

Modeling and Discrete Simulation

Project Report



Ramazan Karkin - 150119512

HOSPITAL EMERGENCY ROOM

I built a hospital emergency room simulation. There is doctor, nurse, technician and patient in this emergency room. Patients spend time in a waiting room to receive medical attention. They are queuing to the emergency room according to their registrations.

Relationships between system components: Nurse and technician helps to doctor to treat patient. technicians control the patient with medical equipment. The nurse discharges the patients that the doctor takes care of. A doctor, nurse and technician take care of each patient. Each patient is taken to the emergency room according to the risk level.

State variables: Number of patients treated, number of waiting patient

Input variables: DoctorServiceVariable, NurseServiceVariable, TechnicianServiceVariable

Output variables: I measured the system time, waiting time in the registration, average patient treatment time for doctor, nurse and technician in hospital emergency room.

Type of input parameters: DoctorServiceVariable, NurseServiceVariable, TechnicianServiceVariable are CDF type. randomVarDoctor, randomVarNurse, randomVarTechnician are Double random type.

Cumulative Probability	Technician Service Time
0	5
0.1	9
0.3	13
0.5	18
0.7	26
0.8	32

Cumulative Probability	Patient Waiting Time
0	1
0.1	4
0.3	7
0.6	9
0.8	11
1	11

Cumulative Probability	Doctor Service Time
0	1
0.1	3
0.3	8
0.5	9
0.7	10
0.8	12

Cumulative Probability	Patient Waiting Time
0	1
0.1	4
0.3	7
0.6	9
0.8	11
1	11

System Time	Waiting time	Doctor Service Time	Nurse Service Time	Technician Service Time	Seed
21.65	14.44	6.4	5.6	5.3	1
23.83	16.41	6	4.7	4.5	2
22.15	14.93	5	6	6.1	3
21.92	14.75	6.4	4.8	5.4	4
24.64	16.86	5.2	5.7	5.4	5
26.29	18.38	5.1	5.6	4.5	6
23.37	15.89	5.6	6.4	5.6	7
27.37	19.3	6.1	5.6	5.1	8
23.44	15.92	5.7	5.6	5.9	9
24.84	17.2	6.4	5.9	5.8	10
23.22	15.57	4.7	6	5.9	11
26.14	18.26	5.2	5	5.1	12
22.37	15.01	6.3	4.7	4.3	50
21.52	14.25	5.3	6.1	5.7	67
18.35	11.54	5.7	4.8	6.5	88

	System Time	Waiting time	Doctor Service Time	Nurse Service Time	Technician Service Time
Mean (\bar{x})	23.41	15.91	5.67	5.5	5.41
Standard Deviation (s)	2.27	1.95	0.57	0.56	0.63
Variance (s^2)	5.17	3.80	0.33	0.32	0.39

System Time output

a. 95% confidence interval for System Time output

$$23.41 \pm \frac{2.27}{\sqrt{15}} * 2.145$$

$$23.41 \pm 1.26$$

b. The total number of replications needed

the standard error of the mean (ME)

I took the error criterion ε as a margin error (ME).

$$ME = \frac{227\sqrt{15}}{1500} = 1.15$$

$$\varepsilon = 1.15$$

$$R = \frac{(1.64)^2(2.27)^2}{(1.15)^2} = 10.48$$

c. 95% prediction intervals for the output parameters

$$23.41 \pm 2.145 * 2.27 * \sqrt{1 + 1/15}$$

$$23.41 \pm 5.028$$

Waiting Time output

a. 95% confidence interval for Waiting Time output

$$15.91 \pm \frac{1.95}{\sqrt{15}} * 2.145$$

$$15.91 \pm 1.08$$

b. The total number of replications needed

the standard error of the mean (ME)

I took the error criterion ε as a margin error (ME).

$$ME = \frac{13\sqrt{15}}{100} = 0.986$$

$$\varepsilon = 0.986$$

$$R = \frac{(1.64)^2(1.95)^2}{(0.986)^2} = 10.519$$

c. 95% prediction intervals for the output parameters

$$15.91 \pm 2.145 * 1.95 * \sqrt{1 + 1/15}$$

$$15.91 \pm 4.319$$

Doctor Service Time output

a. 95% confidence interval for Doctor Service Time output

$$5.67 \pm \frac{0.57}{\sqrt{15}} * 2.145$$

$$5.67 \pm 0.31$$

b. The total number of replications needed

the standard error of the mean (ME)

I took the error criterion ε as a margin error (ME).

$$ME = \frac{19\sqrt{15}}{500} = 0.288$$

$$\varepsilon = 0.288$$

$$R = \frac{(1.64)^2(0.57)^2}{(0.288)^2} = 10.535$$

c. 95% prediction intervals for the output parameters

$$5.67 \pm 2.145 * 0.57 * \sqrt{1 + 1/15}$$

$$5.67 \pm 1.262$$

Nurse Service Time output

a. 95% confidence interval for Nurse Service Time output

$$5.5 \pm \frac{0.56}{\sqrt{15}} * 2.145$$

$$5.5 \pm 0.30$$

b. The total number of replications needed

the standard error of the mean (ME)

I took the error criterion ε as a margin error (ME).

$$ME = \frac{14\sqrt{15}}{375} = 0.283$$

$$\varepsilon = 0.283$$

$$R = \frac{(1.64)^2(0.56)^2}{(0.283)^2} = 10.531$$

c. 95% prediction intervals for the output parameters

$$5.5 \pm 2.145 * 0.56 * \sqrt{1 + 1/15}$$

$$5.5 \pm 1.24$$

Technician Service Time output

a. 95% confidence interval for Technician Service Time output

$$5.41 \pm \frac{0.63}{\sqrt{15}} * 2.145$$

$$5.41 \pm 0.35$$

b. The total number of replications needed

the standard error of the mean (ME)

I took the error criterion ε as a margin error (ME).

$$ME = \frac{21\sqrt{15}}{500} = 0.318$$

$$\varepsilon = 0.318$$

$$R = \frac{(1.64)^2(0.63)^2}{(0.318)^2} = 10.556$$

c. 95% prediction intervals for the output parameters

$$5.41 \pm 2.145 * 0.63 * \sqrt{1 + 1/15}$$

$$5.41 \pm 1.395$$

Changed system
Second Simulation

The number of patients per capita decreased for doctors and increased for nurses and technicians.
While the doctor's service time for the patient was extended, it increased for the nurse and technician.

System Time	Waiting time	Doctor Service Time	Nurse Service Time	Technician Service Time	Seed
111.82	89.31	7.55	11.84	9.79	1
130.72	106.98	6.25	9.32	11.16	2
111.25	92.36	6.11	11.24	11.57	3
115.15	92.92	5.75	11.9	11.05	4
136.6	111.38	5.6	11.91	10.94	5
130.66	108.77	5.76	10.49	10.48	6
128.62	106.38	6.58	11.6	11.02	7
148.1	122.57	4.81	12.73	9.57	8
130.2	106.15	6.04	12.34	10.5	9
122.71	99.52	5.41	9.53	12.23	10
114.27	92.19	5.54	11.23	10.66	11
118.57	95.45	6.38	11.39	10.83	12
127.47	104.9	6.99	12.4	9.36	50
122.73	100.26	5.99	11.63	9.36	67
125.83	102.76	5.39	11.76	10.8	88

	System Time	Waiting Time	Doctor Service Time	Nurse Service Time	Technician Service Time
Mean (\bar{x})	124.98	102.127	6.01	11.421	10.621
Standard Deviation (s)	9.683	8.609	0.662	0.941	0.788
Variance (s^2)	93.768	74.108	0.438	0.885	0.621

System Time output

a. 95% confidence interval for System Time output

$$124.98 \pm \frac{9.683}{\sqrt{15}} * 2.145$$

$$124.98 \pm 5.362$$

b. The total number of replications needed

the standard error of the mean (ME)

I took the error criterion ε as a margin error (ME).

$$ME = \frac{242\sqrt{15}}{375} = 4.898$$

$$\varepsilon = 4.898$$

$$R = \frac{(1.64)^2(9.683)^2}{(4.898)^2} = 10.51$$

c. 95% prediction intervals for the output parameters

$$124.98 \pm 2.145 * 9.683 * \sqrt{1 + 1/15}$$

$$124.98 \pm 21.451$$

Waiting Time output

a. 95% confidence interval for Waiting Time output

$$102.127 \pm \frac{8.609}{\sqrt{15}} * 2.145$$

$$102.127 \pm 4.767$$

b. The total number of replications needed

the standard error of the mean (ME)

I took the error criterion ε as a margin error (ME).

$$ME = \frac{43\sqrt{15}}{75} = 4.352$$

$$\varepsilon = 4.352$$

$$R = \frac{(1.64)^2(8.609)^2}{(4.352)^2} = 10.524$$

c. 95% prediction intervals for the output parameters

$$102.127 \pm 2.145 * 8.609 * \sqrt{1 + 1/15}$$

$$102.127 \pm 19.071$$

Doctor Service Time output

a. 95% confidence interval for Doctor Service Time output

$$6.01 \pm \frac{0.662}{\sqrt{15}} * 2.145$$

$$6.01 \pm 0.366$$

b. The total number of replications needed

the standard error of the mean (ME)

I took the error criterion ε as a margin error (ME).

$$ME = \frac{11\sqrt{15}}{250} = 0.333$$

$$\varepsilon = 0.333$$

$$R = \frac{(1.64)^2(0.662)^2}{(0.332)^2} = 10.693$$

c. 95% prediction intervals for the output parameters

$$6.01 \pm 2.145 * 0.662 * \sqrt{1 + 1/15}$$

$$6.01 \pm 1.466$$

Nurse Service Time output

a. 95% confidence interval for Nurse Service Time output

$$11.421 \pm \frac{0.941}{\sqrt{15}} * 2.145$$

$$11.421 \pm 0.521$$

b. The total number of replications needed

the standard error of the mean (ME)

I took the error criterion ε as a margin error (ME).

$$ME = \frac{47\sqrt{15}}{750} = 0.475$$

$$\varepsilon = 0.475$$

$$R = \frac{(1.64)^2(0.941)^2}{(0.475)^2} = 10.555$$

c. 95% prediction intervals for the output parameters

$$11.421 \pm 2.145 * 0.941 * \sqrt{1 + 1/15}$$

$$11.421 \pm 2.084$$

Technician Service Time output

a. 95% confidence interval for Technician Service Time output

$$10.621 \pm \frac{0.788}{\sqrt{15}} * 2.145$$

$$10.621 \pm 0.436$$

b. The total number of replications needed

the standard error of the mean (ME)

I took the error criterion ε as a margin error (ME).

$$ME = \frac{79\sqrt{15}}{1500} = 0.399$$

$$\varepsilon = 0.318$$

$$R = \frac{(1.64)^2(0.788)^2}{(0.399)^2} = 10.49$$

c. 95% prediction intervals for the output parameters

$$10.621 \pm 2.145 * 0.788 * \sqrt{1 + 1/15}$$

$$10.621 \pm 1.745$$

Comparison of the first simulation with the changed simulation

When we look up two systems depend on 95% confidence interval to make a comparison between that it should be should apply Hypothesis testing. I didn't find a hypothesis testing example in the slides. Since the lecture videos were not uploaded to UES, I could not check it from there.

In the first simulation 95% prediction intervals for the output parameters for doctor 5.67 ± 0.31

In the changed simulation 95% prediction intervals for the output parameters for doctor 6.01 ± 0.366