Appendix I

Updated October 25, 2013

**Mortality Predictions on Admission as a Context for Organizing Healthcare**

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**Variables Considered for Inclusion in the Multi-variable Sub-Models**

The following 48 variables were considered for inclusion in the multivariable model, with those selected underlined.

1. Age, gender
2. Indicator variables (1,0) for whether or not the patient had a previous hospitalization within the previous 365 days, if ever placed in extended care facility following a hospitalization within the previous 365 days
3. Indicator variables for emergency admission type, admitting department medicine or surgery.
4. The following binary conditions noted to be present on admission: stroke, injury, pneumonia, shock, acute myocardial infarction, heart failure, chronic obstructive pulmonary disease, venous thromboembolism, syncope, sepsis, respiratory failure, gastrointestinal hemorrhage
5. Current or previous diagnosis: atrial fibrillation, leukemia/lymphoma, metastatic cancer, cancer (other than leukemia, lymphoma, metastatic cancer), coagulopathy, cognitive disorder, paralysis, peripheral vascular disease, other neurological conditions (eg. Parkinson’s, multiple sclerosis, epilepsy, coma and stupor), valvular heart disease.

Clinical laboratory values: Blood urea nitrogen, serum potassium, serum sodium value, white blood count, anion gap, serum troponin, prothrombin time (international normalized ratio - INR), aspartate aminotransferase (SGOT), B-natriuretic protein (BNP), hemoglobin, platelet count, serum albumin, arterial pH, serum amylase, total bilirubin, arterial partial pressure of carbon dioxide (pCO2), arterial partial pressure of oxygen (pO2), serum glucose, serum lactate. See following table for imputation and transformation formulae for laboratory parameters in the final multivariable model.

**Definitions of Diagnosis-related Co-morbidities in Prediction Models**

**(All binary indicators)**

| **Diagnosis** | **Definition** |
| --- | --- |
| RESPIRATORY FAILURE present on admission | Clinical Classification: 131: Respiratory Failure, Insufficiency, Arrest (Adult) |
| HEART FAILURE present on admission | Clinical Classification: 108: Congestive Heart Failure, Non-hypertensive |
| INJURY, present on admission | Clinical Classification: 225: Joint disorders and dislocations, trauma-related; 226: Fracture of neck of femur (hip); 227: Spinal cord injury; 228: Skull and face fractures; 229: Fracture of upper limb; 230: Fracture of lower limb; 231: Other fractures; 232: Sprains and strains; 233: Intracranial injury; 234: Crushing injury or internal injury; 235: Open wounds of head, neck, and trunk; 236: Open wounds of extremities; 239: Superficial injury, contusion; 240: Burns; 244: Other injuries and conditions due to external causes; 2601: E Codes: Cut pierce; 2603: E Codes: Fall; 2604: E Codes: Fire/burn; 2605: E Codes: Firearm |
| SEPSIS present on admission | Clinical Classification: 2: Septicemia (Except In Labor); ICD9 Diagnosis Code: 995.90: Systemic Inflammatory Response Syndrome; 995.91: Sepsis; 995.92: Severe Sepsis |
| Current or past history of ATRIAL FIBRILLATION | Primary or secondary ICD9 diagnosis code: 427.31: Atrial fibrillation; 427.32: Atrial flutter |
| Current or past history of solid-tumor CANCER (set to zero if metastatic cancer , lymphoma, leukemia also present) | Clinical Classifications: 11: Cancer of head and neck; 12: Cancer of esophagus; 13: Cancer of stomach; 14: Cancer of colon; 15: Cancer of rectum and anus; 16: Cancer of liver and intrahepatic bile duct;17: Cancer of pancreas; 18: Cancer of other GI organs, peritoneum; 19: Cancer of bronchus, lung; 20: Cancer, other respiratory and intrathoracic; 21: Cancer of bone and connective tissue; 22: Melanomas of skin; 23: Other non-epithelial cancer of skin; 24: Cancer of breast; 25: Cancer of uterus; 26: Cancer of cervix; 27: Cancer of ovary; 28: Cancer of other female genital organs; 29: Cancer of prostate; 30: Cancer of testis; 31: Cancer of other male genital organs; 32: Cancer of bladder; 33: Cancer of kidney and renal pelvis; 34: Cancer of other urinary organs; 35: Cancer of brain and nervous system; 36: Cancer of thyroid; 41: Cancer, other and unspecified primary; 44: Neoplasms of unspecified nature or uncertain behavior |
| Current or past history of METASTATIC CANCER (regardless whether or not leukemia or lymphoma also present) | Clinical Classification: 42: Secondary Malignancies; 43: Malignant Neoplasm Without Specification Of Site |
| Current or past history of LEUKEMIA or LYMPHOMA | Clinical Classification: 37: Hodgkin's disease; 38: Non-Hodgkin's lymphoma; 39: Leukemias; 40: Multiple myeloma |
| Current or past history of OTHER NEUROLOGICAL CONDITION | Clinical Classification: 79: Parkinson's disease; 80: Multiple sclerosis; 81: Other hereditary and degenerative nervous system conditions; 83: Epilepsy, convulsions; 85: Coma, stupor, and brain damage |
| Current or past history of COGNITIVE DEFECT | Clinical Classification: 653: Delirium dementia and amnestic and other cognitive disorders |

**Clinical Laboratory Parameters Used For Predictions**

|  |  |
| --- | --- |
| **Description** | Imputation and Transformation Formula |
| **Maximum serum blood urea nitrogen (mg/dl**), *continuous, logged transformation* | If maxbun = . then impute 18.9  if maxBUN ge 100 then maxBUNc=100; else maxBUNc=maxBUN;  labbun = log(maxbunc + 1)  then subtract group mean labbun and divide by group std dev for labbun:  labbun\_c = (labbun – 2.9886 ) / 0.5093 |
| **Maximum white blood count (1000/UL**), *continuous, logged transformation* | If maximum wbc = . then impute 9.7  if . lt maxwbc le 1 then wbctrans=30; else if maxwbc ge 30 then wbctrans=30; else wbctrans=abs(maxwbc-9.7);  labWBC = log(wbctrans + 1)  then subtract group mean labwbc and divide by group std dev for labwbc:  labwbc\_c = (labwbc– 1.0548) / 0.7821 |
| **Minimum platelet count (1000/UL),** *continuous, square root transformation* | If minimum platelet = . then impute 242  if minplt gt 500 then labplt=500; else labplt=minplt;  labplt = sqrt(labplt)  then subtract group mean labplt and divide by group std dev for labplt:  labplt\_c = ( labplt – 15.2340) / 2.6497 |
| **Minimum hemoglobin**, (gm/dl) *continuous* | If minimum hemoglobin = . then impute 12.0  if minhgb lt 8 then labhgb=8; else if minhgb ge 15 then labhgb=15;  else labhgb=minhgb;  then subtract group mean labhgb and divide by group std dev for labhgb :  labhgb\_c = (labhgb– 12.2683) / 1.8297 |
| **Minimum serum albumin (gm/dl),** *binary indicator* | If minimum albumin = . then impute 3.14  if minimum albumin lt 3.14 then lablowalb=1; else lablowalb=0; |
| **Minimum arterial pH**, *binary indicator* | If minimum arterial pH = . then impute 7.36  if minaph lt 7.3 or minaph gt 7.5 then lababnph=1; else lababnph=0; |
| **Minimum arterial pO2 (mmHg),** *binary indicator* | If minimum arterial pO2 = . or > = 100 then minimum pO2=100  if minpo2 lt 85 then lablowpo2=1; else lablowpo2=0; |
| **Maximum serum troponin (ng/ml),** *binary indicator* | If maximum troponin = . then impute 0  if max troponin gt .04 then labhightrop=1; else labhightrop=0; |
| **Maximum serum lactate** binary indicator | if maxlactic=. then maxlactic=0.3;  if maxlactic gt 4 then labhighlac=1; else labhighlac=0; |

**Formulation of Variables Used in Multivariable Logistic Regression Models**

**Outcome = Death within 30 days of admission**

if femalesex=**0** and pasthospge = **0** then submodel='a';

if femalesex=**1** and pasthospge = **0** then submodel='b';

if femalesex=**0** and pasthospge = **1** then submodel='c';

if femalesex=**1** and pasthospge = **1** then submodel='d';

if emergentadm=**0** and adm\_medicine=**0** then do; em\_or\_med3=**0**; em\_or\_med2=**0**; em\_or\_med1=**0**; end;

else if emergentadm=**1** and adm\_medicine=**1** then do; em\_or\_med3=**1**; em\_or\_med2=**0**; em\_or\_med1=**0**; end;

else if emergentadm=**0** and adm\_medicine=**1** then do; em\_or\_med3=**0**; em\_or\_med2=**1**; em\_or\_med1=**0**; end;

else if emergentadm=**1** and adm\_medicine=**0** then do; em\_or\_med3=**0**; em\_or\_med2=**0**; em\_or\_med1=**1**; end;

if anycog=**0** and anyotherneuro=**0** then do; neuro2=**0**; neuro1=**0**;end;

else if anycog=**1** then do; neuro2=**1**; neuro1=**0**; end;

else if anyotherneuro=**1** then do; neuro2=**0**; neuro1=**1**; end;

seplacpO2=sum(poa\_sepsis, labhighlac, lablowpo2);

if anymets=**0** and anycancer=**0** and anyleuk=**0** then lmc=**0**;

if anymets=**0** and anycancer=**1** and anyleuk=**0** then lmc=**1**;

if anymets=**0** and anycancer=**0** and anyleuk=**1** then lmc=**2**;

if anymets=**1** and anycancer=**0** and anyleuk=**0** then lmc=**3**;

if anymets=**1** and anycancer=**0** and anyleuk=**1** then lmc=**4**;

if poa\_chf=**0** and labhightrop = **0** and anyafib=**0** then heart=**0**;

if labhightrop=**0** and (poa\_chf=**1** or anyafib=**1**) then heart=**1**;

if labhightrop=**1** and poa\_chf=**0** and anyafib=**0** then heart=**2**;

if labhightrop=**1** and ((poa\_chf=**1** and anyafib=**0**)

or (poa\_chf=**0** and anyafib=**1**)

or (poa\_chf=**1** and anyafib=**1**)) then heart=**3**;

/\*lab and age spline\*/

if labbun\_c le **.005** then labbun1\_c=**0**; else labbun1\_c=labbun\_c -**.005**;

if labplt\_c le **.15** then labplt1\_c=**0**; else labplt1\_c=labplt\_c -**.15**;

if labwbc\_c le **1** then labwbc1\_c =**0**; else labwbc1\_c =labwbc\_c - **1**;

if ageyear le **85** then ageyear1=**0**; else ageyear1=ageyear-**85**;

**Covariates and Parameter Estimates for the 4 submodels**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **[A]** | **[B]** | **[C]** | **[D]** |
| Intercept | -6.6841 | -8.1943 | -5.6654 | -6.8029 |
| Injury present on admission | 0.4507 | 0.0695 | 0.2262 | 0.2743 |
| Respiratory failure present on admission | 1.1356 | 1.2940 | 0.9231 | 1.0435 |
| Low albumin | 0.8156 | 0.7437 | 0.6303 | 0.6843 |
| Abnormal pH | 1.3287 | 0.7044 | -0.0474 | 0.0168 |
| em\_or\_med1 | 0.7104 | 1.3714 | 0.5665 | 0.5993 |
| em\_or\_med2 | 0.8885 | 1.5493 | 0.6553 | 0.8036 |
| em\_or\_med3 | 0.6853 | 1.4135 | 0.6525 | 0.7911 |
| neuro1 | 0.9899 | 0.6768 | 0.2762 | -0.0522 |
| neuro2 | 0.8038 | 0.7710 | 0.4586 | 0.3353 |
| seplacpO2 | 0.3124 | 0.8292 | 0.3676 | 0.3855 |
| lmc | 0.7390 | 0.6969 | 0.5965 | 0.5828 |
| heart | 0.1978 | 0.2684 | 0.1171 | 0.0976 |
| labbun\_c | 0.0970 | 0.0446 | 0.2484 | -0.0216 |
| labbun1\_c | 0.1310 | 0.2459 | 0.0318 | 0.3606 |
| labplt\_c | -0.1443 | -0.2938 | -0.1573 | -0.2114 |
| labplt1\_c | 0.0489 | 0.4942 | 0.3477 | 0.2536 |
| labwbc\_c | -0.1302 | -0.1492 | -0.0054 | -0.1128 |
| labwbc1\_c | 0.4060 | 0.3602 | 0.1192 | 0.4940 |
| labhgb\_c | -0.1632 | -0.0296 | -0.0501 | 0.0124 |
| ageyear | 0.0270 | 0.0332 | 0.0167 | 0.0289 |
| ageyear1 | 0.0927 | 0.0759 | 0.1008 | 0.0211 |

**Definitions of Intra-hospitalization Complication**

We considered a “complication” occurred if any of the following primary or secondary diagnoses were recorded as not being present on admission: acute myocardial infarction, atrial fibrillation, cellulitis, coagulopathy, other dysrhythmias, gastrointestinal bleed, gastrointestinal dysfunction, heart failure, liver dysfunction, other neurological events, paralysis, peptic ulcer, pneumonia, post-operative infection, renal dysfunction, respiratory failure, sepsis, shock, stroke, urinary tract infection, and venous thromboembolism.

# Definition of Unplanned Intensive Care Unit transfer

An unplanned intensive care unit transfer is defined as an intensive care unit stay for patients whose first nursing unit was not an intensive care unit and whose most recent hospital unit was not the Operating Room.

**Parameter Estimates for Other Outcomes of Interest**

Logistic regression models were created for each outcome of interest using the calculated probability of dying within 30 days and its logarithm as the 2 covariates.

|  |  |  |  |
| --- | --- | --- | --- |
| **Outcome** | **Intercept** | **pmort30** | **logpmort30** |
|
| Death within hospitalization | -0.8717 | 1.0731 | 0.9625 |
|
| Intra-hospital complication | -0.166 | -0.8017 | 0.4694 |
|
| Intensive Care Unit stay | -0.8995 | 0.797 | 0.3403 |
|
| Discharge with palliative care status | 0.6497 | -2.1733 | 1.4859 |
|
| 30 day readmission | 0.1481 | -1.9729 | 0.5274 |
|
| Death within 180 days | 2.2252 | -1.3197 | 1.3224 |
|
| Unplanned transfer to an intensive care unit within the first 24 hours | -2.8435 | 0.0705 | 0.5045 |
|
| Cardiopulmonary arrest | -3.9749 | 0.7636 | 0.4481 |
|

**Calibration of Mortality Risk Strata**

**Derivation Hospital D1**

| **Interval of predicted mortality risk** | **Actual**  **Proportion** | **Lower**  **95% Confidence Limit** | **Upper**  **95% Confidence Limit** | **Mean**  **Prediction** | **flag** |
| --- | --- | --- | --- | --- | --- |
| **0-0.0008** | 0 |  |  | 0.00071 | \* |
| **0.0008-0.0011** | 0.0004 | 0.0000 | 0.0020 | 0.00095 |  |
| **0.0011-0.0021** | 0 |  |  | 0.00147 | \* |
| **0.0021-0.0033** | 0.0014 | 0.0004 | 0.0037 | 0.00268 |  |
| **0.0033-0.0049** | 0.0025 | 0.0010 | 0.0051 | 0.00409 |  |
| **0.0049-0.0067** | 0.0036 | 0.0017 | 0.0066 | 0.00576 |  |
| **0.0067-0.0087** | 0.0054 | 0.0030 | 0.0088 | 0.00766 |  |
| **0.0087-0.0108** | 0.0075 | 0.0046 | 0.0114 | 0.00973 |  |
| **0.0108-0.0134** | 0.0079 | 0.0049 | 0.0119 | 0.01208 | \* |
| **0.0134-0.0165** | 0.0111 | 0.0075 | 0.0157 | 0.01492 |  |
| **0.0165-0.0201** | 0.0146 | 0.0105 | 0.0198 | 0.01826 |  |
| **0.0201-0.0247** | 0.0264 | 0.0208 | 0.0331 | 0.02233 |  |
| **0.0247-0.0308** | 0.0246 | 0.0192 | 0.0311 | 0.02755 |  |
| **0.0308-0.0392** | 0.0353 | 0.0288 | 0.0429 | 0.03480 |  |
| **0.0392-0.0503** | 0.0475 | 0.0399 | 0.0560 | 0.04454 |  |
| **0.0503-0.0669** | 0.0629 | 0.0541 | 0.0725 | 0.05811 |  |
| **0.0669-0.0916** | 0.0871 | 0.0770 | 0.0982 | 0.07858 |  |
| **0.0916-0.1308** | 0.1243 | 0.1123 | 0.1371 | 0.10936 | \* |
| **0.1308-0.2186** | 0.1768 | 0.1628 | 0.1914 | 0.16752 |  |
| **0.2186-1.0** | 0.3518 | 0.3341 | 0.3698 | 0.36999 | \* |

**Calibration of Mortality Risk Strata**

**Validation Hospital V1**

| **Interval of predicted mortality risk** | **Actual**  **Proportion** | **Lower**  **95% Confidence Limit** | **Upper**  **95% Confidence Limit** | **Mean**  **Prediction** | **flag** |
| --- | --- | --- | --- | --- | --- |
| **0-0.0008** | 0 |  |  | 0.00071 | \* |
| **0.0008-0.0011** | 0 |  |  | 0.00095 | \* |
| **0.0011-0.0021** | 0.0008 | 0.0000 | 0.0042 | 0.00146 |  |
| **0.0021-0.0033** | 0.0021 | 0.0004 | 0.0062 | 0.00267 |  |
| **0.0033-0.0049** | 0.0021 | 0.0004 | 0.0061 | 0.00406 |  |
| **0.0049-0.0067** | 0.0033 | 0.0011 | 0.0076 | 0.00577 |  |
| **0.0067-0.0087** | 0.0038 | 0.0014 | 0.0083 | 0.00766 |  |
| **0.0087-0.0108** | 0.0059 | 0.0027 | 0.0113 | 0.00973 |  |
| **0.0108-0.0134** | 0.0089 | 0.0047 | 0.0151 | 0.01207 |  |
| **0.0134-0.0165** | 0.0136 | 0.0084 | 0.0207 | 0.01492 |  |
| **0.0165-0.0201** | 0.0111 | 0.0063 | 0.0183 | 0.01827 |  |
| **0.0201-0.0247** | 0.0166 | 0.0108 | 0.0245 | 0.02220 |  |
| **0.0247-0.0308** | 0.0331 | 0.0244 | 0.0440 | 0.02759 |  |
| **0.0308-0.0392** | 0.0390 | 0.0299 | 0.0498 | 0.03491 |  |
| **0.0392-0.0503** | 0.0406 | 0.0310 | 0.0522 | 0.04451 |  |
| **0.0503-0.0669** | 0.0656 | 0.0535 | 0.0793 | 0.05818 |  |
| **0.0669-0.0916** | 0.0935 | 0.0786 | 0.1103 | 0.07789 | \* |
| **0.0916-0.1308** | 0.1294 | 0.1113 | 0.1493 | 0.10905 | \* |
| **0.1308-0.2186** | 0.2029 | 0.1813 | 0.2259 | 0.16836 | \* |
| **0.2186-1.0** | 0.3938 | 0.3667 | 0.4214 | 0.37268 |  |

**Calibration of Mortality Risk Strata**

**Validation Hospital V2**

| **Interval of predicted mortality risk** | **Actual**  **Proportion** | **Lower**  **95% Confidence Limit** | **Upper**  **95% Confidence Limit** | **Mean**  **Prediction** | **flag** |
| --- | --- | --- | --- | --- | --- |
| **0-0.0008** | 0 |  |  | 0.00070 | \* |
| **0.0008-0.0011** | 0 |  |  | 0.00094 | \* |
| **0.0011-0.0021** | 0 |  |  | 0.00148 | \* |
| **0.0021-0.0033** | 0 |  |  | 0.00274 | \* |
| **0.0033-0.0049** | 0.0016 | 0.0000 | 0.0091 | 0.00406 |  |
| **0.0049-0.0067** | 0.0015 | 0.0000 | 0.0086 | 0.00577 |  |
| **0.0067-0.0087** | 0.0015 | 0.0000 | 0.0083 | 0.00762 |  |
| **0.0087-0.0108** | 0.0030 | 0.0004 | 0.0109 | 0.00968 |  |
| **0.0108-0.0134** | 0.0092 | 0.0034 | 0.0198 | 0.01212 |  |
| **0.0134-0.0165** | 0.0087 | 0.0032 | 0.0189 | 0.01497 |  |
| **0.0165-0.0201** | 0.0110 | 0.0048 | 0.0216 | 0.01830 |  |
| **0.0201-0.0247** | 0.0122 | 0.0056 | 0.0231 | 0.02227 |  |
| **0.0247-0.0308** | 0.0197 | 0.0113 | 0.0318 | 0.02764 |  |
| **0.0308-0.0392** | 0.0281 | 0.0183 | 0.0412 | 0.03475 |  |
| **0.0392-0.0503** | 0.0490 | 0.0361 | 0.0648 | 0.04461 |  |
| **0.0503-0.0669** | 0.0502 | 0.0372 | 0.0660 | 0.05838 |  |
| **0.0669-0.0916** | 0.0840 | 0.0678 | 0.1026 | 0.07834 |  |
| **0.0916-0.1308** | 0.1345 | 0.1140 | 0.1571 | 0.10903 | \* |
| **0.1308-0.2186** | 0.2344 | 0.2094 | 0.2609 | 0.16930 | \* |
| **0.2186-1.0** | 0.4160 | 0.3893 | 0.4431 | 0.38507 | \* |