**ADVANCING MENTAL HEALTH CARE WITH PREDICTIVE ANALYTICS**

**PROJECT STATEMENT**

These web sites contain brief overviews of some major Analytics success stories:

1. <https://www.sas.com/en_us/customers.html>,

2. <https://www03.ibm.com/software/businesscasestudies/us/en/corp>

3. [https://www.informs.org/Impact/O.R.- Analytics-Success-Stories](.%20https:/www.informs.org/Impact/O.R.-%20Analytics-Success-Stories)

***CASE STUDY OVERVIEW***

<https://www.sas.com/en_us/customers/camh.html>

**Case Background:**

***Brief Introduction about Mental Illness and Centre for Addiction and Mental Health (CAMH)***

*My case study is based on the efforts taken my CAMH (Canadian based mental healthcare center)* ***to remove stigma from mental illness and addiction and providing care to mentally ill patients.*** *Mental illness is the condition that affects thinking, behavior and mood. It can be dementia, bipolar disorder, anxiety disorders etc. In Canada, there is ratio of 1 in 5 people having mental illness and CAMH is focused on delivering to care to mentally ill people who are not able to receive world class care.*

*I identified* ***three major problems faced by CAMH****. They are as follows:*

1. ***Increase patient flow*** *in emergency department by 82% in the last 6 years*
2. *the* ***ALC***(*i.e., alternative level of care: patients who are occupying an acute care hospital bed but are not in need of inpatient medical service)* *patients who occupies the bed for longer time.*
3. *Due to increased number of patients and limited resources in CAMH,* ***need to additional clinic to accompany new patients.***

**Case Summary:**

CAMH could use this valuable information to improve clinical outcomes and streamline operations. Their aim is predicting the number of patient so that they can devise the right care models and process optimization models to accommodate future needs. Also, identifying the ALC patient is or not, helps to optimize the bed space

**Data Sources:**

Electronic Health Records

Appointment’s data

Lab’s data

Medication’s data

Demographics

Medical History of patients

Population data from Ministry of Health

Social Determinant data

**Analytical approach to understand the emergency activity**

***Descriptive Analytics:*** It will help us to understand the patient activity in emergency Department

1.Admission rate in emergency Department.

2. Percentage of ALC patient

3. patient to bed ratio

4. Discharge rate of patients

Based on the problems faced by CAHM, I would suggest the three models to address the problems and they are as listed below:

**Details of Models that Could be Used:**

***1.MODEL 1***

**The HoltWinters model /CUSUM**

This model is used to track the trends of the new admission inpatient, which provide methodological basis for reducing crowding. It forecast the monthly and daily number of new admission inpatients. Once the number of inpatients in emergency is forecasted, a CUSUM model could be used to detect the changes over time.

**Given**: Daily, monthly, yearly flow of patients (admission and discharges data). I would assume data has no missing value and updated regularly.

**Use:** Time series data sets usually contain significant random or error data. In order to analyze the trend rule in the data, we hope to delete these random fluctuations byexponential smoothing. In the time series data with seasonal factors, the data can be decomposed into trend factors, seasonal factors, and random factors. The trend component can capture the change of future cycles, the seasonal component can capture the seasonal change of a cycle, and the random / error component can capture the random change that cannot be explained by the trend or seasonal change.

In addition, to ensure that the prediction model is the best, it is also a good way

to check whether the prediction error has a normal mean of 0 and constant

variance. It could also apply CUSUM to detect any changes in patient flow outside the usual trends and seasonality.

**To:** Since we are looking at time series data, we would be able to use exponential smoothing for forecasting by leveraging past data and consistently adjust as more data comes in. The goal would be to forecast the incoming inpatient for a given data while adjusting alpha while considering trends and seasonality effects. CAMH could also implement some form of change detection for them to make any changes where patient flow seem to act away from expected behavior. For example, if they see that overcrowding of patient in emergency department, CAMH would need to arrange staff and resources to deliver care to patients. If, on the other end, patient flow seems to be dropping, CAMH may need make their strategy and allocation of resources as required which will reduce its operations cost.

***2.MODEL 2***

**Queuing and** **Linear Regression models**

Queuing Management will help to manage the queue of patients and understand the queue length and waiting times. In CAMH, it is essential as the patient will be ill and need to get urgently admitted in hospital**.** Linear Regression is used to predict the length of stay of patients based on medical history. It helps the hospital to manage the bed space as per prediction and provide quality of care and streamline operations.

***Given:*** Predictors considered included patient age, primary complaint, provider, designation (ED or fast track), arrival mode, and urgency level (emergency severity index assigned at triage).

***Use:*** I am assuming arrival of patient and the line behavior would mimic that of a Poisson distribution. I am also assuming the arrival rate of the patient in emergency department is random and are independent and individually distributed. With those assumptions, CAMH would need to facilitate some form of queue management and mitigate the long wait times. By running simulations in Arena or Simpy(python), CAMH would be able to simulate the patient coming in and out of line to see if the number of lines it has can sustain to get patient admitted to Emergency department of a Poisson distribution while using a queuing model.

Linear Regression can also predict the actual length of stay of patient based on retrospective data which helps to estimate bed space for new patients.

***To:***Queuing Models will help to mitigate long lines and waiting time CAMH*.* CAMH could linear regression performed the best in predicting total bed need. It can predict the actual length of stay of patients. It will help CAMH to make effective use of bed and if needed more can ask government for funding to set up clinic to meet the additional flow of patient in emergency department. This predictive information could be used for improved real-time bed management, patient flow, and discharge processes.

***3.MODEL 3***

**Logistic Regression model**

Identify patients requires alternate level of care nor not based on the medical history of patients.

***Given:*** Patient medical history, demographics, EHR

***Use***: Logistic Regression

***To***: estimate the probability of inpatient admission requires ALC or not. Identifying the ALC patient is or not, helps to optimize the bed space. This will help to classify the ALC with other patients, as ALC patient requires long time to stay in hospital but doesn’t need inpatient medical service. Classifying ALC patient or not, we can use bed for other new patients who requires inpatient medical service.

***4.Clustering:***

K-means clustering to identify group of people who are mentally ill in that area based on population data and social determinant data and previous record in EHR such as Demographics

***Given:*** Population data, demographics, social determinant data

***Use:*** K-means clustering

***To:*** identify the different group of people having mental illness in the specific area. It helps to outline the number of cases in that area. Hence, it helps to maintain patient to bed ratio based on forecasted future patients.

***Re-Runs***

The ability to update the re-runs elements of this case study is the daily admission and discharge data of patients. All the models need to be updated based on updated data which is used to forecast and predict the patient flow.

The hospital can update the data frequently based on daily patient flow in hospital. There is less chance of missing data as it is related to cost factor. After identifying ALC patients, the remaining beds can be used effectively, and it is updated based on daily data of patients.

All the models are simple and can be updated in regular basis. The cost to reflect the models can ne minimum and results of models helps the hospital to streamline operations and secure the government funding to set up clinic.

**Summary**

In this study, I demonstrate how multiple modeling can be used in combination with interpretable machine learning techniques to provide accurate predictions on critical aspects of patient flows.

At present, patients' demand for medical treatment is not only expected to obtain effective medical services at a reasonable cost but also expected to receive timely medical services at a reasonable cost as they pay more attention to the service quality and service perception of the medical behavior itself.

The HoltWinters model can be is used to forecast the monthly flow of patients over the next month or year. ACF, PACF, and residual histogram can be used to verify the accuracy of the prediction model. Combined with the prediction of patient flow, a more reasonable and fair horizontal allocation of medical resources can be proposed. Optimization of bed space can be done by identifying the ALC patients. Forecasting patient flow also helps to optimize the hospital resources based on the flow patients to improve clinical outcomes.

There are many other models SARIMA, CART, XGBOOST, SVM which can be implied but I propose these models considering its pros and cons.

Models results and implication can be helpful for optimizing the allocation of medical resources, reducing medical costs, and improving service efficiency and quality in mental healthcare.