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

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 2). 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 2: Rapid Detection and Response (RDR) Alert Triggers

Measure	Purple	Red	Yellow	Yellow	Red	Purple
		Low			High	
Respiration (breaths/min)	7		10	21	26	31
O_2 Saturation (%)	88	91	94	NA	NA	NA
O_2 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 (°C)		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 followed by an inpatient (IP) admission with sepsis diagnosis identified by the ICD-10 codes, Table 3 [1] (based on a journey, see appendix 5.1).

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 two of the following vital signs are recorded in the EMR during the presentation: respiration, O_2 Saturation, systolic blood pressure, pulse rate and temperature[2] (Table 2).

The IP admission is required to be the first episode of care (EoC) after any ED presentations [3]. 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 two observations of vital signs of interest have been made (see Table 2). There are Y ED presentations with at least two vital signs recorded which included 2,761 presentations that resulted in an inpatient admission which includes at least one ICD-10 code matching a Sepsis diagnosis. Note, X (14%) out of a total Y ED presentations do not have at least two observations of vital signs recorded in the EMR and have been excluded from the analysis.

Two verification data sets are used. The first, the Metropolitan Verification dataset, is created from ED presentations from 2024. There are Y_2 presentations with at least two vital signs recorded of which X $result in an inpatient admission which includes at least one ICD-10 code matching a Sepsis diagnosis. The second, the Country Verification dataset, is created using Emergency presentations at country hospitals that are using the EMR. There are 149,193 presentations from the 1 January 2023 through 31 December 2024 that have at least two recorded vital signs which results in X inpatient admission.

[1] We have removed infant Sepsis ICD-10 codes from the previous work.
[2] O_2 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.
[3] Note to self, need to look at joining transfers. See CAP and COPD analyses.

5 Appendices

5.1 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.

5.2 Sepsis ICD-10 Codes

Table 3: 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		

6 SQL Commands

6.1 ED Presentations

[language=SQL] create or replace view $DEV_DAP_CAE05_DB.SEPSIS.VW_ED_VISIT()asSELECT*FROM(SELECTROW$
$FROMDEV_DAP_CAE05_DB.JNY.TB_PATIENT_JOURNEY_MAPPING_NEWASVISITWHEREvisit.HOSPITAL$
$FROMDEV_DAP_CAE05_DB.SEPSIS.VW_CONFIG_HOSPITAL)ANDTYPECODE =' Emergency'ANDAGEON$
$15ANDVISIT.ADMITDTMbetween'2023-01-01'andDATEADD(month, -1, to_date(getdate()))))WHEREED_SEQ$
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References

1. Sunrise EMR & PAS deteriorating patient reference guide (July 2024). Available at: https://inside.sahealth.sa.gov.au/wps/wcm/connect/non-public+content/sa+health+intranet/it+systems/sunrise/resources/sunrise+deteriorating+patient+reference+guide.