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| Simulation modelFlow charts The simulation requires flowcharts to effectively convey the model accurately.  Initially the patient arrival times are generated and recorded with the arrivals process.  Figure 1: Arrivals flow charts  The Patient Process steps through each event that occurs within the model for category from 1, 2, and 3. Once the category of the patient is determined, the patient will follow 1 of 2 paths depending on their category. For category 1 patients, the patient immediately requests a doctor, the sub routine is mapped below as it is a priority resource. From there the patient requests a Resuscitation room. After being allocated a doctor and a resus room, the patient is given a timeout time for the resus action and is then discharged from the Emergency Department.  Figure 2: Patient Process - Category 1  The patient process specific for category 2 and 3 begins with requesting to see the triage nurse. After the nurse has separated the patients between category 2 and 3 the process for each patient is the same but the priorities change between each patient. A bed request is based on the priority for each patient, as is the doctor, both priority resource allocation processes are shown below. Once both a bed and a doctor are assigned the patients timeout for a period for consultation, the doctor is then released. Nurses out of the scope of this model monitor the patient for an amount of time referred to as the observation time. The original doctor allocated to the patient must be requested once again for and allocated for a period for the treatment of the patient. |
| Figure 3: Patient Process - Category 2 & 3  The doctor priority resource allocation process will activate the server if there are any servers idle. If there are no servers available it will place the patient in the queue. Once a patient is in the queue, the process will test whether the patient has a higher priority than the patient in front of it and will switch places in the queue if so. The beds priority resource allocation process works in the same way.    Figure 4: DOCTOR PROCESS - Priority Resource    Figure 5: BEDS PROCESS - Priority Resource |  |
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| Simulation ManualRunning the Simulation Running the python file without any changes to the code will execute the simulation for 100 replications with simulation end at 6000, which is equivalent to 100 hours. Once run, the console will produce statistics for each replication of each of the performance measures as shown below.    Figure 6: Performance measures printed to the python console  Running the simulation will also create an excel file filled with all the data displayed in the python console. This will appear in the same folder as the python script. The file will contain values for each of the performance measure for each rep and will also display the average value for each measure across the given number of replications. Changing inputs The total number of resources, arrival rates for each category, the number of replications, and the length of simulation can all be changed at the end of the python script show below.    Figure 7: Adjustable Inputs Model validation The table below corresponds to historical data to assist in validating the model using the performance measures.  Table 1: Historical Data of performance measures   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | |  | Time of total stay | avg doctor wait | avg resus wait | avg bed wait | avg consult wait | avg treatment wait | | Category 1 | 86.1430203 | 2.588604061 | 7.743121827 | 0 | 0 | 0 | | Category 2 | 139.364401 | 0 | 0 | 3.51603185 | 2.602044586 | 12.90561 | | Category 3 | 163.927274 | 0 | 0 | 19.7566494 | 4.061580534 | 18.93425 |   The simulated data shown below is very close to the historical data above. | |
| Table 2: Simulation data of performance measures   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | |  | Time of total stay | avg doctor wait | avg resus wait | avg bed wait | avg consult wait | avg treatment wait | | Category 1 | 79.93471 | 0.954159 | 4.163763 | 0 | 0 | 0 | | Category 2 | 138.1377 | 0 | 0 | 2.702003 | 1.057961 | 13.78993 | | Category 3 | 154.8683 | 0 | 0 | 11.35381 | 2.396551 | 20.65491 | | |
|  | |
| Table 3: Absolute Error between simulated and historic data   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | |  | Time of total stay | avg doctor wait | avg resus wait | avg bed wait | avg consult wait | avg treatment wait | | Category 1 | 6.208307 | 1.634445 | 3.579359 | 0 | 0 | 0 | | Category 2 | 1.226669 | 0 | 0 | 0.814029 | 1.544084 | 0.884316 | | Category 3 | 9.058957 | 0 | 0 | 8.402836 | 1.665029 | 1.72065 |   The absolute error between the simulated model is relatively small and is negligent. The greatest difference is the time of total stay for category 3 which is only 9 minutes. Therefore, the model is validated as accurately modelling the emergency department. | |

# Simulation Analysis

## Confidence intervals

The aim of this simulation was to achieve 95% confidence of 2 minutes for the time of stay for each of the categories. The table below shows this was achieved.

Table 4: Confidence intervals for KPI's

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Time of stay Category 1 | | Time of stay Category 2 | | | Time of stay Category 3 | | |
| Upper bound | 80.17173 | | | 138.4139 |  | | 155.6631 |  |
| CI | <u< |  | | <u< |  | | <u< |  |
| Lower Bound | 79.69769 |  | | 137.8616 |  | | 154.0736 |  |

With this requirement achieved, a further study can be conducted using the model.

## Expansion Scenario

The expansion scenario increases the rate of arrivals of patients in all of the categories. To once again achieve the required 95% confidence interval of 2 minutes for the time of stay in each category the following inputs are needed.  
  
Doctors = 12

Resus Rooms = 6

Triage Nurses = 3

Beds = 35

Table 5: Confidence Intervals for KPI's (Extended Case)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Time of stay Category 1 | | Time of stay Category 2 | | Time of stay Category 3 | |
| Upper bound | 75.16568 |  | 132.5684 |  | 138.0046 |  |
| CI | <u< |  | <u< |  | <u< |  |
| Lower Bound | 74.98324 |  | 132.34 |  | 137.773 |  |