Disaster Management
Project
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Simulation of Hospital Operations for Regional Disaster Relief

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Introduction:

During a disaster, the role of hospital becomes even more critical. It is vital to provide timely treatment to patients injured in the disaster in order to minimize the fatalities. When a disaster occurs, the number of patients who require treatment may increase 3–5 times the normal volume.
The project aims at

- identifying the waiting time for the (average volume of) patients before a disaster and its comparative study with steady state post-disaster waiting time.
- Calculation of hospital resource distribution giving preference to patients according to the severity of their injuries.
- Study the dependence of waiting time with incoming patient volume,patient mix and efficiency of the hospital.

Problem Statement:

To develop a web-based application which will help the end-users(like the hospital management or disaster recovery people) to determine the tentative waiting time for a given number of casualties and given number of hospital resources.

For a given input data of hospital resources and corresponding waiting time data, study the effect of change of patient mix on average waiting time with the help of graphs.
To calculate the behavior of patient's waiting time with varying patient arrival rate at the time of disaster.

Project Need:

As already stated, patient-volume increase 3-5 times the normal volume during the time of a critical disaster. There is a lot of chaos and confusion as to where to send the injured(to avoid crowding in the emergency centers and transfer from one hospital to another). Preparedness helps to

cope with the sudden surge of patients with the limited available resources. Timely treatment of injured victims helps to decrease the mortality rate.

Platform Used:
Django web framework(python,html,css) : To create the web application.

Data Used:
We have built our application in such a way so that it can accept any data which includes all the necessary information (like for hospitals – number of beds, Operating Rooms and efficiency and the corresponding waiting time which had been observed during previous disaster scenarios.) Once the data is in place, we calculate the waiting time in accordance to it.

By default we use the data we found in a research paper: “Transient Modeling in Simulation of Hospital Operations for Emergency Response” by Jomom Aliyas Paul,Santosh K. George, Pengfei Yi and Li Lin.
The paper uses the statistics of five earthquakes in California which happened between the late 1970s to mid 1990s.

				alpha		
				0.083	0.165	0.248
Beds	Operating Rooms	Efficiency	Patient Volume	Waiting Time (minutes)		
100	5	600	31	4,8531	10,8146	16,5517
100	5	900	31	10,5023	15,4255	23,5067
100	5	1,200	31	14,2524	19,8112	24,7213
100	10	600	31	2,1967	3,0947	4,074
100	10	900	31	6,4086	8,4955	8,8829
100	10	1,200	31	6,4086	8,4955	10,2198
300	5	600	82	2,3212	13,9292	32,9342
300	5	900	82	2,1284	3,952	34,435
300	5	1,200	82	11,5771	26,4176	47,074
300	10	600	82	1,2986	3,1649	7,7487
300	10	900	82	3,3908	5,5468	9,6877
300	10	1,200	82	5,2393	8,7313	12,988
300	15	600	82	1,2795	1,3984	2,4558
300	15	900	82	2,1284	3,952	6,5724
300	15	1,200	82	3,2383	5,3244	7,9636
500	10	600	132	1,0961	3,4816	15,1162
500	10	900	132	2,5929	8,2064	23,0929
500	10	1,200	132	4,5248	11,4507	22,5292
500	15	600	132	1,0408	1,7086	4,2834

Sample data.

Kolkata data(incomplete)

Table 1.3 : Population served per bed in select districts in West Bengal

District	Estimated Population, 2007			Total no. beds			Population served per bed		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Bankura	3239857	245254	3485111	914	2572	3486	3545	95	1000
Bardhaman	4763706	2655382	7419087	1337	7503	8840	3563	354	839
Birbhum	3020271	269411	3289682	914	1714	2628	3304	157	1252
Darjeeling	1192705	542568	1735273	441	3909	4350	2705	139	399
Hooghly	3674526	1759534	5434060	924	4724	5648	3977	372	962
Howrah	2323656	2243521	4567177	613	3882	4495	3791	578	1016
Kolkata	0	4767375	4767375	0	25698	25698	0	186	186
Total	63263453	23381152	86644605	13921	82160	96081	4544	285	902

Name of the MCH	Total critical patients attending emergency (in lakh)	Number of patients admitted (in lakh)	Percentage of admission to emergency patients
CMCH	3.67	1.75	48
NRSMCH	2.57	1.00	39
RG KMCH	4.50	1.03	23
SSKMH	3.55	0.38	11
Medinipur MCH	1.88	1.45	77

Algorithm used:

Following two dependencies were obtained from the research paper:
Waiting time of patients(for a given hospital)

<u>Pre-Steady State Waiting Time:</u>

$Z = C0 + C1*B + C2*O + C3*E + C4*B*B + C5*O*O + C6*E*E + C7*B*O + C8*B*E + C9*O*E$

<u>Post-Steady State Waiting Time:</u>

$Z = C0 + C1*B + C2*O + C3*E + C4*A + C5*B*B + C6*O*O + C7*E*E + C8*A*A + C9*B*O + C10*B*E + C11*B*A + C12*O*E + C13*O*A + C14*E*A$

Where B: Number of beds , E: Efficiency Index of hospital , O: Number of Operating rooms , A:Arrival rate of patients

For example:
For the above data(first equation) the coefficients come out to be:

1.86714, -2.3017839, 7.91394534e+0, -7.1279706
4.86800114e+00 -1.8239664 1.40248999e+00 2.87492952e+00
-3.59990922e+00

Second equation:
-6.43959880 5.70559976 -1.65228025 -7.75756407 1.00773956
-8.16669335 1.34663054 -9.99928953 9.99928953 -2.99423199
-8.90541369 2.37300334 -1.18650167 1.60905626 -1.60905626

Details of each hospital(number of beds, operating rooms,efficiency,waiting time) are already fed to the system. The coefficients are unknown and can be calculated afresh from each new data set. Once the coefficients are known, the user can enter the details of any hospital whose characteristics match up with the fed data and get to know the result.
Another important parameter is the number of casualties(which will depend on the damage extent of the disaster) is also entered to get the post-disaster steady state waiting time (Steady state refers to average waiting time-- normally waiting time might vary from the average depending upon various situations) . The number of casualties is assumed to be the incoming patient volume(Number of patients/day) for that hospital.

The coefficients are calculated using the matrix-inverse equation method. The 15x15 or 10x10 matrix is fed with a minimum of 15 and 10 sample data(of hospital) respectively to obtain them. These coefficients can be negative or positive according to their influence on the waiting time.

For **A = a + bx + cz^2** where a,b,c are unknown constants and A depends on variables x and z,

3-variable equation needs at least 3 sets of data. Obtain A0, A1, A2 ,x_0,x_1,x_2, z_0,z_1,z_2 from the data, create a matrix equation and solve.

[A0,A1,A2] = [a b c] [1 1 1
x_0 x_1 x_2
z_0^2 z_1^2 z_2^2]

[A0,A1,A2] inverse([1 1 1
x_0 x_1 x_2 = [a b c]
z_0^2 z_1^2 z_2^2])

Similarly, for a given set of data we can calculate the dependency of patient volume with the waiting time(taking logarithm) --- only for a given hospital configuration

$$\mathbf{ln(T_s) = a + b\lambda}$$

where Ts is the steady state waiting time,
a and b are constants,
and λ is the patient arrival rate.

We have also calculated the effect of varying the severity of injured patients on the waiting time. The parameter used is α (alpha) which is defined as

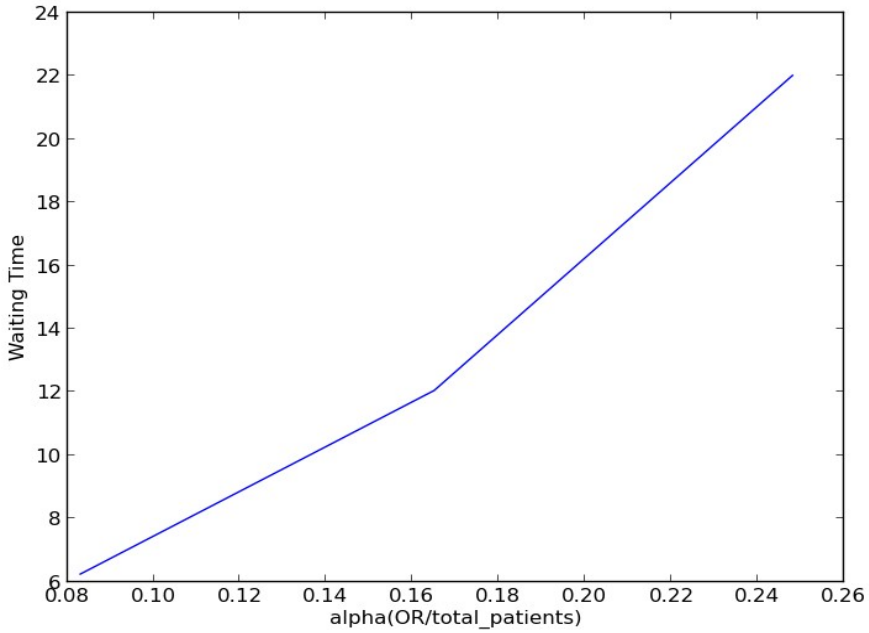
α = Number of OR patients/ Total number of patients

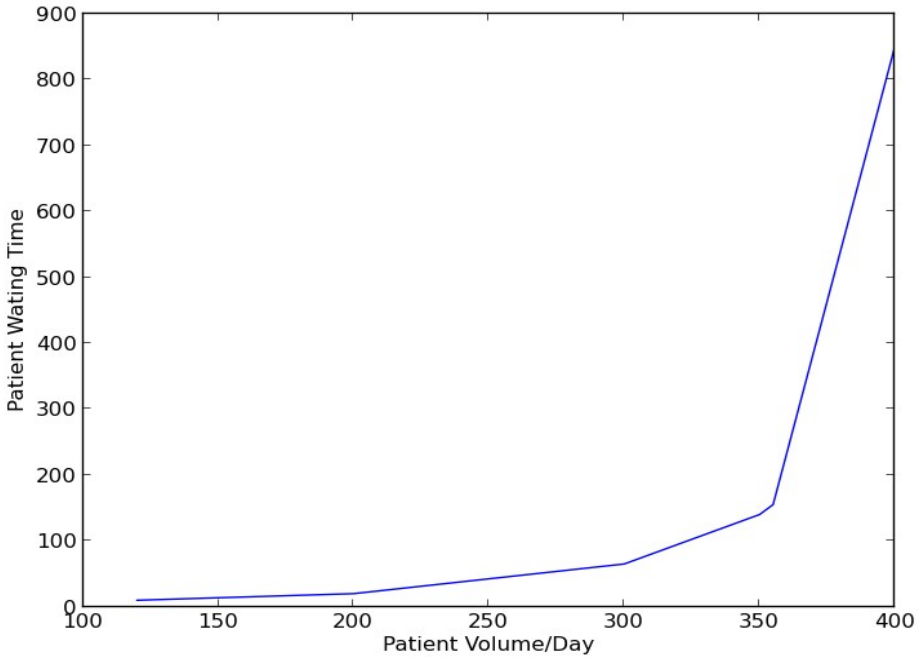
where OR = operation Room

Number of OR patients = Number of (Severity-2+Severity-3) patients.

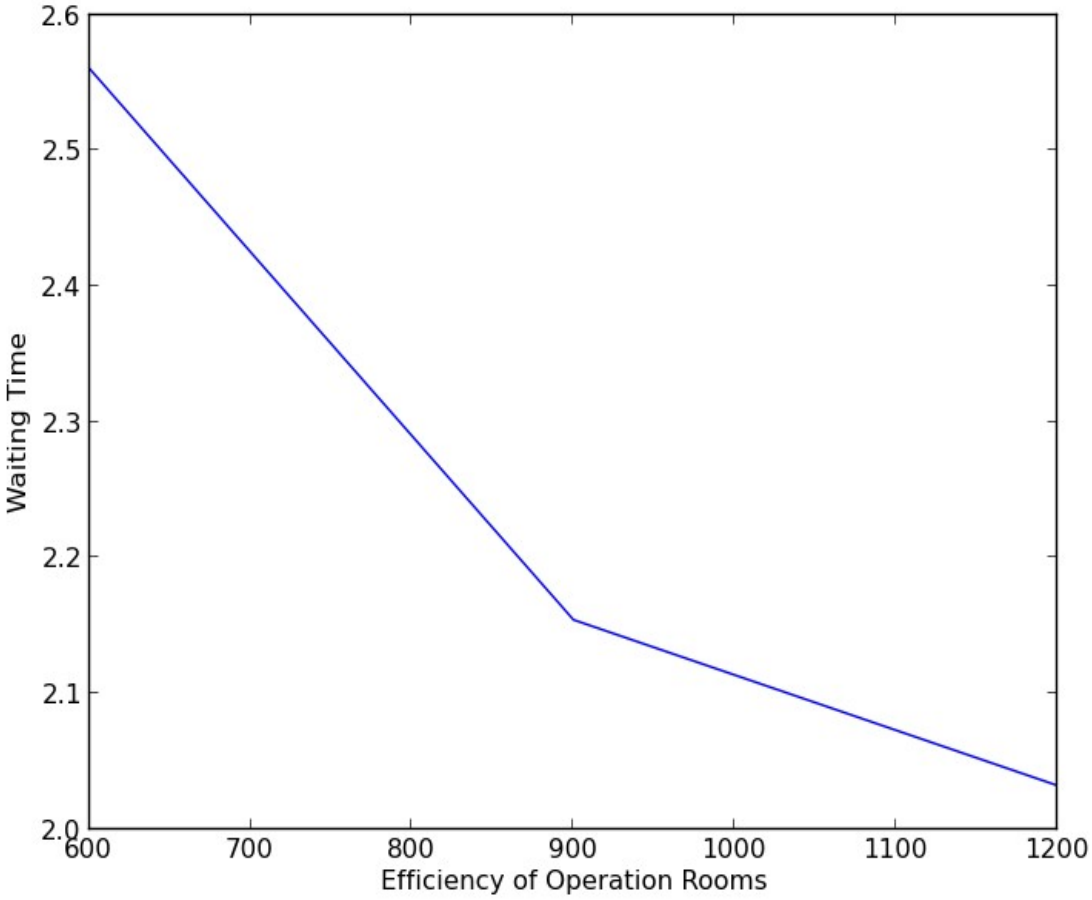
Survivability time of severity-2 patients – 270 minutes and severity-3 patients – 80 minutes

Sample graphs:




Patient Wating Time
Patient Volume/Day
900
800
700
600
500
400
300
200
100
0
100
150
200
250
300
350
400

Project


Waiting Time
Efficiency of Operation Rooms
2.6
2.5
2.4
2.3
2.2
2.1
2.0
600
700
800
900
1000
1100
1200

Project In Detail:
Using the web-app: User should know the hospital details and he can get the corresponding results. Also he can enter any specific data to suit his needs. Once we are done with the results, the patient could be routed to the hospital with minimum waiting time and maximum survivability probability.

Accessing the codes: The waiting times are calculated in the python codes pre-steady.py and post-steady.py. It takes input data from the uploaded file, which in case is missing defaults to the California data . Graph is generated in graph.py

Problems Faced:

Data collection was the tricky part. We could not find sufficient information of hospitals in part of the country. We tried with Kolkata, but still there were some values missing.

Also, the study of coefficient calculation and there dependency on all variables took us some time, when we finally settled with inverse-matrix method.