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Using SIMIO Modeling Software to Simulate Operations in a Small Medical Private Practice

James M. Patton

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by

James M. Patton

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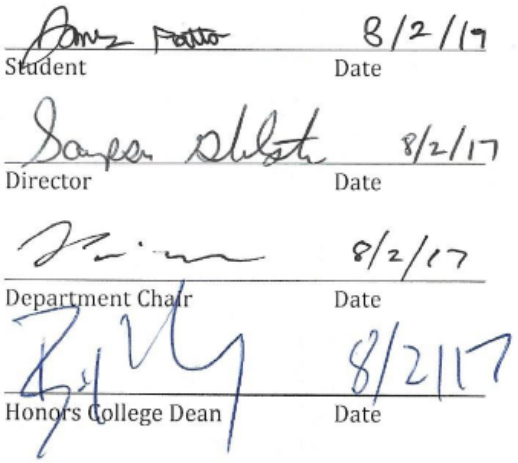
Honors Capstone Director: Dr. Sampson Gholston
Assistant Professor, Industrial and Systems Engineering and Engineer Management



Honors College
Frank Franz Hall
+1 (256) 824-6450 (voice)
+1 (256) 824-7339 (fax)
honors@uah.edu

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James Patton
Student Name (printed)

James Patton
Student Signature

8/2/17
Date

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Acknowledgement

This paper contains the work from James Patton and Judd Childers ISE428 & ISE429 senior design project. I (James Patton) created the SIMIO simulation model that this paper focuses on; however, Judd assisted in data collection, communication with Innova Primary Care, and in the writing of some sections of this paper.

Abstract

SIMIO simulation software has been used to model various operations from manufacturing production lines to hospitals operations; however, little research was found on the use of SIMIO simulations in small medical private practices. In this paper, SIMIO was used to model the daily operations at Innova Primary Care, a medical private practice located in Huntsville, Alabama. SIMIO experiments were used to determine how much the business could grow, the current service provider capacity (Nurse Practitioners (NPs) and Medical Doctors (MDs)), and the future service provider capacity. Currently Innova uses a maximum of 4 service providers (NPs and/or MDs) to serve around 80 patients per day. With no changes to the current process, Innova can expand to 6 service providers, serving around 120 patients per day (with no negative impact to patient time in the system). With future improvements, Innova could both expand to 8 service providers, serving around 160 patients per day, and improve patient time in the system.

Introduction

The simulation models in this paper were created using data gathered at Innova Primary Care, a small medical private practice that focuses on general medical services. Innova is trying to re-invent the way patients are serviced during a doctors' visit, with the help of lean techniques. Innova Primary Care hopes to boost the efficiency of its health care processes, similar to how many manufacturing facilities have increased efficiency and decreased waste by adopting the lean thinking mentality. With the help of SIMIO simulation software, measured data can be used to simulate daily operations, identify which processes most need improvement, modify resources, and help in future planning.

Literature Review

Simulation software such as ARENA and SIMIO have been recognized as efficient technology for improving the effectiveness of the health care industry (Oueida, Soraia et al. 2016). SIMIO has been used in a wide range of applications, these include optimization of production lines (Guiquang, Pan 2014), modeling possible disruptions events to a hospital, such as flooding (Chen, Wanying, et al. 2015), and optimizing various processes within hospitals. However, this research was unable to find applications using SIMIO on small healthcare facilities such as Innova.

Likewise, no research was found on the use of other simulation software, such as ARENA, on small healthcare facilities. Most of the healthcare related research that uses ARENA focuses on intensive care units (Sarawati, Trisha and Basri, Mursyid 2016) or emergency rooms (Y Zare Mehrjardi, et al. 2011).

The objective of this research is to analyze the performance of a health care facility using SIMIO simulation software and address the lack of simulation models created to model small healthcare facilities.

Phase 1: Old Facility

The group observed service times of Nurse Practitioners at Innova Primary Care, a small medical private practice. By using SIMIO simulation software to make a complete model of the medical facility (figure 1), the team could accurately simulate daily operations at Innova Primary Care. Initially, data was gathered at the old facility, with a focus on the six available exam rooms and the lobby. The data collected was used to calculate the following metrics: time in room, time spent waiting for provider, time without a provider in room, time spent with a provider, and time patient spent in the lobby before being placed in one of the six exam rooms. Data was collected during a time when the facility had three Nurse Practitioners on schedule. Innova Care also operated on a scheduling model that buffers patient times by 5 minutes.

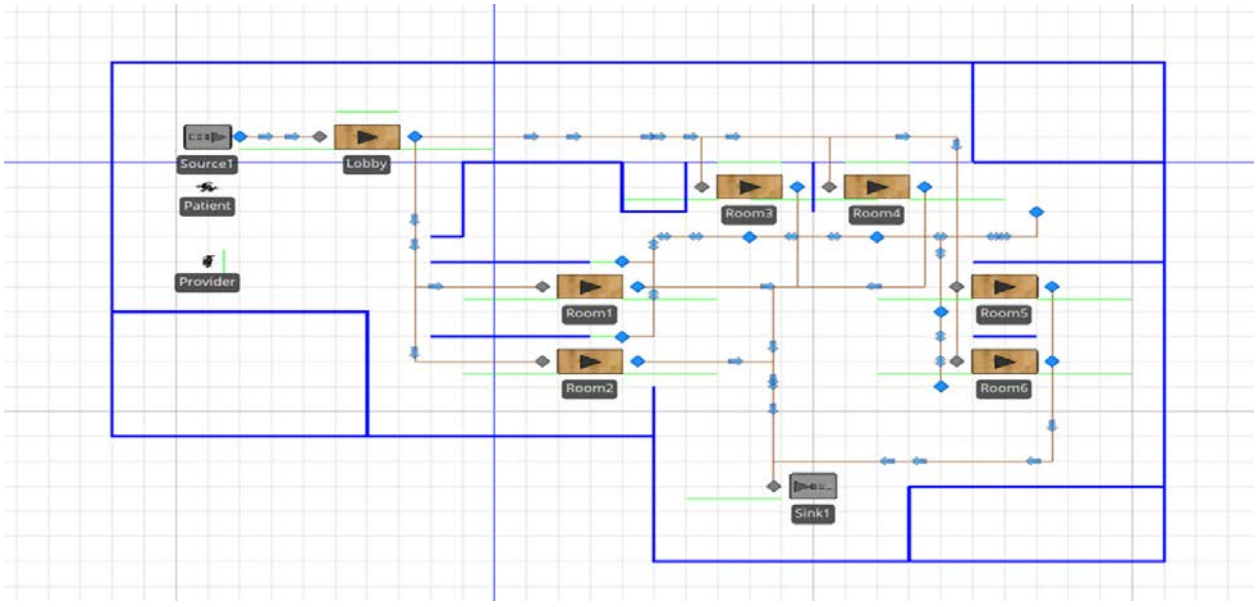

Figure 1: Old Facility SIMIO Process Layout

Designing the Experiment

Entering into the project, the Innova Primary Care manager informed the senior design team that the current facility was no longer able to keep up with the growing number of patients being accepted, and also it was the hope of management at Innova Primary Care to hire additional Nurse Practitioners in the future. This was needed to keep up with demand and help alleviate stress, on the already "thinly stretched" personnel currently employed. To help accommodate the expanding business, Innova Primary Care would be moving from the six exam room facility, where the lobby and inventory system was shared with another private practice, into a newly built twelve exam room facility that would include two separate sections that would contain six exam rooms apiece, along with one consultation room in each section (the diagram of the new facility can be seen in figure 2). Currently, the new facility operates with one Nurse Practitioner being assigned three of the rooms; at the old facility Nurse Practitioners were not assigned specific rooms. Also, to cut down on wasted movement/time, each room would employ a flag system to signal the patient status, depending on which flag was raised, the patient could need/be in the process of paperwork, bloodwork, setting up follow up appointments, etc.

Figure 2: New Facility Diagram

Phase 2: New Facility

Once operations were moved into the new facility, the same studies conducted at the old facility would be repeated at the new. Time records for: patient time in room, time spent waiting for provider, time without a provider in room, time spent with a provider, and time patient spent in lobby before being placed in one of the twelve exam rooms, would be monitored. Once enough data points were gathered to accurately reflect the new facility's processes, a new simulation could be built, (shown in figure 3), that would compare the new "improved" facility to the old facility. This comparison, could effectively show how the new facility, and its many new features was affecting the process outputs of the SIMIO model.

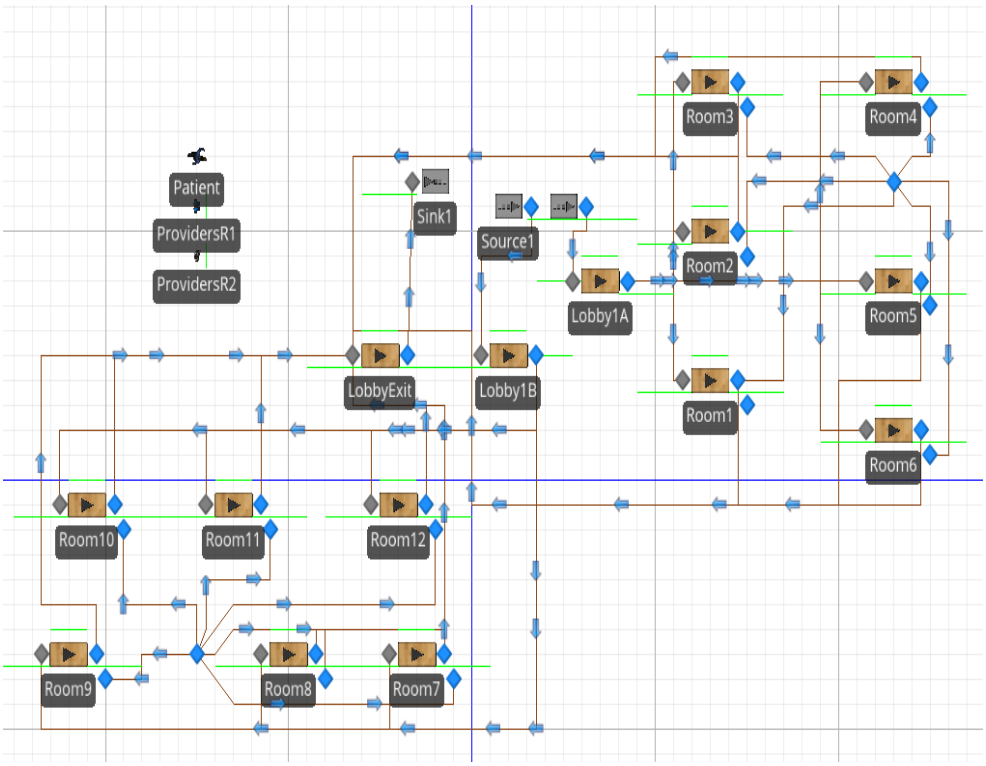

Figure 3: New Facility SIMIO Model

Hypothesis testing of data

Two sample t-tests were done to determine whether the data gathered at the new facility was different than that of the old facility. It was found that the Patient Time in the Room, Patient Time Without a Provider, and The Patient Time in the Lobby differed at a significance level of $\alpha = 0.02$. The results are shown in the table below.

Process	H_0	H_1	Time old (min)	Time new (min)	Sample Size (old)	Sample Size (new)	Test statistic	Degrees of Freedom	P-Value	Reject Null
Time in room	$\mu_1 = \mu_2$	$\mu_1 \neq \mu_2$	34.02	43.19	50	37	3.08	78	0.003	Reject
Time without a provider	$\mu_1 = \mu_2$	$\mu_1 \neq \mu_2$	22.12	29.35	50	37	2.72	69	0.008	Reject
Time with a provider (old)	$\mu_1 = \mu_2$	$\mu_1 \neq \mu_2$	12.43	13.83	50	37	0.97	77	0.337	Accep t
Time in lobby (old)	$\mu_1 = \mu_2$	$\mu_1 \neq \mu_2$	9.2	12.6	50	37	2.66	48	0.011	Reject

Table 1: Hypothesis Testing

Using MINITAB to find distributions that fit the data

Probability Plots were created in Minitab in order to find distributions that would model the processes within Innova Primary Care. A probability plot assesses whether or not a data set follows a given distribution. Data is plotted against a theoretical distribution in a way that the points should form approximately a straight line. A P-Value is then computed. If the P-Value is less than α (generally 0.05), then the data should not be modeled by that particular distribution. Figure 2 shows an example of a probability plot generated in MINITAB.

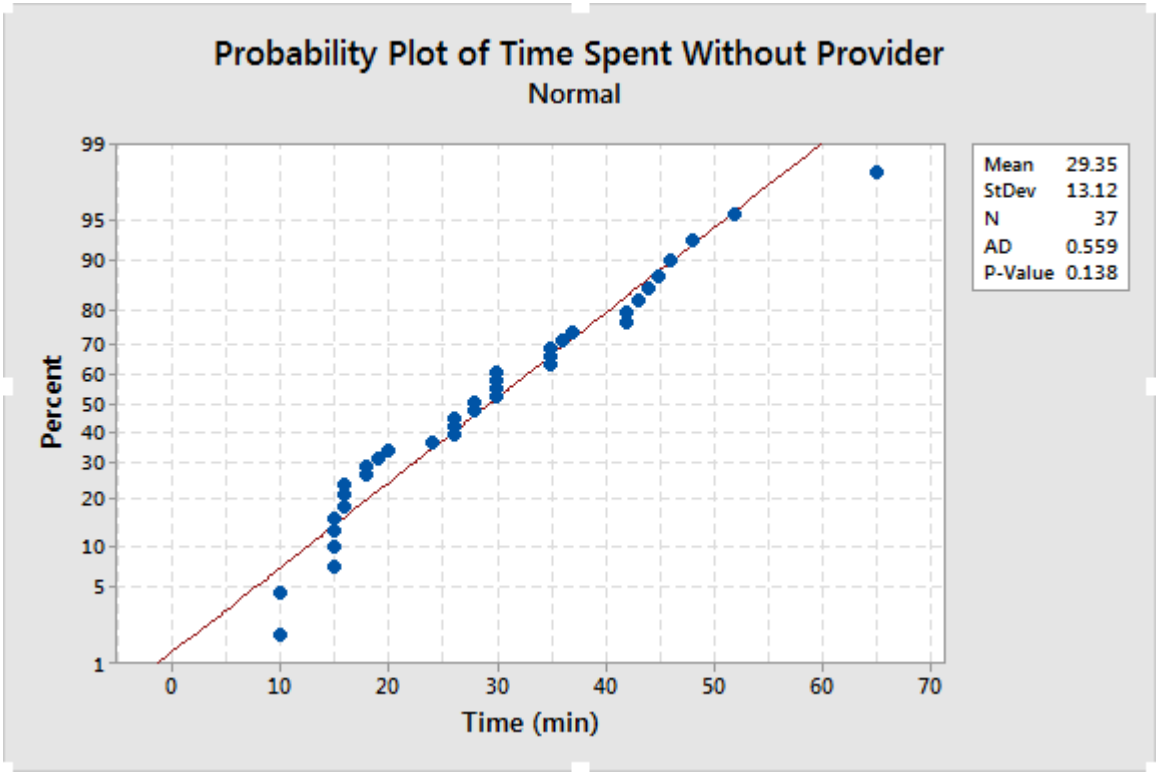

Figure 2: Probability Plot

The table below details the distributions used for each process in the SIMIO model. Note: the distribution used to model "time in room with a provider" uses data gather from the old facility.

Process	Distribution
Time in Lobby	Random.Triangular(2.5 , 10 , 19)
Time in room (without provider)	Math.min(Math.Max(0.01 , Random.Normal(29.35 , 6.56)), 65)
Time in room (with provider)	Random.Exponential(12.43)

Table 2: Distributions

Processes in the SIMIO Model:

The table below details what SIMIO Object Type models the real process.

Real Process	SIMIO Object Type
Patient Arrivals	Source
Provider (NP)	Worker
Time in room	Server
Time in Lobby	Server
Patient Exiting Lobby	Server

Table 3: SIMIO Object Types

Serval SIMIO processes had to be added to the model to accurately Simulate Innova's daily operations. Patients are not scheduled around 75 minutes before lunch and around 60 minutes before close of business. To model this, an assign is used to determine if lunch is about to start or it is almost close of business. Then a delay is used to delay patient arrivals.

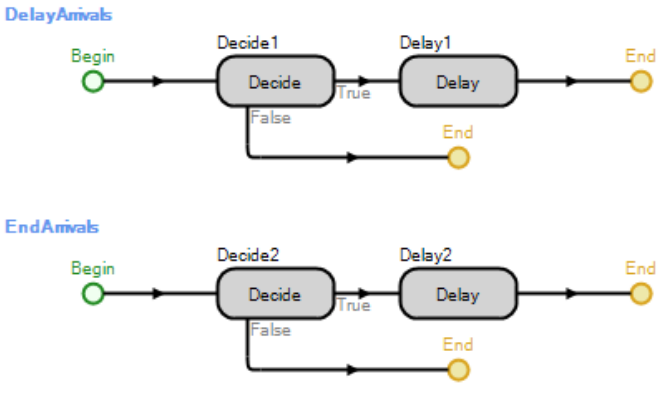

Figure 3: SIMIO Processes

In order to model the service providers using the worker SIMIO object type the following SIMIO processes are used as add-on process triggers. The processes used for room one are shown below, as an example.

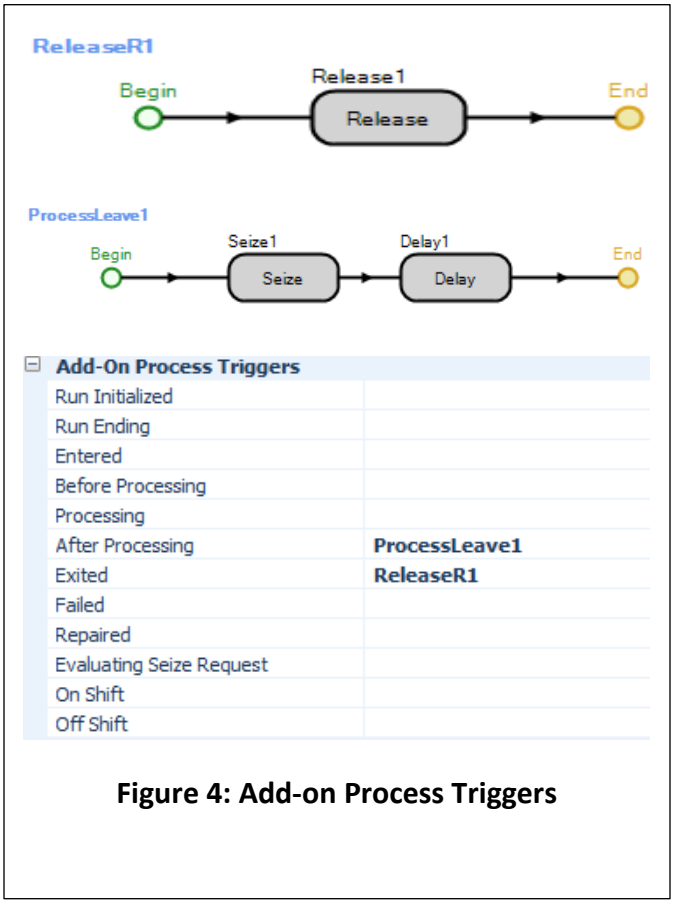

Figure 4: Add-on Process Triggers

ProccessLeave1 moves a worker (provider) from their home node (office) to room one, and then delays them by the time it takes for the provider to serve the patient. ReleaseR1 returns them to their home node.

Results from SIMIO

Several SIMIO experiments simulating 100 days of operation at Innova were ran. These simulations involved changing the number of service providers and the time/standard deviation of various processes. Some important observations to note: changing to 6 service providers had no impact on the patient time in the system, improvements to other processes did not cause a large impact until the number of providers was increased to 6, and it will be possible for Innova to operate with 8 providers once other processes are improved. The results are shown in the table(s) below.

SIMIO Experiment (ran 100 days of operation, 4 providers)	Patients Seen (on average)	Patient Total Time in System	Half width
Normal Run	78.77	55.69 min	.6330 min
Reduced patient time without a provider by 9 min, reduced StDev of patient time without provider by 50%	78.80	48.31 min	.5184 min
Reduced patient time without a provider by 9 min, reduced StDev of patient time without provider by 50%, and reduced lobby wait time by 2.5 min	78.69	45.76min	.5460min
Reduced patient time without a provider by 9 min, reduced StDev of patient time without provider by 50%, reduced lobby wait time by 2.5 min, and reduced time for provider to serve by 1 min	78.44	44.14 min	.5052 min
Only reducing time for provider to serve patient by 1 min.	78.50	54.15 min	.4962 min
Only reducing lobby wait time by 2.5 min	78.59	52.91 min	.5214min

Table 5: Current 4 Provider System

SIMIO Experiment results (ran 100 days of operation, 6 providers)	Patients Seen (on average)	Total Time in System	Half width
Normal Run	118.86	55.71 min	.708 min
Reduced patient time without a provider by 9 min, reduced StDev of patient time without provider by 50%	118.11	45.11 min	.3300 min
Reduced patient time without a provider by 9 min, reduced StDev of patient time without provider by 50%, and reduced lobby wait time by 2.5 min	118.01	42.44 min	.3366 min
Reduced patient time without a provider by 9 min, reduced StDev of patient time without provider by 50%, reduced lobby wait time by 2.5 min, and reduced time for provider to serve by 1 min	118.80	41.43 min	.3270 min
Only reducing time for provider to serve patient by 1 min.	118.53	53.82 min	.570 min
Only reducing provider time by 2.5 min	118.86	53.00 min	.627 min

Table 3: *6* Provider System

SIMIO Experiment results (ran 100 days of operation, 8 providers)	Patients Seen (on average)	Total Time in System	Half width
Normal Run	156.80	69.19 min	1.341 min
Reduced patient time without a provider by 9 min, reduced StDev of patient time without provider by 50%, reduced lobby wait time by 2.5 min, and reduced time for provider to serve by 1 min	157.03	42.31 min	0.4134 min

Figure 4: *8* Provider System

Conclusions

The data shown in figures 8, 9, and 10 shows that with no changes to the current processes, Innova can expand to 6 service providers and see 120 patients per day. By reducing patient time spent in the exam room by 10 minutes (9 minutes without provider/1 min with provider), reducing the variance of the patient time spent without a provider, and reducing lobby times by 2.5 minutes, Innova could expand to 8 service providers, see 160 patients per day, and improve patient time in the system.

To further improve this model, the NAs (nurse assistants) could also be modeled as SIMIO workers and/or different patient types could be added.

NAs, although not specifically modeled within the SIMIO model, are a resource than can be changed to impact patient time in the system. Furthermore, increasing the number of providers (NPs & MDs) will likely require more NAs. The SIMIO model discussed in this paper is unable to determine how many NAs are needed per provider.

The various different patient types seen in a general care medical practice could be a primary cause of high variability, observed in the “patient time in room without a provider” process. Collecting data on the service times of various patient types could allow for a model that could help optimize patient scheduling.

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