SALIENT: ED Machine Learning Sepsis Prediction

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# 1 About this document

This technical document has been developed as part of the ‘Gen Med Project’ by the Commission on Excellence and Innovation in Health (CEIH). The project forms part of a program of work that is funded through the Acute Models of Care Grant 2022 by the Medical Research Future Fund (MRFF). The project’s primary goal is to reduce unwarranted clinical variation in general medicine, using a data analytics and machine learning approach.

Sepsis was identified as a focus area from early analysis that looked at high bed day consumption and high opportunity Diagnosis Related Groups (DRGs) that included shortness of breath as a symptom.

# 2 Document Revisions

| No. | Date | Description | Person |
| --- | --- | --- | --- |
| 0.1 | 30/10/24 | First Draft Document describing the ED Sepsis Presentation ML model, and the various verification requirements for the model. | Iain Bertram |
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|  |  |  |  |

# 3 Introduction

A new adult sepsis pathway has been proposed for use with public hospitals within South Australia. This pathway is intended to identify patients who are at risk of developing Sepsis and initiating a standardised treatment programme. The patients are identified using Rapid Detection and Response (RDR) Observation Charts as implemented within the public hospital Electronic Medical Record (EMR) using the Sunrise Deteriorating Patient Reference Guide [1].

There are two pathways for flagging a patient as being at risk of Sepsis and requiring either review by a Senior Medical Officer or a Medical Emergency response. The Purple pathway is triggered if any of the patient’s observations in the Rapid Detection and Response (RDR) are in the purple zone (Table 1). The Red pathway is triggered if there are two or more red zone observations.

This report describes the development of a Machine Learning (ML) model that can be used in place of these pathways. I.e. to develop machine learning models that identify people who will be admitted to hospital and will have a sepsis diagnosis (based on ICD-10 codes) on inpatient discharge based on measurement of the patient’s vital signs.

Table 1: Rapid Detection and Response (RDR) Alert Triggers

| Measure | Purple | Red | Yellow | Yellow | Red | Purple |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | Low |  |  | High |  |
| Respiration (breaths/min) | 7 |  | 10 | 21 | 26 | 31 |
| O2 Saturation (%) | 88 | 91 | 94 | NA | NA | NA |
| O2 Flow (L/min) | NA | NA | NA | 5 | 7 | 8 |
| Blood Pressure Systolic (mm Hg) | 89 | 99 | NA | 170 | 180 | 200 |
| Pulse Rate (beats/min) | 39 | 49 | 59 | 100 | 120 | 140 |
| Temperature (ºC) |  | 35 | 35.5 | 38.1 | 38.6 |  |
| Level of Consciousness | NA | NA | NA |  | 2 | 3 |

# 4 Cohort

The data for this study was sourced from the South Australian Electronic Medical Record system (EMR). The data set is composed of Emergency Department (ED) presentations by an adult (age of at least 16 years) followed by an inpatient (IP) admission with sepsis diagnosis identified by the ICD-10 codes, Table 23 [[1]](#footnote-13) (based on a journey, see appendix 7.1).

Specifically we only include the first ED presentation in a journey. This excludes presentations that are part of the admission process when the patient is transferred from one hospital to another. We also require that at least three of the following vital signs are recorded in the EMR during the presentation: respiration, O2 Saturation, systolic blood pressure, pulse rate and temperature[[2]](#footnote-14) (Table 1).

The IP admission is required to be the first episode of care (EoC) after any ED presentations [[3]](#footnote-15). IP admissions where the patient does not leave the ED are excluded (these are identified by an IP discharge date/time within 60 minutes of the discharge date/time of the ED presentation and a location that includes the string “ED-Admin”.)

The training data set includes all presentations to Emergency Departments at metropolitan hospitals in the calendar year 2023 in which at least three observations of vital signs of interest have been made (see Table 1). There are 272,199 ED presentations with at least three vital signs recorded which included 2,844 presentations that resulted in an inpatient admission which includes at least one ICD-10 code matching a Sepsis diagnosis (of these 1,002 have sepsis as the primary, or first-listed, diagnosis). Note, 59,468 (17.9%) out of a total 331,667 ED presentations do not have at least three observations of vital signs recorded in the EMR and have been excluded from the analysis.

The first verification data set is created from all ED presentations at metropolitan hospitals in the calendar year 2024 in which at least three observations of vital signs of interest have been made. There are 279,884 ED presentations with at least three vital signs recorded which included 1,815 presentations that resulted in an inpatient admission which includes at least one ICD-10 code matching a Sepsis diagnosis (of these 1,067 have sepsis as the primary, or first-listed, diagnosis). Note, 53,908 (16.9%) out of a total 333,792 ED presentations do not have at least three observations of vital signs recorded in the EMR and have been excluded from the analysis.

The fraction of Sepsis cases that are not identified, ICD-10 A41.9, i.e. where pathology tests have not identified the infection agent, is 66.7% in the 2023 training data set and 68.5% in the 2024 verification data set (see Tables 24 & 25).

# 5 Validation Metrics

The performance of the ML model will evaluated in comparison with current scoring systems in terms of sensitivity/specificity and against the proposed adult sepsis pathway. The two scoring systems used are qSOFA and the SIRS criteria. In addition the fraction of patients who require ICU usage and patient mortality will also be examined.

## 5.1 qSOFSA

The quick Sequential Organ Failure Assessment (qSOFA) [2] is used to identify high-risk patients for in-hospital mortality with suspected infection outside the ICU. Two or more of the following criteria need to be met for a positive qSOFA:

* Glasgow Coma Scale < 15,
* Respiratory rate 22,
* Systolic Blood Pressure 100 mmHg.

## 5.2 Systemic Inflammatory Response Syndrome (SIRS)

There are multiple levels to the SIRS schema [3,4] relating to the severity of the response. The first is the basic SIRS criteria which requires at least two of the following conditions:

* T 36 C or T 38 C,
* Heart rate 90,
* Respiratory rate 20,
* White Blood Count 12

The second level is the Sepsis Criteria (SIRS + Source of Infection) which has not yet been implemented in this study as it requires searching the free text progress notes.

The third level is Severe Sepsis Criteria (Organ Dysfunction, Hypotension, or Hypoperfusion) which requires at least one of the following to be satisfied (we have excluded the drop in blood pressure as the patients being reviewed have just presented to the ED and usually only have one set of vital signs):

* Lactate Blood Gas 4,
* Systolic Blood Pressure 90.

## 5.3 Adult Sepsis Pathway

There are two pathways for flagging a patient as being at risk of Sepsis and requiring either review by a Senior Medical Officer or a Medical Emergency response. The Purple pathway is triggered if any of the patient’s observations in the Rapid Detection and Response (RDR) are in the purple zone (Table 1). The Red pathway is triggered if there are two or more red zone observations.

## 5.4 ICU Usage

A stay in the ICU is identified by matching the patient’s location to the ICU wards in the first episode of care (EoC) after inpatient admission. .

## 5.5 Mortality

Mortality is measured using the patients date of death and the date/time of the presentation at the ED. The mortality is calculated for death as an inpatient and at after admission are.

## 5.6 Triage Category

We categorise the patients based on the the triage category assigned on presentation at the emergency department. Patients with Sepsis, especially this in triage category 3, 4 or 5 can have there triage classification changed if they deteriorate while waiting to be seen.

## 5.7 Waiting Times

In order to understand the clinical workflow the various time stamps recorded in the ED status board will be analysed in order to measure the time waiting to be seen (‘WTB’), the decision to admit, when ready for ward transfer.

## 5.8 Sepsis Patients

The demographics for the 2023 training sample are given in Table 2 amd for the 2024 validation data set in Table 3

The metrics for the 2023 training sample are given in Table 4 and for the 2024 validation sample Table 5.

The outcomes for the 2023 training sample are give in Table 6 and for the 2024 validation sample Table 7.

Table 2: Demographics of the patients diagnosed with sepsis in 2023 training sample

| Triage Category | EoC | Average Age | Indigenous | Female | Indeterminate | Unknown |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | 254 | 74.1 | 8 | 119 | 0 | 0 |
| 2 | 1351 | 71.7 | 46 | 600 | 0 | 0 |
| 3 | 1081 | 70.7 | 45 | 511 | 0 | 0 |
| 4 | 150 | 66.7 | 7 | 75 | 0 | 0 |
| 5 | 8 | 58.2 | 2 | 4 | 0 | 0 |
| Total/Mean | 2844 | 71.3 | 108 | 1309 | 0 | 0 |

Table 3: Demographics of the patients diagnosed with sepsis in 2024 validation sample

| Triage Category | EoC | Average Age | Indigenous | Female | Indeterminate | Unknown |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | 265 | 75.1 | 2 | 109 | 0 | 0 |
| 2 | 1371 | 71.9 | 45 | 507 | 0 | 0 |
| 3 | 984 | 70.3 | 37 | 400 | 0 | 0 |
| 4 | 194 | 69.8 | 12 | 84 | 0 | 0 |
| 5 | 1 | 97 | 0 | 0 | 0 | 0 |
| Total/Mean | 2815 | 71.5 | 96 | 1100 | 0 | 0 |

Table 4: Metrics for the for patients diagnosed with sepsis in 2023 training sample

| Triage Category | EoC | Average Age | >2 vital signs available | qSOFA Flag | SIRS Flag | SIRS Severe | Purple >0 Flag | Red >1 Flag |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 254 | 74.1 | 254 | 138 | 139 | 46 | 84 | 35 |
| 2 | 1351 | 71.7 | 1351 | 478 | 767 | 171 | 265 | 171 |
| 3 | 1081 | 70.7 | 1081 | 182 | 545 | 59 | 81 | 56 |
| 4 | 150 | 66.7 | 150 | 14 | 62 | 2 | 10 | 6 |
| 5 | 8 | 58.2 | 8 | 0 | 2 | 0 | 0 | 0 |
| Total/Mean | 2844 | 71.3 | 2844 | 812 | 1515 | 278 | 440 | 268 |

Table 5: Metrics for the for patients diagnosed with sepsis in 2024 validation sample

| Triage Category | EoC | Average Age | >2 vital signs available | qSOFA Flag | SIRS Flag | SIRS Severe | Purple >0 Flag | Red >1 Flag |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 265 | 75.1 | 265 | 75 | 159 | 73 | 133 | 45 |
| 2 | 1371 | 71.9 | 1371 | 235 | 803 | 177 | 364 | 225 |
| 3 | 984 | 70.3 | 984 | 76 | 478 | 65 | 120 | 69 |
| 4 | 194 | 69.8 | 194 | 13 | 94 | 17 | 24 | 11 |
| 5 | 1 | 97 | 1 | 0 | 1 | 0 | 0 | 0 |
| Total/Mean | 2815 | 71.5 | 2815 | 399 | 1535 | 332 | 641 | 350 |

Table 6: Outcomes for the for patients diagnosed with sepsis in 2023 training sample

| Triage Category | EoC | Average Age | ICU Stay | Died as IP | Died 30 days after admission |
| --- | --- | --- | --- | --- | --- |
| 1 | 254 | 74.1 | 95 | 83 | 115 |
| 2 | 1351 | 71.7 | 441 | 220 | 315 |
| 3 | 1081 | 70.7 | 283 | 145 | 197 |
| 4 | 150 | 66.7 | 46 | 26 | 31 |
| 5 | 8 | 58.2 | 3 | 0 | 0 |
| Total/Mean | 2844 | 71.3 | 868 | 474 | 658 |

Table 7: Outcomes for the for patients diagnosed with sepsis in 2024 validation sample

| Triage Category | EoC | Average Age | ICU Stay | Died as IP | Died 30 days after admission |
| --- | --- | --- | --- | --- | --- |
| 1 | 265 | 75.1 | 87 | 90 | 106 |
| 2 | 1371 | 71.9 | 398 | 231 | 262 |
| 3 | 984 | 70.3 | 262 | 138 | 159 |
| 4 | 194 | 69.8 | 51 | 17 | 24 |
| 5 | 1 | 97 | 0 | 0 | 1 |
| Total/Mean | 2815 | 71.5 | 798 | 476 | 552 |

Table 8: ED presentations for patients diagnosed with sepsis in 2023 training sample

| Triage Category | FMC | LMH | MPH | NHS | QEH | RAH | Row Total |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 82 | 83 | 11 | 1 | 45 | 32 | 254 |
| 2 | 292 | 317 | 62 | 10 | 219 | 451 | 1351 |
| 3 | 194 | 241 | 128 | 30 | 195 | 293 | 1081 |
| 4 | 24 | 34 | 15 | 5 | 34 | 38 | 150 |
| 5 | 1 | 4 | 0 | 0 | 1 | 2 | 8 |
| Total | 593 | 679 | 216 | 46 | 494 | 816 | 2844 |

Table 9: ED presentations for patients diagnosed with sepsis in 2024 validation sample

| Triage Category | FMC | LMH | MPH | NHS | QEH | RAH | Row Total |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 103 | 50 | 10 | 3 | 62 | 37 | 265 |
| 2 | 325 | 314 | 82 | 22 | 234 | 394 | 1371 |
| 3 | 167 | 236 | 133 | 32 | 170 | 246 | 984 |
| 4 | 19 | 48 | 25 | 5 | 52 | 45 | 194 |
| 5 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Total | 614 | 648 | 250 | 62 | 519 | 722 | 2815 |

### 5.8.1 Discharge Disposition of Sepsis Patients

The discharge disposition from the ED of the patients diagnosed with Sepsis are listed in Tables 10 & 11. This shows the number of patients who are admitted directly as inpatients, who are admitted to the EECU and are transferred to another hospital, and those that died in the ED.

In addition there is a small cohort of patients who were not admitted included as patients “admitted” with Sepsis (15 in 2023 and 24 in 2024). This is caused by our journey definition. We have required the ED presentation to be the first in in a set of connected EoC. In this case the patient has represented at an ED with 6 hours of discharge and been admitted with Sepsis. We have used this journey definition so as not to double count patients who are transferred between hospitals.

*Add patient timelines for some of these to the appendix*.

Table 10: Discharge Disposition for the for patients diagnosed with sepsis in 2023 training sample

| Triage Category | EoC | Average Age | Admit as Inpatient | Admit to EECU | Transfer to Other Hospital | Not admitted as inpatients | Died in the ED | Row Total |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 254 | 74.1 | 245 | 5 | 4 | 0 | 0 | 254 |
| 2 | 1351 | 71.7 | 1262 | 39 | 42 | 7 | 1 | 1351 |
| 3 | 1081 | 70.7 | 924 | 73 | 78 | 6 | 0 | 1081 |
| 4 | 150 | 66.7 | 122 | 17 | 9 | 2 | 0 | 150 |
| 5 | 8 | 58.2 | 8 | 0 | 0 | 0 | 0 | 8 |
| Total/Mean | 2844 | 71.3 | 2561 | 134 | 133 | 15 | 1 | 2844 |

Table 11: Discharge Disposition for the for patients diagnosed with sepsis in 2024 validation sample

| Triage Category | EoC | Average Age | Admit as Inpatient | Admit to EECU | Transfer to Other Hospital | Not admitted as inpatients | Row Total |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 265 | 75.1 | 253 | 7 | 5 | 0 | 265 |
| 2 | 1371 | 71.9 | 1263 | 47 | 54 | 7 | 1371 |
| 3 | 984 | 70.3 | 810 | 87 | 74 | 13 | 984 |
| 4 | 194 | 69.8 | 156 | 22 | 12 | 4 | 194 |
| 5 | 1 | 97 | 1 | 0 | 0 | 0 | 1 |
| Total/Mean | 2815 | 71.5 | 2483 | 163 | 145 | 24 | 2815 |

## 5.9 Patients without Sepsis

Table 12: Demographics of the patients diagnosed with sepsis in 2023 training sample

| Triage Category | EoC | Average Age | Indigenous | Female | Indeterminate | Unknown |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | 4118 | 58.3 | 275 | 1894 | 0 | 2 |
| 2 | 56635 | 57.9 | 2690 | 27636 | 5 | 5 |
| 3 | 132754 | 55.1 | 6682 | 72737 | 23 | 6 |
| 4 | 67583 | 49.3 | 3921 | 36566 | 13 | 7 |
| 5 | 8240 | 43.8 | 648 | 3888 | 0 | 1 |
| Total/Mean | 269330 | 53.9 | 14216 | 142721 | 41 | 21 |

Table 13: Demographics of the patients diagnosed with sepsis in 2024 validation sample

| Triage Category | EoC | Average Age | Indigenous | Female | Indeterminate | Unknown |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | 4019 | 57.2 | 256 | 1421 | 0 | 3 |
| 2 | 57496 | 57.7 | 2567 | 22407 | 2 | 3 |
| 3 | 134384 | 55.2 | 5999 | 57371 | 17 | 4 |
| 4 | 72223 | 49.6 | 3658 | 29025 | 7 | 3 |
| 5 | 8907 | 43.9 | 640 | 3133 | 1 | 1 |
| Total/Mean | 277029 | 54.0 | 13120 | 113357 | 27 | 14 |

Table 14: Metrics for the for patients diagnosed with sepsis in 2023 training sample

| Triage Category | EoC | Average Age | >2 vital signs available | qSOFA Flag | SIRS Flag | SIRS Severe | Purple >0 Flag | Red >1 Flag |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 4118 | 58.3 | 4118 | 736 | 1535 | 237 | 683 | 212 |
| 2 | 56635 | 57.9 | 56635 | 3414 | 16640 | 652 | 2936 | 1108 |
| 3 | 132754 | 55.1 | 132754 | 2861 | 31327 | 444 | 2090 | 766 |
| 4 | 67583 | 49.3 | 67583 | 474 | 12184 | 88 | 572 | 130 |
| 5 | 8240 | 43.8 | 8240 | 19 | 1408 | 2 | 46 | 10 |
| Total/Mean | 269330 | 53.9 | 269330 | 7504 | 63094 | 1423 | 6327 | 2226 |

Table 15: Metrics for the for patients diagnosed with sepsis in 2024 validation sample

| Triage Category | EoC | Average Age | >2 vital signs available | qSOFA Flag | SIRS Flag | SIRS Severe | Purple >0 Flag | Red >1 Flag |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 4019 | 57.2 | 4019 | 429 | 1554 | 213 | 986 | 295 |
| 2 | 57496 | 57.7 | 57496 | 2252 | 17020 | 727 | 4434 | 1754 |
| 3 | 134384 | 55.2 | 134384 | 1717 | 31391 | 513 | 2534 | 934 |
| 4 | 72223 | 49.6 | 72223 | 310 | 13087 | 96 | 585 | 195 |
| 5 | 8907 | 43.9 | 8907 | 8 | 1545 | 4 | 36 | 17 |
| Total/Mean | 277029 | 54.0 | 277029 | 4716 | 64597 | 1553 | 8575 | 3195 |

Table 16: Outcomes for the for patients not diagnosed with sepsis in 2023 training sample

| Triage Category | EoC | Average Age | ICU Stay | Died as IP | Died 30 days after admission |
| --- | --- | --- | --- | --- | --- |
| 1 | 4118 | 58.3 | 458 | 195 | 431 |
| 2 | 56635 | 57.9 | 1255 | 772 | 2015 |
| 3 | 132754 | 55.1 | 968 | 690 | 2410 |
| 4 | 67583 | 49.3 | 158 | 107 | 440 |
| 5 | 8240 | 43.8 | 9 | 0 | 13 |
| Total/Mean | 269330 | 53.9 | 2848 | 1764 | 5309 |

Table 17: Outcomes for the for patients not diagnosed with sepsis in 2024 validation sample

| Triage Category | EoC | Average Age | ICU Stay | Died as IP | Died 30 days after admission |
| --- | --- | --- | --- | --- | --- |
| 1 | 4019 | 57.2 | 355 | 205 | 327 |
| 2 | 57496 | 57.7 | 1297 | 752 | 1632 |
| 3 | 134384 | 55.2 | 960 | 701 | 2027 |
| 4 | 72223 | 49.6 | 150 | 100 | 446 |
| 5 | 8907 | 43.9 | 5 | 3 | 18 |
| Total/Mean | 277029 | 54.0 | 2767 | 1761 | 4450 |

Table 18: ED presentations for patients not diagnosed with sepsis in 2023 training sample

| Triage Category | FMC | LMH | MPH | NHS | QEH | RAH | Row Total |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1303 | 945 | 141 | 59 | 432 | 1238 | 4118 |
| 2 | 14265 | 11336 | 4331 | 4054 | 5656 | 16993 | 56635 |
| 3 | 27755 | 22211 | 15288 | 14161 | 19721 | 33618 | 132754 |
| 4 | 11505 | 12659 | 6458 | 10172 | 12358 | 14431 | 67583 |
| 5 | 1304 | 2926 | 515 | 1123 | 585 | 1787 | 8240 |
| Total | 56132 | 50077 | 26733 | 29569 | 38752 | 68067 | 269330 |

Table 19: ED presentations for patients not diagnosed with sepsis in 2024 validation sample

| Triage Category | FMC | LMH | MPH | NHS | QEH | RAH | Row Total |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1228 | 675 | 148 | 135 | 576 | 1257 | 4019 |
| 2 | 15798 | 10475 | 4414 | 3932 | 5780 | 17097 | 57496 |
| 3 | 27348 | 21905 | 17982 | 13866 | 20446 | 32837 | 134384 |
| 4 | 10961 | 14909 | 8189 | 10339 | 14637 | 13188 | 72223 |
| 5 | 1150 | 3338 | 913 | 1426 | 735 | 1345 | 8907 |
| Total | 56485 | 51302 | 31646 | 29698 | 42174 | 65724 | 277029 |

### 5.9.1 Discharge Disposition of Patients without Sepsis

Table 20: Discharge Disposition for the for patients not diagnosed with sepsis in 2023 training sample

| Triage Category | EoC | Average Age | Admit as Inpatient | Admit to EECU | Transfer to Other Hospital | Not admitted as inpatients | Died in the ED | Row Total |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 4118 | 58.3 | 2644 | 411 | 59 | 985 | 16 | 4115 |
| 2 | 56635 | 57.9 | 22831 | 8514 | 1424 | 23660 | 38 | 56467 |
| 3 | 132754 | 55.1 | 36755 | 20381 | 2695 | 71812 | 19 | 131662 |
| 4 | 67583 | 49.3 | 10181 | 7150 | 732 | 47243 | 1 | 65307 |
| 5 | 8240 | 43.8 | 657 | 389 | 42 | 6548 | 0 | 7636 |
| Total/Mean | 269330 | 53.9 | 73068 | 36845 | 4952 | 150248 | 74 | 265187 |

Table 21: Discharge Disposition for the for patients not diagnosed with sepsis in 2024 validation sample

| Triage Category | EoC | Average Age | Admit as Inpatient | Admit to EECU | Transfer to Other Hospital | Not admitted as inpatients | Died in the ED | Row Total |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 4019 | 57.2 | 2456 | 558 | 95 | 882 | 18 | 4009 |
| 2 | 57496 | 57.7 | 23670 | 10793 | 1529 | 21321 | 29 | 57342 |
| 3 | 134384 | 55.2 | 35837 | 24683 | 3033 | 69198 | 26 | 132777 |
| 4 | 72223 | 49.6 | 10408 | 9237 | 957 | 48555 | 1 | 69158 |
| 5 | 8907 | 43.9 | 607 | 513 | 49 | 7036 | 0 | 8205 |
| Total/Mean | 277029 | 54.0 | 72978 | 45784 | 5663 | 146992 | 74 | 271491 |

# 6 Machine Learning

The data described in the earlier section is used to train and validate diagnosis classifier models Sepsis. The data is prepared by setting any missing measurement from in the data set with the defaults listed in Table 22. Numerical variables are transformed on to the range . Categorical values are passed through the One Hot Encoder algorithm [6] to turn them into a complete set of logical variables. The data set is split into training and validation sets using an 80:20% split. An XG Boost model [7] is optimised by randomly scanning through the possible model settings and minimising the false positive rate for a true positive rate of 85%. The optimized model is then tested on the validation samples.

Table 22: Data used in the ML models. If no result has been recorded the default value is assigned. If the default is NA (not applicable) then there is no default value.

| Property or Result | Default |
| --- | --- |
| Age | NA |
| Sex | NA |
| Respiration (breaths/min) | 15 |
| O2 Saturation (%) | 98 |
| Blood Pressure Systolic (mm Hg) | 120 |
| Pulse Rate (beats/min) | 80 |
| Temperature (ºC) | 37.5 |
| Level of Consciousness | 0 |

# 7 Appendices

## 7.1 Patient Journey

Descriptions and variable names listed below are based on the SA Health EMR. Episodes of Care are joined into a journey if they meet the following criteria. If the value is set to zero, the EoC is part of the same journey.

1. Check if the previous CHARTGUID entry (for the same  
   CLIENTGUID order by discharge datetime) is the same as the current CHARTGUID.  
   If yes, set the value to 0.
2. Check if the time difference between the previous discharge datetime (for the same) and current admission datetime is within 6 hours (either before or after).  
   If yes, set the value to 0.
3. Check if the time difference between the previous discharge datetime (for the same CLIENTGUID) and current admission datetime is within 24 hours (either before or after) and the ‘previous\_discharge\_disposition’ (for the same CLIENTGUID order by admission datetime) is in this list (‘IP Other hosp - Down’, ‘IP Other hosp - Up’, ‘IP Other Hospital - DOWN’,‘IP Other Hospital - UP’).  
   If yes, set the value to 0.
4. Check if the previous discharge datetime (for the same CLIENTGUID order by discharge datetime) is before the current admission datetime and the previous admission datetime (for the same CLIENTGUID order by admission datetime) date is after the current admission datetime.  
   If yes, set the value to 0.
5. Check if the time difference between the previous discharge datetime (for the same CLIENTGUID order by admission datetime) and current admission datetime is within 24 hours (either before or after) and the previous episode\_of\_care(for the same CLIENTGUID order by admission datetime) is ‘Rehabilitation’ and the current episode\_of\_care is ‘Hospital at Home - Rehab at Home’.  
   If yes, set the value to 0.
6. Check if the time difference between the previous admission datetime (for the same CLIENTGUID order by admission datetime) and current admission datetime is within 24 hours (either before or after) and the previous TYPECODE (for the same CLIENTGUID order by admitdate asc) is ‘Emergency’ and the current source\_of\_referral is ‘IP Casualty-Emergency’ and the current TYPECODE is ‘Inpatient’.  
   If yes, set the value to 0.

If none of the above conditions are met start a new journey.

## 7.2 Sepsis ICD-10 Codes

Table 23: Sepsis Diagnosis Codes (from APC Reference Table\_corrected - ICD-10-AM 11th edition 2019)

| Code | Diagnosis | Code | Diagnosis |
| --- | --- | --- | --- |
| A021 | Salmonella sepsis | A412 | Sepsis due to unsp staphylococcus |
| A227 | Anthrax sepsis | A413 | Sepsis dt Haemophilus influenzae |
| A267 | Erysipelothrix sepsis | A414 | Sepsis due to anaerobes |
| A327 | Listerial sepsis | A415 | Sepsis dt oth & unsp gram neg organisms |
| A40 | Streptococcal sepsis | A4150 | Sepsis dt unsp Gram neg organisms |
| A400 | Sepsis dt streptococcus group A | A4151 | Sepsis dt Escherichia coli [E coli] |
| A401 | Sepsis dt streptococcus group B | A4152 | Sepsis due to Pseudomonas |
| A402 | Sepsis dt streptococcus grp D & enteroc | A4158 | Sepsis dt other gram neg organisms |
| A403 | Sepsis dt Streptococcus pneumoniae | A418 | Other specified sepsis |
| A408 | Other streptococcal sepsis | A419 | Sepsis, unspecified |
| A409 | Streptococcal sepsis unspecified | A427 | Actinomycotic sepsis |
| A41 | Other sepsis | B377 | Candidal sepsis |
| A410 | Sepsis due to Staphylococcus aureus | O85 | Puerperal sepsis |
| A411 | Sepsis dt other spec staphylococcus |  |  |

## 7.3 ICD-10 Breakdown of Samples

Table 24: ICD-10 Codes for the 2023 Training data sample

| Top Level | Number | Decsription | 2nd Level | Number | Description | 3rd Level | Number | Description |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A02.1 | 5 | Salmonella sepsis |  |  |  |  |  |  |
| A40 | 225 | Streptococcal sepsis | A40.0 | 41 | Sepsis dt streptococcus group A |  |  |  |
|  |  |  | A40.1 | 30 | Sepsis dt streptococcus group B |  |  |  |
|  |  |  | A40.2 | 61 | Sepsis dt streptococcus group D |  |  |  |
|  |  |  | A40.3 | 24 | Sepsis dt Streptococcus pneumoniae |  |  |  |
|  |  |  | A40.8 | 69 | Other streptococcal sepsis |  |  |  |
|  |  |  | A40.9 | 5 | Streptococcal sepsis unspecified |  |  |  |
| A41 | 2612 | Other sepsis | A41.0 | 122 | Sepsis due to Staphylococcus aureus |  |  |  |
|  |  |  | A41.1 | 41 | Sepsis dt other spec staphylococcus |  |  |  |
|  |  |  | A41.2 | 8 | Sepsis due to unsp staphylococcus |  |  |  |
|  |  |  | A41.3 | 2 | Sepsis dt Haemophilus influenzae |  |  |  |
|  |  |  | A41.4 | 18 | Sepsis due to anaerobes |  |  |  |
|  |  |  | A41.5 | 453 | Sepsis dt oth & unsp gram neg organisms | A41.50 | 15 | Sepsis dt unsp Gram neg organisms |
|  |  |  |  |  |  | A41.51 | 294 | Sepsis dt Escherichia coli (E coli) |
|  |  |  |  |  |  | A41.52 | 47 | Sepsis due to Pseudomonas |
|  |  |  |  |  |  | A41.58 | 112 | Sepsis dt other gram neg organisms |
|  |  |  | A41.8 | 96 | Other specified sepsis |  |  |  |
|  |  |  | A41.9 | 1896 | Sepsis, unspecified |  |  |  |
| A42.7 | 1 | Actinomycotic sepsis |  |  |  |  |  |  |
| B37.7 | 23 | Candidal sepsis |  |  |  |  |  |  |
| O85 | 11 | Puerperal sepsis |  |  |  |  |  |  |

Table 25: ICD-10 Codes for the 2024 Verification data sample

| Top Level | Number | Decsription | 2nd Level | Number | Description | 3rd Level | Number | Description |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A02.1 | 4 | Salmonella sepsis |  |  |  |  |  |  |
| A40 | 217 | Streptococcal sepsis | A40.0 | 28 | Sepsis dt streptococcus group A |  |  |  |
|  |  |  | A40.1 | 35 | Sepsis dt streptococcus group B |  |  |  |
|  |  |  | A40.2 | 54 | Sepsis dt streptococcus group D |  |  |  |
|  |  |  | A40.3 | 32 | Sepsis dt Streptococcus pneumoniae |  |  |  |
|  |  |  | A40.8 | 57 | Other streptococcal sepsis |  |  |  |
|  |  |  | A40.9 | 16 | Streptococcal sepsis unspecified |  |  |  |
| A41 | 2597 | Other sepsis | A41.0 | 126 | Sepsis due to Staphylococcus aureus |  |  |  |
|  |  |  | A41.1 | 43 | Sepsis dt other spec staphylococcus |  |  |  |
|  |  |  | A41.2 | 3 | Sepsis due to unsp staphylococcus |  |  |  |
|  |  |  | A41.3 | 2 | Sepsis dt Haemophilus influenzae |  |  |  |
|  |  |  | A41.4 | 10 | Sepsis due to anaerobes |  |  |  |
|  |  |  | A41.5 | 408 | Sepsis dt oth & unsp gram neg organisms | A41.50 | 11 | Sepsis dt unsp Gram neg organisms |
|  |  |  |  |  |  | A41.51 | 265 | Sepsis dt Escherichia coli (E coli) |
|  |  |  |  |  |  | A41.52 | 35 | Sepsis due to Pseudomonas |
|  |  |  |  |  |  | A41.58 | 104 | Sepsis dt other gram neg organisms |
|  |  |  | A41.8 | 86 | Other specified sepsis |  |  |  |
|  |  |  | A41.9 | 1928 | Sepsis, unspecified |  |  |  |
| A42.7 | 0 | Actinomycotic sepsis |  |  |  |  |  |  |
| B37.7 | 19 | Candidal sepsis |  |  |  |  |  |  |
| O85 | 11 | Puerperal sepsis |  |  |  |  |  |  |

# 8 SQL Commands

## 8.1 ED Presentations

create or replace view DEV\_DAP\_CAE05\_DB.SEPSIS.VW\_ED\_VISIT()  
as SELECT \* FROM (  
SELECT ROW\_NUMBER() OVER (PARTITION BY JOURNEY\_ID ORDER BY ADMITDTM) ED\_SEQ\_BY\_JOURNEY,  
\* FROM (  
SELECT \* FROM DEV\_DAP\_CAE05\_DB.JNY.TB\_PATIENT\_JOURNEY\_MAPPING\_NEW AS VISIT  
WHERE visit.HOSPITAL IN (SELECT \* FROM DEV\_DAP\_CAE05\_DB.SEPSIS.VW\_CONFIG\_HOSPITAL)  
AND TYPECODE = 'Emergency'  
AND AGEONADMIT > 15  
AND VISIT.ADMITDTM between '2023-01-01' and DATEADD(month,-1,to\_date(getdate()))))  
WHERE ED\_SEQ\_BY\_JOURNEY=1

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1. We have removed infant Sepsis ICD-10 codes from the previous work. [↑](#footnote-ref-13)
2. O2 Flow and the sedation score are not included as these are not usually filled out if the patient is not receiving oxygen or is awake and aware. [↑](#footnote-ref-14)
3. Note to self, need to look at joining transfers. See CAP and COPD analyses. [↑](#footnote-ref-15)