Industrial Training Report

Prepared by

Sandra Adel Aziz Gebraiel

sandra.gebraiel99@eng-st.cu.edu.eg

October 07, 2022

Table of Contents:

1. Training Establishment Profile:

1.1 History:

In 2009, Sir Magdi Yacoub's *Aswan Heart Centre* started working in one of *Aswan's Educational Hospital* buildings with just two surgical suites, one catheter suite and twelve ICU beds. After embarking on a robust program to train and recruit young Egyptian healthcare providers with the help visiting international professionals, *Aswan Heart Centre (AHC)* grew from an idea to a state-of-the-art modern hospital with more than 600 dedicated personnel, 41 ICU beds, 50 ward beds, 2 modern surgical suites, 2 modern catheter suites, 9 outpatient exam rooms and an advanced imaging centre. In addition, a fully operational research building was opened in 2016.

Sir Magdi Yacoub's Aswan Heart Centre

1.2 Mission:

Magdi Yacoub's Global Heart Foundation, represented in *Aswan Heart Centre*, works to dramatically change health outcomes of the most vulnerable, particularly children, by improving advanced cardiac care to all people in need free of charge. It seeks to be a true centre of medical excellence through:

- Service: By providing free advanced medical care to all patients regardless of colour or religion.
- Learning: By advancing research and innovation in basic science and applied biomedical research.
- Teaching: By offering training and apprenticeship for next generation of young doctors, nurses, engineers, scientists and technicians from the Middle East at the highest international standards.

1.3 Services:

AHC's clinical program primarily serves the population of Aswan (about 1.5 million), Upper Egypt and the rest of the country in addition to patients referred from Africa. Over each year, the centre performs around 1100 open heart operations, 2800 cardiac catheterizations and over 25,000 outpatient consultations. Moreover, AHC acts as a referral centre for many congenital heart disease cases such as *Transposition of Great Arteries (TGA)*, whether they are neonatal, paediatric, or adult. As a result, the uniqueness of this program provides huge opportunities for research and discovering mechanisms of disease and innovative treatment techniques.

1.4 Departments:

The AHC consists of a treatment centre and a research centre. The main departments of the treatment centre are Cardiac Surgery, Cardiology, Paediatric Cardiology, Paediatric ICU, Adult ICU, Cardiac Catheterization Lab, Coronary Care Unit, Radiology, Biomedical Engineering, Anaesthesia, Clinical Pharmacy, Laboratory and Blood Bank.

On the other hand, the treatment centre includes two main labs: Biomedical Engineering and Innovation Laboratory and Life Sciences and Molecular Research Laboratory.

Aswan Heart Centre Departments

1.5 Future Development:

Since AHC has been constructed, it has served more than 200,000 patients and performed more than 22,000 complex operations for the less fortunate free of charge, but demand is in continual increase and became too overwhelming. To meet this demand, construction started in the new *Magdi Yacoub's Global Heart Hospital* in 6th October District, Cairo, to open doors in 2023. The new hospital will increase bed capacity from 100 to 300, patient treatment capacity from 4,000 to 17,000, outpatient capacity from 33,000 to 140,000 and annual trainees, from professionals and scientists, from 550 to 2,300.

Magdi Yacoub's Global Heart Hospital in Cairo

2. Technical Training Experience

2.1 Introduction:

Last year, I spent my two-week Observership program in the following departments:

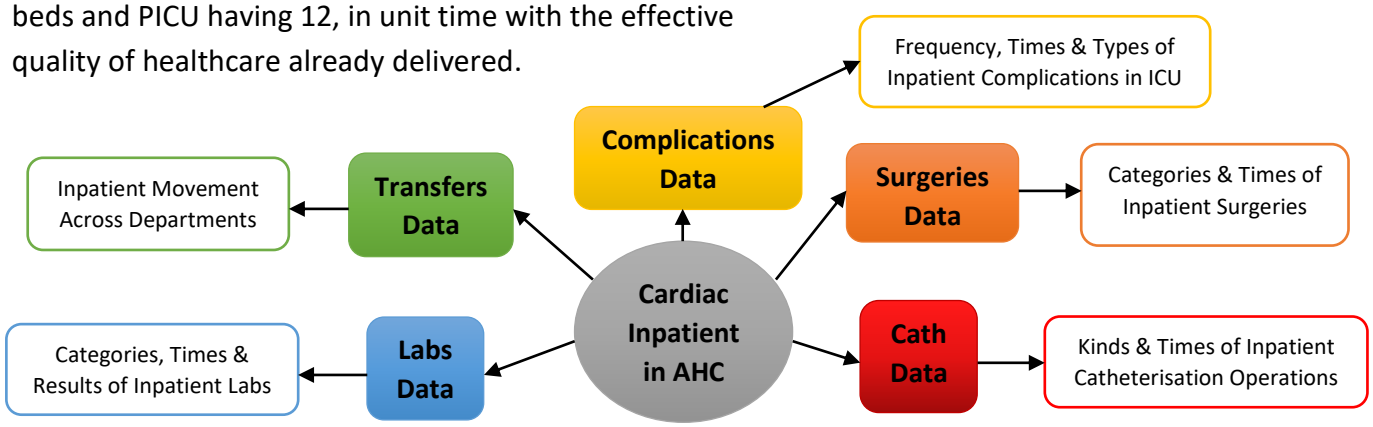
- Biomedical Engineering
- Research, Biomedical Engineering and Innovation Lab
- Clinical Data Management
- Radiology

This year, in the light of my discovered passion for the field of data analytics and artificial intelligence, I spent my five-week internship program in the *Clinical Data Management* department carrying out a machine learning project along with having the privilege of attending educational seminars delivered by the department members in the scope of the department's views and my project's scope.

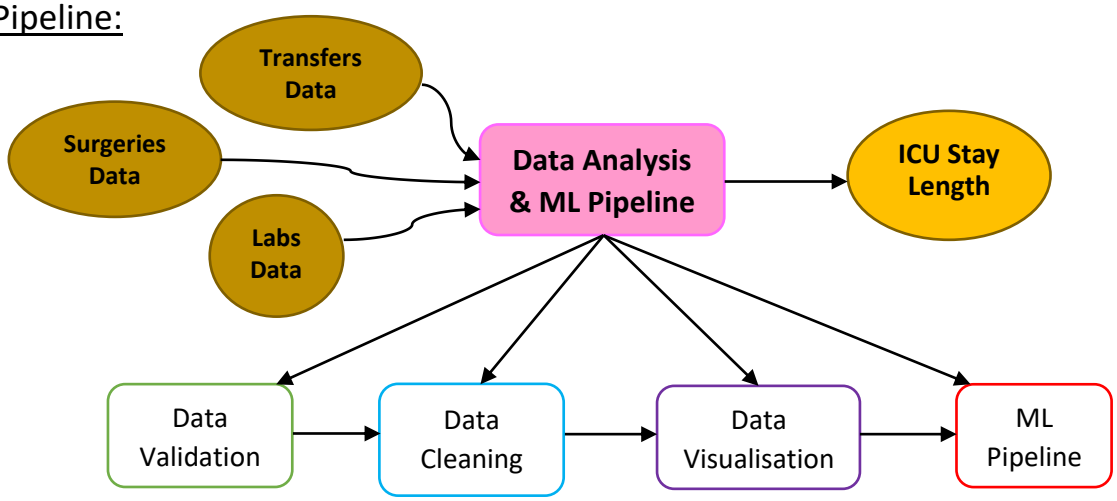
2.2 Internship Project Description:

2.2.1 Intuition:

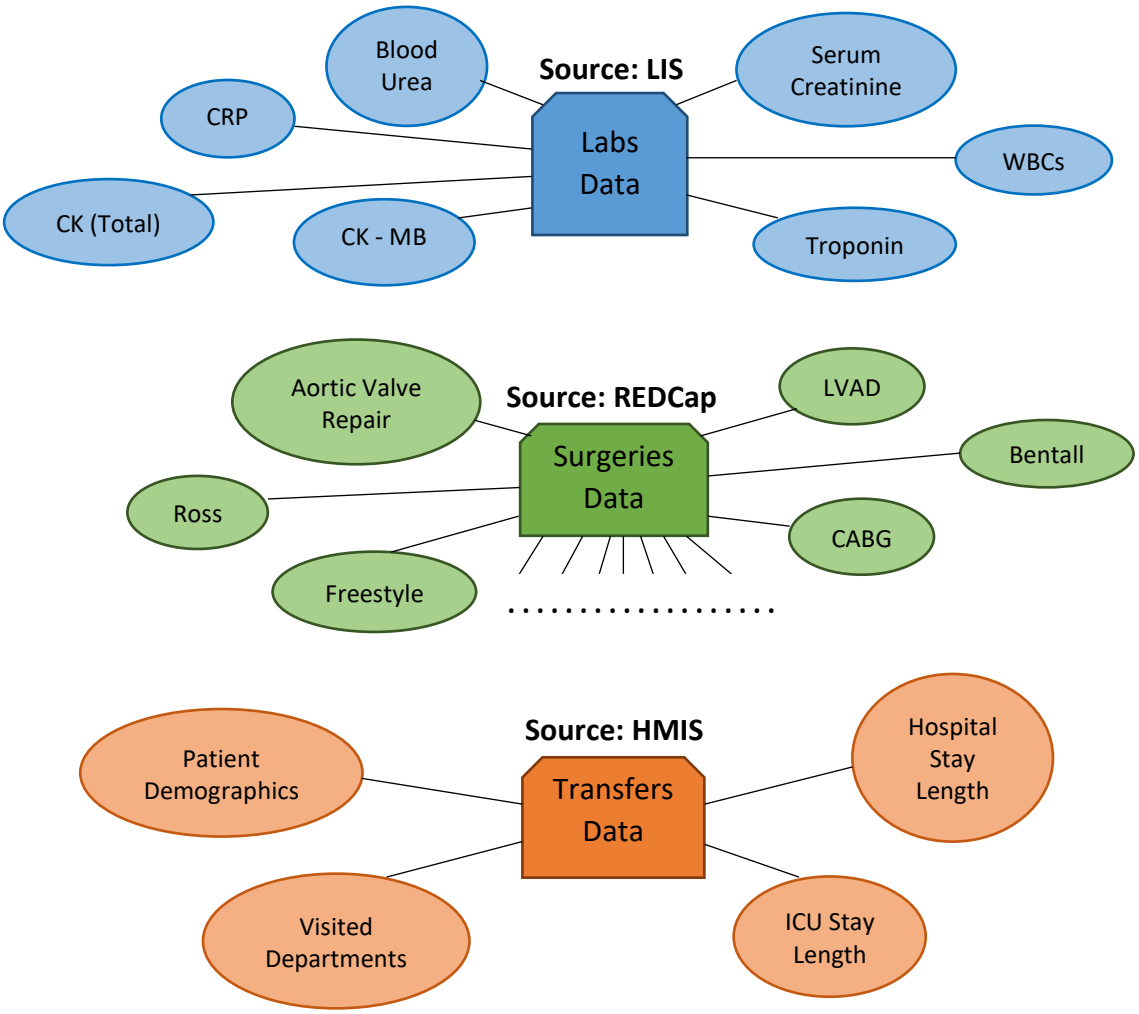
Integrating some of the diverse data collected from patients during their hospital stay to roughly estimate the length of their stay in the intensive care unit for logistic reasons; primarily to plan patient flow through the unit as to efficiently accommodate as many patients as possible, with AICU having 20 beds and PICU having 12, in unit time with the effective quality of healthcare already delivered.



2.2.2 Pipeline:

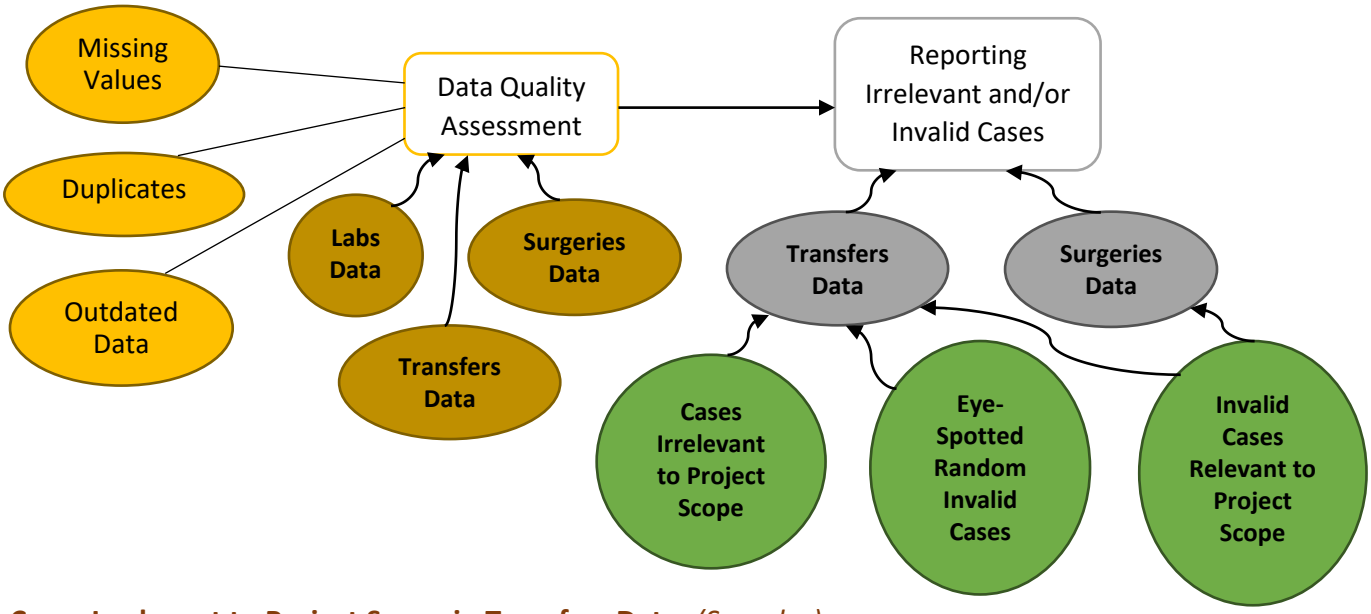


2.3 Internship Project Input:



2.4 Internship Project Pipeline:

2.4.1 Data Validation:



Cases Irrelevant to Project Scope in Transfers Data: *(Samples)*

- If a patient visit consists only of an *Admission* event followed by a *Cancel Admission* event:

Result:

```
Reporting Conformity to Condition:
     ~ If the visit consists of only an Admission followed by a Cancel Admission.  ~
Result:
     ~ There are [redacted] visits satisfying the condition out of total [redacted] visits, forming [redacted] of the data. ~
-------------------------------------------------------------
```

Sample:

	status_n	visit_number	row_date	depn	mrn
110586	Admission	2	2022-08-29 13:23:50	Pediatric ICU	[redacted]
110587	Cancel Admission	2	2022-08-29 15:49:32	Pediatric ICU	[redacted]

- If a patient visit includes neither OR nor ICU as visited units:

Result:

```
Reporting Conformity to Condition:
     ~ If the visit includes neither OR nor ICU as units.  ~
Result:
     ~ There are [redacted] visits satisfying the condition out of total [redacted] visits, forming [redacted] of the data. ~
-------------------------------------------------------------
```

Sample:

	status_n	visit_number	row_date	depn	mrn
110428	Admission	3	2022-09-22 10:11:02	Pediatric Ward	[redacted]
110429	Transfer To	3	2022-09-26 06:45:13	Pediatric Ward	[redacted]
110430	Transfer From	3	2022-09-26 06:45:13	Pediatric Ward	[redacted]
110431	Transfer From	3	2022-09-27 21:24:56	Pediatric Ward	[redacted]
110432	Transfer To	3	2022-09-27 21:24:56	Pediatric Ward	[redacted]
110433	Discharge	3	2022-09-27 22:45:27	Pediatric Ward	[redacted]

Eye-Spotted Random Invalid Cases in Transfers Data: *(Samples)*

❖ If a patient visit has a missing *Transfer From/Transfer To* event:

Result:

```
Reporting Conformity to Condition:
     ~ If a visit has a missing Transfer From/Transfer To event.  ~
Result:
     ~ There are  visits satisfying the condition out of total  visits, forming  of the data. ~
------------------------------------------------------------
```

Sample:

106061	Transfer From	2	2022-04-23 05:11:42	Pediatric ICU	[redacted]
106062	Transfer To	2	2022-04-23 05:11:42	Pediatric ICU	[redacted]
106063	Transfer From	2	2022-05-02 12:20:28	Pediatric ICU	[redacted]
106064	Transfer To	2	2022-05-02 12:20:28	Cath	[redacted]
106065	Transfer To	2	2022-05-02 12:50:42	Pediatric ICU	[redacted]
106066	Transfer From	2	2022-05-02 12:50:42	Cath	[redacted]
106067	Transfer To	2	2022-05-02 12:50:50	CCU 1	[redacted]
106068	Transfer From	2	2022-05-02 12:50:50	Cath	[redacted]
106069	Transfer From	2	2022-05-02 12:53:59	CCU 1	[redacted]

- It is noticed that in records number 106065 and 106066: the patient was transferred from *Cath* to *Pediatric ICU*, while only after two seconds in records number 106067 and 106068: that the patient was transferred from *Cath* to *CCU 1*.
- In the next event, the patient transferred from *CCU 1*, which means that the records numbered 106065 & 106066 are wrong.

Invalid Cases Relevant to Relevant Scope in Transfers Data: *(Samples)*

❖ If a patient visit has two separate *Discharge* events:

Result:

```
Reporting Conformity to Condition:
     ~ If there are two seperate Discharge events in the same visit.  ~
Result:
     ~ There are  visits satisfying the condition out of total  visits, forming  of the data. ~
------------------------------------------------------------
```

Sample:

	status_n	visit_number	row_date	depn	mrn
60712	Admission	2	2017-04-24 09:31:17	CCU 2	[redacted]
60713	Transfer To	2	2017-04-24 11:53:42	Cath	[redacted]
60714	Transfer From	2	2017-04-24 11:53:42	CCU 2	[redacted]
60715	Transfer From	2	2017-04-24 12:40:40	Cath	[redacted]
60716	Transfer To	2	2017-04-24 12:40:40	CCU 2	[redacted]
60717	Discharge	2	2017-04-25 16:00:00	CCU 2	[redacted]
60718	Discharge	2	2017-04-25 16:00:05	CCU 2	[redacted]

❖ If unit of *Admission* event in a patient visit does not match that of first *Transfer From* event:

Result:

```
Reporting Conformity to Condition:
    ~ If the unit of the Admission event in a visit does not match that of the first Transfer From event in that same visit.
Result:
    ~ There are  visits satisfying the condition out of total  visits, forming  of the data. ~
------------------------------------------------------------
```

Sample:

	status_n	visit_number	row_date	depn	mrn
100754	Admission	2	2022-04-24 00:11:05	Adult ICU	[redacted]
100755	Transfer From	2	2022-04-24 08:42:27	New WARD	[redacted]
100756	Transfer To	2	2022-04-24 08:42:27	OR	[redacted]
100757	Transfer From	2	2022-04-25 02:05:54	OR	[redacted]
100758	Transfer To	2	2022-04-25 02:05:54	Adult ICU	[redacted]
100759	Transfer To	2	2022-04-26 07:49:55	Adult Ward	[redacted]
100760	Transfer From	2	2022-04-26 07:49:55	Adult ICU	[redacted]
100761	Transfer From	2	2022-04-29 08:25:11	Adult Ward	[redacted]
100762	Transfer To	2	2022-04-29 08:25:11	Adult Ward	[redacted]
100763	Transfer From	2	2022-05-01 21:37:21	Adult Ward	[redacted]
100764	Transfer To	2	2022-05-01 21:37:21	Adult Ward	[redacted]
100765	Discharge	2	2022-05-04 12:27:27	Adult Ward	[redacted]

Invalid Cases Relevant to Relevant Scope in Surgeries Data: *(Samples)*

❖ Adult patients performing pediatric-specific surgeries:

Result:

```
Reporting Conformity to Condition:
There are  rows satisfying the condition: (If adult patient performed pediatric surgeries), forming  of the data.

No change or drop was applied to rows satisfying the condition: (If adult patient performed pediatric surgeries).
------------------------------------------------
```

Sample:

Age Group	Performed Surgeries
Adult	myectomy,

❖ Patients who performed no surgeries:

Result:

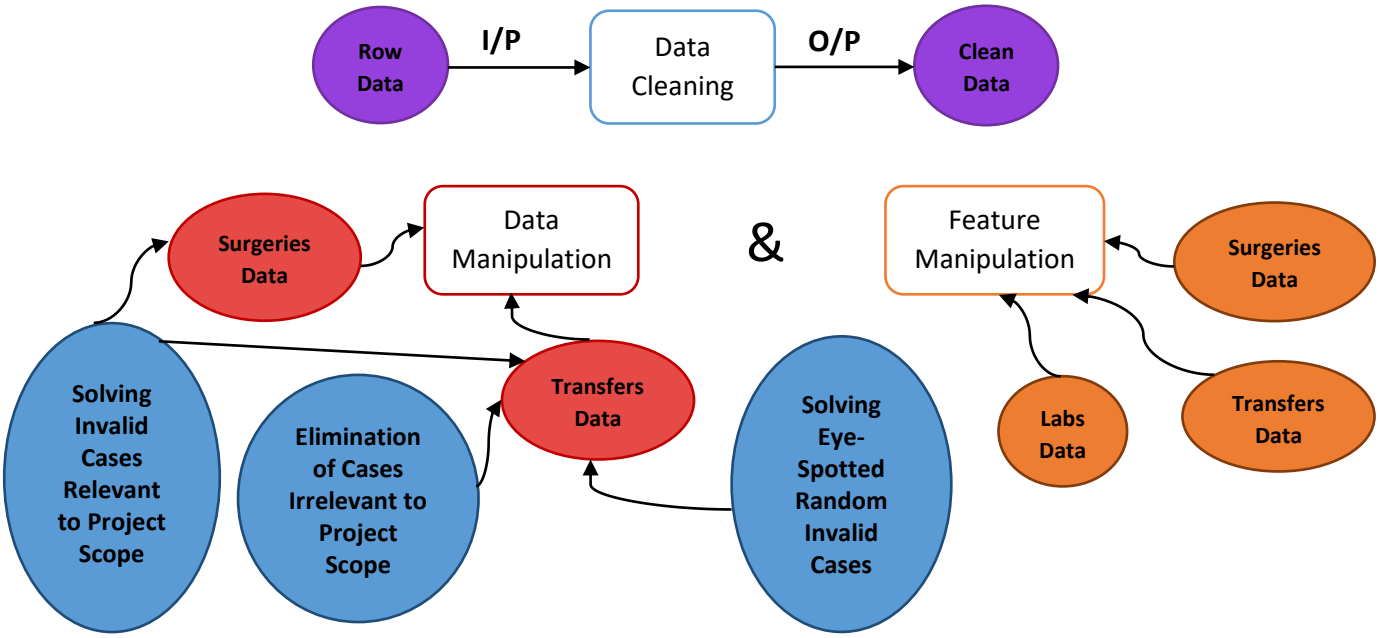
```
Reporting Conformity to Condition:
There are  rows satisfying the condition: (If patient did not perform any surgery), forming  of the data.

No change or drop was applied to rows satisfying the condition: (If patient did not perform any surgery).
------------------------------------------------
```

Sample:

Age Group	Performed Surgeries
Pediatric	

2.4.2 Data Cleaning:



Elimination of Cases Irrelevant to Project Scope in Transfers Data: *(Samples)*

- If a patient visit consists only of an *Admission* event followed by a *Cancel Admission* event:

Result:

```
Reporting Conformity to Condition:
     ~ If the visit consists of only an Admission followed by a Cancel Admission.  ~
Result:
     ~ There are [redacted] visits satisfying the condition out of total [redacted] visits, forming [redacted] of the data. ~
     ~ All visits satisfying the condition were dropped. ~
------------------------------------------------------------
```

- If a patient visit includes neither OR nor ICU as visited units:

Result:

```
Reporting Conformity to Condition:
     ~ If the visit includes neither OR nor ICU as units.  ~
Result:
     ~ There are [redacted] visits satisfying the condition out of total [redacted] visits, forming [redacted] of the data. ~
     ~ All visits satisfying the condition were dropped. ~
------------------------------------------------------------
```

Solving Eye-Spotted Random Invalid Cases in Transfers Data: *(Samples)*

- If a patient visit has a missing *Transfer From/Transfer To* event:

Result:

```
Reporting Conformity to Condition:
     ~ If a visit has a missing Transfer From/Transfer To event.  ~
Result:
     ~ There are [redacted] visits satisfying the condition out of total [redacted] visits, forming [redacted] of the data. ~
     ~ In all visits satisfying the condition, the complementary Transfer From/Transfer To event to the missing one was dropped. ~
```

Solving Invalid Cases Relevant to Project Scope in Transfers Data: *(Samples)*

- ❖ If a patient visit has two separate *Discharge* events:

Result:

```
Reporting Conformity to Condition:
     ~ If there are two seperate Discharge events in the same visit.  ~
Result:
     ~ There are  visits satisfying the condition out of total  visits, forming  of the data. ~
     ~ For all visits satisfying the condition, the first Discharge event was dropped. ~
```

- ❖ If unit of *Admission* event does not match that of first *Transfer From* event:

Result:

```
Reporting Conformity to Condition:
     ~ If the unit of the Admission event in a visit does not match that of the first Transfer From event in that same visit.  ~
Result:
     ~ There are  visits satisfying the condition out of total  visits, forming  of the data. ~
     ~ For all visits satisfying the condition, the unit of the first Transfer From event was changed to match that of the Admission event. ~
```

Solving Invalid Cases Relevant to Project Scope in Surgeries Data: *(Samples)*

- ❖ Adult patients performing pediatric-specific surgeries:

Result:

```
Reporting Conformity to Condition:
There are  rows satisfying the condition: (If adult patient performed pediatric surgeries), forming  of the data.

Applying Change:
The column (Age Group) in all rows satisfying the condition: (If adult patient performed pediatric surgeries) has been changed with: (Pediatric).
--------------------------------------------------
```

- ❖ Patients who performed no surgeries:

Result:

```
Reporting Conformity to Condition:
There are  rows satisfying the condition: (If patient did not perform any surgery), forming  of the data.

Applying Drop:
The rows satisfying the condition: (If patient did not perform any surgery) have been dropped.
--------------------------------------------------
```

Features Manipulation in Transfers Data: *(Samples)*

- ❖ *Length of ICU Stay* and *Length of Hospital Stay* features calculation:

Result:

status_n	visit_number	row_date	depn	mrn	Length of ICU Stay	Length of Hospital Stay
Admission	10	2018-09-03	CCU 2		2	19
Transfer From	10	2018-09-03	CCU 2		2	19
Transfer To	10	2018-09-03	Cath		2	19
Transfer To	10	2018-09-03	CCU 2		2	19
Transfer From	10	2018-09-03	Cath		2	19
Transfer To	10	2018-09-03	Adult Ward		2	19

Features Manipulation in Surgeries Data: *(Samples)*

❖ *Age Group* and *Performed Surgeries* features formation:

Result:

Age Group	Performed Surgeries
Adult	av_canal_repaircomplete,
Pediatric	mbt_shunt,
Pediatric	glenn,
Pediatric	first_stage_switchpab,_bts,
Pediatric	mbt_shunt,

Features Manipulation in Labs Data: *(Samples)*

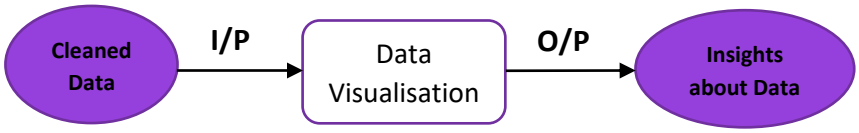
❖ *Lab* names and results re-structuring:

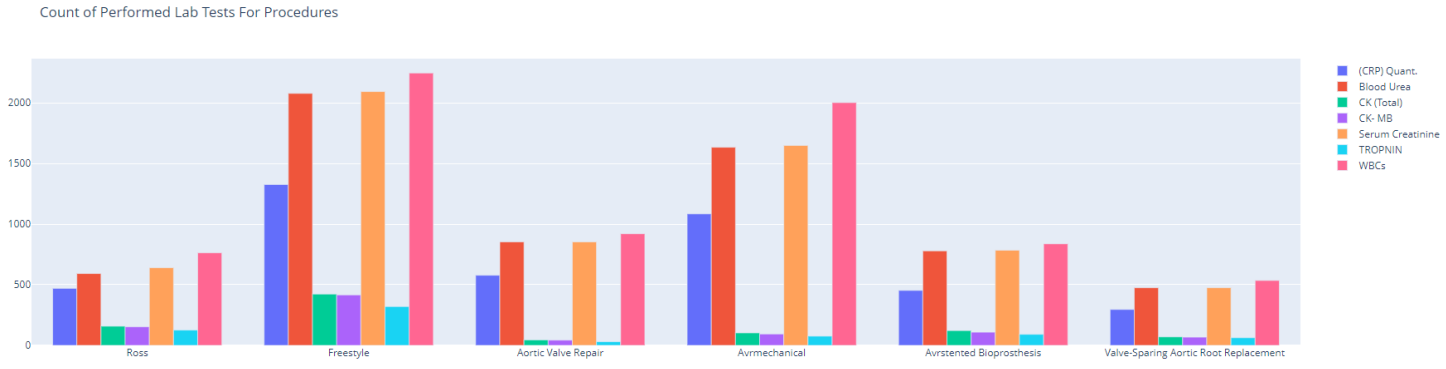
- The tests data in the dataframe were re-structured so that each order for a patient in a visit is represented by a row, whose columns are the test names and the column values being the test result in that specific order, while keeping the 'MEDICALNO', 'VISITNO' and 'ORDERNO' constant.
- Concerning that 'TESTTIME', since each test in the order is carried at a different time but they are all on the same day (most of the time), the time will be trimmed from the date before re-structuring.

TESTNAME	SERVICENAME	MEDICALNO	VISITNO	TESTRESULT	TESTTIME	ORDERNO
Serum Creatinine	SERUM CREATININE	[redacted]	2	1.5	2013-12-01 13:37:50	55948
WBCs	COMPLETE BLOOD COUNT (CBC)	[redacted]	3	16.2	2013-12-01 18:57:00	56005
Blood Urea :	BLOOD UREA	[redacted]	3	23.0	2013-12-01 19:00:36	56005
Blood Urea :	BLOOD UREA	[redacted]	1	33.0	2013-12-02 15:09:44	56157
Serum Creatinine	BLOOD UREA	[redacted]	1	0.8	2013-12-02 15:09:44	56157

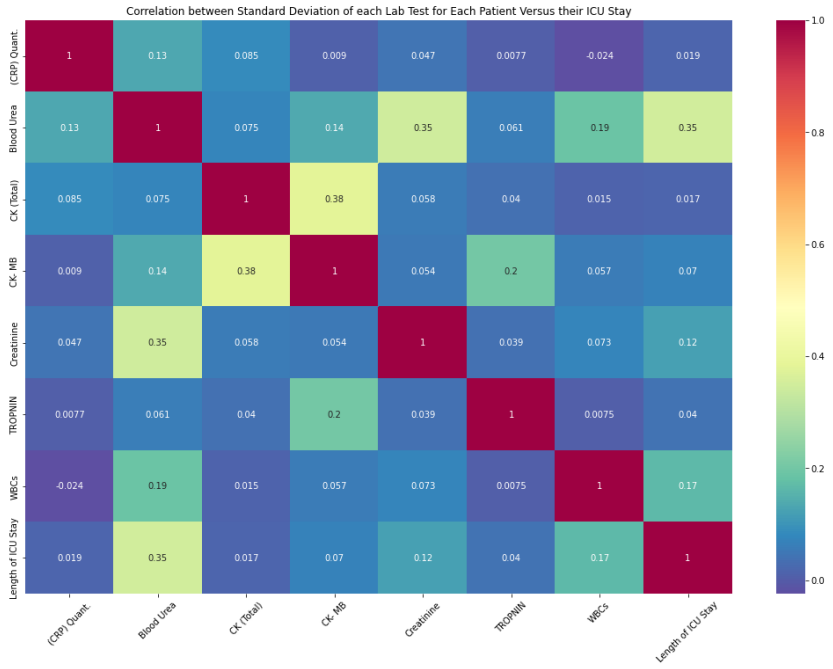
MEDICALNO	VISITNO	ORDERNO	TESTTIME	(CRP) Quant.	Blood Urea	CK (Total)	CK- MB	Serum Creatinine	TROPNIN	WBCs
[redacted]	8	180639	2015-12-18	NaN	NaN	NaN	NaN	NaN	NaN	10.4
[redacted]	8	180639	2015-12-19	2.82	NaN	NaN	NaN	NaN	NaN	NaN
[redacted]	10	182617	2015-12-29	NaN	NaN	NaN	NaN	NaN	NaN	20.6
[redacted]	10	182617	2015-12-30	0.88	14.3	NaN	NaN	0.3	NaN	NaN

2.4.3 Data Visualisation: *(Examples)*

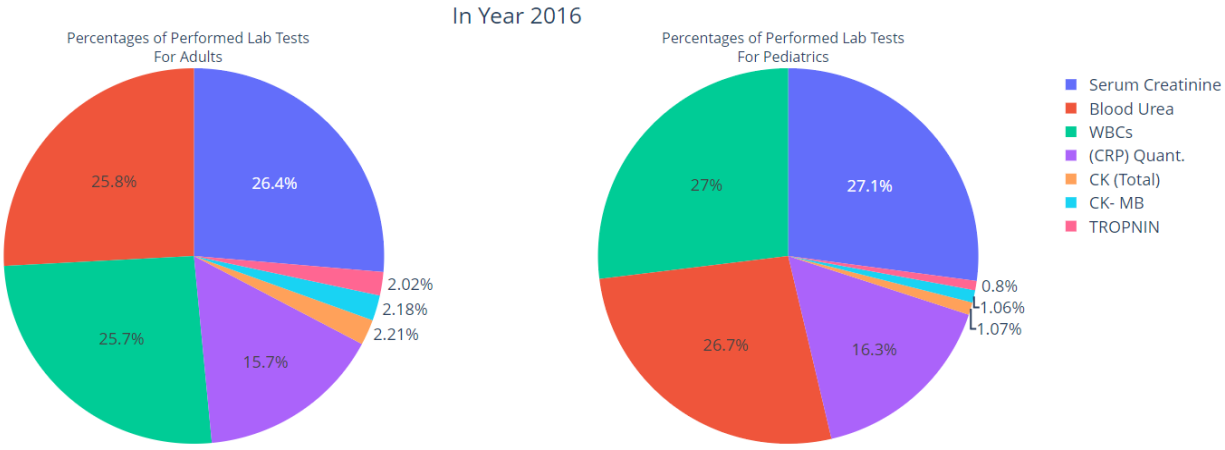




Grouped Bar Chart of Count of Performed Lab Tests for Specific Surgeries



Heatmap of Correlation between Standard Deviation of each Lab Test for each Patient Versus Length of their ICU Stay



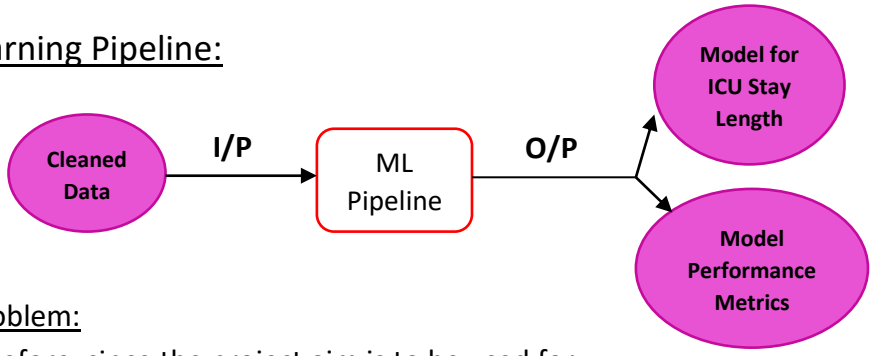
Pie Chart of Percentages of Performed Lab Tests for Adults and Pediatrics for Year of 2016

Figure Consisting of:

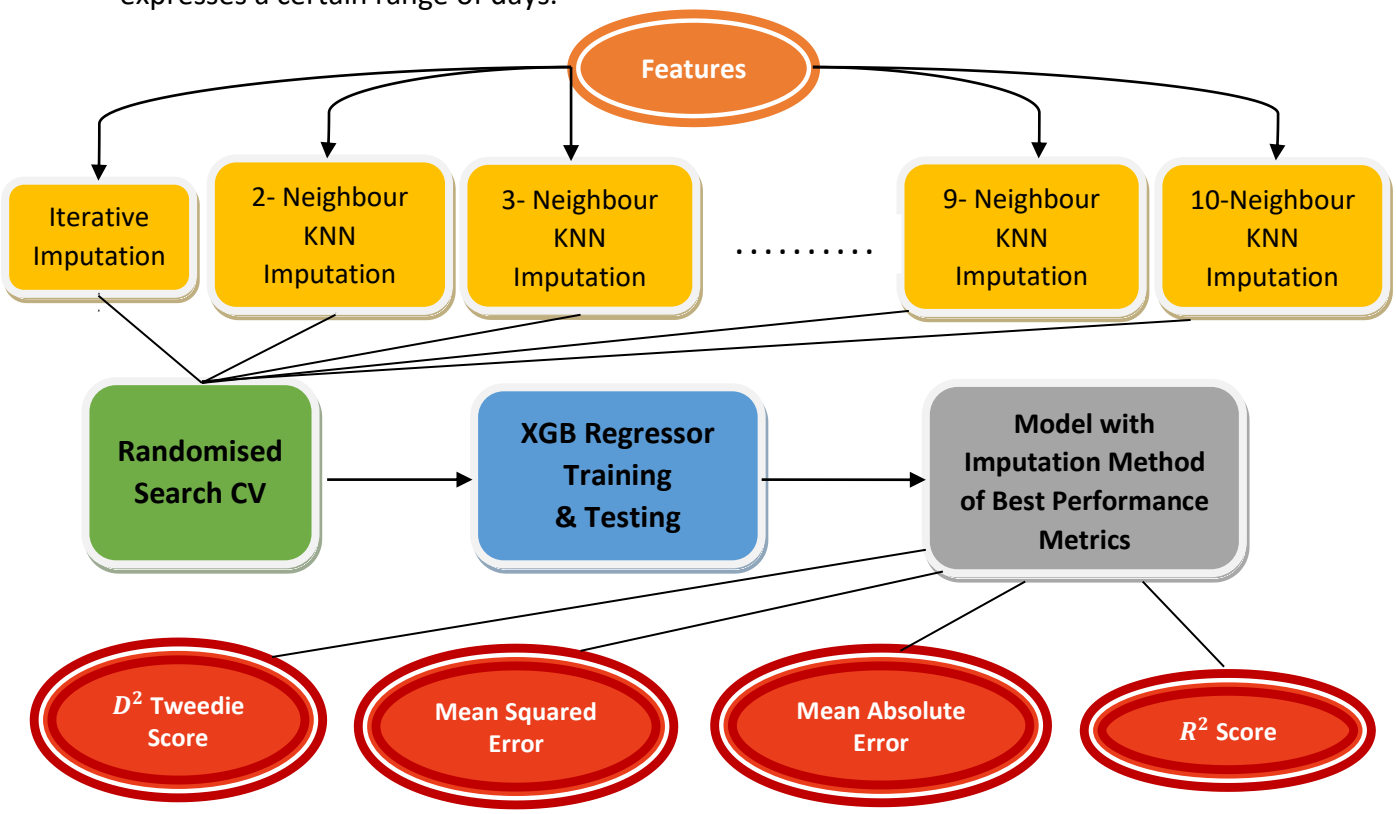
i) Two Separate Numbers Summarising Mean Percentage of ICU Stay Length to Hospital Stay Length for both Adults and Pediatrics.

ii) Four Histograms of ICU Stay Length and Hospital Stay Length for both Adults and Pediatrics.

2.4.4 Machine Learning Pipeline:

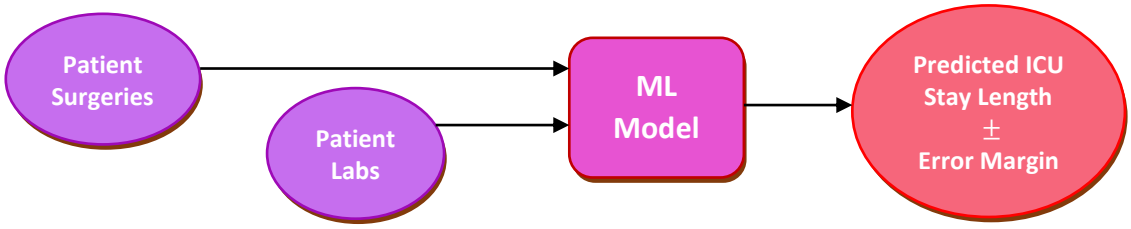


- Regression Problem:
  As explained before, since the project aim is to be used for logistic reasons, the problem was treated as regression to output the predicted number of days of a patient's stay in the ICU in addition to a margin of error but not classification as in each class expresses a certain range of days.



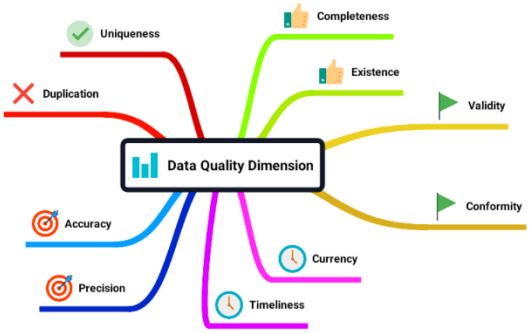
- Using XGB Regressor:
  Due to time limitation reasons in addition to strong consensus viewed in literature review of the problem, the machine learning algorithm used was XGB Regressor to determine the imputation method of best performance.

2.5 Internship Project Output:



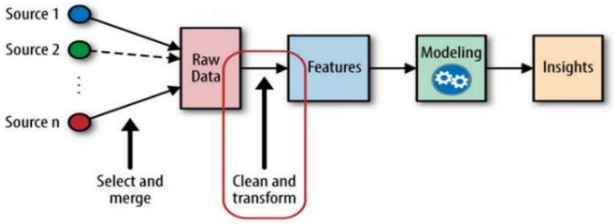
2.6 Clinical Data Management Seminars: *(Given by Department Members)*

2.6.1 Tidy Data:



- Definition and purpose of tidy data, and data restructuring.
- Messy datasets and their most common problems, and quality issues.

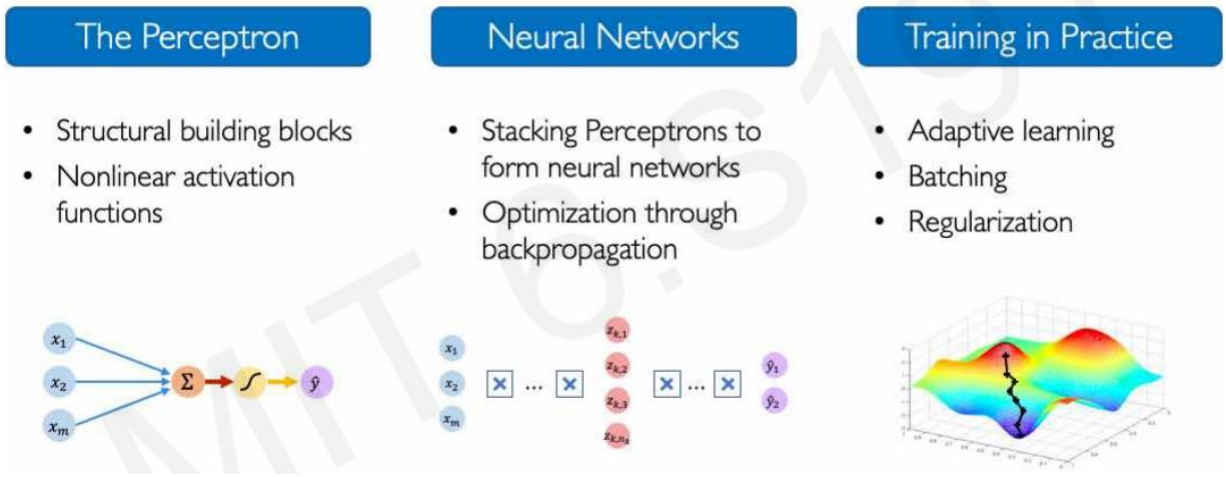
2.6.2 Feature Engineering:



- Types of features, and purpose of feature engineering.
- Feature expansion, enhancement and reduction.
- Dimensionality reduction, and feature extraction.

2.6.3 Introduction to Deep Learning:

- Resurgence of deep learning, and structure of perceptron.
- Importance and examples of activation functions.
- Building networks, and basic examples of their application.
- Loss optimisation, learning rate setting, mini-batches and regularisation.



3. References: *(Sections 1 and 2.6)*

1) https://myf-egypt.org/aswan-heart-centre/
2) https://myglobalheart.org/mission/
3) https://myglobalheart.org/new-magdi-yacoub-global-heart-centre/
4) https://myglobalheart.org/new-hospital/
5) Wickham, H. (2014). Tidy Data. Journal of Statistical Software, 59(10), 1–23. https://doi.org/10.18637/jss.v059.i10
6) DTI5216 Fundamentals for Applied Data Science Course, University of Ottawa
7) 6.S191 Introduction to Deep Learning Course, MIT MIT Deep Learning 6.S191 (introtodeeplearning.com)