      | 5 (4.3)      | 1 (0.8)     | 1 (0.8)     | 4 (3.3)   | 3 (2.3)   | 2 (1.8)   | 0.438 |
| All Fractures = Yes (%)                             | 13 (1.5)    | 1 (0.8)      | 1 (0.9)      | 1 (0.8)     | 1 (0.8)     | 4 (3.3)   | 3 (2.3)   | 2 (1.8)   | 0.583 |
| Brain trauma = Yes (%)                              | 83 (9.7)    | 14 (10.6)    | 7 (6.1)      | 14 (11.8)   | 16 (12.8)   | 10 (8.1)  | 13 (10.0) | 9 (8.0)   | 0.604 |
| Other ill defined cerebrovascular disease = Yes (%) | 9 (1.1)     | 3 (2.3)      | 1 (0.9)      | 0 (0.0)     | 3 (2.4)     | 0 (0.0)   | 2 (1.5)   | 0 (0.0)   | 0.224 |
| Syncope = Yes (%)                                   | 12 (1.4)    | 1 (0.8)      | 4 (3.5)      | 2 (1.7)     | 0 (0.0)     | 2 (1.6)   | 2 (1.5)   | 1 (0.9)   | 0.41  |
| Transient Cerebral ischemia= Yes (%)                | 49 (5.7)    | 9 (6.8)      | 4 (3.5)      | 9 (7.6)     | 9 (7.2)     | 3 (2.4)   | 8 (6.2)   | 7 (6.2)   | 0.522 |
| Visual impairment = Yes (%)                         | 74 (8.6)    | 11 (8.3)     | 11 (9.6)     | 9 (7.6)     | 7 (5.6)     | 7 (5.7)   | 14 (10.8) | 15 (13.3) | 0.325 |

Legend: \* Includes only ICD-10 codes related to dementia.

## 583 Supplementary Table 3 - Clinical Information Details – Delirium Risk Factors

| Variable                                  | Source | Туре                 | Description  |
|---|--------|----------------------|--|
| Cerebrovascular Accidents                 | Code   | Binary (Y=1,<br>N=0) | Cerebrovascular A binary: CCS codes: 109, 111, 112, 110, 112, 113.   |
| Acute Cerebrovascular disease             | Code   | Binary (Y=1,<br>N=0) | Acute cerebrovascular disease: CCS code 109.   |
| Epilepsy                                  | Code   | Binary (Y=1,<br>N=0) | Epilepsy: CCS code 83.   |
| Dementia                                  | Code   | Binary (Y=1,<br>N=0) | ICD-10 codes: F0150, F0151, F0280, F0281, F0390, F0391, F1026,<br>F1027, F1096, F1097, F1327, F1397, F1817, F1827, F1897,<br>F1917, F1927, F1997, G300, G301, G308, G309, G3101, G3109,<br>G311, G312, G3183 and R4181 |
| Fall                                      | Code   | Binary (Y=1,<br>N=0) | Fall: CCS code 2603.   |
| All Fractures                             | Code   | Binary (Y=1,<br>N=0) | All fractures: CCS codes 226 to 231.   |
| Brain trauma                              | Code   | Binary (Y=1,<br>N=0) | Brain trauma: CCS code 233.  |
| Other ill-defined cerebrovascular disease | Code   | Binary (Y=1,<br>N=0) | Other and ill-defined cerebrovascular disease: CCS code 111.   |
| Syncope                                   | Code   | Binary (Y=1,<br>N=0) | Syncope: CCS code 245.   |
| Transient Cerebral ischemia               | Code   | Binary (Y=1,<br>N=0) | Transient cerebral ischemia: CCS code 112.   |
| Visual impairment                         | Code   | Binary (Y=1,<br>N=0) | Visual impairment: CCS codes 89 or 87 or 86 or 90 or 91.   |

Legend: CCS Codes = Clinical Classifications Software (ACUP-AHRQ-CCS).

## **Supplementary Table 4 - Modified CAM Assessments Information**

| Variable                                    | Source | Туре          | Description  |
|---|--------|---------------|--|
| CAM date and time                           | EHR    | date and time | Date and Time when the CAM assessment was performed.   |
| CAM assessment result                       | EHR    | text          | <ul> <li>Recorded CAM assessment result (4 levels):</li> <li>0. Negative (no delirium)</li> <li>1. Positive(delirium)</li> <li>2. Unable to Assess - Brain Injury/Severe Cognitive Deficit</li> <li>3. Unable to Assess - Sedation Score 4 or great OR RASS less than or equal to -4</li> </ul>  |
| First Recorded CAM                          | Code   | date and time | Timestamp representing the first time a CAM assessment was<br>performed on the patient.  |
| First Positive CAM                          | Code   | date and time | Timestamp representing the first time a CAM assessment was recorded as positive for delirium.  |
| CAM by 72h                                  | Code   | text          | Variable created to identify the following scenarios:<br>Delirium: at least oneCAM assessment was recorded as positive<br>during the first 72 hours from admission.<br>No Delirium: at least one assessment was recorded as negative<br>and none as positive during the first 72 hours from admission.<br>NA: No CAM assessment was recorded during the first 72 hours<br>from admission.  |
| CAM Any Day                                 | Code   | text          | Variable created to identify the following scenarios:<br>Delirium: at least one CAM assessment was recorded as positive<br>during the encounter (admission to discharge).<br>No Delirium: at least one assessment was recorded as negative<br>and none as positive during the encounter (admission to<br>discharge).<br>NA: No CAM assessment was recorded either positive or negative<br>during the encounter (admission to discharge). |
| Number of CAM<br>assessments                | Code   | integer       | Number of CAM assessments were recorded during the encounter (admission to discharge).   |
| Admission to first CAM recorded             | Code   | integer       | Number of hours between the admission and the first CAM assessment recorded.   |
| Admission to first positive<br>CAM recorded | Code   | integer       | Number of hours between the admission and the first positive CAM assessment recorded (delirium).   |

**Legend:** EHR = Electronic Health Record. CAM = Confusion Assessment Method

## 601 Supplementary Table 5 – Admission Department (not ED) vs Days of the Week

|                           | Overall<br>5838 | Sunday<br>538 | Monday<br>985 | Tuesday<br>917 | Wednesday<br>1009 | Thursday<br>1001 | Friday<br>894 | Saturday<br>494 | p-value |
|---------------------------|-----------------|---------------|---------------|----------------|-------------------|------------------|---------------|-----------------|---------|
| Admission Department* (%) |                 |               |               |                |                   |                  |               |                 | < 0.001 |
| Study Neurology Floor     | 3719 (63.7)     | 507 (94.2)    | 583 (59.2)    | 519 (56.6)     | 517 (51.2)        | 584 (58.3)       | 551 (61.6)    | 458 (92.7)      |         |
| Perioperative Dept        | 1686 (28.9)     | 14 (2.6)      | 299 (30.4)    | 305 (33.3)     | 420 (41.6)        | 344 (34.4)       | 285 (31.9)    | 19 (3.8)        |         |
| Other                     | 433 (7.4)       | 17 (3.2)      | 103 (10.5)    | 93 (10.1)      | 72 (7.1)          | 73 (7.3)         | 58 (6.5)      | 17 (3.4)        |         |

602 Legend: \* Not included: admissions to Emergency Department and then transferred to the Study Neurology Floor.

## 603 Supplementary Table 6 – Discharge from Study Neurology Floor vs Days of the Week

604

|  | Overall     | Sunday    | Monday     | Tuesday    | Wednesday  | Thursday   | Friday     | Saturday   | p-value |
|--|-------------|-----------|------------|------------|------------|------------|------------|------------|---------|
|  | 7296        | 605       | 843        | 1099       | 1276       | 1335       | 1286       | 852        |         |
| Discharge Disposition = Institutionalized* (%) | 2294 (32.3) | 82 (14.3) | 272 (33.3) | 412 (38.1) | 471 (37.9) | 453 (34.7) | 422 (33.3) | 182 (22.4) | < 0.001 |

605 Legend: \* Includes: Skilled Nursing Facility; Psych, Substance Abuse, or Rehab Hospital; Outside Health Care Facility; Outside Hospital or Ambulatory Surgery Center.

| 608 | Supplementary Table 7 – Cox Regression with Propensity Score (Friday as Reference) |
|-----|--|
| 609 |  |
|     |  |

|           | Hazard Ratio (95% CI) | p-value |
|-----------|-----------------------|---------|
| Sunday    | 1.542 (1.361- 1.748)  | <.0001  |
| Monday    | 1.233 (1.088- 1.397)  | 0.0010  |
| Tuesday   | 1.387 (1.220-1.577)   | <.0001  |
| Wednesday | 1.204 (1.055-1.374)   | 0.0059  |
| Thursday  | 1.121 (0.990-1.271)   | 0.0724  |
| Saturday  | 1.142 (1.007-1.294)   | 0.0380  |

#### Supplementary Table 8 – Cox Regression with Propensity Score plus Shift (Friday as Reference)

|             | Hazard Ratio (95% CI) | p-value |  |  |
|-------------|-----------------------|---------|--|--|
| Sunday      | 1.543 (1.361-1.749)   | <.0001  |  |  |
| Monday      | 1.234 (1.089-1.399)   | 0.0010  |  |  |
| Tuesday     | 1.389 (1.221-1.579)   | <.0001  |  |  |
| Wednesday   | 1.204 (1.055-1.374)   | 0.0060  |  |  |
| Thursday    | 1.121 (0.990-1.271)   | 0.0727  |  |  |
| Saturday    | 1.142 (1.007-1.294)   | 0.0379  |  |  |
| Shift (Day) | 0.989 (0.920-1.064)   | 0.7756  |  |  |

## **Supplementary Table 9 – Cox Regression with Propensity Score (High Demand Days)**

|  | Hazard Ratio (95% CI) | p-value |
|--|-----------------------|---------|
| High Demand Days                                   | 1.242 (1.045-1.477)   | 0.0140  |
| Estimated Propensity Score                         | 0.761 (0.262-2.207)   | 0.6145  |
| Legend: Estimated Propensity Score HR 0.761 (0.262 | 2-2.207)              |         |
|  |                       |         |
|  |                       |         |
|  |                       |         |
|  |                       |         |
|  |                       |         |
|  |                       |         |
|  |                       |         |

#### Supplementary Table 10 – Logistic Model for Delirium as Outcome – Fully Adjusted

|   | Odds Ratio (95% CI) | p-value |
|---|---------------------|---------|
| Day of the Week (reference: Saturday)           |                     |         |
| Sunday  | 1.955 (1.050-3.643) | 0.2259  |
| Monday  | 1.177 (0.601-2.307) | 0.2069  |
| Tuesday   | 1.725 (0.900-3.306) | 0.6101  |
| Wednesday                                       | 2.676 (1.417-5.052) | 0.0056  |
| Thursday  | 1.471 (0.768-2.815) | 0.7917  |
| Friday  | 1.392 (0.734-2.641) | 0.5878  |
| Age at Admission                                | 1.072 (1.051-1.094) | <.0001  |
| Gender (reference: Female)                      | 0.895 (0.641-1.252) | 0.5180  |
| Race (reference: non-white)                     | 0.709 (0.424-1.184) | 0.1884  |
| Primary Insurance                               |                     |         |
| Commercial                                      | 0.161 (0.031-0.837) | 0.2440  |
| Medicaid  | 0.127 (0.013-1.205) | 0.3486  |
| Medicare  | 0.146 (0.028-0.754) | 0.1371  |
| Delirium Risk Factor                            | 1.048 (0.671-1.637) | 0.8356  |
| Admission Source (reference: Home or Self Care) | 0.558 (0.399-0.781) | 0.0007  |

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#### Supplementary Table 11 – Days of the Week vs Delay 634

|                      | Overall    | < 4.97 hours (No Delay) | > 13.4 hours (Delay) |
|----------------------|------------|-------------------------|----------------------|
|                      | 858        | 211                     | 215                  |
| Days of the Week (%) |            |                         |                      |
| Sunday               | 132 (15.4) | 33 (15.6)               | 35 (16.3)            |
| Monday               | 116 (13.5) | 20 (9.5)                | 32 (14.9)            |
| Tuesday              | 119 (13.9) | 34 (16.1)               | 40 (18.6)            |
| Wednesday            | 125 (14.6) | 25 (11.8)               | 36 (16.7)            |
| Thursday             | 123 (14.3) | 35 (16.6)               | 26 (12.1)            |
| Friday               | 130 (15.2) | 30 (14.2)               | 25 (11.6)            |
| Saturday             | 113 (13.2) | 34 (16.1)               | 21 (9.8)             |

**Legend**: Delay means ED to neurology floor waiting time greater than 13.4 hours.

## Supplementary Table 12 – Sensitivity Analysis

|                                 | Model 1, HR<br>(95% CI) |         | Model 2, HR<br>(95% CI) |         | Model 3, HR<br>(95% CI)    |         | Model 4, HR<br>(95% CI)    |         | Model 5, HR<br>(95% CI)             |         | Model 6, HR<br>(95% CI)    |         |
|---------------------------------|-------------------------|---------|-------------------------|---------|----------------------------|---------|----------------------------|---------|-------------------------------------|---------|----------------------------|---------|
|                                 | Hazard<br>Ratio         | p-value | Hazard<br>Ratio         | p-value | Hazard<br>Ratio            | p-value | Hazard<br>Ratio            | p-value | Hazard<br>Ratio                     | p-value | Hazard<br>Ratio            | p-value |
| High Demand Days of the<br>Week | 1.231<br>(1.040-1.459)  | 0.0160  | 1.219<br>(1.029-1.445)  | 0.0293  | 1.224<br>(1.033-<br>1.451) | 0.0199  | 1.224<br>(1.032-<br>1.452) | 0.0203  | 1.245<br>(1.048-<br>1.479)          | 0.0128  | 1.242<br>(1.045-<br>1.477) | 0.0140  |
| Age at admission                |                         |         | 0.992<br>(0.982-1.002)  | 0.1167  | 0.991<br>(0.981-<br>1.001) | 0.0920  | 0.991<br>(0.981-<br>1.001) | 0.0922  | 0.991<br>(0.980-<br>1.001)          | 0.0798  | 0.991<br>(0.980-<br>1.001) | 0.0796  |
| Gender (reference<br>Female)    |                         |         |                         |         | 1.069<br>(0.900-<br>1.269) | 0.4490  | 1.069<br>(0.900-<br>1.269) | 0.4491  | 1.085<br>(0.911-<br>1.291)          | 0.3606  | 1.086<br>(0.912-<br>1.293) | 0.3519  |
| Race(reference non-<br>white)   |                         |         |                         |         |                            |         | 0.996<br>(0.791-<br>1.254) | 0.9744  | 0.957<br>(0.746-<br>1.229)          | 0.7331  | 0.955<br>(0.742-<br>1.229) | 0.7196  |
| Primary Insurance<br>Commercial |                         |         |                         |         |                            |         |                            |         | 0.823<br>(0.257-                    | 0.7422  | 0.823<br>(0.257-           | 0.7434  |
| Medicaid                        |                         |         |                         |         |                            |         |                            |         | 2.631)<br>0.989<br>(0.272-          | 0 9865  | 2.635)<br>0.987<br>(0.272- | 0 9843  |
| Medicara                        |                         |         |                         |         |                            |         |                            |         | (0.272<br>3.589)<br>0.795<br>(0.250 | 0.000   | 3.583)<br>0.796            | 0.5045  |
| medicare                        |                         |         |                         |         |                            |         |                            |         | (0.230-<br>2.530)<br>0.857          | 0.0979  | (0.250-<br>2.534)<br>0.855 | 0.0990  |
| Delirium Risk Factor (0)        |                         |         |                         |         |                            |         |                            |         | (0.686-<br>1.070)                   | 0.1725  | (0.684-<br>1.068)<br>1.012 | 0.1679  |
| or Self Care)                   |                         |         |                         |         |                            |         |                            |         |                                     |         | (0.843-<br>1.215)          | 0.8949  |

#### Supplementary Text 1 – Statistical Code

```
data data1;
proc contents data=data1;
run;
proc freq data = data1;
tables WeekDayAd*Delay;
run;
**Overall sample data;
proc freq data = data1;
tables FinancialClassDSC*WeekDayAd/chisq;
run;
proc freq data = data1;
tables (cereb vasc A acute cereb dis epilepsy fall all fract
brain trauma other ill def cereb dis syncope trans cereb isc
visual imp dementia);
run;
proc freq data = data1;
tables dementia;
run;
proc freq data = data1;
tables Delirium risk factor;
run;
proc freq data = data1 ;
table AdmitSourceDSC*WeekDayAd/chisq;
run;
proc freq data = data1 ;
table WhiteYN;
run;
proc freq data = data1 ;
```

```
table CAM 72h ad;
run;
proc freq data = data1 ;
table CAM 72h tr;
run;
*Outcomes analysis;
proc lifetest data=data1 plots= s(atrisk ) notable ;
  time survival ad72h d * deliriumcnsr(1);
  title "Short-term Delirium Survival curve";
run;
proc lifetest data=data1 plots= s(atrisk ) notable ;
  strata WeekDayAd;
  time survival_ad72h_d * deliriumcnsr(1);
  title "Short-term Delirium Survival curve";
run;
proc lifetest data=data1 plots= s(atrisk ) notable ;
  strata Wednesday;
  time survival ad72h d * deliriumcnsr(1);
  title "Short-term Delirium Survival curve";
run;
proc lifetest data=data1 plots= s(atrisk ) notable ;
  strata Sunday;
  time survival ad72h_d * deliriumcnsr(1);
  title "Short-term Delirium Survival curve";
run;
proc lifetest data=data1 plots= s(atrisk ) notable ;
  strata Tuesday;
  time survival_ad72h_d * deliriumcnsr(1);
  title "Short-term Delirium Survival curve";
run;
```

```
proc lifetest data=data1 plots= s(atrisk ) notable ;
  strata High demand days;
  time survival ad72h d * deliriumcnsr(1);
  title "Short-term Delirium Survival curve";
run;
proc lifetest data=data1 plots= s(atrisk ) notable ;
  strata WeekDayAd 2;
  time survival ad72h d * deliriumcnsr(1);
  title "Short-term Delirium Survival curve";
run;
proc lifetest data=data1 plots= s(atrisk ) notable ;
where Wednesday = "Yes";
  strata WednesdayNight;
  time survival ad72h d * deliriumcnsr(1);
  title "Short-term Delirium Survival curve";
run;
proc lifetest data=data1 plots= s(atrisk ) notable ;
where Tuesday = "Yes";
  strata TuesdayNight;
  time survival ad72h d * deliriumcnsr(1);
  title "Short-term Delirium Survival curve";
run;
/* PS: parametric estimation */
proc logistic data=data1 ;
class Gender WhiteYN FinancialClassDSC AdmitSourceDSC cereb vasc A
acute cereb dis epilepsy fall all fract brain trauma
other ill def cereb dis syncope trans cereb isc visual imp dementia;
model WeekDayAd = AgeAtAdmission Gender WhiteYN FinancialClassDSC
AdmitSourceDSC cereb_vasc_A acute_cereb_dis epilepsy fall all_fract
brain trauma other ill def cereb dis syncope trans cereb isc
visual imp dementia;
output out=est ps2 p=p qsmk2;
run;
```

```
proc print data=est_ps2 ;
     id A;
     var AgeAtAdmission Gender WhiteYN FinancialClassDSC
AdmitSourceDSC cereb_vasc_A acute_cereb_dis epilepsy fall all_fract
brain trauma other ill def cereb dis syncope trans cereb isc
visual imp p qsmk2 survival ad72h d deliriumcnsr dementia;
run;
proc univariate data= est ps2;
     var p qsmk2;
run;
proc means data= est ps2;
     var p_qsmk2;
    class WeekDayAd;
run;
proc means data= est_ps2;
    var p_qsmk2;
     class Gender;
run;
proc means data= est ps2;
    var p qsmk2;
     class WhiteYN;
run;
proc means data= est ps2;
     var p qsmk2;
     class FinancialClassDSC;
run;
proc means data= est_ps2;
     var p qsmk2;
     class AdmitSourceDSC;
run;
```

```
proc univariate data= est ps2;
     var p qsmk2;
run;
proc phreg data=est ps2;
    class WeekDayAd (ref = "6 Friday") ;
    model survival ad72h d * deliriumcnsr(0) = WeekDayAd p qsmk2 /
details rl ties=efron ;
title "cox regression using Propensity scores*";
output out=Outp xbeta=Xb resdev=Dev;
run;
*The following statements plot the residuals against the linear
predictor scores;
   title "Residuals check ";
   proc sgplot data=Outp;
      yaxis grid;
      refline 0 / axis=y;
      scatter y=Dev x=Xb;
      run;
proc phreg data=est ps2;
    class WeekDayAd (ref = "6 Friday") Shift
                                                ;
    model survival ad72h d * deliriumcnsr(0) = WeekDayAd Shift
p qsmk2 / details rl ties=efron;
title "cox regression using Propensity scores*";
run;
/* PS: parametric estimation */
proc logistic data=data1 ;
class Gender WhiteYN FinancialClassDSC AdmitSourceDSC cereb_vasc_A
acute cereb dis epilepsy fall all fract brain trauma
other ill def cereb dis syncope trans cereb isc visual imp dementia;
model WeekDayAd 2 = AgeAtAdmission Gender WhiteYN FinancialClassDSC
AdmitSourceDSC cereb_vasc_A acute_cereb_dis_epilepsy_fall_all_fract
```

```
brain_trauma other_ill_def_cereb_dis syncope trans_cereb_isc
visual_imp dementia;
output out=est_ps p=p_qsmk;
run;
```

```
proc print data=est_ps;
```

id A;

var AgeAtAdmission Gender WhiteYN FinancialClassDSC AdmitSourceDSC cereb\_vasc\_A acute\_cereb\_dis epilepsy fall all\_fract brain\_trauma other\_ill\_def\_cereb\_dis syncope trans\_cereb\_isc visual\_imp p\_qsmk survival\_ad72h\_d deliriumcnsr dementia; run;

```
proc univariate data= est_ps;
    var p_qsmk;
run;
```

# proc phreg data=est\_ps; class WeekDayAd\_2 ; model survival\_ad72h\_d \* deliriumcnsr(0) = WeekDayAd\_2 p\_qsmk / details rl ties=efron; title "cox regression using Propensity scores\*";

```
run;
```

```
*Outcomes - sensitivity 1;
proc lifetest data=data1 plots= s(atrisk cl) notable ;
  time survival_ad72h_d * deliriumcnsr(1);
  title "Short-term Delirium Survival curve";
run;
```

```
proc lifetest data=data1 plots= s(atrisk cl) notable ;
   strata WeekDayAd_2;
   time survival_ad72h_d * deliriumcnsr(1);
   title "Short-term Delirium Survival curve";
run;
```

```
proc phreg data=data1;
```

```
class WeekDayAd 2 ;
    model survival_ad72h_d * deliriumcnsr(0) = WeekDayAd_2 / details
rl ties=efron;
title "Crude model";
run;
proc phreg data=data1;
   class WeekDayAd 2 ;
    model survival ad72h d * deliriumcnsr(0) = WeekDayAd 2
AgeAtAdmission / details rl ties=efron;
run;
proc phreg data=data1;
    class WeekDayAd 2 Gender ;
    model survival ad72h d * deliriumcnsr(0) = WeekDayAd 2
AgeAtAdmission Gender / details rl ties=efron;
run;
proc phreg data=data1;
    class WeekDayAd 2 Gender ;
    model survival ad72h d * deliriumcnsr(0) = WeekDayAd 2
AgeAtAdmission Gender / details rl ties=efron;
run;
proc phreg data=data1;
    class WeekDayAd 2 Gender WhiteYN ;
    model survival ad72h_d * deliriumcnsr(0) = WeekDayAd_2
AgeAtAdmission Gender WhiteYN / details rl ties=efron;
run;
proc phreg data=data1;
    class WeekDayAd 2 Gender WhiteYN FinacialClassDSC
Delirium risk factor;
    model survival_ad72h_d * deliriumcnsr(0) = WeekDayAd_2
AgeAtAdmission Gender WhiteYN FinacialClassDSC
Delirium risk factor/ details rl ties=efron;
run;
```

```
proc phreg data=data1;
    class WeekDayAd 2 Gender WhiteYN FinacialClassDSC
Delirium risk factor AdmitSourceDSC;
    model survival_ad72h_d * deliriumcnsr(0) = WeekDayAd_2
AgeAtAdmission Gender WhiteYN FinacialClassDSC Delirium risk factor
AdmitSourceDSC/ details rl ties=efron;
run;
proc phreg data=data1;
    class WeekDayAd 2 Gender WhiteYN FinacialClassDSC
Delirium risk factor AdmitSourceDSC;
    model survival ad72h d * deliriumcnsr(0) = WeekDayAd 2
AgeAtAdmission Gender WhiteYN FinacialClassDSC Delirium risk factor
AdmitSourceDSC/ details rl ties=efron;
title "fully adjusted model";
run;
**sensitivity analysis - cox with individual variables = high
demand;
proc phreg data=data1_Lunder7;
    class WeekDayAd 2 ;
    model survival ad72h d * deliriumcnsr(0) = WeekDayAd 2 / details
rl ties=efron;
title "Crude model";
run;
proc phreg data=data1;
    class WeekDayAd 2 ;
    model survival ad72h d * deliriumcnsr(0) = WeekDayAd 2
AgeAtAdmission / details rl ties=efron;
run;
proc phreg data=data1;
    class WeekDayAd 2 Gender ;
```

```
model survival ad72h d * deliriumcnsr(0) = WeekDayAd 2
AgeAtAdmission Gender / details rl ties=efron;
run;
proc phreg data=data1;
    class WeekDayAd 2 Gender ;
    model survival ad72h d * deliriumcnsr(0) = WeekDayAd 2
AgeAtAdmission Gender / details rl ties=efron;
run;
proc phreg data=data1;
    class WeekDayAd 2 Gender WhiteYN ;
    model survival ad72h d * deliriumcnsr(0) = WeekDayAd 2
AgeAtAdmission Gender WhiteYN / details rl ties=efron;
run;
proc phreg data=data1;
    class WeekDayAd 2 Gender WhiteYN Fi ncialClassDSC
Delirium risk factor;
    model survival ad72h d * deliriumcnsr(0) = WeekDayAd 2
AgeAtAdmission Gender WhiteYN Fi ncialClassDSC
Delirium risk factor/ details rl ties=efron;
run;
proc phreg data=data1;
    class WeekDayAd 2 Gender WhiteYN Fi ncialClassDSC
Delirium risk factor AdmitSourceDSC;
    model survival ad72h d * deliriumcnsr(0) = WeekDayAd 2
AgeAtAdmission Gender WhiteYN Fi ncialClassDSC Delirium risk factor
AdmitSourceDSC/ details rl ties=efron;
run;
proc phreg data=data1;
    class WeekDayAd 2 Gender WhiteYN Fi ncialClassDSC
Delirium risk factor AdmitSourceDSC;
```

```
model survival ad72h d * deliriumcnsr(0) = WeekDayAd 2
AgeAtAdmission Gender WhiteYN Fi ncialClassDSC Delirium_risk_factor
AdmitSourceDSC/ details rl ties=efron;
title "fully adjusted model";
run;
**Sensitivity analysis;
proc logistic data=data1 ;
class WeekDayAd 2 Gender WhiteYN Fi ncialClassDSC
Delirium risk factor AdmitSourceDSC;
model CAM 72h ad (ref = "No Delirium") = WeekDayAd 2 AgeAtAdmission
Gender WhiteYN Fi ncialClassDSC Delirium_risk_factor
AdmitSourceDSC;
title "Sensitivity analysis - Logistic model for delirium as outcome
- fully adjusted ";
run;
proc logistic data=data1 ;
class WeekDayAd Gender WhiteYN Fi ncialClassDSC
Delirium risk factor AdmitSourceDSC;
model CAM 72h ad (ref = "No Delirium") = WeekDayAd AgeAtAdmission
Gender WhiteYN Fi_ncialClassDSC Delirium_risk_factor
AdmitSourceDSC;
title "Sensitivity analysis - Logistic model for delirium as outcome
- fully adjusted ";
run;
**Validity check 1;
proc logistic data = data1 ;
class WeekDayAd 2 Gender WhiteYN Fi ncialClassDSC
Delirium risk factor AdmitSourceDSC;
model Delay 2 = WeekDayAd 2 AgeAtAdmission Gender WhiteYN
Fi_ncialClassDSC Delirium_risk_factor AdmitSourceDSC;
title "Validity check1 - Logistic model for delay as outcome - fully
adjusted ";
run:
proc logistic data = data1 ;
```

```
class WeekDayAd (ref = "7 Saturday") Gender WhiteYN
Fi_ncialClassDSC Delirium_risk_factor AdmitSourceDSC;
model Delay_2 = WeekDayAd AgeAtAdmission Gender WhiteYN
Fi_ncialClassDSC Delirium_risk_factor AdmitSourceDSC;
title "Validity check1 - Logistic model for delay as outcome - fully
adjusted ";
run;
```

```
**Validity check 2;
proc logistic data=data1 ;
class WeekDayAd_2 Gender WhiteYN Fi_ncialClassDSC
Delirium_risk_factor AdmitSourceDSC;
model CAM_72h_ad (ref = "No Delirium") = WeekDayAd_2 AgeAtAdmission
Gender WhiteYN Fi_ncialClassDSC Delirium_risk_factor
AdmitSourceDSC;
title "Sensitivity analysis - Logistic model for delirium as outcome
- fully adjusted ";
run;
```

proc logistic data=data1 ; class WeekDayAd (ref = "5 Thursday") Gender WhiteYN Fi\_ncialClassDSC Delirium\_risk\_factor AdmitSourceDSC; model CAM\_72h\_ad (ref = "No Delirium") = WeekDayAd AgeAtAdmission Gender WhiteYN Fi\_ncialClassDSC Delirium\_risk\_factor AdmitSourceDSC; title "Sensitivity analysis - Logistic model for delirium as outcome - fully adjusted "; run;

proc freq data = data1\_Lunder7; tables Delirium; run;

proc logistic data=data1 ; class WeekDayAd (ref = "5 Thursday") Gender WhiteYN Fi\_ncialClassDSC Delirium risk\_factor AdmitSourceDSC;

```
model Delirium (ref = "No Delirium") = WeekDayAd AgeAtAdmission
Gender WhiteYN Fi_ncialClassDSC Delirium_risk_factor
AdmitSourceDSC;
title "Sensitivity analysis - Logistic model for delirium as outcome
- fully adjusted ";
run;
```

```
**negative checks;
proc logistic data=data1 ;
class Shift Gender WhiteYN Fi_ncialClassDSC Delirium_risk_factor
AdmitSourceDSC;
model CAM_72h_ad (ref = "No Delirium") = Shift AgeAtAdmission
Gender WhiteYN Fi_ncialClassDSC Delirium_risk_factor
AdmitSourceDSC;
title "Sensitivity analysis - Logistic model for delirium as outcome
- fully adjusted ";
run;
```

proc logistic data=data1 ; class isWeekend Gender WhiteYN Fi\_ncialClassDSC Delirium\_risk\_factor AdmitSourceDSC; model CAM\_72h\_ad (ref = "No Delirium") = isWeekend AgeAtAdmission Gender WhiteYN Fi\_ncialClassDSC Delirium\_risk\_factor AdmitSourceDSC; title "Sensitivity analysis - Logistic model for delirium as outcome - fully adjusted "; run;

```
proc logistic data=data1;
class t_shift Gender WhiteYN Fi_ncialClassDSC Delirium_risk_factor
AdmitSourceDSC;
model CAM_72h_ad (ref = "No Delirium") = t_shift AgeAtAdmission
Gender WhiteYN Fi_ncialClassDSC Delirium_risk_factor
AdmitSourceDSC;
title "Sensitivity analysis - Logistic model for delirium as outcome
- fully adjusted ";
run;
```

\*\*\*end;

#### Supplementary Text 2 - Delirium Prevention Protocol

The delirium prevention and management program was a multimodal, nonpharmacologic delirium prevention program based in part on the "The Hospital Elder Life Program" (HELP). The prevention program was developed by an interdisciplinary committee which included physicians, nurses, occupational therapists, physical therapists, speech and language pathologists. Further input was obtained from pharmacists, case managers, social workers, and nutritionists. The recommendations from the committee were disseminated to nurses through a combination of in-service educational conferences, one-on-one discussions with nursing leadership, and continued feedback from multidisciplinary discussions. Physician residents were trained through a combination of in-service educational conferences, patient simulations, and continued feedback from multidisciplinary discussions. Therapists were trained though specialty specific discussions and educational materials. **Delirium screening:** Patients were screened every shift for delirium by their primary neurology trained registered nurse, using a modified Confusion Assessment Method (CAM). Nurses were prompted on an electronic flowsheet to identify whether core CAM delirium features were present: 1) Acute onset or fluctuating course, 2) Inattention. If both features were positive, then nurses were prompted for the presence of 3) Disorganized thinking or 4) Altered level of consciousness. A positive delirium screen was defined by the presence of both features 1 and 2 with additionally either feature 3 or 4.

**Delirium Prevention and Management:** The following criteria were formally used to determine an increased risk of delirium: Age >65 or cognitive impairment. Additional criteria were considered as clinically indicated. All patients were discussed daily at interdisciplinary rounds, attended by physicians, nursing staff, case managers, a social worker, and occupational and physical therapists. As part of the round structure, the primary nurse was prompted to identify whether a patient was at risk for delirium or had screened positive for delirium. All patients at risk of delirium or who had screened positive for delirium were discussed to reaffirm that appropriate nonpharmacologic measures were being used. Measures were derived from prior delirium guidelines and prevention programs, including the United Kingdom National Institute for Health and Care Excellence (NICE) delirium guidelines and the Hospital Elder Life Program (HELP) (NICE, 2003, Inouye et al., 2000). Measures included orientation/redirection verbally and through the use of an updated whiteboard, decreased overnight awakening, keeping lights on and shade up during the day, early mobilization as tolerated, use of sensory aids such as glasses and hearing aids, avoidance of restraints, assessment of pain, elimination of unnecessary catheters/lines, review of medications, and encouraging fluid intake when appropriate.

| Demographic Information (Day of the Week) |              |              |              |              |              |              |              |              |         |
|---|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------|
|   | Overall      | Sunday       | Monday       | Tuesday      | Wednesday    | Thursday     | Friday       | Saturday     | p-value |
|   | 858          | 132          | 116          | 119          | 125          | 123          | 130          | 113          |         |
| Age at admission (mean (SD))              | 77.99 (8.58) | 77.54 (7.99) | 77.97 (8.58) | 77.02 (8.54) | 78.46 (8.77) | 78.33 (9.45) | 78.35 (8.13) | 78.29 (8.75) | 0.832   |
| Gender = Male (%)                         | 439 (51.2)   | 65 (49.2)    | 60 (51.7)    | 70 (58.8)    | 63 (50.4)    | 64 (52.0)    | 63 (48.5)    | 54 (47.8)    | 0.681   |
| Admission Source = Institutionalized* (%) | 324 (37.8)   | 59 (44.7)    | 40 (34.5)    | 46 (38.7)    | 34 (27.2)    | 46 (37.4)    | 50 (38.8)    | 49 (43.4)    | 0.096   |
| Race (%)                                  |              |              |              |              |              |              |              |              | 0.394   |
| Black                                     | 49 (5.9)     | 3 (2.3)      | 9 (7.8)      | 8 (6.8)      | 13 (10.8)    | 6 (5.2)      | 5 (3.9)      | 5 (4.5)      |         |
| Other **                                  | 60 (7.2)     | 11 (8.5)     | 6 (5.2)      | 10 (8.5)     | 7 (5.8)      | 7 (6.0)      | 9 (7.1)      | 10 (9.0)     |         |
| White                                     | 727 (87.0)   | 115 (89.1)   | 100 (87.0)   | 100 (84.7)   | 100 (83.3)   | 103 (88.8)   | 113 (89.0)   | 96 (86.5)    |         |
| Primary Insurance (%)                     |              |              |              |              |              |              |              |              | 0.545   |
| Commercial***                             | 221 (25.9)   | 32 (24.2)    | 28 (24.1)    | 27 (23.1)    | 31 (25.2)    | 29 (23.6)    | 45 (34.6)    | 29 (25.7)    |         |
| Medicare                                  | 610 (71.4)   | 98 (74.2)    | 86 (74.1)    | 86 (73.5)    | 90 (73.2)    | 91 (74.0)    | 80 (61.5)    | 79 (69.9)    |         |
| Other****                                 | 23 (2.7)     | 2 (1.5)      | 2 (1.7)      | 4 (3.4)      | 2 (1.6)      | 3 (2.4)      | 5 (3.8)      | 5 (4.4)      |         |

Legend: \* Includes: Skilled Nursing Facility; Psych, Substance Abuse, or Rehab Hospital; Outside Health Care Facility; Outside Hospital or Ambulatory Surgery Center. \*\* includes: = Asian; Hispanic or Latino; American Indian or Alaska Native. \*\*\* includes: Blue Cross Blue Shield; Tufts Health Plan; Harvard Pilgrim; Neighborhood Health Plan and Allways Health Partners. \*\*\*\* includes: Medicaid, Free Care; Workers Comp / Motor Vehicle; Other Government; Self-pay and International.









