Van Gestel's Simulation Model in Python Simpy for Presentation

Here is the main Program for the simulation model.

It is OO so most of operations are done outside of this file.

Number of Iterations: 2

Subjects (patients) per iteration: 3000

QALY is calculated based on VFQ score (VFQ-25 questionaire)

In [1]:

```
#error checking measures
import csv
import matplotlib.pyplot as plt
numberofGraphs = 15
def csv_dict_writer(path, fieldnames, data):
    with open(path, "wb") as out_file:
        writer = csv.DictWriter(out_file, delimiter=',', fieldnames=fieldnames)
        writer.writeheader()
        for row in data:
            writer.writerow(row)
masterListforReplications = []
field_names = "QALY,TotalCost".split(",")
from PlottingSystemClass import PlottingSystem
from SimulationSystemClass import SimulationSystem
plottingsystem = PlottingSystem(plt)
order = 1
```

The main code is here

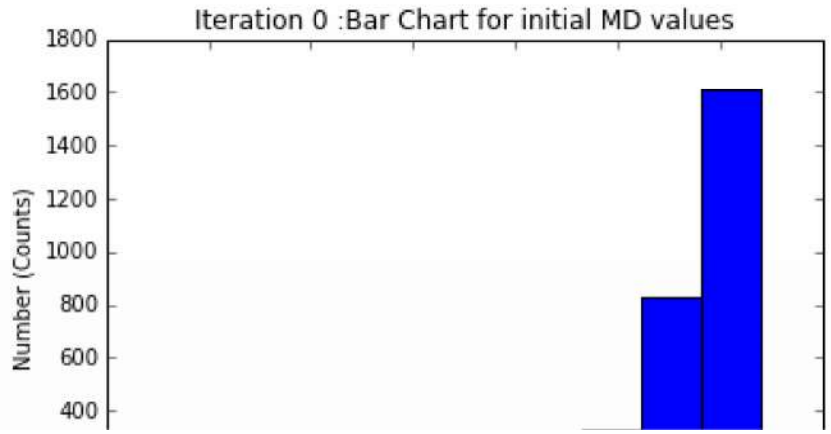
It is run for 20 rounds 7 plots are produced for each iteration

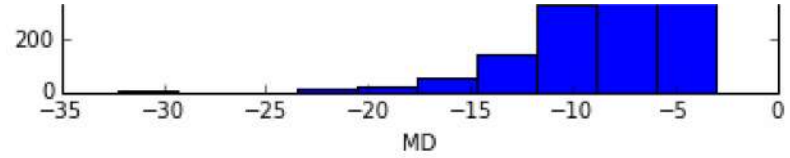
In [3]:

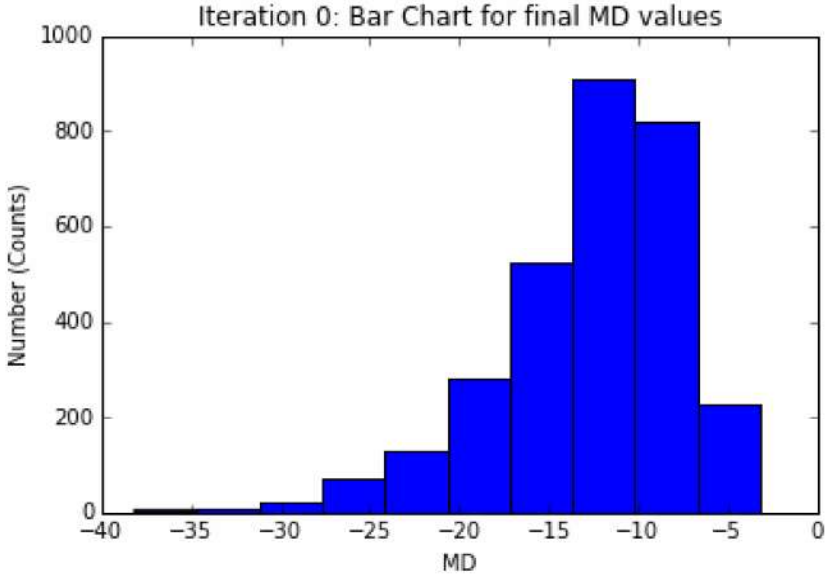
```
%matplotlib inline
for i in range(2):
    sysSimulation = SimulationSystem(3000,"PatientList/Patients_list_{}.csv".format(i
    sysSimulation.SystemSimulation()
    plottingsystem.plot(sysSimulation,order,i,masterListforReplications)
    order += (numberofGraphs*1)
    del sysSimulation
print order
csv_dict_writer("MList.csv",field_names,masterListforReplications)
```

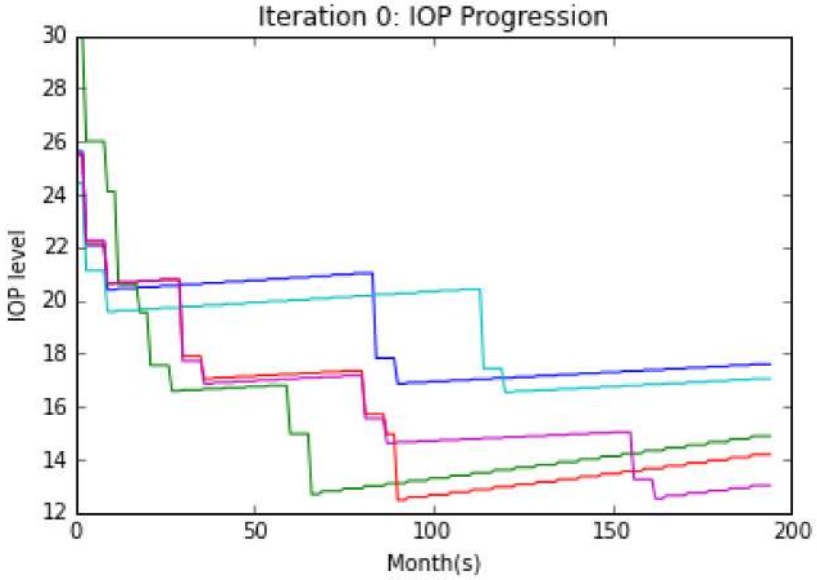
```
CURRENT ITERATION: 0
Average QALY: 12.6025879228
Average Medical Cost: 26246.4198333
Average MD: -12.753006932
```

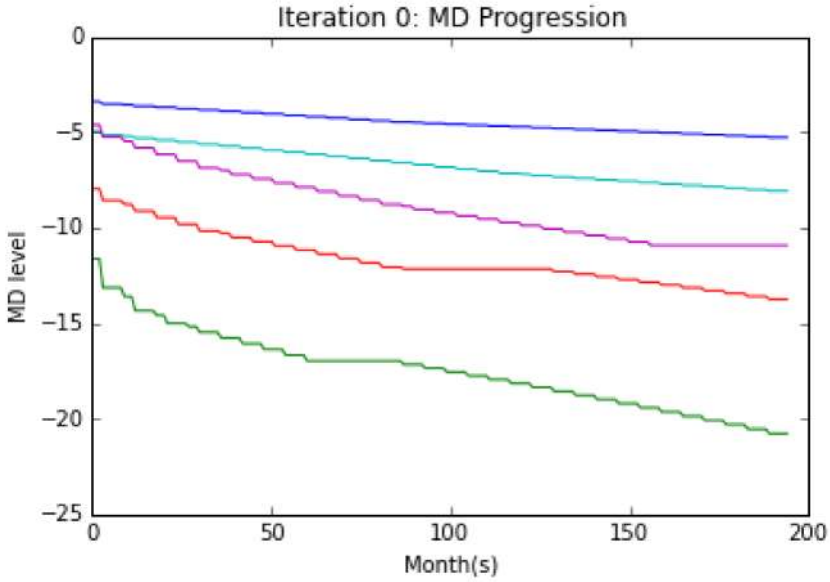
```
Patient 0: List of Medication Progression is [0, 1, 1, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6,
6, 6, 6, 6, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8]
Patient 0: List of Final Medication Amount is [5, 3, 1, 0, 0]
Patient 1: List of Medication Progression is [0, 1, 1, 6, 6, 8, 8, 10, 10, 10, 10, 1
0, 10, 10, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 3
0, 30, 30, 30, 30, 30, 30, 30]
Patient 1: List of Final Medication Amount is [8, 6, 4, 0, 2]
Patient 2: List of Medication Progression is [0, 1, 1, 6, 6, 6, 6, 6, 8, 8, 8, 8, 8,
8, 8, 8, 8, 10, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30,
30, 30, 30, 30, 30, 30, 30]
Patient 2: List of Final Medication Amount is [7, 5, 3, 0, 1]
Patient 3: List of Medication Progression is [0, 1, 1, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6,
6, 6, 6, 6, 6, 6, 6, 6, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8]
Patient 3: List of Final Medication Amount is [5, 3, 1, 0, 0]
Patient 4: List of Medication Progression is [0, 1, 1, 6, 6, 6, 6, 6, 8, 8, 8, 8, 8,
8, 8, 8, 8, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 30, 30, 30, 30, 30,
30, 30, 30, 30, 30, 30, 30]
Patient 4: List of Final Medication Amount is [8, 6, 4, 0, 2]
CURRENT ITERATION: 1
Average QALY: 12.5757205511
Average Medical Cost: 26876.2168667
Average MD: -12.8960616883

Patient 0: List of Medication Progression is [0, 1, 1, 6, 6, 6, 6, 6, 8, 8, 8, 8, 8,
8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 10, 10, 30, 30, 30, 30, 30, 30, 30, 30, 3
0, 30, 30]
Patient 0: List of Final Medication Amount is [8, 6, 4, 0, 2]
Patient 1: List of Medication Progression is [0, 1, 2, 2, 2, 16, 16, 18, 18, 18, 18,
18, 18, 18, 18, 18, 18, 18, 18, 19, 19, 19, 19, 19, 19, 19, 19, 19, 19, 19, 19,
19, 19, 19, 19, 19]
Patient 1: List of Final Medication Amount is [1, 7, 3, 5, 1]
Patient 2: List of Medication Progression is [0, 1, 2, 2, 2, 2, 16, 16, 16, 16, 16,
16, 18, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 30, 30, 30, 30, 30, 30, 3
0, 30, 30, 30, 30, 30, 30]
Patient 2: List of Final Medication Amount is [1, 5, 1, 3, 2]
Patient 3: List of Medication Progression is [0, 1, 1, 6, 7, 7, 7, 13, 13, 14, 14, 1
4, 14, 14, 14, 14, 14, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 3
0, 30, 30, 30, 30, 30, 30, 30, 30, 30]
Patient 3: List of Final Medication Amount is [7, 3, 4, 4, 2]
Patient 4: List of Medication Progression is [0, 1, 1, 6, 6, 6, 8, 8, 8, 8, 8, 10, 1
0, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 30, 30, 30, 30, 30, 30, 30, 3
0, 30, 30, 30, 30, 30, 30]
Patient 4: List of Final Medication Amount is [8, 6, 4, 0, 2]
61
```



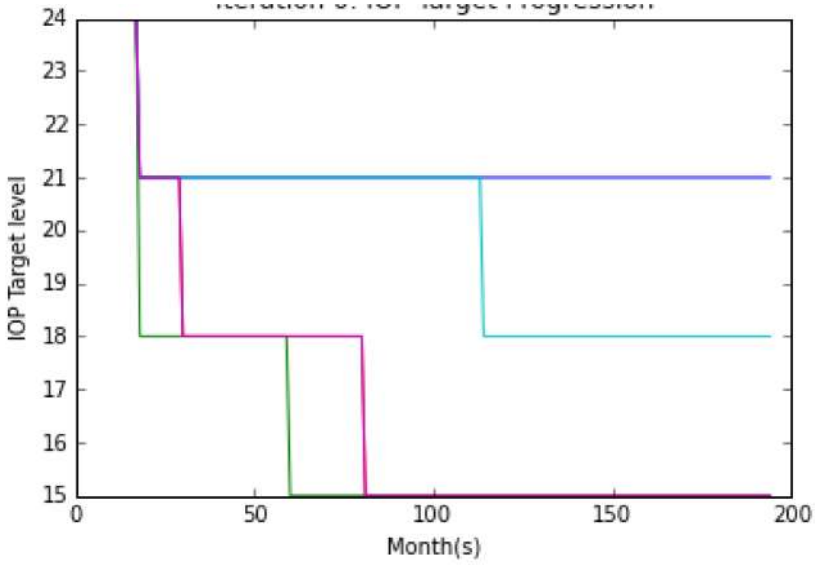


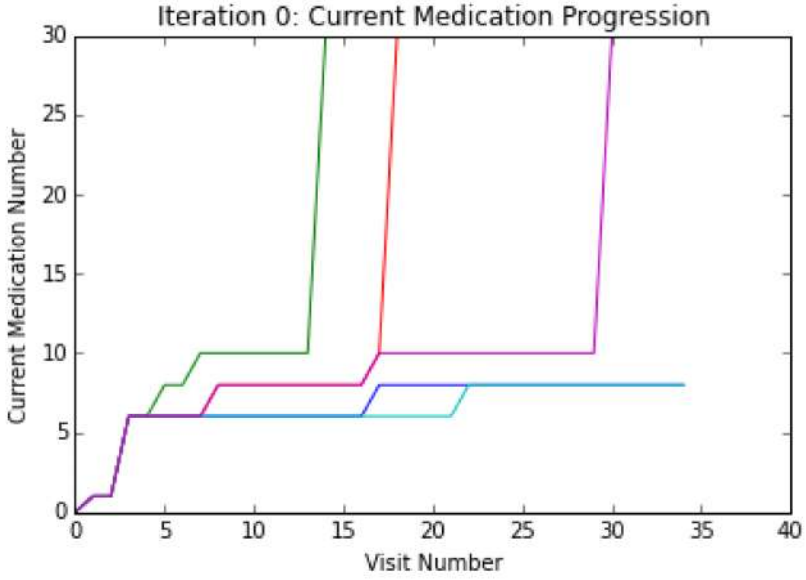


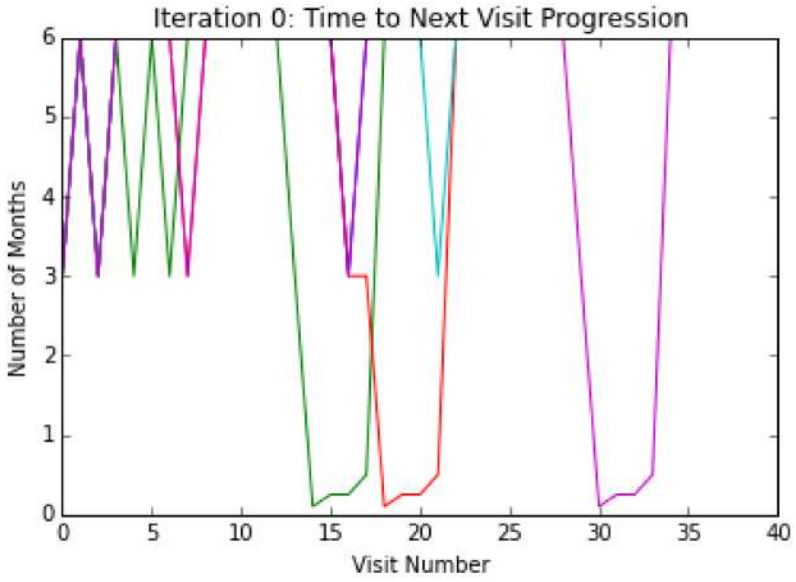


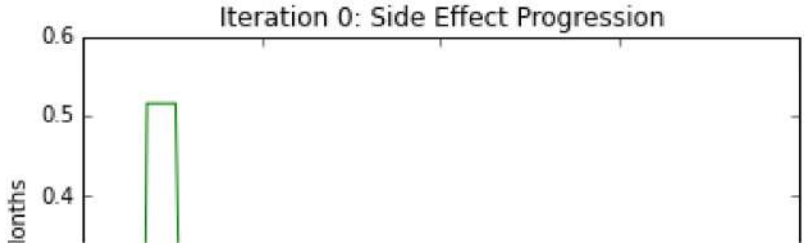


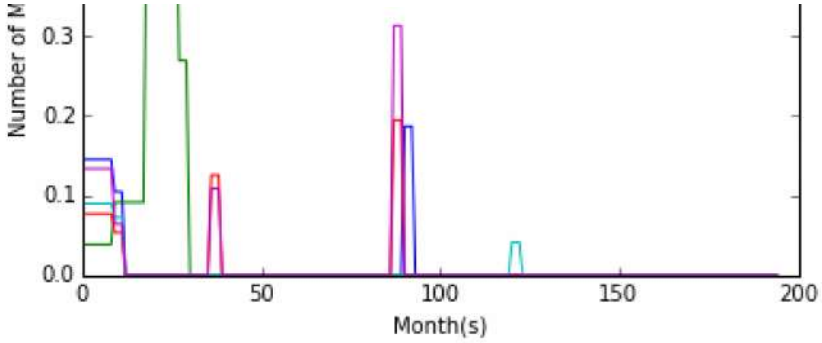
Iteration 0: IOP Target Progression

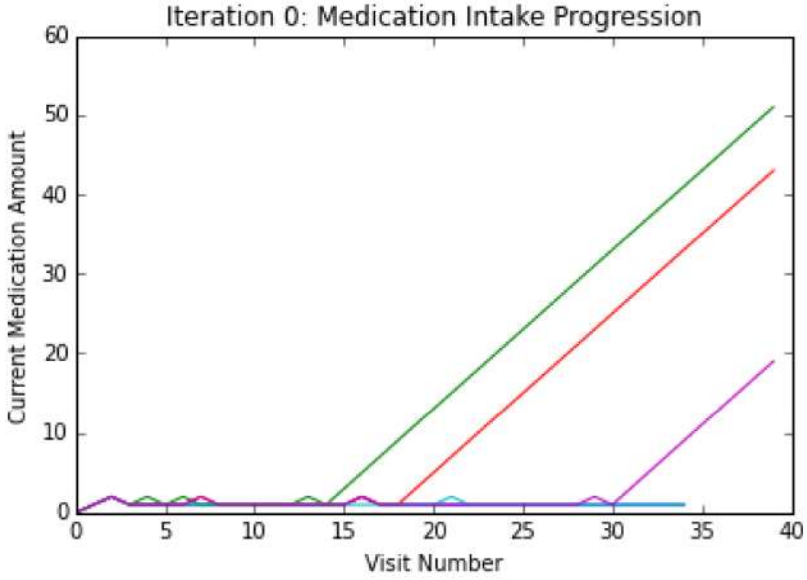

IOP Target level
Month(s)

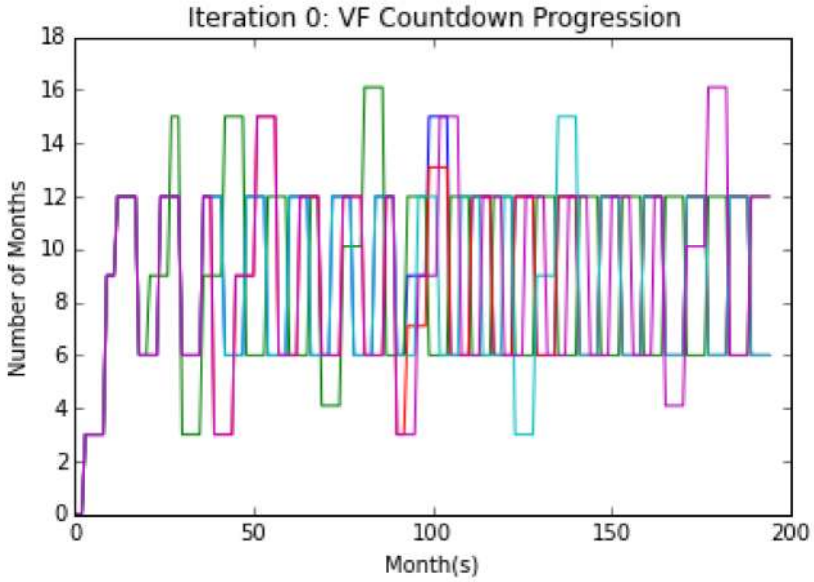

Iteration 0: Current Medication Progression
Current Medication Number
Visit Number

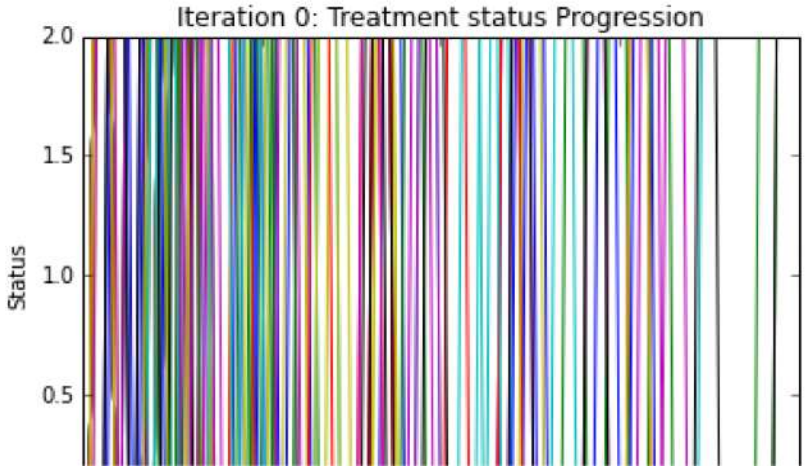

Iteration 0: Time to Next Visit Progression
Number of Months
Visit Number


Iteration 0: Side Effect Progression

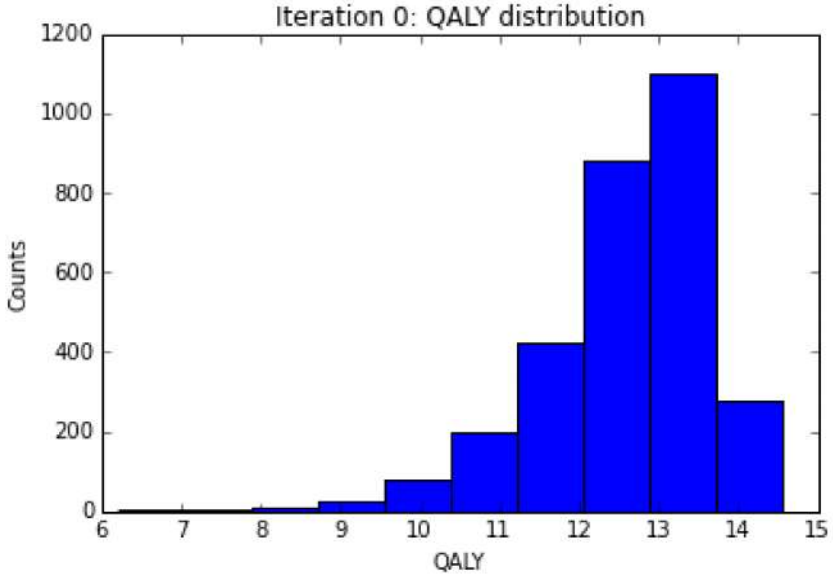

Number of M
0.0
0.1
0.2
0.3
0
50
100
150
200
Month(s)

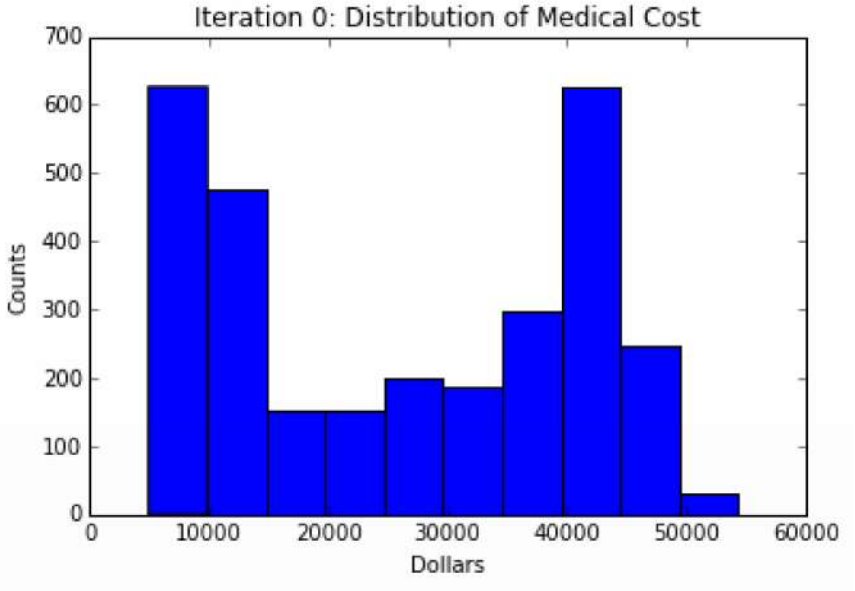

Iteration 0: Medication Intake Progression
Current Medication Amount
0
10
20
30
40
50
60
0
5
10
15
20
25
30
35
40
Visit Number

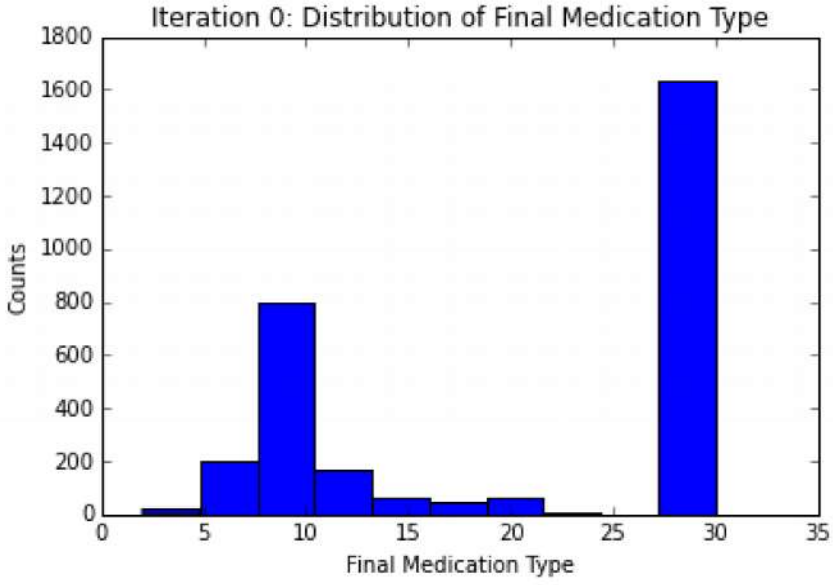

Iteration 0: VF Countdown Progression
Number of Months
0
2
4
6
8
10
12
14
16
18
0
50
100
150
200
Month(s)

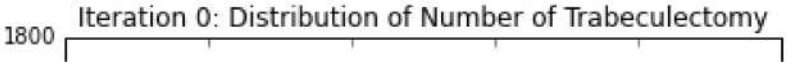

Iteration 0: Treatment status Progression
Status
0.5
1.0
1.5
2.0

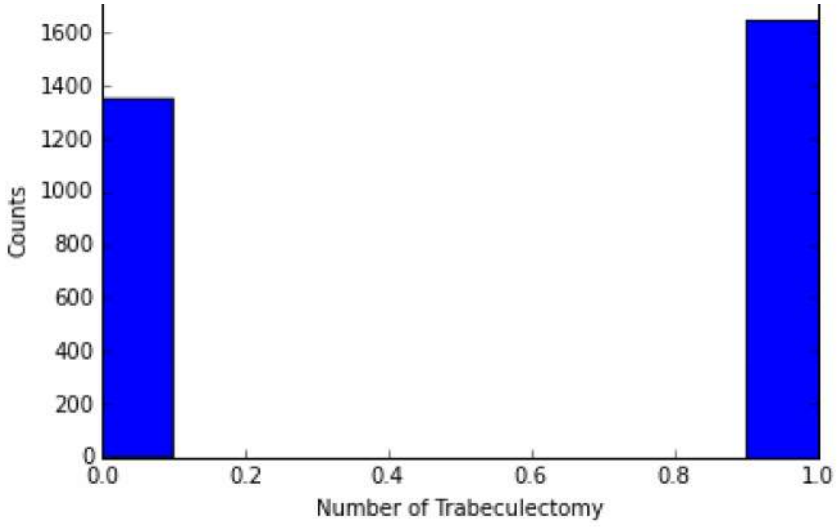

0.0
0
50
100
150
200
Month(s)

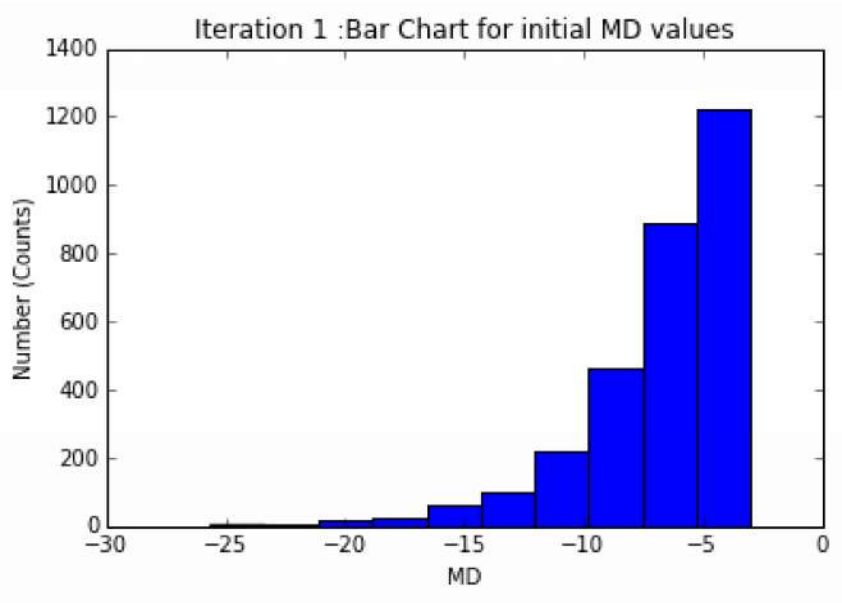

Iteration 0: QALY distribution
Counts
QALY
0
200
400
600
800
1000
1200
6
7
8
9
10
11
12
13
14
15

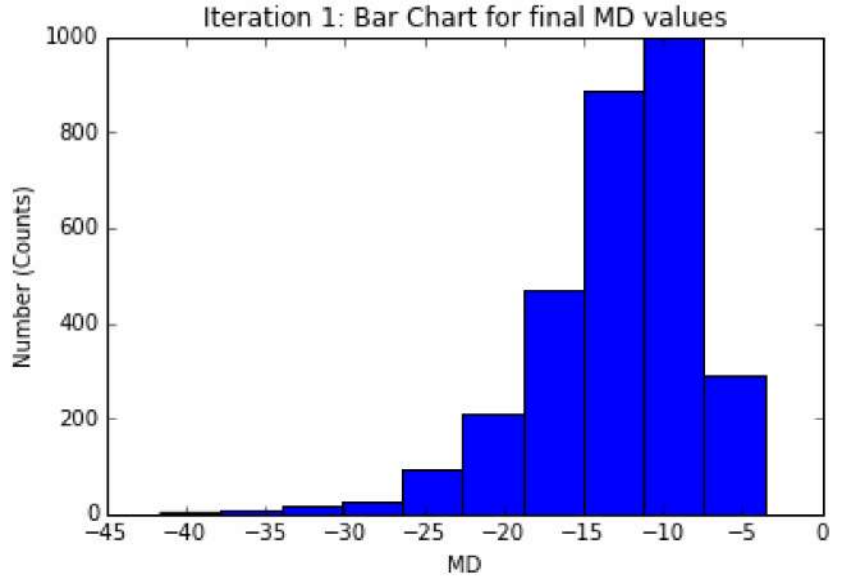

Iteration 0: Distribution of Medical Cost
Counts
Dollars
0
100
200
300
400
500
600
700
0
10000
20000
30000
40000
50000
60000

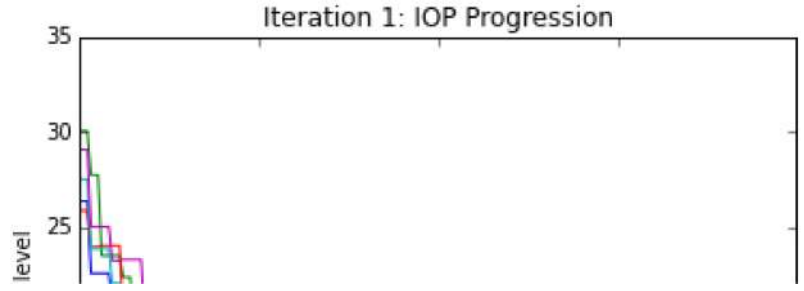

Iteration 0: Distribution of Final Medication Type
Counts
Final Medication Type
0
200
400
600
800
1000
1200
1400
1600
1800
0
5
10
15
20
25
30
35

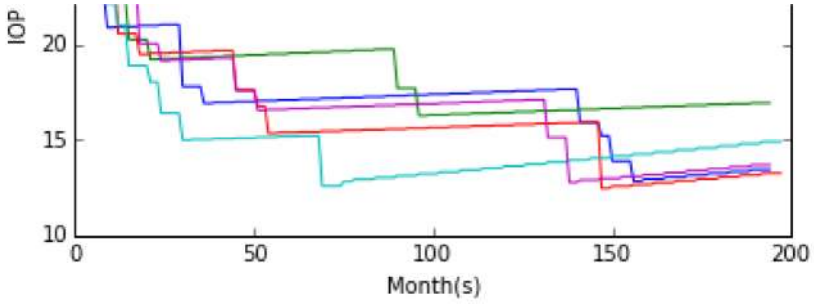

Iteration 0: Distribution of Number of Trabeculectomy
1800

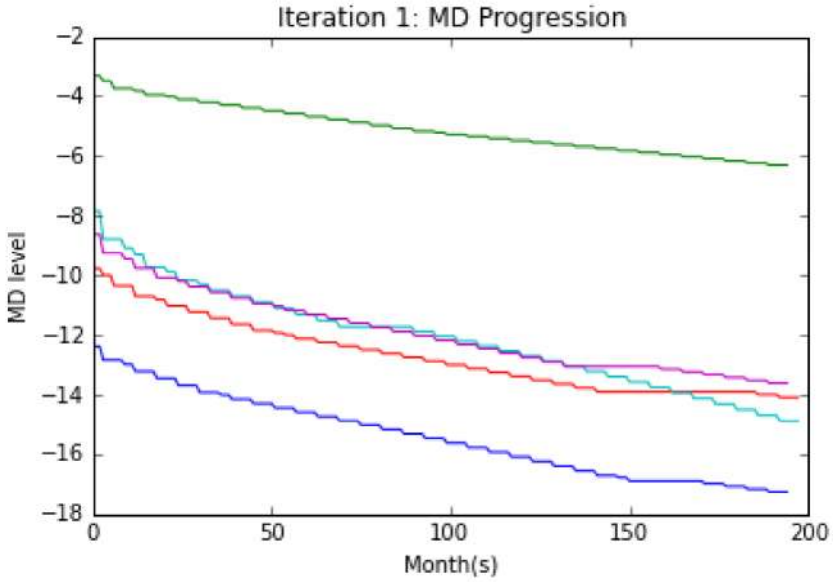

Counts
Number of Trabeculectomy

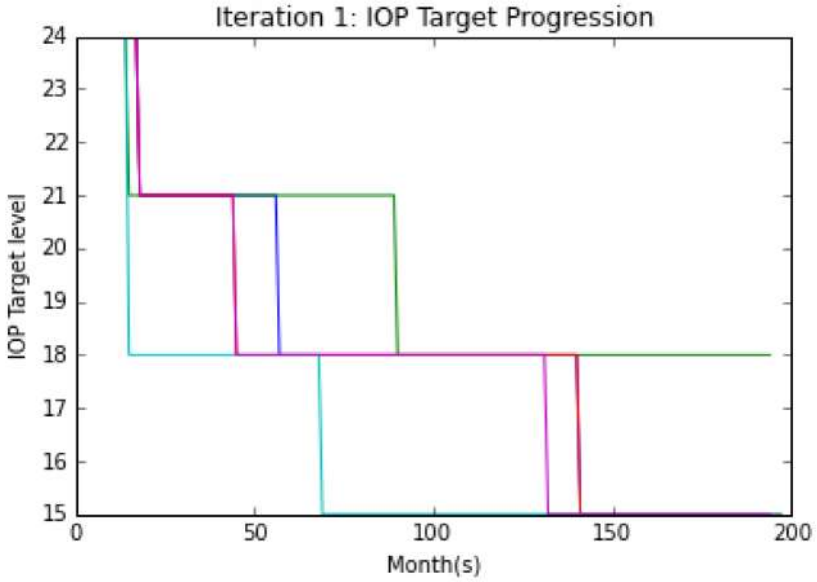

Iteration 1 :Bar Chart for initial MD values
Number (Counts)
MD

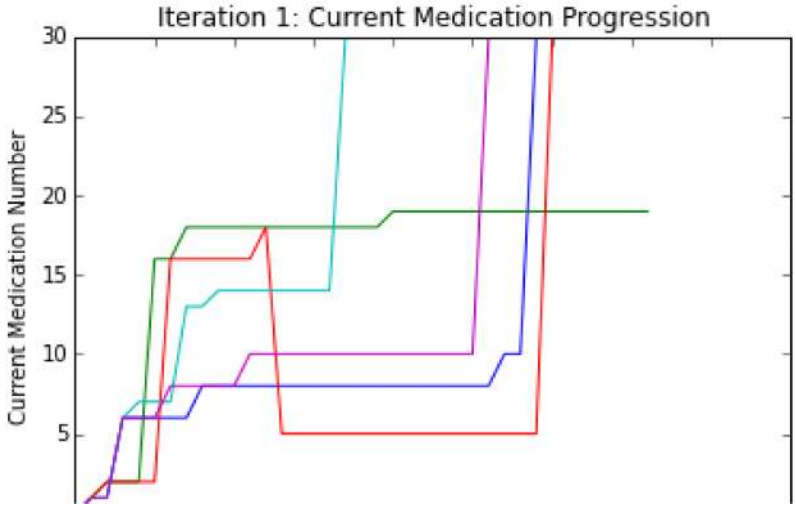

Iteration 1: Bar Chart for final MD values
Number (Counts)
MD

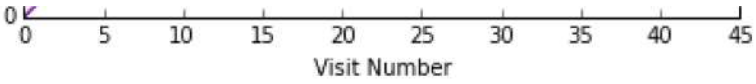

Iteration 1: IOP Progression

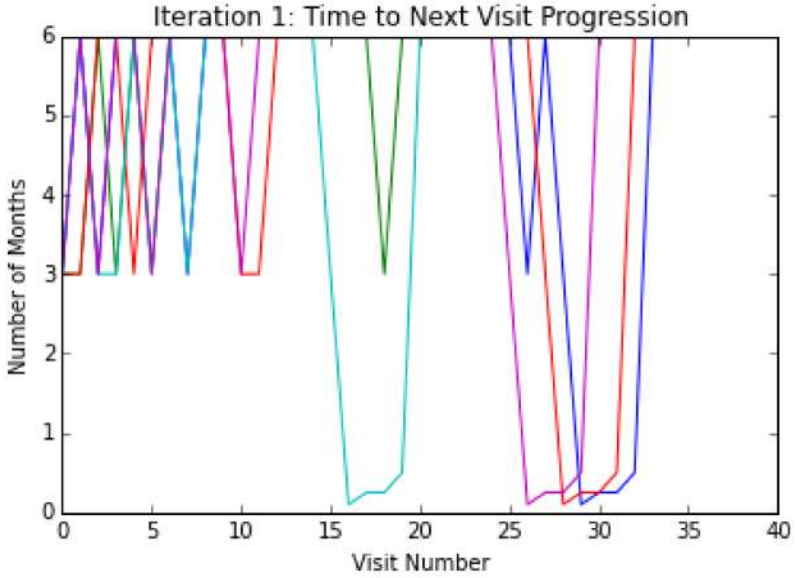

IOP
Month(s)

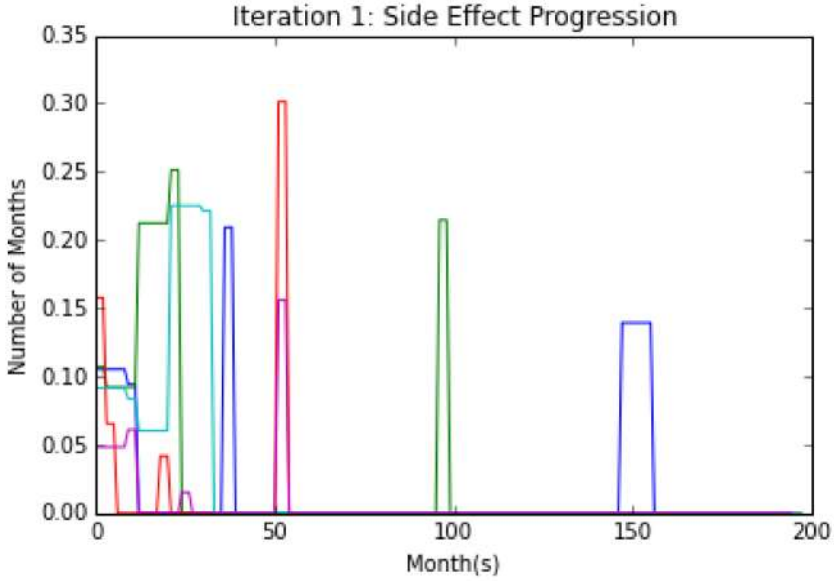

Iteration 1: MD Progression
MD level
Month(s)

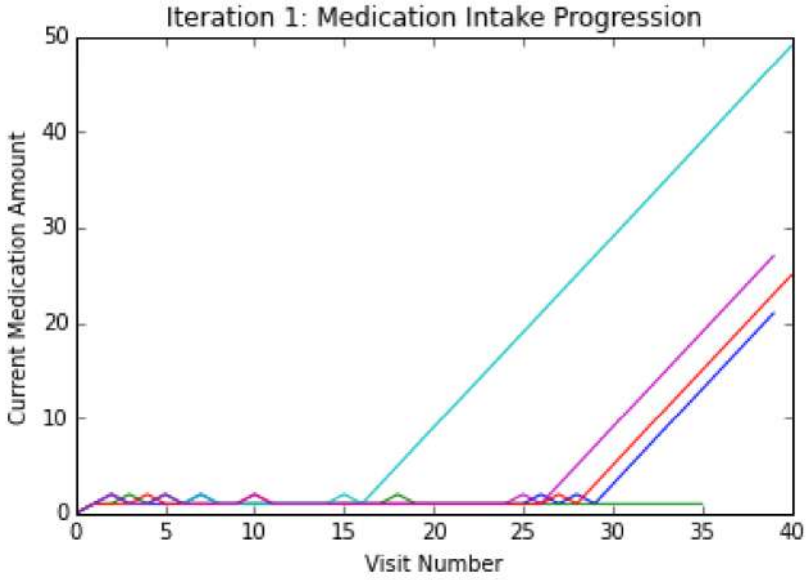

Iteration 1: IOP Target Progression
IOP Target level
Month(s)


Iteration 1: Current Medication Progression
Current Medication Number

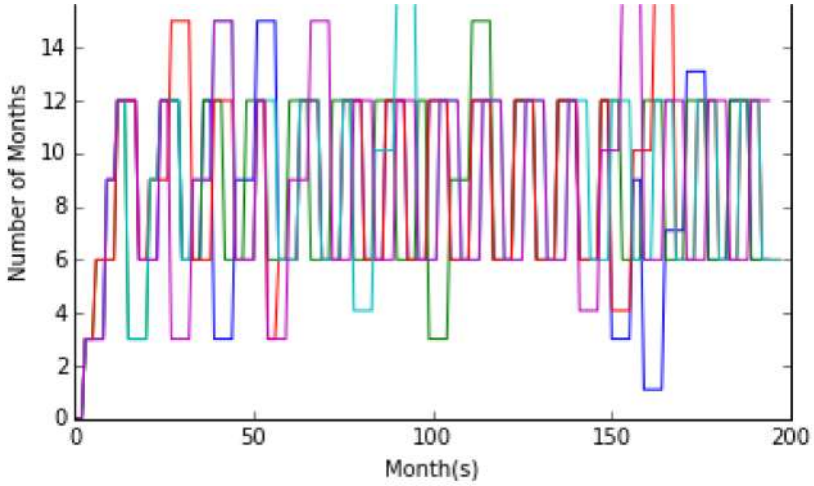

0
0 5 10 15 20 25 30 35 40 45
Visit Number

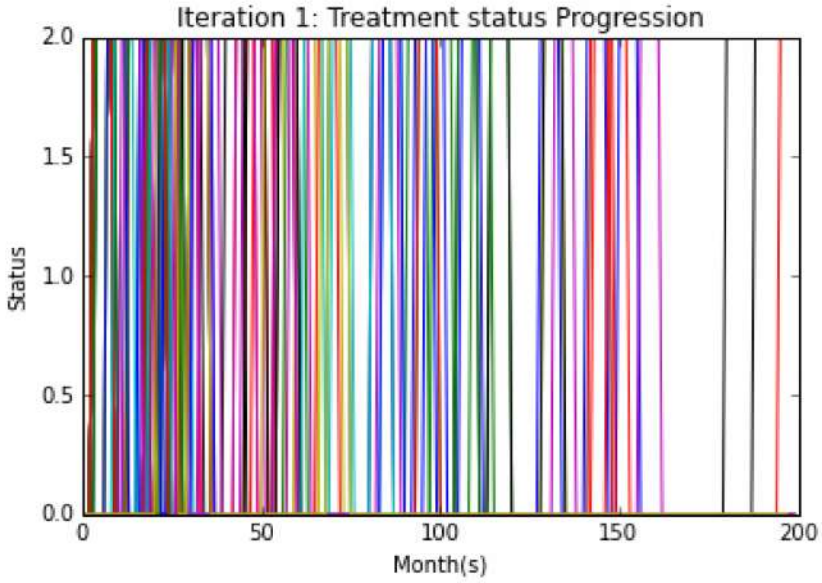

Iteration 1: Time to Next Visit Progression
Number of Months
0 1 2 3 4 5 6
0 5 10 15 20 25 30 35 40
Visit Number

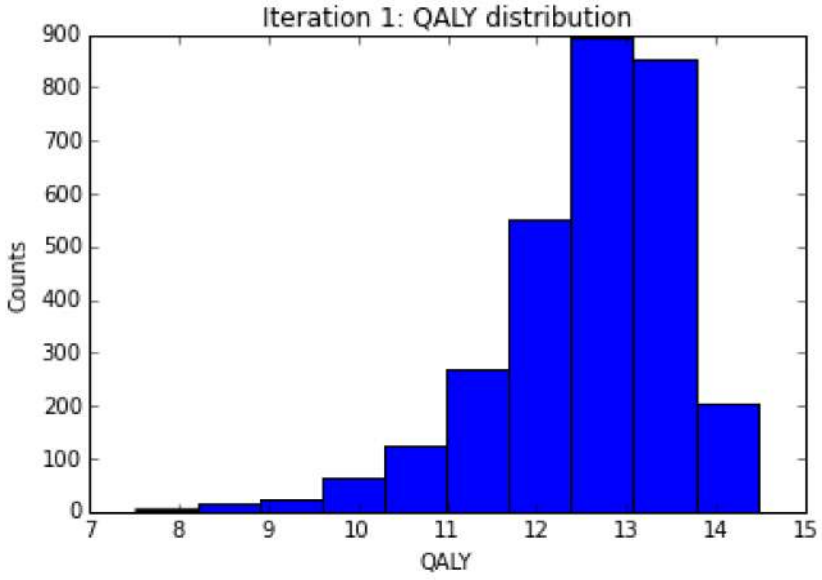

Iteration 1: Side Effect Progression
Number of Months
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35
0 50 100 150 200
Month(s)

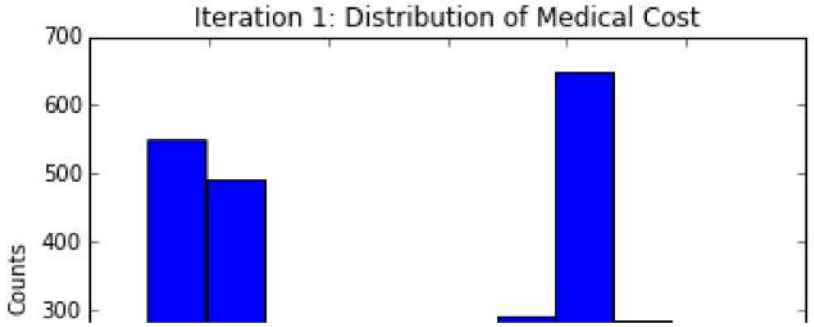

Iteration 1: Medication Intake Progression
Current Medication Amount
0 10 20 30 40 50
0 5 10 15 20 25 30 35 40
Visit Number

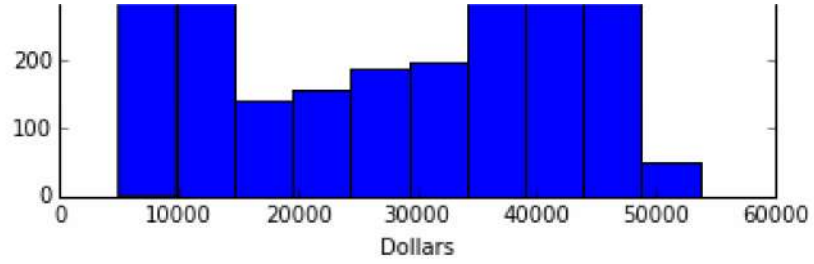

Iteration 1: VF Countdown Progression
18
16

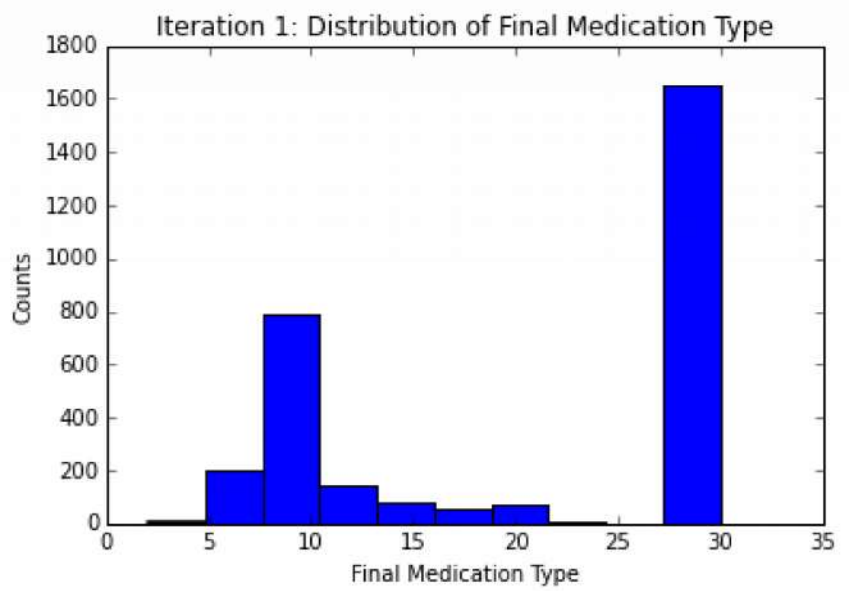

Number of Months
Month(s)
0
2
4
6
8
10
12
14
0
50
100
150
200

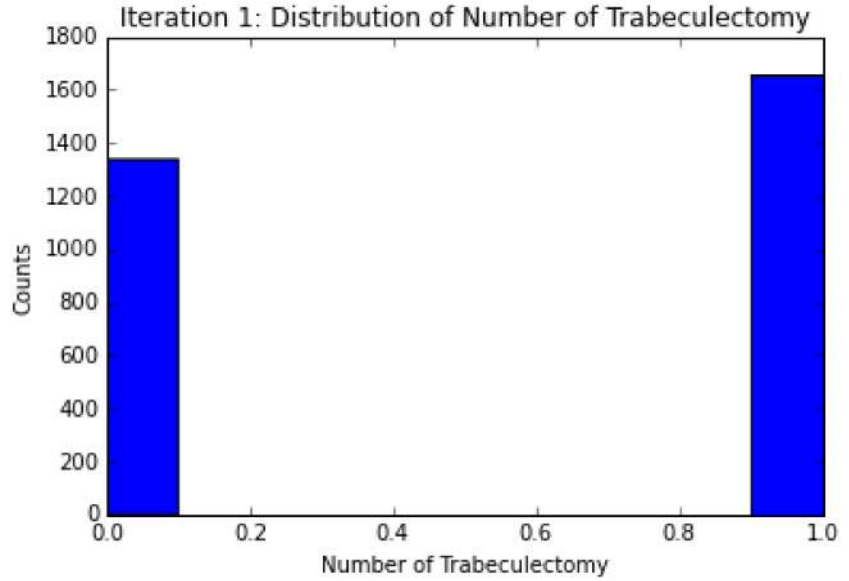

Iteration 1: Treatment status Progression
Status
Month(s)
0.0
0.5
1.0
1.5
2.0
0
50
100
150
200


Iteration 1: QALY distribution
Counts
QALY
0
100
200
300
400
500
600
700
800
900
7
8
9
10
11
12
13
14
15


Iteration 1: Distribution of Medical Cost
Counts
300
400
500
600
700

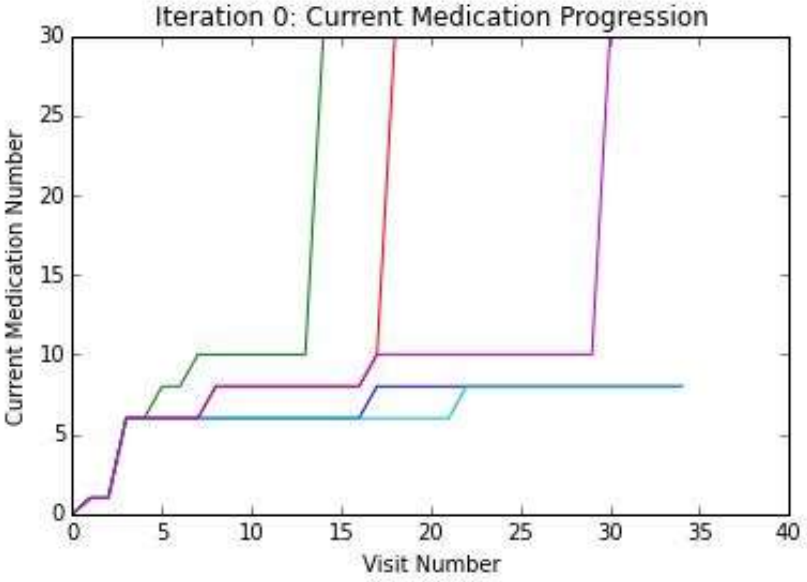


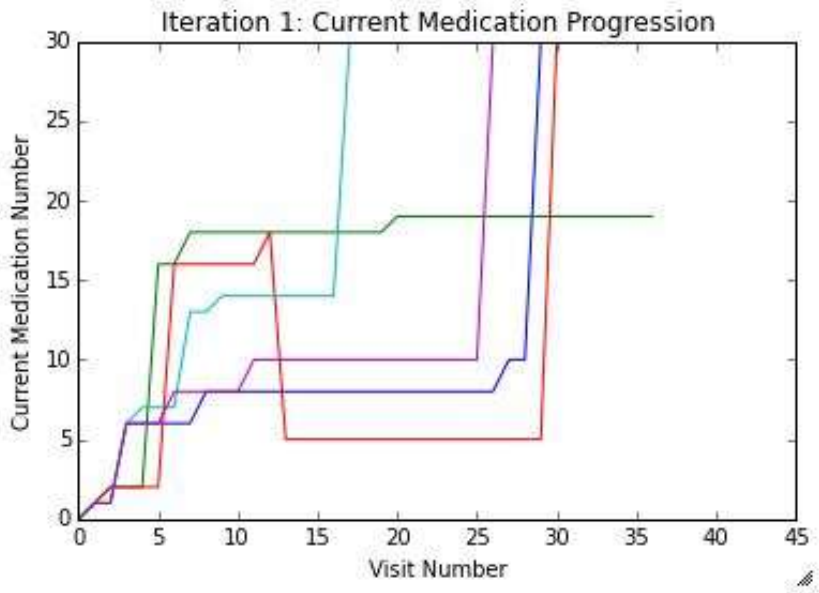




How Patients are moved within the system

In order to track what type of medication/treatment patients are currently under, we can use this chart:

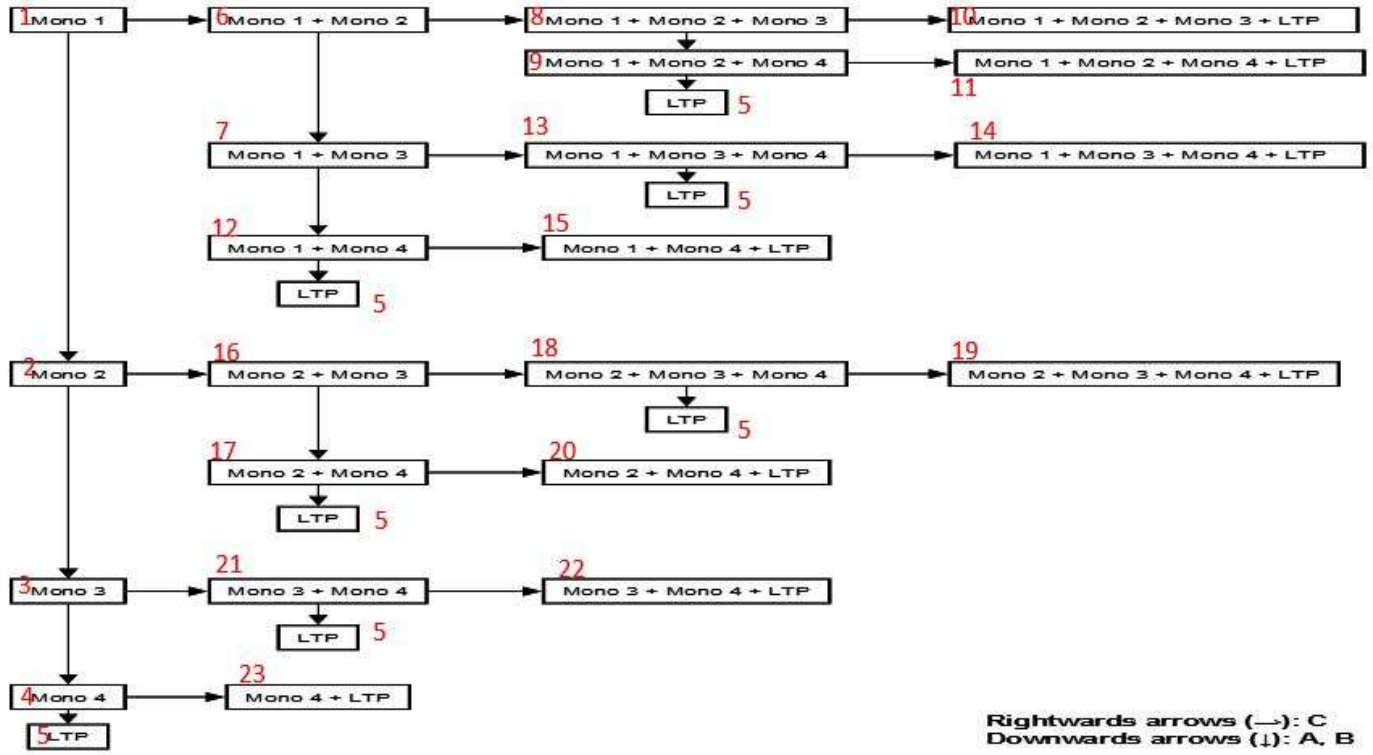




From 1 to 23 are the medications/combinations of Block 1.

Number 30 is Trabeculectomy, number 31 is implant

The key map to identify which medication/combination the patients are currently on is this:



A closer look at the medication type movement

For Iteration 0:

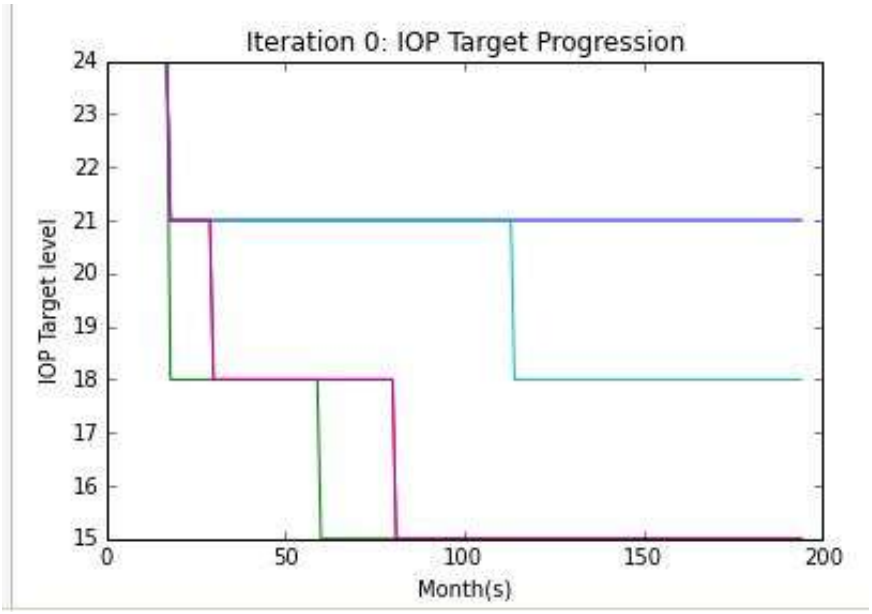
```
Patient 0: List of Medication Progression is [0, 1, 1, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8,
8, 8, 8, 8, 8, 8, 8, 8]
Patient 0: List of Final Medication Amount is [5, 3, 1, 0, 0]
Patient 1: List of Medication Progression is [0, 1, 1, 6, 6, 8, 8, 10, 10, 10, 10, 10, 10, 10, 30, 30, 30, 30, 30, 30, 30, 30, 3
0, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30]
Patient 1: List of Final Medication Amount is [8, 6, 4, 0, 2]
Patient 2: List of Medication Progression is [0, 1, 1, 6, 6, 6, 6, 6, 8, 8, 8, 8, 8, 8, 8, 8, 10, 30, 30, 30, 30, 30, 30, 30,
30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30]
Patient 2: List of Final Medication Amount is [7, 5, 3, 0, 1]
Patient 3: List of Medication Progression is [0, 1, 1, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 8, 8, 8, 8, 8,
8, 8, 8, 8, 8, 8, 8, 8]
Patient 3: List of Final Medication Amount is [5, 3, 1, 0, 0]
Patient 4: List of Medication Progression is [0, 1, 1, 6, 6, 6, 6, 6, 8, 8, 8, 8, 8, 8, 8, 8, 10, 10, 10, 10, 10, 10, 10, 10,
10, 10, 10, 10, 30, 30, 30, 30, 30, 30, 30, 30, 30]
Patient 4: List of Final Medication Amount is [8, 6, 4, 0, 2]
```

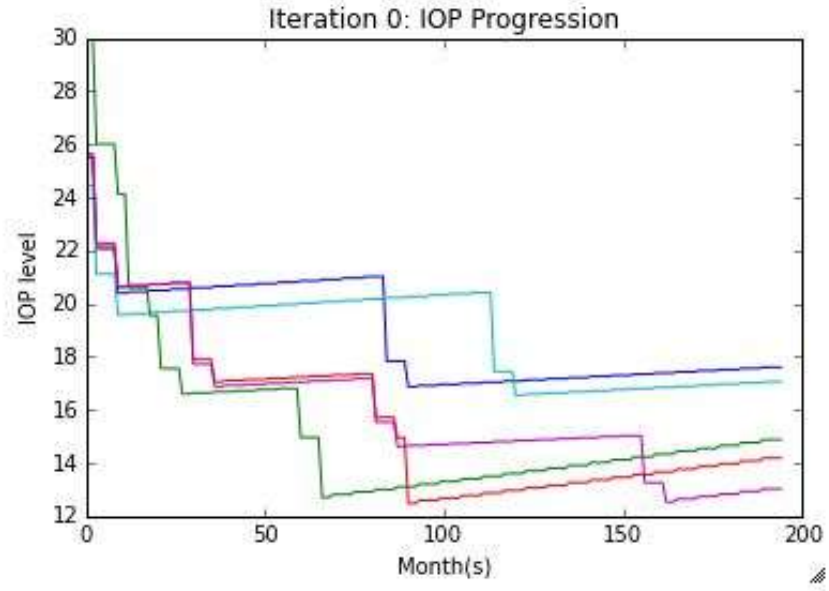
For Iteration 1:

```
Patient 0: List of Medication Progression is [0, 1, 1, 6, 6, 6, 6, 6, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 8, 1
0, 10, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30]
Patient 0: List of Final Medication Amount is [8, 6, 4, 0, 2]
Patient 1: List of Medication Progression is [0, 1, 2, 2, 2, 16, 16, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 19, 19,
19, 19, 19, 19, 19, 19, 19, 19, 19, 19, 19, 19, 19]
Patient 1: List of Final Medication Amount is [1, 7, 3, 5, 1]
Patient 2: List of Medication Progression is [0, 1, 2, 2, 2, 2, 16, 16, 16, 16, 16, 16, 18, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5,
5, 5, 5, 5, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30]
Patient 2: List of Final Medication Amount is [1, 5, 1, 3, 2]
Patient 3: List of Medication Progression is [0, 1, 1, 6, 7, 7, 7, 13, 13, 14, 14, 14, 14, 14, 14, 14, 30, 30, 30, 30, 30, 3
0, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30]
Patient 3: List of Final Medication Amount is [7, 3, 4, 4, 2]
Patient 4: List of Medication Progression is [0, 1, 1, 6, 6, 6, 8, 8, 8, 8, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 1
0, 10, 10, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30, 30]
Patient 4: List of Final Medication Amount is [8, 6, 4, 0, 2]
```

Other Features of the System

1. IOP Progression and IOP Target

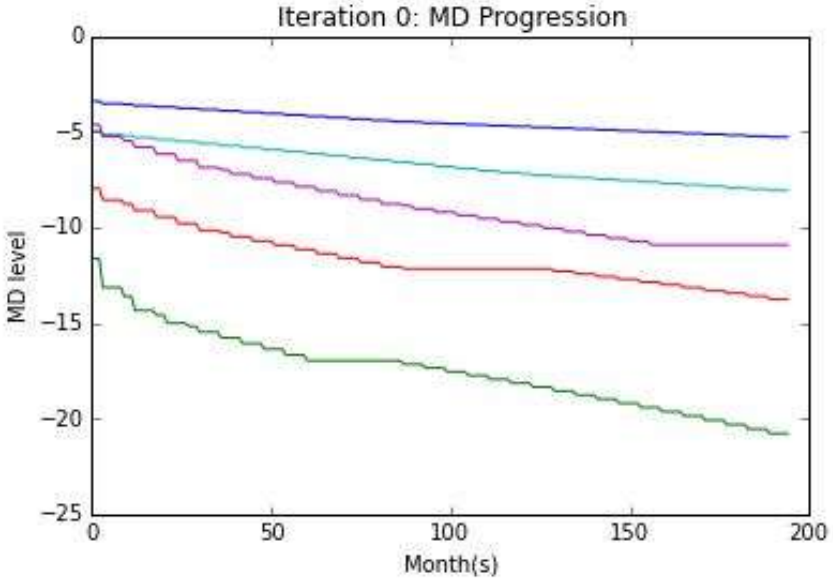


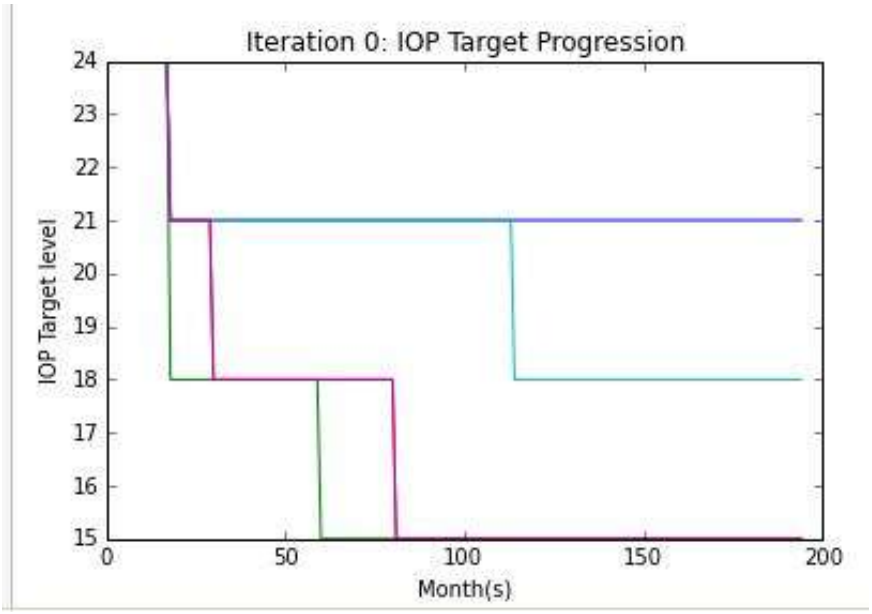


New medication/treatment will be indicated once the IOP > IOP Target

2. When IOP Target will change

This depends on the Progression (MD decrease)

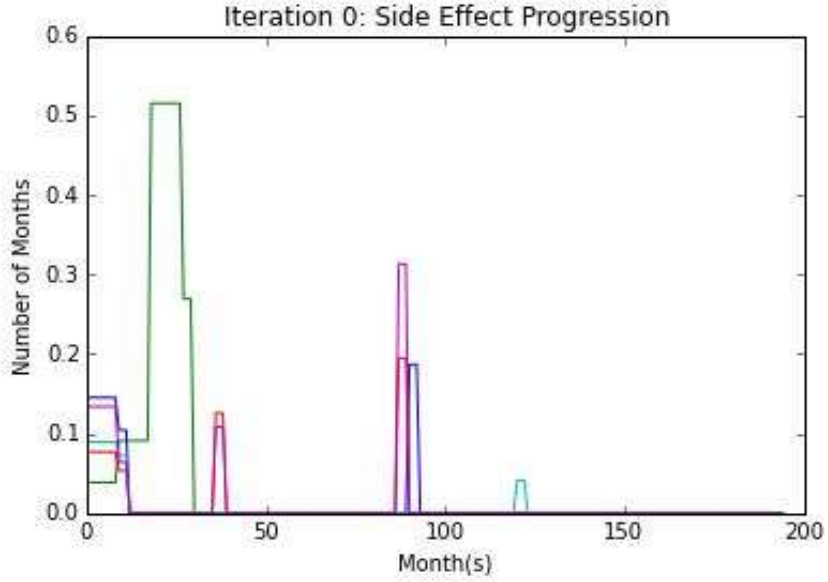


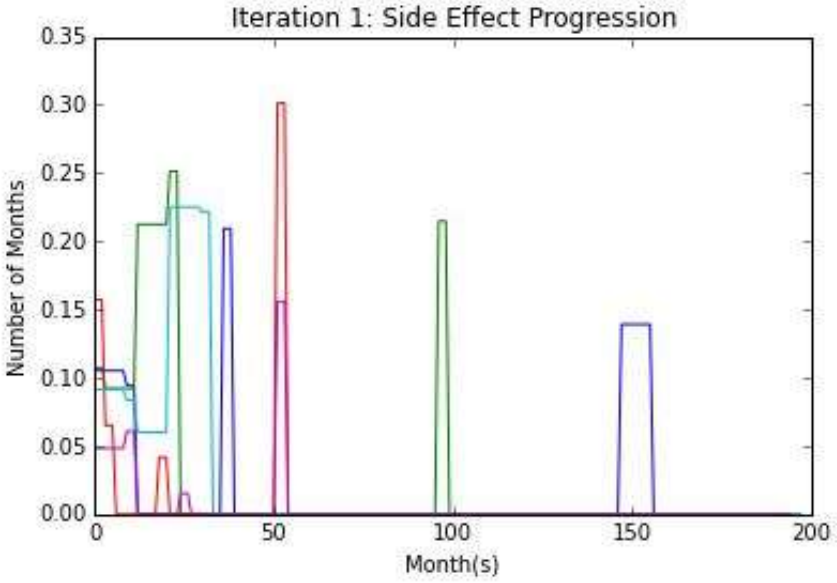


3. When IOP will increase

```
def onNoMedicationOrTrabeculectomy(self):
    self.params['SideEffect'] = 0
        #IOP is supposed to increase 0.5% annually, without medication
    if  self.medicalRecords['OnTrabeculectomy'] == True or self.medicalRecords['OnImplant'] == True:
        self.Attribute['IOP'] = self.Attribute['IOP'] *(1 + (1.5/100)*(self.params['time_next_visit']/12))
        self.medicalRecords['MedicationIntake'] += 1
    else:
        self.Attribute['IOP'] = self.Attribute['IOP'] *(1 + (0.5/100)*(self.params['time_next_visit']/12))
```

4. Side Effect Progression





Side Effect is nullified if:

I. Patients are on Trabeculectomy or Implant

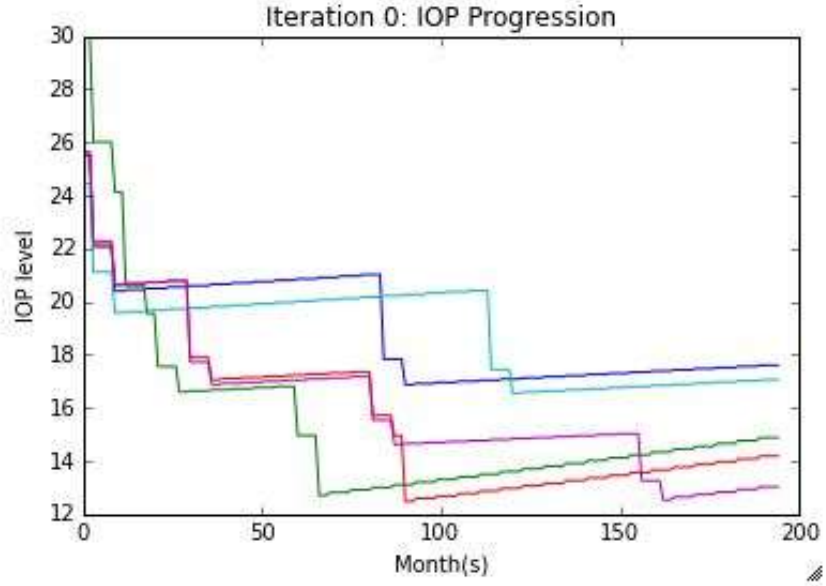
II. Patients' current medication amount is > 10

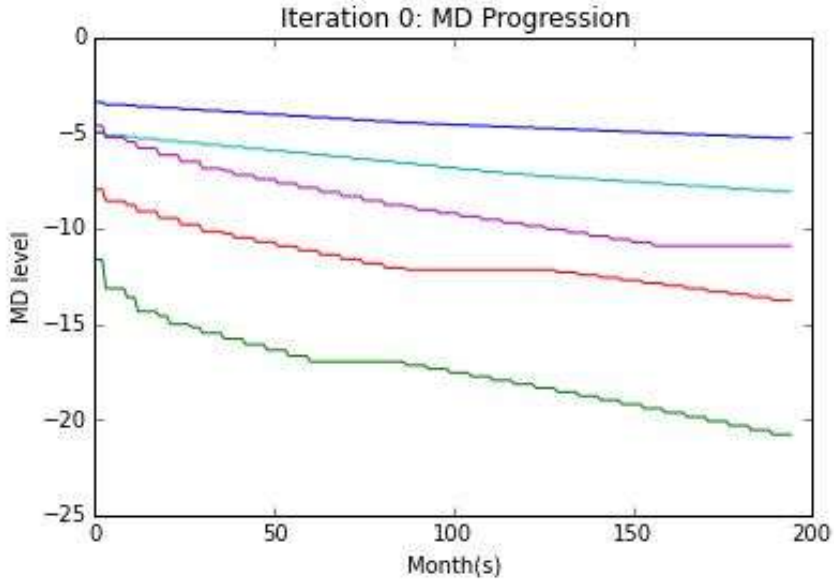
```
def IOPandSideEffectEvaluation(self):
    if self.medicalRecords['MedicationIntake'] > 10 :
        self.params['SideEffect'] = 0
    if self.PatientAttribute['IOP'] > self.PatientAttribute['IOPTarget']:
        self.medicalRecords['TreatmentOverallStatus'] = 2
        self.medicalRecords['ContinueTreatment'] = True
    else:
        self.medicalRecords['ContinueTreatment'] =False
```

III. IOP < IOP Target

```
def onNoMedicationOrTrabeculectomy(self):
    self.params['SideEffect'] = 0
```

5. Effect of IOP on MD





You would notice that there are some flat areas in the MD curves.

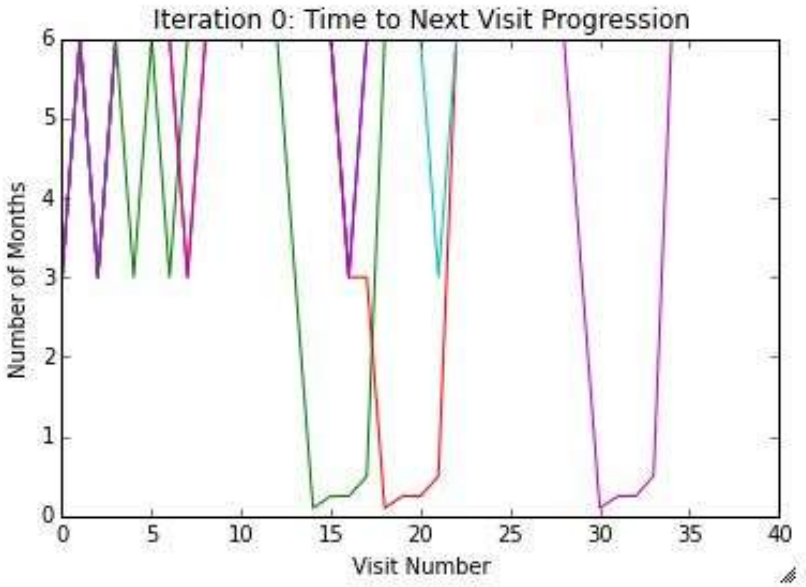
This is because of this behaviour in the system

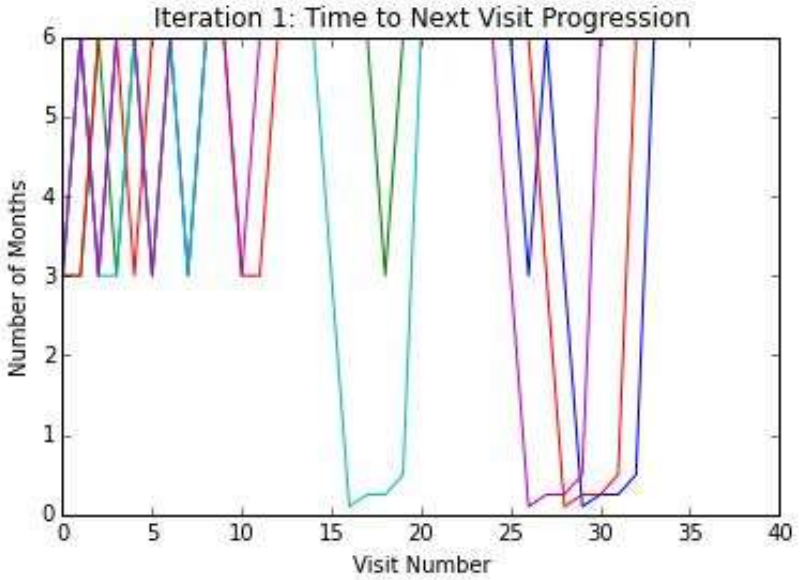
```
if self.Attribute['IOP'] > 13:
    difference = self.Attribute['MDR'] *(1.13**(self.Attribute['IOP'] - 15.5))*(self.params['time_next_visit'])
else:
    difference = 0
```

This is actually a very peculiar feature of the simulation system because if IOP = [13.15) then MD free falls!

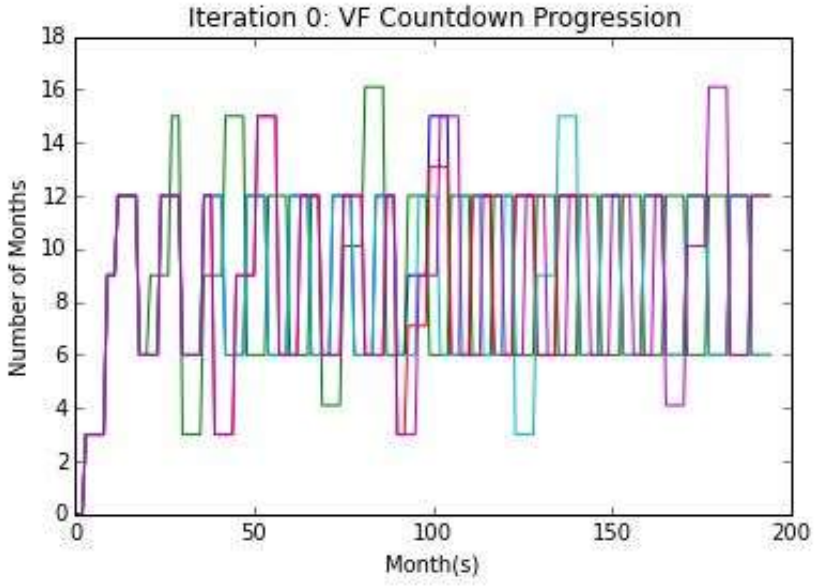
And the system has no way to correct this. The lowest IOP target that warrants change in treatment is 15

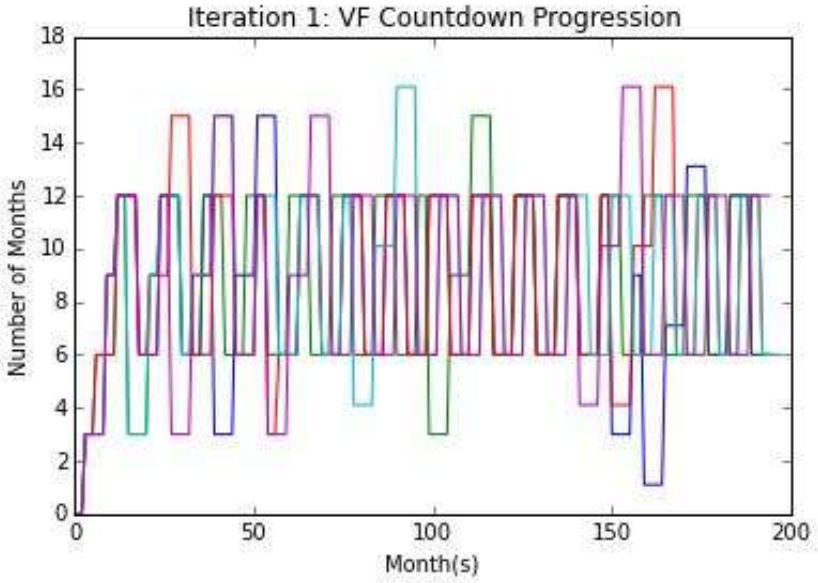
6. Time to Next Visit





7. VF Countdown





8. How the VFQ is calculated

8. Other Misc things

Patients > 85 will not be indicated Surgeries (Trabeculectomy and Implant)

Need a baseline for Cataract formation... Not really important for now but we might need it later

Type *Markdown* and LaTeX: α^2