Proceedings of the 2013Winter Simulation Conference
R. Pasupathy, S.-H. Kim, A. Tolk, R. Hill, and M. E. Kuhl, eds

SIMULATION AS A GUIDE FOR SYSTEMS REDESIGN IN GASTROINTESTINAL ENDOSCOPY: APPOINTMENT TEMPLATE REDESIGN

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ABSTRACT

In this era of health care value-based purchasing, health care systems are increasingly focused on maximizing the utilization of their most expensive resources. This trend is evident in gastrointestinal endoscopy which makes up the largest percentage of ambulatory surgical center claims in Medicare. In response to these pressures, the Duke University Health System plans to shift a majority of low-risk, endoscopic procedures to a lower-cost Ambulatory Surgical Center within the next year. In this paper, we describe our efforts partnering with Duke University Health System to develop a discrete event simulation model of this ambulatory surgical center and use the model to predict the impact of this case-shift. Furthermore, we use modeling to help guide systems redesign efforts by focusing on appointment template design. Through modeling, we uncover a number of operationally meaningful findings that are currently under consideration within the health system.

1 INTRODUCTION

Gastrointestinal endoscopic procedures as a whole make up the largest percentage (32.7%) of ambulatory surgical center claims in Medicare, (U.S. Department of Health and Human Services Report to Congress, 2011) and so significant pressures exist to decrease the costs of endoscopic practice. One mechanism used by insurers to decrease costs is to pursue value-based purchasing of endoscopy services (Deas 2006; Hewett 2010; Kim 2011). While endoscopic practices need to demonstrate value through quality, decreasing costs through improved efficiency has also become critically important.

One approach to improve the value of endoscopic services provided at large health systems is to shift low-risk, routine procedures from hospital-based endoscopy units to ambulatory surgical centers (ASCs) that are able to provide this service at a lower cost. For example, in response to value-based purchasing pressures, the Duke University Health System (DUHS) plans to shift a majority of screening colonoscopy procedures to the Brier Creek Endoscopy Unit in the next year. The Brier Creek Endoscopy Unit is an ASC associated with DUHS. This change is estimated to increase daily procedure volume at Brier Creek by 30-40%. Maximizing efficiency of current resources may obviate the need to hire additional staff to manage this increased volume.

In this paper, we describe our efforts partnering with DUHS to develop strategies to maximize the efficiency of clinical operations in the Brier Creek unit. Our goal was to create a discrete event simulation model of the endoscopy unit and then use this model to recommend changes in patient scheduling to improve the utilization of staff and facility resources and minimize wait time for patients. In this paper, we summarize our review of the literature, provide an introduction to the Brier Creek endoscopy unit, and discuss in detail the creation of the discrete event simulation model. We then review our results, including scenario analyses, and discuss recommendations for actionable changes within the endoscopy unit.

978-1-4799-2076-1/13/$31.00

2 LITERATURE REVIEW

Despite the advantages of discrete event simulation (DES), its use in endoscopy units is limited. Berg et al. (2009) used a discrete event simulation model to study the efficiency of an endoscopy suite. Their analysis was limited to only colonoscopy procedures and thus may not be applicable to endoscopy units that perform additional procedures. Centeno et al. (2010) also used DES modeling to study the causes of low throughput in a community endoscopy center. Their analysis was similarly limited to general endoscopic procedures. We extended the work of Centeno and Berg by applying DES to a large, hospital-based endoscopy unit that performs a number of procedures not discussed in the previous analyses, including Endoscopic Retrograde Cholangiopancreaticography (ERCP), Endoscopic Ultrasound (EUS) and Bronchoscopy (Taheri 2012). Furthermore, our analysis explored the impact of monitored anesthesia care on nurse-patient ratios in the recovery area.

More recently, Berg et al. (2013) utilized a discrete event simulation model to evaluate multiple potential strategies for minimizing the impact of no-shows on a university-affiliated ASC. They demonstrated the value of an overbooking strategy to minimize the loss associated with no-shows. They compared these scenarios to a reference scenario of perfect attendance for the established template. This work further supports the value of simulation modeling in guiding systems redesign activities in gastrointestinal endoscopy. Our analysis is complimentary to Berg et al. by exploring scheduling strategies that improve resource utilization and capacity in a similar unit by altering the structure of this “established template.” Furthermore, we explicitly consider patient waiting time as a defined metric, which is an important consideration in designing patient-centered strategies for improving health care value.

3 OVERVIEW OF THE BRIER CREEK ENDOSCOPY UNIT

The Brier Creek gastrointestinal endoscopy unit is an outpatient ASC with two procedure rooms and seven shared preparation and recovery bays. Inpatient cases are not performed and same-day add-on cases are rare. Physicians in this ASC perform general endoscopic procedures such as upper endoscopy, flexible sigmoidoscopy and colonoscopy as well as a combination of colonoscopy and upper endoscopy or flexible sigmoidoscopy, referred to as a *double*. Trainees are not present.

Currently about 56 procedures are performed per week. Procedural sedation is provided by nurses who administer conscious sedation with fentanyl and midazolam under the supervision of the physician endoscopist. Figure 1 shows the breakdown of the procedure volume.

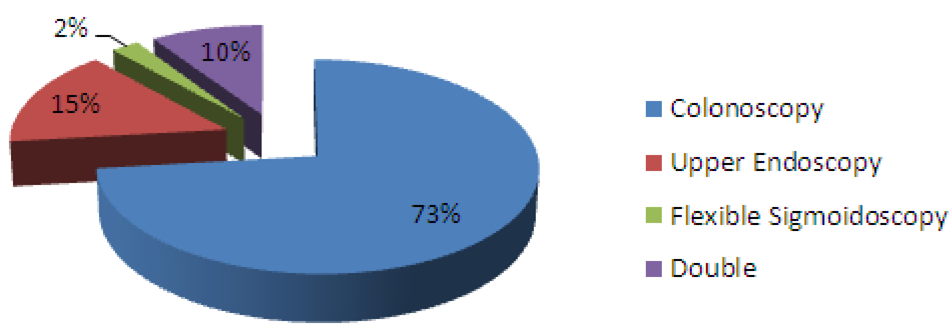

Figure 1: Proportion of procedures performed in the Brier Creek endoscopy unit

3.1 Appointment Template

The clinic is currently using two appointment templates, depending on the number of rooms/endoscopists that are available (see Table 1). Each appointment slot corresponds to a planned start time of a procedure. Patients are asked to arrive 30 minutes earlier than their appointment time, and this time is used for the preparation activity. In the case of the “two MD’s” template, each procedure room is allocated to a single endoscopist performing 11 procedures per day – a total of 22 procedures per day for both endoscopists. In the case of the "single MD's" template, both procedure rooms are allocated to a single endoscopist performing 14 procedures per day each. Upon arriving in the morning, endoscopists are assigned room(s) which they keep for their entire shift. In either scenario, two appointment slots are reserved for *double* procedures which can be scheduled in any consecutive pair of appointment slots.

Table 1: Current Appointment Templates

Two MDs	Room 1	7:45 AM	8:25 AM	9:05 AM	9:45 AM	10:25 AM	11:05 AM	11:45 AM	1:00 PM	1:40 PM	2:20 PM	3:00 PM
	Room 2	8:00 AM	8:40 AM	9:20 AM	10:00 AM	10:40 AM	11:20 AM	12:45 PM	1:25 PM	2:05 PM	2:45 PM	3:25 PM
Single MD	Room 1	7:45 AM	8:45 AM	9:45 AM	10:45 AM	1:00 PM	2:00 PM	3:00 PM				
	Room 2	8:15 AM	9:15 AM	10:15 AM	11:15 AM	1:30 PM	2:30 PM	3:30 PM				

3.2 Patient and Work Flow

Figure 2 depicts the patient flow and workflow in the Brier Creek Endoscopy Unit. Patients arrive at the clinic following an appointment template. Patients check in at reception and wait in the waiting room to be called in by the nurse. Patients are required to have a driver with them. In this endoscopy unit, the preparation and the recovery bays are shared. This "U-shape" configuration offers some flexibility to share nurses to support preparation and recovery. When a bay is available, a nurse picks up the paperwork and summons the patient.

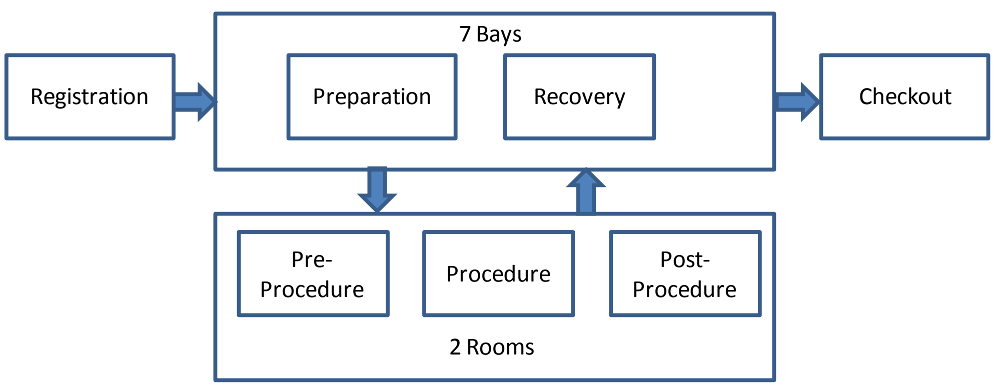

Figure 2: Patient Flow and Workflow in the Brier Creek Endoscopy Unit

The prep nurse, after explaining the procedure to the patient's driver, then prepares the patient for the procedure in one of the 7 prep/recovery bays. There is no physical difference between these seven bays and patients can be prepared for their procedure or recovered in any of the bays. Consent is also obtained by the nurses and then reviewed by the physician prior to the procedure. While patients are waiting for a procedure room to become available after they have been prepared, they do not need to be monitored by a nurse. When a procedure room is available, a procedure nurse comes to the prep/recovery area and wheels the patient on a stretcher to the procedure room. When the procedure is completed, the procedure nurse wheels the patient to one of the 7 prep/recovery bays. After signing over the care of the patient to one of the recovery nurses, the procedure nurse returns to the procedure room to help turn the room over for the next procedure with an endoscopy technician who is assigned to each room. The patient remains in recovery until ready for discharge. Discharge can occur when three criteria are met: 1) the patient is clinically recovered from anesthesia; 2) the physician has spoken to the patient about the results of the procedure; and 3) the patient's driver is available to assume responsibility for the patient. If any of these three criteria are not met, the patient remains in recovery.

The staff work schedule is as follows: One prep nurse works from 7:15 AM-3:30 PM. A supervising nurse, called the *charge* nurse, can assist with preparation in the morning and afternoon if the prep nurse is busy. We assume the charge nurse is available to prepare patients the entire operation hours of the unit, however, the prep nurse is preferred when available. Each room is staffed by a procedure nurse and a technician – scheduled to start at 7:45 AM and 8:00 AM respectively. Two recovery nurses support the recovery room during the entire operating hours. There is no scheduled lunch break for the nurses – the mid-day interruption in the appointment allows the prep and charge nurses to take a lunch break and fill in for other nurses as needed to allow lunch breaks.

4 SIMULATION MODEL

4.1 Data Analysis

We used 23 days of historical timestamp data collected by the nursing staff in Provation® MultiCaregiver (WoltersKluwer Health) for our study. In this data set we had 256 patients, two "no-shows," and 248 with completed procedures: 183 colonoscopies, 38 upper endoscopies, 22 double, and 5 flexible sigmoidoscopies. On 15 days, the two procedure rooms were assigned to a single endoscopist with an average of 10 filled appointment slots per day (slot utilization = 10/14 or 71%), and on 8 days, each procedure room was assigned to a single endoscopist with an average of 15 filled appointment slots per day (slot utilization = 15/22,or 68%). Figures 3 and 4 depict the discharge time of the last patient per day for each case, demonstrating a significant variation in day-to-day use of the appointment slots.

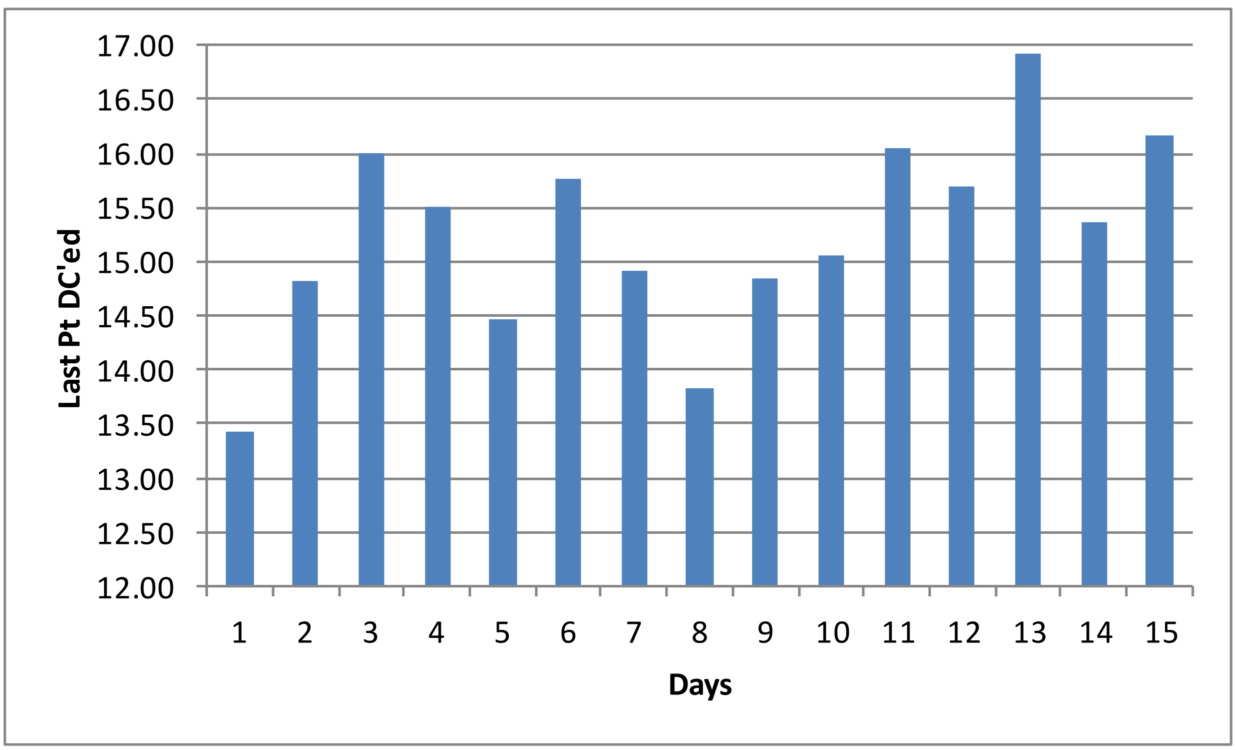

Figure 3: Last Patient Discharged – Two Rooms Per Endoscopist

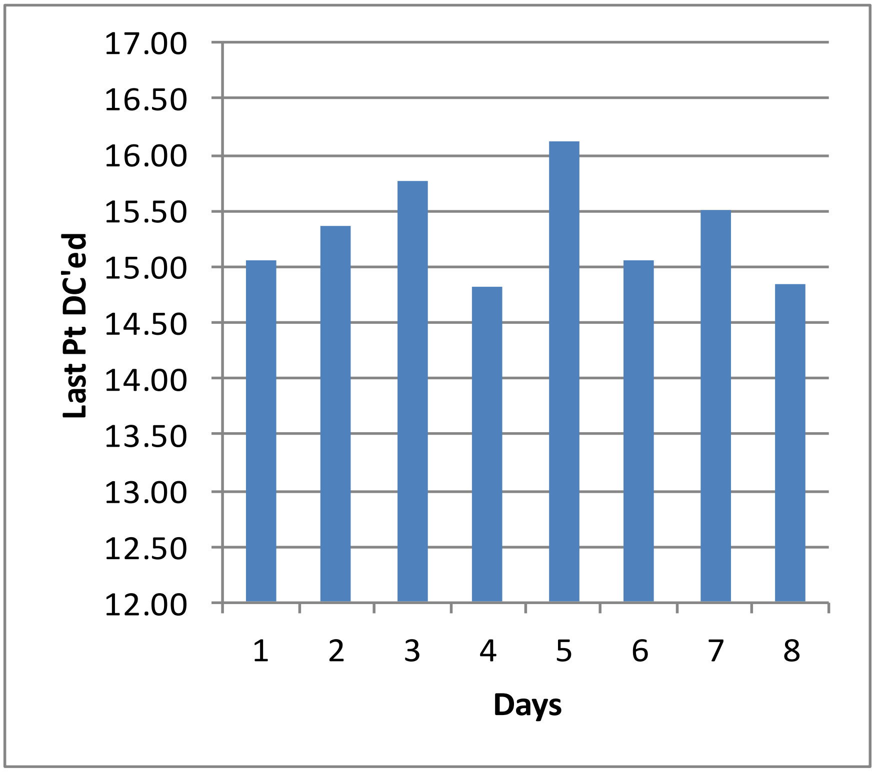

Figure 4: Last Patient Discharged – Single Room Per Endoscopist

As Figure 5 demonstrates 85% of patients arrive 30 minutes or more prior to their scheduled appointment.

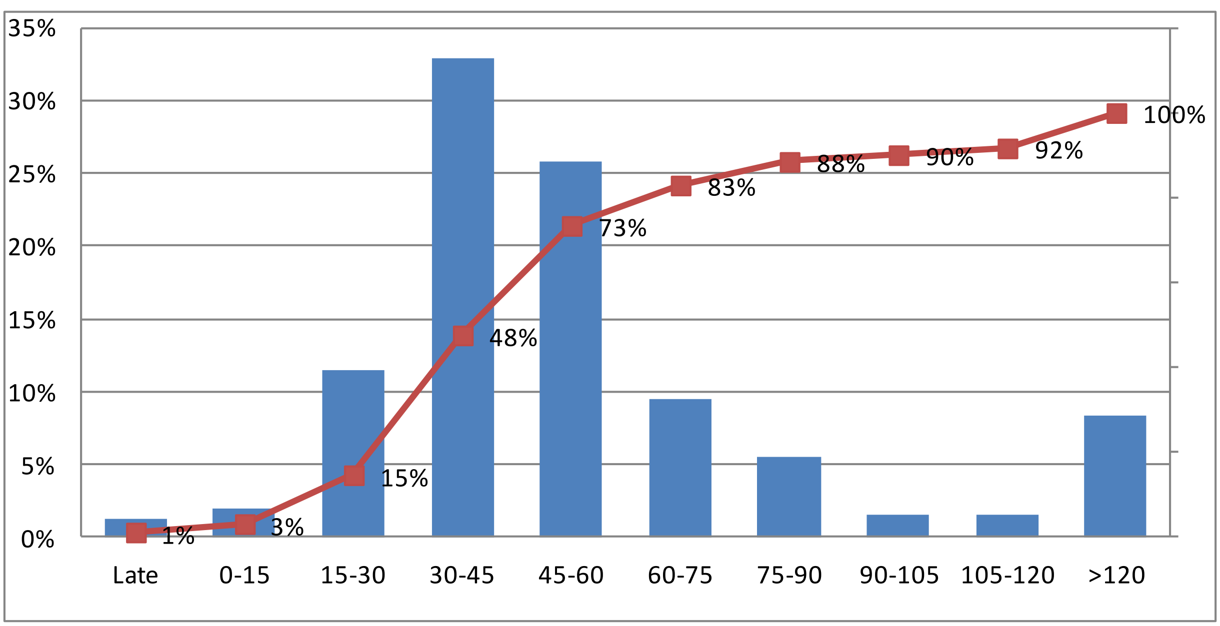

Figure 5: Patient Arrivals Prior to Appointment (Minutes)

4.2 The Baseline Model

A discrete event simulation model of patient flow in the Brier Creek endoscopy unit was developed using Simio (Kelton et al. 2010). The flow of patients is organized in three phases: preparation, procedure and recovery. Seven bays, numbered from 1 to 7, are shared for the preparation of patients as well as recovery, with reverse preference - preparation prefers rooms in the order of 1, 2, …, 5 while recovery prefers rooms in the order of 7, 6, …,1 – to avoid possible blocking, bays six and 7 are used for recovery only.

In the procedure room, three activities were modeled: pre-procedure; procedure, and post-procedure. Each procedure room is staffed by a nurse and a technician. The procedure nurse is required for all three activities. She/he is also responsible for escorting the patient from the procedure room to recovery. The technician was not explicitly modeled as we assumed that the technician is always available and there is sufficient time to turn the room over after the completion of the procedure. An endoscopist is required for each procedure. At the completion of the procedure, the endoscopist returns to his/her station to write the procedure report and prepare for the next case. She/he also revisits the patient, once they are sufficiently recovered from anesthesia to inform the patient about the results of the procedure as well as to discharge the patient. We did not explicitly model the report writing and the discharging activities as the total time of pre-procedure and post-procedure exceeds the time required for writing the report and discharging the patient. Once the procedure is completed, after the post-procedure time is elapsed, the procedure nurse hands off the patient at the recovery bay to a recovery nurse. Once a patient is discharged by the endoscopist, the recovery nurse then assists and escorts the patient to the exit.

We modeled 23 days of the clinic operations, using an *arrival table* that included actual appointment times, actual procedure type, and actual endoscopist and room assignments. For procedure types, we aggregated upper endoscopy and flexible sigmoidoscopy since the sample sizes were small and in term of effort and time, these two procedures are very similar.

For the duration of the activities, we used the historical data discussed earlier and Arena Input Analyzer [Kelton et al, 2009] to estimate the probability distributions for all the pertinent activities. The probability distribution for the preparation is [GAMMA(5.98, 2.89) + 2] minutes. Table 2 depicts the probability distributions for remaining activities during colonoscopy, upper endoscopy, and double procedures.

Table 2: Probability Distributions (minutes)

	Colonoscopy	Upper Endoscopy	Double
Pre-Procedure	GAMMA(4.9, 2.17) + 1	GAMMA(5.05, 1.4) + 2	GAMMA(11.4, 0.835) + 2
Procedure	GAMMA(2.52,7.25)	GAMMA(1.83, 2.16) + 1	TRIANGULAR(11,29.4,35)
Post-Procedure	GAMMA(.448,7.47) + 1	GAMMA(.777,4.56) + 2.12	TRIANGULAR(0,5.6,8)
Recovery	GAMMA(3.08,8.95) + 16	GAMMA(1.7,16.3) + 14	GAMMA(12,1.71) + 29

4.3 The results for the Baseline model

The baseline model was run for 50 replications for 23 days operating for 10 hours starting at 7:15 in the morning, “tracing” the data. The patient average flow time was 106.48 minutes with a 95% confidence interval of 0.44 minutes. Table 3 depicts the bay average utilization as well as the their associated 95% confidence interval.

Table 3: Bay Utilization

Bay No.	1	2	3	4	5	6	7
Percent Utilization	30.87	9.34	1.09	1.69	9.05	26.41	44.27
95% Confidence Interval	0.19	0.28	0.19	0.17	0.31	0.34	0.36

Table 4 depicts the utilization and the associated 95% confidence interval for the other resources, namely: the prep nurse and charge nurse (proportion of time she/he was helping with the preparation of patients), endoscopists (the utilization of the second endoscopist is adjusted for the number of days she/he was performing procedures), and the room utilization. While the prep nurse utilization is "scheduled utilization," the other utilizations are based on the unit operating for 10 hours. Low room and endoscopists' utilization figures reflect the fact that the current appointment slots are not completely filled. Because there is no overtime at baseline, there was no need to adjust reported utilizations statistics.

Table 4: Resource Utilization

Resource	Prep Nurse	Charge Nurse	MD1	MD2	Rm1	RM2
Percent Utilization	28.26	8.92	20.06	24.16	29.28	31.75
95% Confidence Interval	0.2	0.28	0.16	0.31	0.16	0.31

To validate the model, we utilized a number of animation features available in Simio, such as adding labels to the entities, for face validation. In addition, when compared with the average patient flow time reported by the model (106.48 ± 0.44) minutes, the actual patient flow time of 107.53 minutes is reasonably predicted by the model. In the next section, we will use this baseline model to study several appointment templates and their use under high volume.

4.4 Analysis of Appointment Templates

To study the effectiveness of potential appointment templates, we used our base model to compare several key performance measures: 1) *Patient Waiting Time* is the length of time patient is waiting past their appointment time in the waiting room; 2) *Patient Flow Time* is the length of time beginning at the time the patient is called in by the preparation nurse to the time that patient is discharged; 3) *Endoscopist Utilization*: the percentage of time the endoscopist is performing procedures; 4) *Prep Nurse Utilization*: the percentage of time prep nurses are preparing patients for procedure; 5) *Bay Utilization*: the percentage of time each bay is occupied by a patient; 6) *Room Utilization*: the percentage of time procedure rooms are assigned to a patient; 7) *Overtime*: is the length of time past 5:00 PM that the last patient is discharged.

4.5 Analysis of Current Appointment Templates

We used our baseline model to evaluate the unit capacity for each of the two appointment templates that Brier Creek currently uses (Table 1). We developed two five-day appointment schemes, one for each template, assuming that the number of endoscopists working in the unit stayed constant. Additionally, in contrast to the baseline where there was incomplete booking of the appointment slots, in this scenario, we completely filled the templates each day – recovering the 30% shortfall in volume increase (see section 4.1). The procedure types were randomly assigned proportionally following the current mix of procedure types (Figure 1) with a condition that there will be no double procedures assigned to the last slot of the morning and afternoon shifts – a policy that is currently practiced by the Brier Creek endoscopy unit. The models were run for 50 replications each for 11 hours, to ensure all patients are moved through the system. With exception of the prep nurse whose utilization is reported based on scheduled shifts, other utilization for resources are based on 11 hours – under estimating the actual utilization figures. The overtime is measured based on a 5 P.M. end-of-day time as suggested by the unit manager. **Table 5** summarizes patient waiting, patient flow time, and average overtime per day, as well as their associated 95% confidence intervals. Table 6 summarizes resource utilizations as well as their associated confidence intervals.

Table 5: Time Related Performance Measures – Current Templates

Metric	Single Endoscopist Mean ± 95% CI	Two Endoscopists Mean ± 95% CI
Waiting Time, min	0.35 ± 0.08	6.48 ± 0.69
Flow Time, min	98.13 ± 0.86	98.31 ± 0.70
Average overtime, min	2.60 ± 1.08	3.29 ± 1.32

Table 6: Resource Utilization – Current Templates

Resource Utilization	Single Endoscopist Mean ± 95% CI	Two Endoscopists Mean ± 95% CI
Prep Nurse	36.5 ± 0.3	45.5 ± 0.9
Charge Nurse	2.9 ± 0.4	32.5 ± 1.3
Endoscopist 1	32.2 ± 0.7	22.8 ± 0.6
Endoscopist 2		26.1 ± 0.6
Room 1	34.9 ± 0.7	49.1 ± 0.7
Room 2	29.2 ± 0.6	50.4 ± 0.7
Bay 1	36.7 ± 0.3	44.2 ± 0.7
Bay 7	49.3 ± 0.8	57.2 ± 0.8

Regarding the bay utilization, for ease of interpretation, we report the utilization of bay 1, the one that is most preferred to prepare the patient and bay 7, the bay that is most preferred to recover the patient. As these statistics show, there is sufficient capacity to accommodate either of these two appointment templates when they are completely filled.

4.6 Analysis of Revised Appointment Templates

Currently, when a patient is scheduled for a double procedure, two appointment slots are used. To calculate the difference in time requirements for double versus single procedures, we computed the expected combined time for the procedure, post procedure and recovery periods. The expected length of time for the combination of procedure and post procedure time was 26.45 ±1.14 minutes for the single procedures and 35.97 ±3.13 minutes for the double procedures. The expected length of recovery time was 42.79 ±1.27 minutes for single procedures and 49.41 ±6.78 minutes for double procedures. Comparing these statistics for the two categories of single procedures and double procedures suggests that using two appointment slots for the double procedures may not be warranted because the difference in times is significantly less than a 40 or 60 minute appointment slot.

In this section, we use our baseline model to evaluate the unit capacity when the policy of assigning two slots for the double procedures is revised so that double procedures are assigned a single slot. This results in a 10% increase in the number of scheduled patients per day. Again, the models were run for 50 replications each. Table 7 summarizes patient waiting, patient flow time, and average overtime per day, as well as their associated 95% confidence intervals. Table 8 summarizes resource utilizations as well as their associated confidence intervals.

Table 7: Time Related Performance Measures – Revised Templates

Metric	Single Endoscopist Mean ± 95% CI	Two Endoscopists Mean ± 95% CI
Waiting Time, min	0.37 ± 0.07	7.86 ± 0.58
Flow Time, min	97.56 ± 1.15	99.84 ± 0.92
Average overtime, min	2.9 ± 1.42	7.47 ± 2.25

Table 8: Resource Utilization – Revised Templates

Resource Utilization	Single Endoscopist Mean ± 95% CI	Two Endoscopists Mean ± 95% CI
Prep Nurse	39.5 ± 0.4	50.9 ± 0.8
Charge Nurse	3.4 ± 0.4	38.7 ± 1.2
Endoscopist 1	34.4 ± 0.9	25.6 ± 0.6
Endoscopist 2		29.0 ± 0.7
Room 1	36.8 ± 0.8	54.3 ± 0.6
Room 2	32.2 ± 0.6	54.9 ± 0.8
Bay 1	39.7 ± 0.4	48.5 ± 0.7
Bay 7	49.5 ± 0.7	60.1 ± 0.7

As the results from running the model for the revised templates indicate, again there is sufficient capacity to treat 10% more patients than current appointment templates allow. One possible area of concern is the availability of the prep nurse. More specifically, in the case of two endoscopists, the average utilization of the charge nurse is substantially increased. Since preparing patients in not one of charge nurse's main responsibilities, this increased utilization may be problematic. To accommodate the additional volume, the unit may need to reorganize nurse activities or add a part time nurse in the morning to help with the preparation.

5 CONCLUSION

In this paper, we describe our efforts partnering with Duke University Health System to develop a discrete event simulation model of an ambulatory surgery center and use this model to help guide systems redesign efforts to shift average-risk endoscopic services from the hospital to the lower cost ASC. Our modeling revealed a number of operationally relevant findings, including: first, increasing the average patient volume in the unit to recover the 30% shortfall in volume did not substantially impact the time-related performance measures of the endoscopy unit; secondly, eliminating the second appointment slot for double procedures increased the capacity of the unit by 10% without substantial impact on time-related performance measures; finally, as others have found (Berg et al., 2010), scheduling one physician in two endoscopy rooms maximizes the utilization of the physician but impedes the utilization of other resources, namely nursing and space. The decision on whether to run one or two rooms depends on the relative costs of these resources as well as the perspective taken in the analysis. These findings have been shared with endoscopy unit leadership within Duke Health System. Additional scenarios utilizing the same model are currently being evaluated.

REFERENCES

Berg B, B. Denton, H. Nelson, H. Balasubramanian , A. Rahman , A. Bailey, and K. Lindor. 2010. "A Discrete Event Simulation Model to Evaluate Operational Performance of a Colonoscopy Suite." *Medical Decision Making* 30(3): 380-387.

Berg B, M. Murr, D. Chermak, J. Woodall, M. Pignone, R. Sandler, and B. Denton. 2013. "Evaluating the Cost of No-Shows and Evaluating the Effects of Mitigation Strategies." *Medical Decision Making*, in press.

Centeno M.A., M. Dodd, M. Aranda, and J. Sanchez. 2006. "A Simulation Study To Increase Throughput In An Endoscopy Center." *Proceedings of the 2010 Winter Simulation Conference* 2462-2473.

Deas, T.M., "Health-care value-based purchasing." *Gastrointest Endosc Clin N Am.* 16(4): p.643-56.

Gellad Z.F., and D. Provenzale. 2010. "Colorectal cancer: national and international perspective on the burden of disease and public health impact." *Gastroenterology* 138:2177-90.

Harewood, G.C. and D. Lieberman, 2004. "Colonoscopy practice patterns since introduction of Medicare coverage for average-risk screening." *Clin. Gastroenterol. Hepatol*. 2: p. 72-77.

Hewett, D.G. and D.K. Rex, 2010. "Improving Colonoscopy Quality Through Health-Care Payment Reform." *Am J Gastroenterol* 105(9): p. 1925-1933.

Kelton W.D, R.P. Sadowski, D.T. Sturrock, and N.B. Swets. 2009. *Simulation With Arena*, McGraw-Hill Higher Education .

Kelton W.D., J.S. Smith, D.T. Sturrock, and V. Verbraeck. 2010. *Simio & Simulation*, McGraw-Hill Higher Education.

Kim, L.S. 2011. "How Will Accreditation of Your Ambulatory Endoscopy Center Be an Essential Component of Showing Value-Based Health Care?" *Clin Gastro Hep* 9(1): p. 21-23.

Lieberman, D.A., J.E. Holub, D. Kraemer, and C.D. Morris. 2005. "Utilization of colonoscopy in the United States: results from a national consortium." *Gastrointest Endoscopy*. 62: p. 875-883.

Reid, P.P., W.D. Compton, J.H. Grossman, and G. Fanjiang, eds. 2005.*Building a Better Delivery System: a new engineering/health care partnership, in Committee on Engineering and the Health Care System;* National Academy of Engineering and Institute of Medicine. National Academy Press: Washington, DC.

Rex D.K., B.J. Lahue, R.W. Dronzek, and M.J. Lacey. 2005. "Impact of Two Procedure Rooms Per Endoscopist on Productivity: Computer Simulation Examines the Impact of Process Change in the Hospital Gasroenterology Department." *Gastrointestinal Endoscopy*. 61:AB154-AB.

Schenck A.P., S.C. Peacock, C.N. Klabunde, P. Lapin, J.F. Coan, and M.L. Brown., 2009. "Trends in Colorectal Cancer Test Use in the Medicare Population, 1998-2005." *American Journal of Preventive Medicine*. 37(1): p. 1-7.

Seeff L.C., D.L. Manninen, F.B. Dong, S.K. Chattopadhyay, M.R. Nadel, F.K. Tangka, and N.A. Molinaril. 2004. "Is there endoscopic capacity to provide colorectal cancer screening to the unscreened population in the United States?" *Gastroenterology*. 127(6): p. 1661.

Taheri J., Z.F. Gellad, D. Burchfield, and K.Cooper. "A Simulation Study to Reduce Nurse Overtime and Improve Patient Flow Time at a Hospital Endoscopy Unit." *Proceedings of the 2012 Winter Simulation Conference.*

U.S. Department of Health and Human Services Report to Congress: Medicare Ambulatory Surgical Center Value-Based Purchasing Implementation Plan, accessed 11/3/2011 at https://www.cms.gov/ASCPayment/

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