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Provider Scheduling at the Worcester VA Community Based Outpatient Clinic

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Abstract

The implementation of a Patient-Centered Medical Home (PCMH) concept, known as the Patient Aligned Care Team (PACT) model at the Worcester Community Based Outpatient Clinic (CBOC), revealed provider scheduling and utilization challenges. A linear programming based planning tool described in this report identifies optimal provider schedules The planning tool, named ProSkedge, is able to be modified to fit the varying operating constraints the CBOC faces. Also included is a simulation model to validate the linear program and to perform scenario analysis. Additional recommendations for improved facility operations are provided based on observation and a review of the literature.

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Linear Programming Model

A	total number of periods required for administrative time during the planning cycle
a_k	appointment length for a patient of type k
i	index, provider
J	total number of periods in the planning cycle
j	index, time period
k	index, patient type
L	length of the periods j in minutes
M	minimum number of providers to be scheduled during period j
P_k	percentage of patients of type k to be serviced (facility goal or other guideline)
p_{ij}	preference of provider i during period j
R	total number of rooms available to be used
r_{ij}	number of rooms required by provider i during period j
S	total of all patients serviced over all periods in the planning cycle
s_k	number of patients of type k serviced in a specified period
T	total number of periods required for triage work during the planning cycle
x_{ij}	binary decision variable equal to 0 when provider i is not scheduled during period j or 1 when provider i is scheduled during period j

Statistical Analysis

H_A	alternative hypothesis
H_0	null hypothesis
n	number of replications
s	standard deviation
μ_1	linear programming model value to compare
μ_2	simulation model value to compare

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Authorship

All authors of this report have contributed equally to ensure the success of the project; all aspects of the project and the written work from the background research to the model development and the generation of conclusions and recommendations were joint efforts. We therefore accept equal responsibility for the project and the content found within this report.

Executive Summary

The United States Department of Veterans Affairs (VA) is a government-run, military benefit system. The Veterans Health Administration (VHA) consists of numerous hospitals, veteran centers, regional offices, national cemeteries, and Community Based Outpatient Centers (CBOCs). A CBOC is medical facility that enables patient access by providing care closer to where veterans reside separate from the parent VHA hospital in the area.

Patient-centered medical home (PCMH) is a managed care model developed to foster patient-provider relationships in an effort to improve health care delivery. Because of the national 2009-2010 health care reform debates, there is some urgency to determine the feasibility of the PCMH model (Nutting, 2009). Furthermore, the complexities and risks associated with the transition to such a managed care model must be thoroughly investigated and mitigated.

The VHA requires all CBOCs to implement a Patient Aligned Care Team (PACT) model, the VA's version of the PCMH model, by October 2011. The transition is expected to allow CBOCs to better meet the needs of the growing veteran population, as well as changes in veteran needs. The Worcester CBOC in particular faces many challenges as it works to meet this deadline.

The challenges faced by the CBOC during its transition to a PACT model include: (1) providers are unable to coordinate group visits and/or telephone calls to patients because of schedule uncertainties (e.g. varying vacation time) and lack of time to facilitate the visits; (2) visiting specialists' schedules can disrupt schedules of on-site providers; (3) providers are using personal time to complete required visit documentation for established patients; and (4) approximately 100 new patients per month are being added into the Worcester CBOC alone, and this number is expected to grow as more veterans return from Iraq and Afghanistan.

This report addresses how the Worcester CBOC can improve scheduling practices of providers in order to enable the transition to a PACT care model while still allowing for optimal patient throughput. Given the constraints that limit the CBOC's flexibility in scheduling providers, a planning tool called ProSkedge is built to aid the clinic in provider scheduling.

To achieve a usable planning tool, six steps are taken. First, the problem and specific user needs are identified. This also allows for a better understanding of patient flow logic and clinic

operations. Data collection is performed to identify the model inputs, facility constraints, and patient flow logic. The next three steps involve model creation. Development begins with a linear programming model built in Microsoft Excel 2007 to maximize scheduling preferences of providers. A simulation model using Arena software is created to verify the linear program, measure resource utilization, and perform scenario analysis. The following step is validation and verification of both models. Lastly, a user interface built within Excel provides the end-user with the ability to both modify and run ProSkedge, and allows for implementation at the CBOC. Ultimately, the model and user interface create an easily accessible and interpretable system to aid clinics in implementing a patient-centered care model and making future decisions on care management.

Linear programming is a mathematical optimization technique that can provide robust solutions to complex problems and is the foundation of ProSkedge. The model, comprised of two linear programs, is built into a Microsoft Excel 2007 spreadsheet and solved using the Excel Solver add-in. The first linear program generates a feasible provider schedule by maximizing individual provider scheduling preferences, subject to numerous constraints which include room availability, administrative and triage period requirements, and minimum numbers of providers in clinical duty. The second model calculates patient throughput given the recommended schedule output by the first linear program. This model is constrained by available provider time (calculated using the first model's schedule output) and the patient mix percentages required by the PACT initiative.

A simulation model mimics system behavior in accelerated time so that experiments can be conducted to provide a better understanding of system behavior under a given set of conditions. A simulation model developed in Arena is used in this project to verify the linear programming models and to perform scenario analysis. The schedule generated by the first linear programming model is input to the simulation via Arena's "schedule" tool.

Scenario analyses are performed using the simulation model to better understand the impact of extended operating hours, additional examination rooms, additional providers, and patient mix on potential patient throughput. Each scenario is first run in ProSkedge, and then though 100 replications in the Arena simulation model. Patient throughput values from ProSkedge and Arena are compared statistically with hypothesis tests to observe the differences between the model and the actual clinic. Resource utilization is captured by the simulation to understand how well the schedule generated by ProSkedge allows for best provider utilization.

The scenario analyses resulted in four major findings when compared to a base model. First, the greatest throughput increase occurs when the number of providers was increased by two (a 22% increase). Second, with the addition of one exam room, a 12% throughput increase was observed, but a room increase to two did not improve throughput further. Thus, there is a benefit in patient throughput with the transition of one room to an exam room, but adding additional rooms does not impact throughput. Third, increasing the operating hours each day by one hour increased throughput by 12%. Similarly, a fully-staffed Saturday clinic resulted in a 20% increase in patient throughput. Last, an increase in the percentage of new patients significantly negatively impacted patient throughput, resulting in a 10% overall decrease due to the longer appointment times required.

In addition to the project's main objective of developing a provider scheduling tool, additional factors may improve other operational issues faced by the CBOC. Through observations and discussions with CBOC staff, one opportunity for improvement is to decrease the need for physical room readjustment. This can be done by limiting the number of rooms to which a provider may be assigned and also standardizing the layouts of exam rooms. Also, patient flow may be improved after time studies are performed and appointment preparation time is better understood. This will aid in scheduling patients more efficiently and improving the flow of patients over the course of the day. Lastly, checklists and templates would aid the providers in ensuring that all steps are completed, reducing the time necessary to write up encounter notes, and making notes written by other providers more easily transferable.

ProSkedge provides the Worcester CBOC with a tool to identify potential provider schedules conducive to maximum throughput and also the ability to benchmark potential throughput with actual patient throughput. Adjustments to ProSkedge inputs can be easily made as the CBOC grows and new operating constraints surface. The conclusions and recommendations summarized here are detailed in the full report.

1 Introduction

In an effort to incorporate the Patient-Aligned Care Team (PACT) model, the Worcester Community-Based Outpatient Clinic (CBOC) is experiencing resource scheduling and utilization challenges. These challenges are a result of uncertainties in specialist schedules and patient demand as well as physical space availability. This project provides a planning tool to the CBOC staff to improve resource scheduling by integrating a linear programming (LP) approach with a discrete-event simulation model. The ultimate goal of this report is to apply successful techniques to the resource scheduling and utilization problems experienced by the Worcester CBOC in such a way that they will prove useful in practice.

This report first contextualizes the specific problems being faced by the Worcester CBOC. A literature review follows providing findings on resource scheduling and utilization problems facing healthcare. The review then compares the benefits and functions of existing solution methods including simulation, linear programming, and combination models. A methodology section outlines the steps of data collection, modeling building, and model verification and validation leading up to implementation. Following this section, a description of each model and the scenario analyses using these models is provided. Additional suggestions based on team observations of the CBOC are outlined prior to conclusions and future recommendations.

2 Background

An understanding of the Department of Veterans Affairs and the Patient-Centered Medical Home model is necessary to provide a backdrop for discussion of the specific situation at the Worcester CBOC requiring the resource utilization and scheduling tool. Organized into three sections, this section will introduce the reader to the Department of Veterans Affairs (2.1), the Patient-Centered Medical Home concept (2.2), the implementation of this concept at Community Based Outpatient Centers (2.3). A subsection of 2.3 describes the specific situation in the Worcester, Massachusetts facility (2.3.1).

2.1 Introduction to the Department of Veterans Affairs

The United States Department of Veterans Affairs (VA), a comprehensive veteran assistance program, is a government-run, military benefit system. A 2010 study of the VA performed by the National Center for Veterans Analysis and Statistics confirmed that the organization consists of

153 hospitals, 260 veteran centers, 57 regional offices, 131 national cemeteries, and 773 Community Based Outpatient Centers (CBOCs). A CBOC is medical facility that enables patient access by providing care closer to where veterans reside separate from the parent VA hospital in the area. The department employs slightly over 300,000 workers nationwide. Additionally, there are over eight million enrollees in the VA health care system out of 23 million current projected U.S. veterans, of which 8% are female. ("VA Benefits & Health Care Utilization", 2010)

2.2 The Patient-Centered Medical Home

Patient-centered medical home (PCMH), a concept first introduced in 1967 by the American Academy of Pediatrics (AAP), is a model of managed care which fosters patient-provider partnerships to improve care delivery. The implementation of such a model should fundamentally focus on access to continuous, comprehensive care by a dedicated personal physician. (American Academy of Family Physicians, 2007) It has been implemented in some capacity in almost every state of the United States, and because of the 2009-2010 health care reform debates, there is some urgency to determine the feasibility of the PCMH model (Nutting, 2009). The concept was studied in 2006 in the National Demographic Project, launched by the American Academy of Family Physicians. Six lessons concluded from the study are as follows: (1) change requires a transformation of the organization instead of small changes within it; (2) patient-centered medical homes are distinct yet interdependent and require new scheduling and access arrangements; (3) the information technology required to make the transition is quite complicated; (4) the transition requires all doctors and staff to be willing and able to alter current work methods into a more team-based atmosphere; (5) organizations must have a stable structure to maintain operations, but also an ability to be adaptive to thrive upon change; and (6) the change is a local process (Nutting, 2009).

These conclusions led to guidelines and suggestions for success with the PCMH transition. The guidelines include ensuring adequate financial sources for the changes, implementing PCMH in such a way that suits the organization, and providing assistance to each physician to improve their methods of delivering primary care. To achieve success, clinics are encouraged to set realistic goals and timelines for implementation and create a change plan that is responsive and flexible to allow for the transformation to take place in the unique practice atmosphere. (Nutting, 2009)

The transition to PCMH has been rather rushed in an effort to quickly improve health care delivery. There are several cultural and organizational challenges associated with such a transition. Some physician interviews suggested that smaller organizations have more difficulty than larger organizations in assuring that patients receive the systematic assessments, education, and group support that the PCMH concept encourages. Another potential barrier is the development and maintenance of new operational processes and information systems to improve access and communication, patient care coordination, and data to provide for future evidence-based decisions. (Berenson et al., 2008)

2.3 The PCMH Model at VA CBOCs

The VA is in the process of implementing a PCMH environment within its CBOCs, denoting the model as a Patient Aligned Care Team (PACT) model, by October 2011. As a result of this transition, the expectation is that clinics will be better able to meet the needs of a growing veteran population and changes in veteran needs.

2.3.1 PACT Transition at the Worcester CBOC

The Worcester CBOC is made up of eight primary care providers, including two nurse practitioners and six physicians. In addition to these providers, there is also other support staff on site and various specialists that visit the clinic on a scheduled basis to provide additional care services to patients. The CBOC, with the support of this staff, began discussions about the concept and started progressing toward the achievement of PACT goals in early 2010.

The facility faces a number of challenges as it transitions to a PACT. Some of these include: (1) providers are unable to coordinate group visits and/or telephone calls to patients because of uncertainties such as others' vacation time in their schedule as well as finding provider time to facilitate the visits; (2) visiting specialists' schedules can disrupt work and administrative schedules of on-site providers; (3) providers are using personal time to complete required visit documentation for established patients; and (4) approximately 100 new patients per month are being added into the Worcester CBOC alone, and this number is expected to grow as more veterans return from Iraq and Afghanistan. These intricacies have somewhat stagnated the transition process at the Worcester CBOC.

3 Problem Definition

The Worcester CBOC seeks to improve scheduling practices of care providers to enable the transition to a managed care model and allow for enhanced patient access. Patient access is challenged by physical space constraints, growing patient demand and predictable yet variable specialists' schedules. A planning tool, named ProSkedge in this report, is built to aid in provider scheduling. An Arena-based simulation model incorporates ProSkedge's results to determine utilization of resources considering the various complexities at an outpatient clinic and the transition to a PACT environment. Following this literature review, the planning tool is discussed in detail.

4 Literature Review

There is much pressure for health care providers at all facilities to provide high-quality and efficient care because of the high cost associated with medical care. Cayirli and Veral (2003) explained that outpatient services are becoming more essential as medicine practices require shorter lengths of stay and preventative medicine begins to play a larger role in society. Thus, researchers are searching for new techniques to improve scheduling and efficiency in outpatient clinics. This literature review is organized as follows: in Section 4.1 we broadly examine the problem of resource scheduling and utilization, identifying the applications of solutions at different facilities under different conditions; Section 4.2, organized in subsections, is a discussion of the techniques used to develop the aforementioned solutions, specifically simulation only (4.2.1) and linear programming/optimization only (4.2.2) solutions (see Appendices A and B for a justification of the reasons simulation and optimization techniques are reviewed here). These reviews are then followed by hybrid approaches (4.3). Finally, Section 4.4 presents our conclusions based on the review.

4.1 Resource Scheduling and Utilization: A Common Problem

Resource scheduling and utilization is not a unique problem to the Worcester CBOC. One of the earliest research studies on this topic examined staffing policy changes and their effect on current bottlenecks in an outpatient family planning clinic (Alessandra et al. 1978). The clinic operated in such a way that patients had to move through four major work stations and two main waiting areas to where employees were located. Patient flow and staff management was improved through decisions justified by scenario analyses. This study was one of the first to showcase the use of sophisticated analytical techniques in health care delivery planning.

Kumar and Kapur (1989) addressed similar scheduling problems within the setting of Georgetown University Hospital's emergency room (ER) with an emphasis on scheduling nursing staff. This particular ER "[was] a complex probabilistic system treating both trauma (15%) and non-trauma patients (85%) twenty four hours a day" (Kumar & Kapur, 1989). Because workload and system behavior within such an ER is very dynamic in nature, nursing staff scheduling became very difficult and attaining optimal resource utilization was nearly impossible without the correctly applied solution and numerous scheduling alternatives examined. As a result of various types of experiments performed on the scheduling of the nursing staff, a feasible cost effective schedule was produced and implemented

Wijewickrama and Takakuwa (2005) addressed the problem in an outpatient department of internal medicine. This facility was experiencing long treatment waiting times and rushed consultations with the providers. The outpatient department operates from 8:30am to 5:30pm on weekdays and treats four patient types including appointed patients, walk-ins, exam patients, and new patients. Appointed patients made up the largest percentage of these. One issue that added to the complexity of the resource scheduling and utilization problem at this particular facility was identifying the effects of no-shows, consultation time variance, and walk-ins. The study outcome was efficient appointment schedules which reduced patient waiting time and kept provider idle times as low as possible without additional resources.

4.2 Methods for Solutions to Resource Scheduling and Utilization

4.2.1 Simulation Approaches to Scheduling Optimization & Utilization Maximization

Simulation models mimic system behavior in accelerated time. It is the process of designing and creating a model of a real or proposed system for the purpose of conducting numerical experiments to provide a better understanding of the behavior of that system for a given set of conditions. (Law & Kelton, 1999; Kelton, Sadowski, & Sturrock, 2007) In terms of this project, discrete-event simulation, a simulation in which a system's state or a variable within the system changes at discrete points in time, is examined. For further information on simulation or discrete-event simulation in particular, the authors refer the reader to Law and Kelton's *Simulation Modeling and Analysis* (1999), Ross's *Simulation* (2006), Pooch and Wall's *Discrete Event*

Simulation: A Practical Approach (1993), and Fishman's *Discrete-Event Simulation: Modeling, Programming, and Analysis* (2001). For additional reviews of discrete-event simulation approaches to health care problems, the authors refer the reader to Jacobson, Hall, and Swisher's article "Discrete-Event Simulation of Health Care Systems" (2006).

Simulation is well suited for modeling complex systems and is commonly used to approach utilization problems. This is particularly true in the health care industry because of its ability to model interactions between care provider and patient and to allow for in-depth scenario analysis. Côté (1999) studied a family practice clinic providing various outpatient services. Patient load oftentimes extended beyond the operating hours of the clinic. Côté developed a discrete-event simulation model written in SIMAN IV to determine the steady state condition of the clinic's operations. The author concluded that taking advantage of known patient flow paths and estimating service distributions allowed a discrete-event simulation model for even a small outpatient clinic to provide valuable analysis. For this reason, simulation is an appropriate quantitative tool to offer sound insight into decisions related to operations.

Guo, Wagner, and West (2004) similarly explored the benefits of simulation but in terms of determining triage prioritization rules to better utilize providers at a children's hospital. A staff of only six physicians, despite growth in patient demand, successfully decreased appointment backlog with a new scheduling system. In order to better understand the operational variables that affect patient flow and waiting times as they relate to resource schedule utilization, a model was created. It incorporated external appointment demand, available provider time, patient flow paths, and scheduling algorithms. The added intricacy of nine appointment types and provider preferences of individual patients was evidence that provider availability was highly variable with weekly appointment slot availability. To optimize the scheduling algorithm currently based on the level of urgency of an appointment, a simulation model using Arena software was developed. A Visual Basic module accessed and modified a Microsoft Access database housing provider schedules. This research corroborates Côté's conclusion that simulation models are well suited to represent complexities and interactions and can be used as a support tool to make evidence-based decisions.

More recently, Santibanez, Chow, and French (2009) provided a framework to address significant challenges regarding space constraints and resources within a cancer care outpatient ambulatory care unit (ACU). Overcrowding and appointment delays had caused the ACU to experience office and examination room shortages. Patient volume was also expected to increase. The authors examined the simultaneous impact of patient and resource scheduling changes on the operational system by constructing a realistic discrete-event simulation model with Arena simulation software. The model incorporated various distributions for processes within the system, a first-in, first-out (FIFO) queuing rule, and sudden changes in operating hours to ensure all scheduled patients for a day would be seen. Operational, appointment scheduling, and resource allocation factors investigated during scenario analysis led to the conclusion that the discrete-event simulation model provided valuable insight into which of these factors would lead to more favorable operational states.

4.2.2 Linear Programming Approaches to Scheduling Optimization

Mathematical optimization techniques used to model hospital scheduling policies can be seen in many studies. Compared to simulation models, these techniques provide robust mathematical solutions. Lau and Lau (1999) built an outpatient and medical operating room optimization model using linear programming methods off of previous research that had been done using stochastic appointment length. Their model defines total cost given a known schedule. With the objective to minimize total system cost per time unit, the investigators had to consider the following parameters: the number of scheduled appointments, visit length, and arrival rate. Arrival and service distributions were estimated using a four-parameter Beta distribution. This knowledge was used to output an optimal schedule based on arrival sequence resulting in a model that defines appointment schedules to minimize total system cost.

Robinson and Chen (2002) also make use of linear programming to solve resource scheduling and utilization problems. A model was created to aid in optimal scheduling of doctor time with the underlying complexity of random service time. By dividing the working day into equal sections and assigning patients to the beginning of each block, service time rates could be assumed to be identically distributed and therefore able to obtain a more realistic model for scheduling. A heuristic, created to compare different numeric instances, allowed for defining “job allowances” based on optimizing patient time given the realistic assumption that service times were not uniform. For this reason, the authors believe the approach of using linear programming could be used in different facets of hospital planning.

Methods of sole reliance on mathematical optimization techniques can be further examined in the work of Denton, Viapiano, and Vogl (2006). Stochastic optimization was used to determine scheduling and optimization of time and resources in the operating room because of its ability to incorporate visit length uncertainty. Upon the definition of a sequencing rule of given surgery duration variance that can be used in optimizing staff wait times and overtime costs, a two-stage stochastic recourse model was created so that the modelers could input a known surgery sequence to output schedule times. The model optimized scheduling based on waiting time, idle time, and tardiness. The best resultant schedule came from sequencing surgeries within surgeon blocks in order of increasing duration variance.

The complexity of considering various critical factors, such as appointment length, the number of beds, and nursing staff availability, is investigated and solved through a mixed integer linear programming model by Adan, Bekkers, Dellaert, Vissers, and Yu (2009). The case study indicates that master appointment schedules could be generated while also more closely matching target utilization levels set for the numerous resources by considering length of stay either stochastic or random. A master schedule satisfying specified performance criteria is the goal of the study. Based at a tactical level, the researchers are most interested in number of scheduled appointments per day; therefore, patient waiting times and appointment lengths beyond the scheduled block are able to be ignored because the schedule will not be an operational one. Mathematically, the model minimized over- and under-utilization of resources while determining the optimal number of patients of different types to be serviced in a set period.

4.3 Hybrid Approaches to Scheduling Optimization

Some researchers integrate the results of linear programming solutions with simulation to substantiate results and to investigate the effect of varying scenarios on the linear programming output. Centeno et al. (2003) developed a hybrid model by coupling simulation with an integer linear programming model to decrease hospital costs by optimizing staff utilization in an emergency department. A hybrid model was used because the authors found that strictly mathematical approaches to modeling lacked the holistic output of values for use in real-world problems while simulation approaches did not always handle the true complexity of the system effectively. The integer linear programming model, developed in LINGO, generated the optimized staff schedule that was input into the simulation model, created in Arena, which defined staff requirements per period. The modelers integrated the two models in a Visual Basic interface because it allowed for a simple, yet powerful tool to dictate an optimal schedule and staff level based on set visit lengths given demand and service times.

Patrick and Puterman (2006) conducted a comparable study on optimizing resources and minimizing wait time in a hospital CT scanning department given uncertain demand and priority levels. However, unlike the models presented previously, Patrick and Puterman first created a linear programming model to optimize resource overtime and then used Arena simulation to validate the model and perform scenario analysis to study the impact of increased capacity and service time length change on the system.

A recent hybrid approach to optimization in hospitals was used by Takakuwa and Wijewickrama (2008) to decrease waiting time in hospital outpatient centers while at the same time optimize staff time to eliminate the need for additional resources. Like Centeno et al. (2003), Takakuwa and Wijewickrama believed simulation would best be able to handle complex hospital interactions than a mathematical model alone. Simulation models offer the ability to compare objective functions against different scenarios, which enabled Takakuwa and Wijewickrama to analyze such relationships as average patient waiting time to different staffing levels.

4.4 Conclusions

This review leads to two important conclusions. First, resource scheduling and utilization problem at the Worcester CBOC is not unique. The review revealed that various types of facilities, specifically and outpatient clinics, face uncertain scheduling challenges due to the implementation of more patient-centered models of care. Second, linear programming and simulation are both sound techniques used to analyze scheduling practices in an outpatient health care environment (see Appendices A and B). However, hybrid models have proven to be more applicable to the problem addressed in this report as they are able to handle more complexity than either individual solution. Hybrid models are also able to allow for more accurate and in-depth scenario analyses as they incorporate the benefits of each individual solution.

5 Methodology

5.1 Introduction to the Planning Tool

The planning tool will be developed following the framework outlined in Figure 5-1 and will be called ProSkedge, an abbreviation of Provider Schedule. The Arena simulation model (see Section 7) will represent operational reality at the Worcester CBOC. The linear program (see Section 6) will be verified to generate optimal or feasible solutions based on CBOC constraints and will become the foundation of the tool. Note that the simulation model, while an important part of testing the output of the linear program, is not a part of the planning tool itself. A user interface (see Section 8) is built using Visual Basic macros to create functionality and to allow user modifications to linear program settings. These pieces create the planning tool, ProSkedge, which is the ultimate deliverable of this project and is developed by the methods described below.

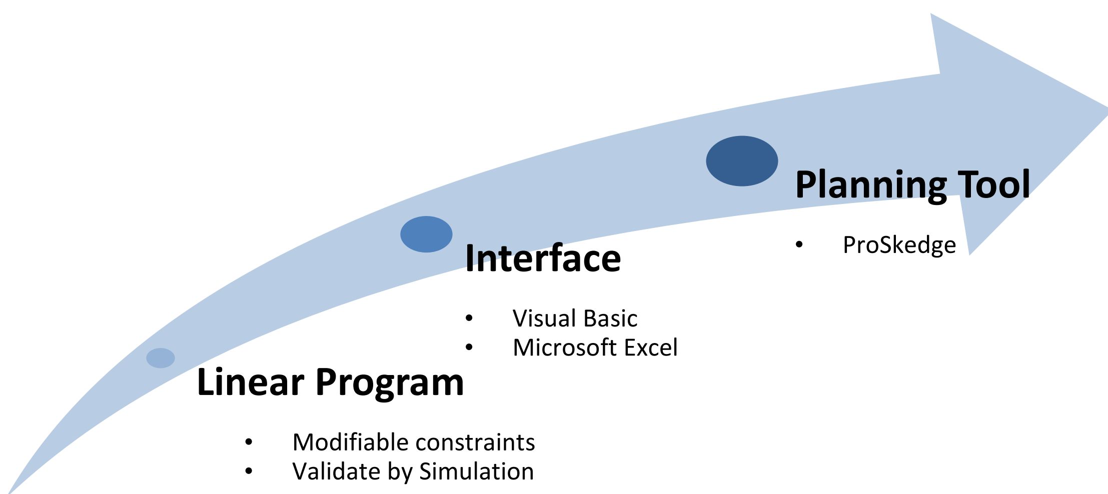


Figure 5-1. Schematic of Planning Tool, ProSkedge

5.2 Phases of Methodology

The method of developing and implementing ProSkedge to be used for scheduling and resource optimization at the Worcester CBOC includes six phases as depicted in Figure 5-2. The ultimate goal is to implement a fully working resource planning tool based on a combination model integrated with Microsoft Excel and accessed through a user-friendly interface for Worcester CBOC staff use in Winter 2011.

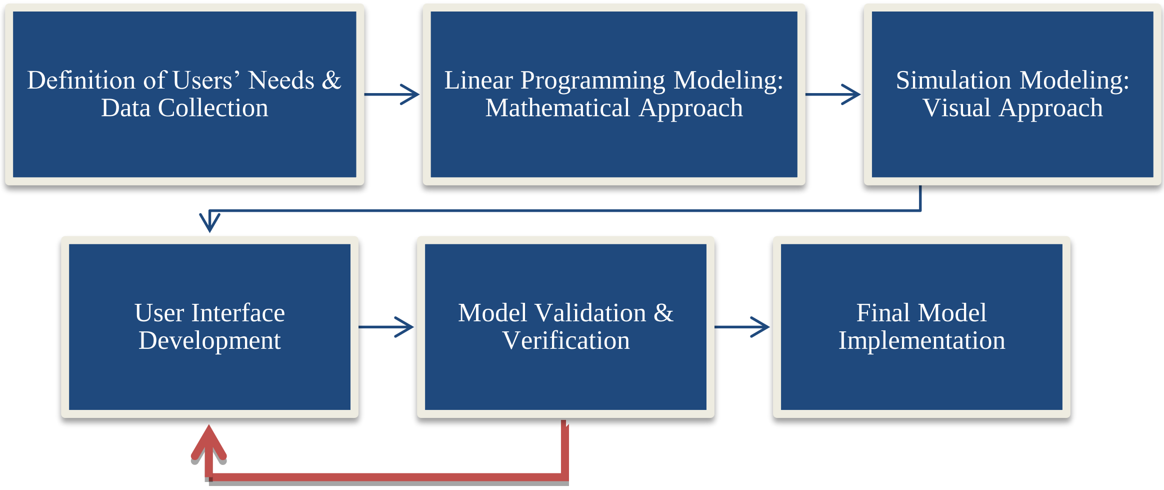


Figure 5-2. Methodology Flow Chart

The initial phase is data collection, which serves two purposes. The first is to define user needs and model parameters; the second is to provide the modelers with a significant understanding of patient flow logic and clinic operations. Physician and specialist schedules will be gathered with the assistance of CBOC staff to aid in the modelers' understanding of staff availability per period. Basic data, such as the number of providers, nurses, and exam rooms, will be collected through discussions and interviews with the CBOC staff.

Steps two through four of the project will involve the physical model creation. The first will be a linear programming model to maximize the scheduling preferences of providers. Known constraints include working hours per period, specialist schedules, and number of exam rooms. This model will output a feasible schedule for providers based on known constraints. A simulation model will be designed simultaneously to further analyze the impact of the optimal provider schedule generated by the linear programming model. This simulation model will also be used for scenario analyses such as varying operating hours, adding Saturday clinics, and increasing the number of providers. A user interface will be created during the final step of model development for ease of use by CBOC staff.

The linear program and simulation model will be validated. This entails collaboration with the CBOC staff, particularly those who will be using the tool. If the presented model does not meet the requirements and expectations originally set by the CBOC staff, modifications will be made and validation meetings will continue until discrepancies are corrected. As validation occurs, verification will also take place to ensure the model is accurately representing the true operational characteristics at the Worcester CBOC. Verification will take place using statistical hypotheses testing to compare the linear program and simulation model results. Section 9.3 details these tests. Again, if any problems are found within the model, alterations will be made to correct them until the model satisfactorily represents operational reality. Once the verification and validation process have ended, ProSkedge will be implemented for use at the Worcester CBOC.

A Gantt chart (see Appendix C) serves as a reference for the implementation of this methodology.

6 Linear Programming Model Development & Description

6.1 Provider Schedule Planning Tool

A linear programming model is constructed as the basis of ProSkedge, the planning tool to be used by the Worcester CBOC. The model is built into a Microsoft Excel spreadsheet and solved using the Excel Solver add-in. The linear program is the foundation of the planning tool because, not only are the results fed into the simulation model for verification and analysis purposes, it is also the final tool that will be used at the CBOC to schedule providers in such a way that adherence to the guidelines of the PACT model will be possible.

The objective of the linear programming model is to determine which providers to schedule for clinical time given various constraints. A binary decision variable represents whether a specific physician is scheduled in a particular time slot. Representing the provider is the index i. Providers are scheduled into morning and afternoon blocks. The CBOC operates in this way, scheduling appointments into morning and afternoon shifts for the five work days of the week. This creates ten scheduling blocks or periods per week. Time is represented in the mathematical model by the index j. In this model, j is equal to an odd integer to represent the morning shifts (i.e. Monday morning = 1, Tuesday morning = 3, etc.) and j is equal to an even integer to represent the afternoons (i.e. Monday afternoon = 2, Tuesday afternoon = 4, etc.).

$$x_{ij} = \begin{cases} 1 \; if \; provider \; i \; is \; scheduled \; during \; period \; j \\ 0 \; if \; provider \; i \; is \; not \; scheduled \; during \; period \; j \end{cases}$$

Maximizing provider preference is the most relevant objective for this model due to the nature of the problem. The benefit of including a preference score into the linear programming model is two-fold: first, specialist availability can be considered directly in the objective function; and second, the preference score allows providers to select when he/she would prefer to be working in triage or completing administrative work. The provider preference matrix for this linear programming model includes values of 0, 1, or 2 for each time block where 0 = provider strongly prefers to not be scheduled, 1 = provider has no preference, and 2 = provider strong prefers to be scheduled. These values can be altered by the decision-maker. Where p_{ij} is the preference of provider i to be scheduled during period j, the objective function can be expressed as shown in Equation 1.

$$Maximize \sum_i \sum_j p_{ij} x_{ij} \qquad (1)$$

Constraints are then identified through communication and collaboration with CBOC staff. A common, although not exclusive, feeling throughout the CBOC is that a major constraint in provider scheduling is room management. With a finite number of rooms, only a specific number of providers can be scheduled for clinical time during the same period which is then complicated by the fact that some providers and specialists require more than one room. Simply put, the number of rooms utilized in any given period must be less than total rooms fit for use (R). The number of rooms required by provider i during period j is represented by r_{ij}. See Equation 2.

$$\sum_i r_{ij} x_{ij} \leq R \ \forall j \qquad (2)$$

An additional constraint is managerial in nature – providers are required to be “off,” or not scheduled for clinical duty, for a number of periods per week specified by the clinic so that providers are given time for administrative work. The number of periods off from clinical duty for administrative time varies between clinics. At the Worcester CBOC, providers are also expected to work one period in triage every other week.

At this point, it is necessary to note that the linear program will be run in one week intervals which are ten blocks long. The planning horizon requested by the CBOC is one month. Therefore, the program runs four consecutive times and the administrative and triage time constraint is modified based on which replication the model is running. Assume J is the number of periods in the week, A is the number of periods off required for administrative time, and T is the number of periods off required for triage every other week. This constraint is expressed in Equation 3.

$$\sum_j x_{ij} = \begin{cases} J - A \text{ } if \text{ } provider \text{ } i \text{ } was \text{ } not \text{ } scheduled \text{ } for \text{ } J - A \text{ } in \text{ } the \text{ } previous \text{ } iteration \\ J - A - T \text{ } if \text{ } provider \text{ } i \text{ } was \text{ } scheduled \text{ } for \text{ } J - A \text{ } in \text{ } the \text{ } previous \text{ } iteration \end{cases} \forall i \qquad (3)$$

The final constraint, shown in Equation 4, ensures the model does not generate a feasible schedule in which there are periods where no providers are assigned to clinical duty (where Σx_{ij} $\forall j = 0$). Assume M is the minimum number of providers that should be scheduled during each period j. Because of the precision and convergence settings in Excel Solver, some decision variables are represented by values such as 0.9999995 or 0.99999975. These values are rounded up to 1 for the purposes of this constraint.

$$\sum_i x_{ij} \geq M \; \forall j \qquad (4)$$

The above model generates a master provider schedule that satisfies the constraints of the available number of rooms for appointments and of required work outside of regular clinical duty.

6.2 Patient Mix/Total Throughput given Optimal Provider Schedule.

Delivering quality care to a large amount of people is one objective of the PACT managed care program. For this reason, a second model is developed to determine, based on the PACT recommended patient mix, the number of patients that could be expected to leave the system given the optimal provider schedule generated in the first model. The objective function is set to a value of 1 (see Equation 5) as it is unimportant to our goal to maximize or minimize any specific variable.

$$Maximize \; 1 \qquad (5)$$

Three patient types are examined in this model: new patients, established/return patients, and phone visit patients. Each type requires a different scheduled length of appointment. PACT also strongly recommends certain goals regarding the percentage of each patient type that should be serviced in a given period of time. The decision variable then becomes s_k which is the number of patients of type k serviced in a specified period. Assume a_k is the appointment length for a patient of type k. (Recall the index j from the first model as a representation of time period where mornings are oddly numbered and afternoons are numbered with even integers.) The total scheduled appointment time for all scheduled patients of any type cannot exceed but should equal the total time of all available/scheduled providers. This is expressed in Equation 6. Assume that L is the length of the time block in minutes.

$$\sum_k a_k s_k = \sum_{odd\ j} \left(L \sum_i x_{ij} \right) + \sum_{even\ j} \left(L \sum_i x_{ij} \right) \qquad (6)$$

The last constraint of this second model aims to force the percentage of patient types to be serviced as recommended by PACT guidelines and is represented by Equation 7. Assume P_k is the percentage of patients of type k and S_k is the total of all patients of each type k serviced (s_k).

$$S_k = P_k \sum_k s_k \ \forall k \qquad (7)$$

6.3 Complete Linear Program

Model 1, Provider Schedule Planning Tool

$$Maximize \sum_i \sum_j p_{ij} x_{ij}$$

$$subject\ to$$

$$\sum_i r_{ij} x_{ij} \leq R\ \forall j$$

$$\sum_j x_{ij} = \begin{cases} J - A\ if\ provider\ i\ was\ not\ scheduled\ for\ J - A\ in\ the\ previous\ iteration \\ J - A - T\ if\ provider\ i\ was\ scheduled\ for\ J - A\ in\ the\ previous\ iteration \end{cases} \forall i$$

$$\sum_i x_{ij} \geq M\ \forall j$$

Model 2, Patient Mix/Total Throughput

$Maximize\ 1$

$subject\ to$

$$\sum_k a_k s_k = \sum_{odd\ j}\left(L\sum_i x_{ij}\right) + \sum_{even\ j}\left(L\sum_i x_{ij}\right)$$

$$S_k = P_k \sum_k s_k\ \forall k$$

7 Simulation Model Development & Description

7.1 Model Overview

A model of the Worcester CBOC patient and provider interaction flow was created using Arena Software by Rockwell Automation Technologies, Inc. (Version 12.00.00 – CPR 9, 2007). This model serves two major purposes: linear programming model verification and scenario analysis. Screenshots of the individual process modules described in this section can be found in Appendix D. The overall model can be seen in the following screenshot.

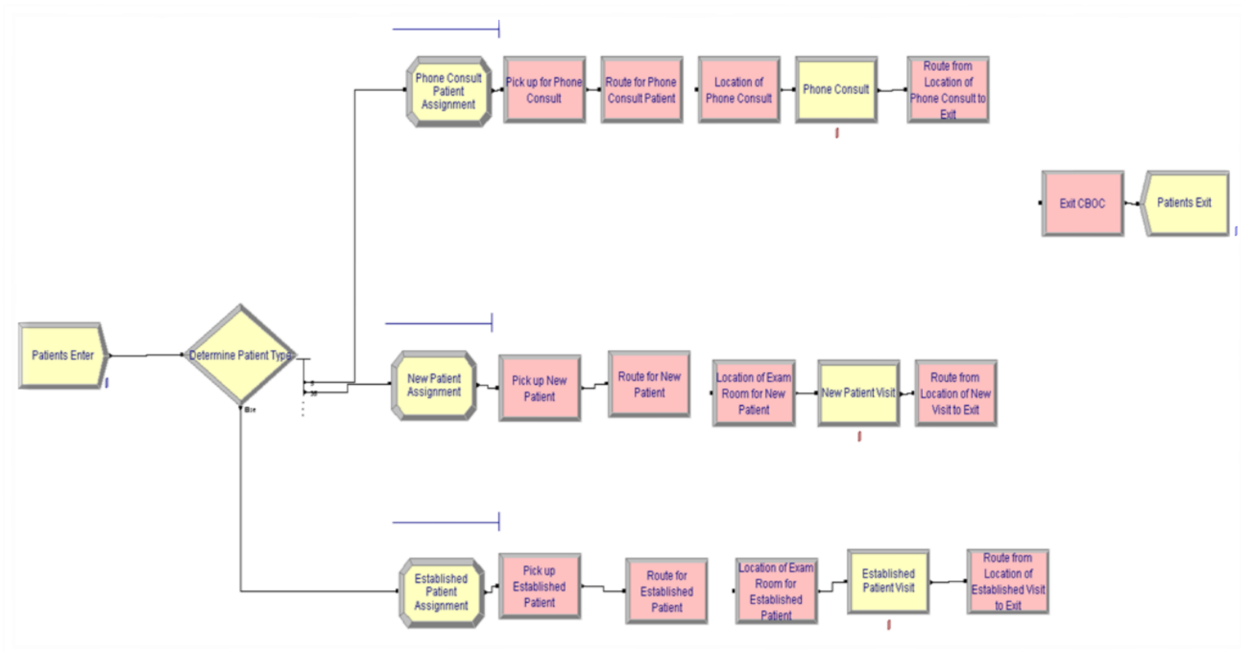


Figure 7-1. Simulation Model Flow Chart

7.2 Model Creation

The Arena model captures patient flow for each major type of provider visit – phone consult patients, new patients, and established patients – to match the variables in the linear programming model. It was created using "create," "process," "decide," "record," "dispose," "station," and "route" modules. The following describes the major flow in the model and describes how process modules support the model at hand. The overall flow of the model can be seen in Figure 7-1.

7.2.1 Patient Entry Module

Patients enter the model using "create" modules for each visit type. Given that the ultimate goal of the linear programming model is to maximize patient throughput based on a recommended provider schedule, patient arrivals do not need to follow a specific arrivals distribution. A distribution based on historical data will limit the number of patients flowing through the model, and may "starve" providers. For this reason, each patient type is based on a constant time between arrival distributions of one minute between arrivals, with an infinite maximum arrival, starting at time 0. A screenshot of the process window for patient entry is provided in Appendix D Figure 2.

7.2.2 Patient Type Decision – Determine Appointment Length

Next, patients enter a "decide" module to separate incoming patients (entities) into the three patient types considered in the linear programming model by the visit percentages set as a constraint in the linear programming model. This is performed by N-way chance separation, separating five percent of patients to be phone patients, 35 percent to be new patients, and the remainder to be established patients. These percentages were set to match the percentages set in the linear programming model to meet PACT standards. The decision window for "Determine Patient Type" is shown in Appendix D Figure 3.

7.2.3 New Patient or Primary Care Patient Flow

Patients are next assigned to their patient type (phone, new, established) through an "assign" module. This module changes the entity type to the patient type as well as the image associated with the entity. Figures 4, 5, and 6 in Appendix D represent the assignment of patient type to each patient entity.

Next, patients enter a "station" module to place them in the simulation model. Each patient type has a distinct station with which to begin. See Appendix D Figures 7, 8, and 9.

Patients then enter a "route" module to move them in the simulation to a new station to "meet" the provider. The route transfers the patient from the designated "pick up" station to the examination room in this step. Note the route time is set for two minutes to reflect the time it takes on average to move within the facility; this also allows for patient visibility along route tracks in the simulation. Appendix D Figures 10, 11, and 12 show the windows for the three different routes and Figures 13, 14, and 15 represent the second set of stations.

At this point, patients considered a phone consult patient continue to a "process" module that "seize, delay, and releases" a provider for a constant time of 5 minutes. New patients move on to a process module that "seize, delay, and releases" a provider for a constant time of 60 minutes, representing the 60 minute block for a new patient appointment. Established patients move on to a similar process module that "seize, delay, and releases" a provider for a constant time of 30 minutes, representing the half hour appointment for established patients. Process module screenshots can be found in Appendix D Figures 16, 17, and 18 for phone consult, new, and established patients respectively.

After being consulted by the provider through the process modules, patients then follow another route module to take them to the exit of the CBOC. The windows for the three different routes and then station for the exit can be found in Appendix D Figures 19, 20, 21, and 22.

7.2.4 Exit Module

All patients leave the model through a "dispose" module. The dispose window for "Patient Exit" can be seen in Appendix D Figure 23.

7.2.5 Simulation Animation

To reflect the outcome of the process flowchart in a simulation, an image of the facility layout is created in Microsoft Office Visio 2007 based off of the exam room map provided by the Worcester CBOC and can be seen in Appendix D Figure 24.

The drawing was placed in the Arena simulation window to allow for the addition of stations and queues. Stations were added from the process flow modules and connected by routes. When simulated, patients flow through the facility layout as they would in real operations. Appendix D Figure 25 displays the simulation above the process flow modules.

7.2.6 Coordination with Linear Programming Model

The output of the linear programming model will be to determine whether or not a provider will be scheduled for given blocks of time. This will be input to the simulation model via the "schedule" tool. Each type of provider has a unique schedule, demonstrating availability per given day of the week. Appendix D Figure 26 provides a screenshot of the process window for "Primary Care Physician Schedule".

7.3 Model Validation and Verification

The team will maintain constant communication with the CBOC staff to ensure the linear programming model meets the reality of the clinic. This will be accomplished by validating model inputs and constraints with CBOC staff to ensure the correct values and components are added to the model. Validation will also include comparing throughput results of the model to current CBOC practices. After the model is validated, it will be verified through use of the simulation model. This will be performed by running a set of scenarios through both models to compare throughput results. Hypothesis testing will be performed to determine if any differences in results between the models are statistically significant. If they are not statistically significantly different, it can be said that the results reflect reality similarly, thus validating the model. Any discrepancies that may arise in the model will lead to linear programming model revisions until the model is proven to be in working condition..

8 ProSkedge: The Working Model

ProSkedge is a linear program able to be modified by a user to suit varying operating states in the clinic environment. These modifications are made through a user interface designed in Microsoft Excel and are linked directly to Visual Basic macros. Schedule generation is performed at the user's command. Figure 8-1 is the tool's welcome screen.

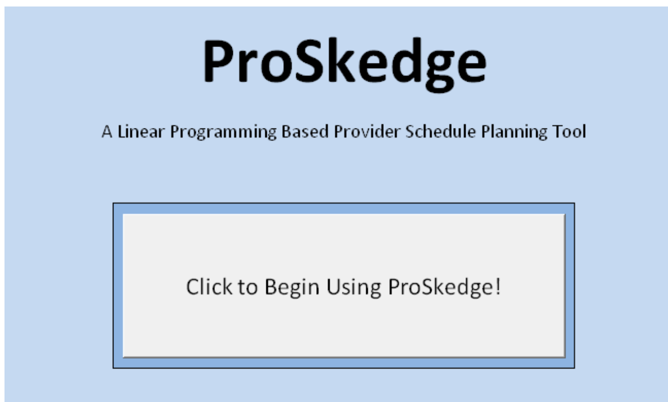


Figure 8-1. ProSkedge Welcome Screen

8.1 User Interface Development & Description

Created in Microsoft Excel 2007, the user is able to modify various parameters of the linear programming model. The main input page is shown in Figure 8-2.

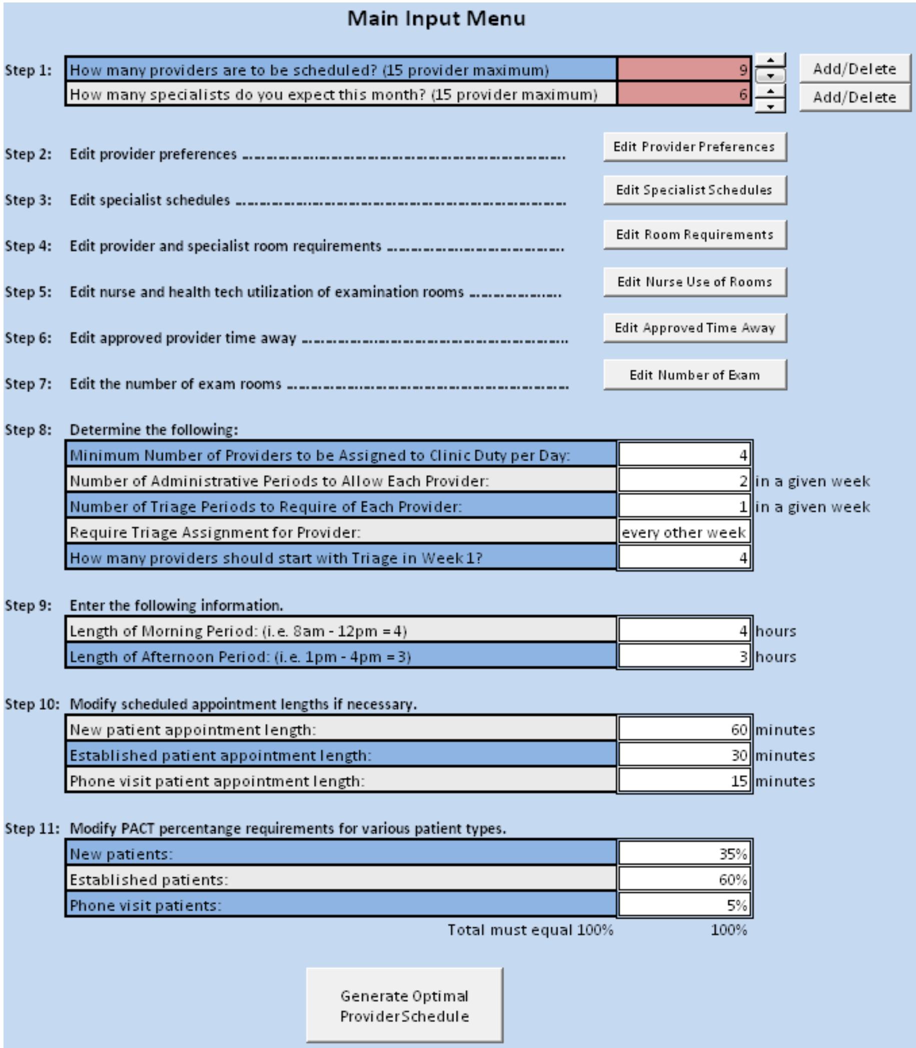


Figure 8-2. ProSkedge Main Input Menu

Provider preferences for working mornings or afternoons for periods of one month is a requirement for the model and is edited through the user interface. The user will be able to define preference on a scale of "0", which means the provider prefers not to be scheduled for clinical duty to "2" meaning high preference for clinical duty. If "0" is selected, this does not mean the provider has time off from work. Instead, this means the provider would prefer to be assigned an administrative or triage period during this time should he or she not be scheduled. See Appendix E Figure 1 for a screenshot of the Provider Preferences input screen.

In a similar manner, time away, which includes approved vacation time or routine time away from the facility, is considered. Time away is represented within the user interface by a "0" for approved vacation time or routine time away from the facility or “1” for expected to be at the clinic. Appendix E Figure 2 is a screenshot of the Time Away input screen.

Specialist schedules may also be modified by the user. The Specialist Schedules input tab (see Appendix E Figure 3) is similar to the Time Away input screen. The user will set each cell to “0” or “1” based on whether the specialist is scheduled to be away from the facility or at the facility respectively.

Providers and specialists may use more than one room for exams in an effort to allow patients to wait in an examination room instead of the clinic waiting room. The number of rooms requested by each provider is critical to the success of generating a feasible provider solution. Appendix E Figure 4 shows the Room Requirements input screen.

The number of rooms available for use by providers and their scheduled patients is also important. This information is located in two different input screens. First, the total number of examination rooms is captured in the Number of Rooms input tab. On this screen, the user can change the number of exam rooms available in the clinic. It is variable on a period by period basis to account for special cause problems (i.e. the plumbing in one examination room causes a room to be unusable on one Wednesday afternoon) in addition to long-term concerns (i.e. one examination has been transformed into a computer room for nurses or a storage room has been turned into an examination room). Nurses also utilize exam rooms for purposes other than patient visits. In this case, the total number of rooms available for patient visits is less than the total number of rooms at the clinic. An expected number of rooms per period anticipated to be in use by nurses for purposes other than patient visits is captured in the Nurse Use of Rooms tab. The default value is zero but each cell can be set to any value that is less than the total number of rooms at the clinic. Appendix E Figure 5 and 6 show the Number of Rooms tab and the Nurse Use of Rooms tab respectively.

The screens described above are accessible from the Main Input Menu. Also on this screen the user can add or delete providers and/or specialists from the model, and alter values such as the number of administrative periods allowed to each provider per week, the length of the morning and afternoon shifts at the clinic, and the scheduled appointment length for various patient types. Once the user modifies the settings of the model as necessary, he or she will click the “Generate

Optimal Provider Schedule" button found at the bottom of the input page. See Appendix E Figure 7 for a screenshot of the input page. When this button is clicked, a Visual Basic macro collects the data that has been edited, modifies the linear programming models, and runs the models in the background. This Visual Basic aspect of the model is discussed in further detail in Section 8.2. Once the models have been solved, the user is immediately taken to the output page that displays the results. Appendix E Figure 8 shows a screenshot of the page on which the schedule generated by ProSkedge is shown. This screen has a "Back to Input Menu" button which will take the user back to the Main Input Menu. The "Throughput Results" button will take the user to the second set of results that provides a benchmark value for the number of patients that could be expected to be seen given the percentage guidelines set by the PACT initiative. This screen is shown in Appendix E Figure 9.

8.2 Behind the Scenes of ProSkedge

Visual Basic (VB) is the driving force behind the workings of ProSkedge. The VB macros are used to perform three major actions: 1) add/delete providers from the model; 2) add/delete specialists from the model; and 3) run the linear program. Dynamically named ranges are used because the user has the ability to add and delete providers and specialists from the model. This ability means that every range of values in the sheets containing the linear programs may change at any time. The addition and deletion of providers and specialists involves adding and deleting rows to the input screens that list the providers and/or specialists. These screens are Provider Preferences, Specialist Schedules, Time Away, and Room Requirements.

The linear programming models are run off of five hidden sheets. They are called Model 1 Week 1, Model 1 Week 2, Model 1 Week 3, Model 1 Week 4, and Model 2. Each sheet contains a separate model that reflects any differences between each week in the planning horizon of one month. The models are run individually in sequential order beginning with Model 1 Week 1 and ending with Model 2 through subroutine calls written into the VB macro.

Excel Solver can be run using a VB macro as long as the Solver add-in is installed in Excel and is referenced by the VB correctly. As noted above, each model has its own subroutine call in VB. For Model 1, Weeks 1 through 4, the decision variable area is cleared and then the Solver requirements are set in the following sequence: 1) objective function; 2) binary decision variable constraint; 3) administrative and triage requirement constraint; 4) room availability constraint; 5) minimum provider constraint; and 6) time away constraint. The time away constraint sets a specific decision variable to “0” if the respective cell on the Time Away input tab is set to “0”. This guarantees that the associated provider is not scheduled for that period that week.

The Solver settings for Model 1 Weeks 1 through 4 are shown in the following Table 8-1.

Max Time	100 seconds
Iterations	100
Precision	0.000001
Assume Linear	False
Integer Tolerance	15%
Auto-Scaling	True
Convergence	0.0001
Assume Non-negative	True

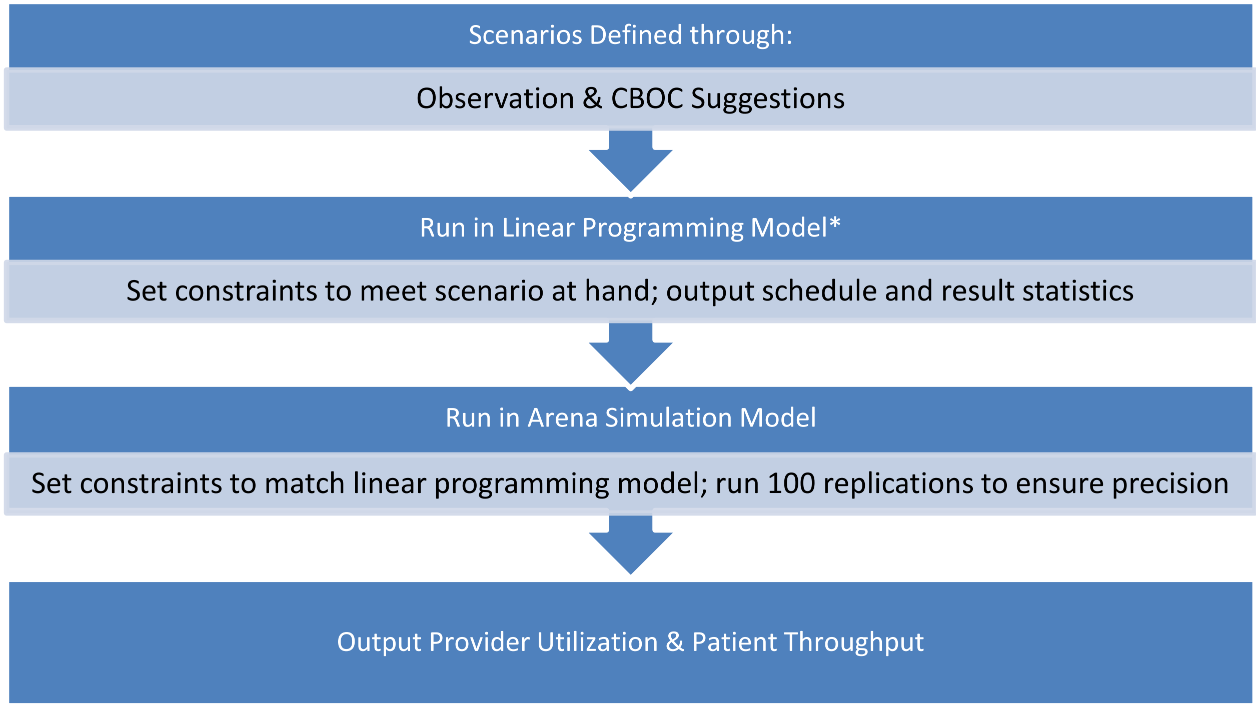
Table 8-1. Model 1 Solver Settings

9 Scenario Analyses

9.1 Scenario Descriptions

Scenario analysis is used to understand the impact of extended hours, number of rooms, number of providers, and patient mix on patient throughput. Each scenario is set up in the user interface to be run through the linear programming model; results will be manually fed into the simulation model. The results from the simulation model serve two major purposes: first, it enables linear programming model verification; and second, it allows for better understanding of inputs on patient throughput and provider utilization. Each scenario is iterated by 100 runs to ensure precise results. The eleven scenarios considered are summarized in Table 9-2.

The steps taken for the scenario analysis can be defined in the following figure.



* Scenarios including Saturday clinics were not run through LP Model

Figure 9-1. Scenario Analysis Process

The first scenario aims to understand the impact of increasing the number of hours providers are available during the regular work week. In order to accomplish this, the clinic hours are increased by one hour during the afternoon block, making each day have a 4-hour morning block and 4-hour afternoon block.

The second set of scenarios analyses to be examined will include those related to the number of examination rooms to understand the impact of room conversion on patient throughput. This is explored through the addition of one examination room in scenario 2 and two additional rooms in scenario 3.

The next set of scenario is aimed at understanding how a change in patient type will impact throughput and utilization. The CBOC is currently in the process of planning a patient merger from the North Hampton CBOC facility; providers are currently considering that this merger will increase the percentage of new patients seen due to additional paperwork requirements per visit. To understand the impact of this merger, scenario 4 increases the number of new patients to 5% and accordingly decreases the number of established patients by 5%. Scenario 5 increases the number of new patients by 10% and decreases established by 10% to consider a greater percentage increase for comparison

Scenarios 6 through 9 look at the impact of creating a Saturday clinic. Scenario 6 and 7 analyze the addition of a half day, or morning block of four hours, for a full staff of eight providers and then a half staff of four providers respectively. Because of the way the scenario run controls are set to reflect full eight hour days to enable provider utilization calculations, it was not possible to set half Saturday clinics automatically in the runs for these two scenarios. Instead, replications of the half Saturday were run for one month for each scenario to reflect the addition of the additional period. These results were added to the base model throughput results for analysis and comparison. Scenarios 8 and 9 examine a full day (four hour morning shift and three hour afternoon shift) for a full staff of eight providers and then a half staff of four providers respectively. Given current constraints on adding periods in the linear programming model, these scenarios were not run through the linear programming model; the schedules were set based on the base model and additional full-day periods and providers set in the scenario description were manually added.

The final set of scenarios investigates the addition of providers to the CBOC. Scenario 10 looks at the addition of one provider, and scenario 11 examines the addition of two.

A base model was also constructed in the linear programming model and run through the simulation model to set a basis for scenario analysis. The settings defined for this base model are defined in Table 9-1.

Base Model	Setting
Provider Preferences	1
Specialist Schedules	1 or 0 (*)
Provider Room Requirements	1 (base line estimation)
# Rooms Required for Nurse Use	0
Approved Time Away	1
# Examination Rooms Available	21*
Minimum Providers Assigned to Clinical Duty	4
# Administrative Periods per Week	2*
# Triage periods	1 triage period every other week*
# Providers starting with Triage	4
Length of Morning (AM) Period	4 hours*
Length of Afternoon (PM) Period	3 hours*
New Patient Length	60 minutes*
Established Patient Length	30 minutes*
Phone Patient Length	15 minutes*
Percentage Established Patients	60% per PACT requirements (estimated)
Percentage New Patients	35% per PACT requirements (estimated)
Percentage Phone Consult Patients	5% per PACT requirements (estimated)

*Current state/operations at Worcester CBOC

Table 9-1. Baseline Model Settings

Table 9-2 outlines the scenarios.

Scenario	Description
Base	Base Model
1	Extend the clinic hours by one hour for all providers for each day of the week (increase the afternoon block by one hour (from 3 to 4 hours) for all providers for each day)
2	The addition of one examination room
3	The addition of two examination rooms
4	Increase of 5% more new patients, 5% less established patients
5	Increase of 10% more new patients, 10% less established patients
6	The addition of a fully-staffed* Saturday AM block
7	The addition of a Saturday AM block for 4 providers
8	The addition of a Saturday AM & PM block for 4 providers
9	The addition of a fully-staffed* Saturday AM & PM block
10	The addition of one full-time provider
11	The addition of two full-time providers

*Fully-staffed includes all 8 current providers

Table 9-2. Scenario Analysis Descriptions

9.2 Simulation Scenario Analysis Results

All scenarios were run through the linear programming model and then through the simulation model except the scenarios 6 – 9 as noted in Figure 9-1. The linear programming output schedule and throughput calculations and the simulation report for each scenario can be found in Appendix E.

The results for the scenarios can be seen in Table 9-4.

9.2.1 Utilization

Given the constraints put on the provider schedule in the linear programming model, when scenarios were run through the simulation model, all provider utilizations were within an 88-90% range. This is due to the fact that the linear programming model was aimed to maximize the number of patients a provider could see in the allotted time range. This value is not 100% due to an hour lunch break defined between provider morning and afternoon blocks. The highest value of provider utilization occurred in Scenario 8, in which four providers worked a half Saturday clinic.

9.2.2 Total Throughput

Figure 9-3 demonstrates the patient throughput results, including total throughput as well as new, established, and phone consult patient visit values per scenario, to highlight the impact of each scenario on throughput.

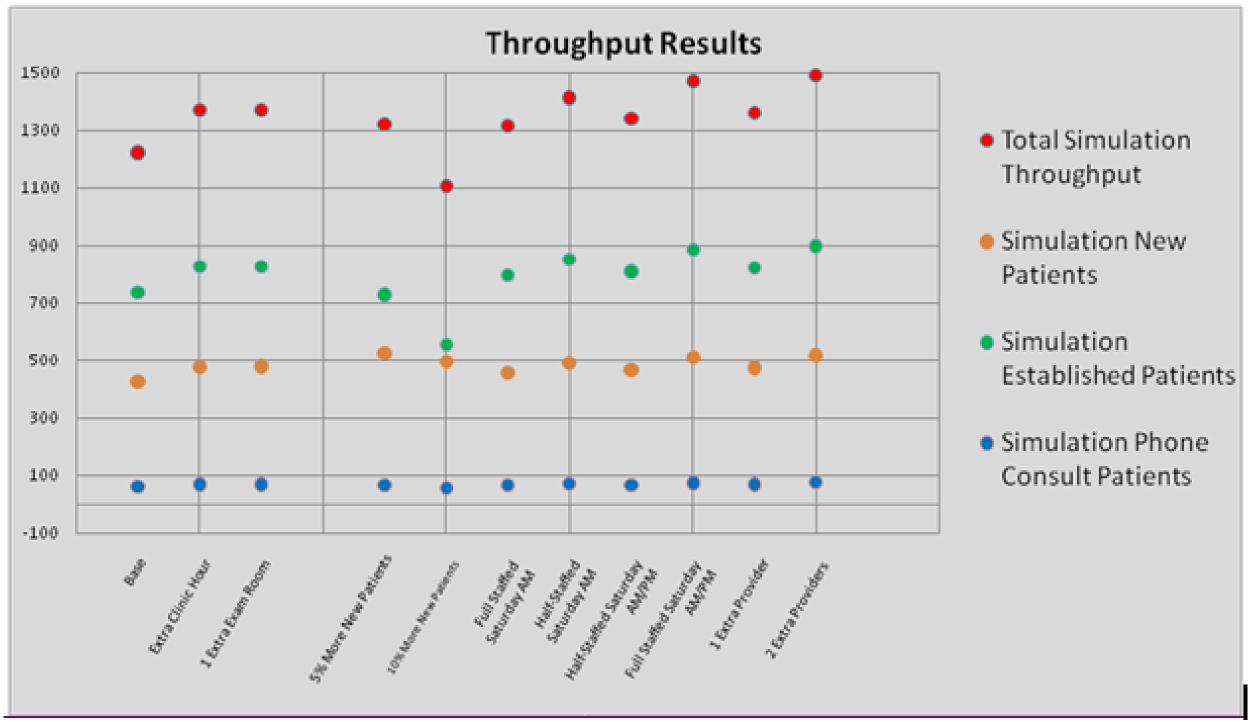


Figure 9-2. Simulation Throughput Results

This scenario analysis demonstrates four major findings related to patient throughput. First, as theorized by CBOC staff, an increase in number of examination rooms, number of physicians available, and Saturday clinics, all increase patient throughput in comparison to the base model. The most significant throughput increases occurred in Scenario 11, in which there was an addition of two physicians to the base model. This resulted in a throughput of 1491 patients versus the 1223 patients seen in the base model (a 22% increase).

The second major finding on throughput is the impact of increasing the number of rooms available. Scenario 2, an increase of one examination room, demonstrated increased patient throughput from 1223 to 1372 (a 12% increase). It should be noted, however, that Scenario 3, an additional two examination rooms, output an identical optimized schedule as Scenario 2 in the linear programming model. That is, increasing the number of available rooms at the CBOC by more than one given will not impact throughput any more than an increase of one room. This is due to constraints on the current number of providers available, triage, and administrative requirements. This finding shows there is a benefit in patient throughput in transitioning a room currently unused for patients to an examination room. However, increasing the number of rooms available for exam rooms beyond that without increasing the number of available providers (or time current providers are available) or incorporating nurse use of rooms will not have a significant further impact on throughput.

The third major finding is the impact of increasing the time providers are available for patient visits. Increasing the workday by one hour demonstrated an increase in throughput from the base of 1223 to 1371 (a 12% increase). The addition of Saturday clinics also poses a beneficial patient throughput increase, with the most significant increase resulting from Scenario 9, a full day, fully staffed Saturday clinic. This increased the number of patients to 1472 (a 20% increase). These changes may be implemented at the Worcester CBOC, however, careful consideration of provider availability for extended hours or Saturday clinics should be evaluated, as well as other administrative and facility constraints (i.e. increased time requirement for security).

The final significant throughput result is on the impact of changing patient mix. Scenario 5, representing an increase of new patients of 10%, had a significant impact on patient throughput. That is, the total number of patients through the model decreased from the base of 1223 to 1105 (a 10% decrease) with the patient mix shift. This is a realistic situation in the near future for the Worcester CBOC as it faces a CBOC merger, which will increase the number of new patients seen. This finding demonstrates that action needs to be taken to allow for maximized throughput in the case of a merger, such as increasing the number of rooms, providers, or periods available.

Scenario	Linear Programming Model Results*				Simulation Model Results*				
	Throughput				Throughput				Utilization
	Total	Total New Patients	Total Established Patients	Total Phone Patients	Total	Total New Patients	Total Established Patients	Total Phone Patients	Provider Utilization **
Base	1267	443	760	63	1223	425	737	61	89.15%
1	1449	507	869	72	1371	477	825	69	88.88%
2	1254	439	752	62	1372	478	826	68	88.66%
3	1254	439	752	62	-	-	-	-	-
4	1208	483	664	60	1322	527	729	66	88.66%
5	1166	524	583	58	1105	495	555	55	88.71%
6***	-	-	-	-	1317	457	794	66	n/a
7***	-	-	-	-	1413	490	852	71	n/a
8***	-	-	-	-	1342	467	808	67	89.87%
9***	-	-	-	-	1472	512	886	74	89.88%
10	1432	501	859	72	1362	473	821	68	88.71%
11	1592	558	955	79	1491	518	898	75	88.71%

*Simulation model results are based on the average of 100 simulation runs
**Utilization value includes 1 hour lunch break between AM and PM shift
***Scenarios for Saturday clinics were run in simulation model only. Results are added to base model to calculate comparable throughput (see model description)

Table 9-3. Scenario Analysis Results

9.3 Statistical Significance of Results

The results from the simulation model can be compared to the results of the linear programming model to determine if the difference between the two sets of results is statistically significant. If they are not statistically significantly different, it can be said that the results reflect reality similarly. By plotting the outputs of each model in terms of throughput, the differences can begin to be analyzed. The following graph displays the total patient throughput, as well as patient mix break down, for both the linear programming outputs and the simulation model results.

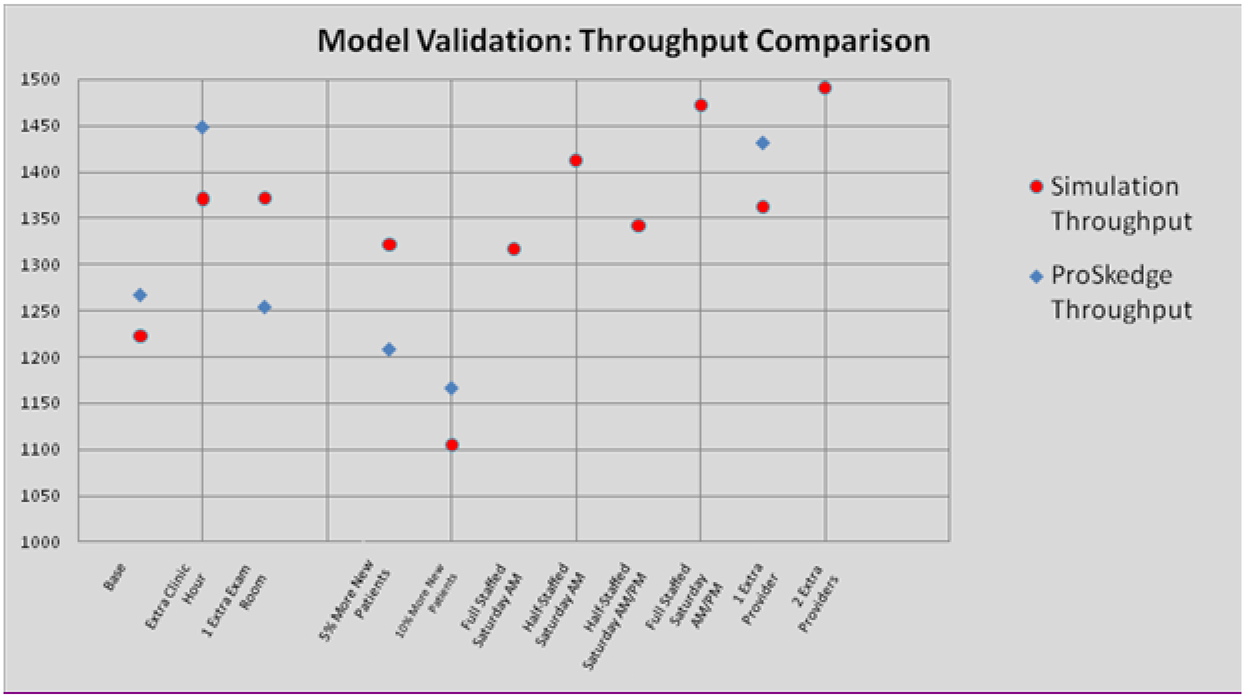


Figure 9-3. Throughput Comparison Results

From the results table (Table 9-4) and this graph (Figure 9-3), it appears that the majority of linear programming throughput results were greater than the simulation results. Hypothesis testing can be used to better understand the statistical significance of this graphical observation. Here, index *1* is equal to values associated with the linear programming model while index *2* is representative of values from the simulation model. The goal is to prove (or reject) that the two throughput values calculated for each scenario are statistically the same. For this reason, the null hypothesis is set to:

$$H_0: \mu_1 = \mu_2$$

Numerically, the linear programming results are typically higher than the simulation results and so the alternative hypothesis is set to:

$$H_A: \mu_1 > \mu_2$$

This analysis was completed by calculating the standard deviation, s, for each visit type in the scenarios run through both the linear programming model and the simulation model. This standard deviation was calculated by using the half width of the average throughput provided in the Arena reports (see Appendix E) to solve for standard deviation using the following formula:

$$Half\ Width\ =\ t_{n-1,1-\alpha/2} * \frac{s}{\sqrt{n}}$$

Here, the t-statistic was based on a 95% confidence interval (α = 0.05) and 100 replications (n) used in each trial to be 1.984.

The calculated standard deviation was used with the linear programming output and simulation results to calculate a critical t-value for the scenario using the following formula:

$$t - critical = \frac{\mu_2\ -\ \mu_1}{s}$$

Corresponding p-values were determined from the critical t-value for each scenario using Excel's 2-tailed t-distribution function (TDIST), defining "x" as the absolute difference between μ_2 and μ_1, degrees of freedom to 99 (n-1).

The results for the hypothesis tests can be found in the Tables 9-4, 9-5, and 9-6 for total new patient visits, total established patient visits, and total phone consult patients respectively.

For a confidence interval of 95%, a p-value less than 0.05 determines if the null hypothesis should be rejected in the comparison between the linear programming model and simulation model results for the scenarios. Several conclusions can be made on the statistical significance of the difference between the linear programming output and simulation scenario results. Any p-value greater than 0.05 is shown in red on the results Tables 9-4, 9-5, and 9-6, which means that the throughput values are statistically significantly the same and the null hypothesis is not to be rejected. Points above the critical p-value of 0.05 (α) allow the null hypothesis to be accepted; points below reject the null hypothesis. First, the p-values for the number of established patients had the highest set of p-values, all above the 0.05 decision value. For this reason, there is statistical evidence that the null hypothesis is correct. This trend is not followed, however, for the p-values for new and phone consult patients. The number of new patients had many p-values significantly below the 0.05 cut off, thus giving evidence that the null hypothesis is rejected in many scenarios. Such a result may mean that the model is not reflecting reality completely or the linear programming model has excessive rounding error.

Scenario	Total # New Patient Visits							
	LP	Simulation	Half Width	n	alpha	s	t	p-value
Base	443	425	2.44	100	0.05	12.298	-1.464	**0.146**
1	507	477	2.66	100	0.05	13.407	-2.238	0.027
2	439	478	2.61	100	0.05	13.155	2.965	0.004
4	483	527	2.49	100	0.05	12.550	3.506	0.001
5	524	495	2.3	100	0.05	11.593	-2.502	0.014
10	501	473	2.64	100	0.05	13.306	-2.104	0.038
11	558	518	2.8	100	0.05	14.113	-2.834	0.006

Table 9-4. Hypothesis Test Results for Total Number of New Patient Visits

Scenario	Total # Established Visits							
	LP	Simulation	Half Width	n	alpha	s	t	p-value
Base	760	737	4.99	100	0.05	25.151	-0.914	**0.363**
1	869	825	5.27	100	0.05	26.563	-1.656	**0.101**
2	752	826	5.19	100	0.05	26.159	2.829	0.006
4	664	729	4.62	100	0.05	23.286	2.791	0.006
5	583	555	4.27	100	0.05	21.522	-1.301	**0.196**
10	859	821	5.31	100	0.05	26.764	-1.420	**0.159**
11	955	898	5.38	100	0.05	27.117	-2.102	0.038

Table 9-5. Hypothesis Test Results for Total Number of Established Patient Visits

Scenario	Total # Phone Consults							
	LP	Simulation	Half Width	n	alpha	s	t	p-value
Base	63	61	1.76	100	0.05	8.871	-0.225	**0.822**
1	72	69	1.89	100	0.05	9.526	-0.315	**0.753**
2	62	68	1.87	100	0.05	9.425	0.637	**0.526**
4	60	66	1.84	100	0.05	9.274	0.647	**0.519**
5	58	55	1.7	100	0.05	8.569	-0.350	**0.727**
10	72	68	1.87	100	0.05	9.425	-0.424	**0.672**
11	79	75	1.88	100	0.05	9.476	-0.422	**0.674**

Table 9-6. Hypothesis Test Results for Total Number of Phone Consults

10 Additional Recommendations

While the main objective of this project is to develop a tool to aid provider scheduling, it is also important to understand additional factors that may improve other operational issues faced by the CBOC. The following is a variety of approaches with the potential to increase patient flow and improve care delivery. A review of the methods described below confirm improvement potential and have the ability to suit the environment at the Worcester CBOC based on observations made by the authors of this report.

10.1 Room Sharing: The Human Factors Perspective

The current practice at the Worcester CBOC requires nurses to assign examination rooms to providers on a daily basis. Varying specialist and provider schedules requiring the use of different rooms over the course of a day or during a period of clinical time and require a significant scheduling time and daily rearranging. Suggestions can be made to the current practice to lessen the negative impact of any human factors issues that may surface involving room sharing.

Human factors engineering, as defined by Wickens, Lee, Liu, and Becker (2004), is concerned with the impact of the environment with which an individual is involved. It should be incorporated in any workplace redesign to ensure safety and comfort, increase productivity, and reduce human error. In particular, workplace design should consider the impact of the work environment on the mental comfort of the worker, which is commonly referred to as working memory. It is suggested that the working memory load of the worker be minimized. This will reduce confusion as improve care delivery because full attention on the patient is restored. During an investigation of the benefits of facility redesign, Wells (2005) afforded that working memory and room standardization would not only result in increased health care professional productivity, but would additionally increase patient comfort level.

The Worcester CBOC may be hesitant to fully redesign examination rooms but instead may want to ensure that the rooms assigned to specific providers are as similar as possible. The main elements in the room (i.e. computer and desk, sink, patient bed) are in the same approximate locations and medical devices and tools are kept in similar areas of the room. Having less to readjust or locate in the examination room at hand will allow providers to better focus on the needs of the patient. Additionally, CBOC nurses should be aware of these human factors issues during room assignment and minimize the number of rooms to which a provider will be assigned. Providers will be able to acquaint themselves with the rooms in which they would be assigned to work and thus decrease the need to mentally readjust to unfamiliar room set-ups.

A suggestion to combine both the physical and mental areas of human factors together would be to encourage physicians with similar physical needs to share the same set of rooms for appointments. This will decrease the need for physical room readjustment as well as decreasing the need for familiarizing oneself with a new room. An example of this would be assigning two physicians with similar stature to a set of three or four rooms. This would also give them the opportunity to personalize the room to increase their level of familiarity – perhaps even add family pictures or art to create a comfortable atmosphere.

10.2 Synchronization

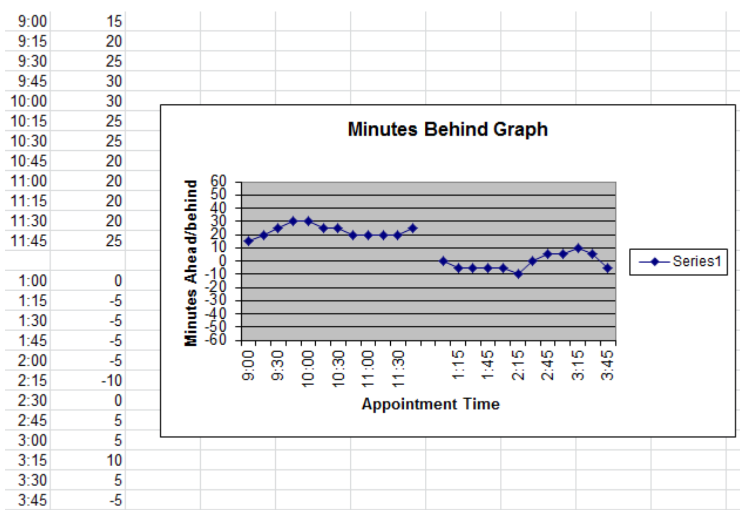
Maintaining a smooth patient flow includes many key aspects related to timing in order to be successful. One approach that sets the tone for scheduling coordination is setting a synchronized appointment start time. When a set task or action (i.e. when a provider enters the examination room) is chosen as the signal to the appointment start time, all tasks before and afterwards can be gauged to synchronize with that start time. All tasks beforehand (e.g. includes preparing a room, seeing a nurse to take vitals, or what time a patient should arrive) should be prepared to be finished by that start time. After a week or two of time studies, a standardized preparation time per appointment type should be able to be identified and turned into a template for future reference (IHI, 2011).

Synchronization for the Worcester CBOC should be broken into a few different sets of pre-appointment tasks. The amount of time and tests needed per appointment type varies, so one set time will not be applicable to all patients. Time studies of pre-appointment tasks could be performed to establish a set of pre-appointment lengths of time. These times would then be communicated to patients when they set up their future appointments based on their appointment type. This would help to ensure that patients are flowing more efficiently so that if one appointment fell behind, the effects of a chain reaction would not be felt throughout the course of the entire morning or afternoon block.

A patient flow and task analysis could aid in synchronizing patient appointment start times. In an analysis of diabetic patients with high wait times in a clinic in Jordan, patients originally checked in with a clerk and then saw a medical officer to perform the tests needed to be passed along to the laboratory. The patients would then wait for results and revisit with a nurse and medical officer. After the sequencing of events changed, testing was completed before checking in with the clerk to reduce waiting time and eliminate multiple visits with medical officers in one appointment. (Ammari, Abu Zahra, & Dreesch, 1991)

In conjunction with synchronization, a task analysis could be performed before beginning time studies to determine what time a patient should enter the clinic. This would aid in the creation of pre-appointment checklists to ensure that routine tasks are not forgotten and also help maintain a steady pace. Checklists and templates are discussed further in Section 11.3.

A way to gauge timing of appointments is to use a “minutes behind graph” (Mark Murray & Associates, 2011) See Figure 11-1 for an example of a minutes behind graph. A minutes behind graph tracks nurse and provider appointment start times throughout the course of a day. Identifying times of day or other tasks outside of seeing a patient that may cause an appointment backlog could point out appointment balancing issues. (Mark Murray & Associates, 2011)



9:00	15
9:15	20
9:30	25
9:45	30
10:00	30
10:15	25
10:30	25
10:45	20
11:00	20
11:15	20
11:30	20
11:45	25
1:00	0
1:15	-5
1:30	-5
1:45	-5
2:00	-5
2:15	-10
2:30	0
2:45	5
3:00	5
3:15	10
3:30	5
3:45	-5

Figure 10-1. Minutes Behind Graph (Mark Murray & Associates, 2011)

The same approach can be taken to judge and assign appropriate patient arrival times based on an average of historical data to ensure patient punctuality. This is critical to synchronizing the start time of the appointment. Various appointments require varying lengths of pre-appointment tasks that could be categorized and used when telling a patient when to enter the facility. A more accurate entrance time based on appointment type when scheduling patients will aid in keeping appointments and providers on time. Also, a study of patient waiting times and how much time is spent with the provider versus waiting time can be turned into metrics to determine frequencies and averages. These results can then be plotted and used to estimate queuing times. (Brahimi & Worthington, 1991)

A "minutes behind graph" and related time study could help to determine when Worcester CBOC providers fall behind or become overwhelmed with tasks and appointments and when they are ahead of schedule. This would translate into improved scheduling practices.

Another possible approach to maintain a steady flow of patients throughout the course of the week is to use staggering. Staggering breaks and lunches to different times could help increase time that patients can be seen, as well as conform to provider preferences. While most of the provider staff is on their lunch break, nurses could be using available rooms to perform nurse visits or reduce appointment backlog.

10.3 Templates & Check Lists

Using check lists can keep providers on task as well as prevent any forgotten tasks. A pre-appointment and appointment check list in a busy environment can aid those preparing a room from error. It also can help prevent delays that would require a patient to wait and allow for a steadier rate of patient flow. Making sure that all necessary information such as lab results, medications and tests needed if any, and patient history prepared beforehand will aid in patient flow. (IHI, 2011) The Worcester CBOC currently uses checklists and templates for some processes and tasks, but encouraging good practices to be shared between providers and staff would help increase overall shared knowledge.

Maintaining specific encounter notes and records without tasking takes up a significant portion of a provider's administrative time; this is another issue faced by the Worcester CBOC in an effort to maximize provider time. Providers require time to write up an encounter as well as efficiently review medical history. This history sometimes comes from different doctors and sources, so a transfer of information that is more standardized could save time and ensure that key information is not missed between care providers. The mental demand on a provider to accurately give individual care to a patient and the increased time required to give a proper amount of care can hopefully be reduced paired with steady accuracy when note encounter templates and task checklists are applied.

A technique to aid in standardizing medical tasks and communication methods currently not performed at the CBOC is the use of document templates. Much of a provider's administrative time throughout a day involves writing encounter notes to accompany a patient's visit. Sharing ideas and methods, as well as creating standardized templates for note taking could aid in reducing provider time taking notes and allow for more transparency between different provider notes.

11 Industrial Engineering Design Capstone Requirement

ABET, Inc. (Accreditation Board for Engineering and Technology) is a widely recognized college and university applied science, computing, engineering, and technology program accreditor. This accrediting body requires students with a major in one of those four programs of study to specifically address the engineering design component of the project. The planning tool, as well as supporting simulation model and additional suggestions for the CBOC inherently follows the ABET definition of an engineering design project. According to ABET, an engineering design is the creation of an iterative mathematical and scientific solution to a specified problem. The design process should include first defining the problem, analyzing the situation, creating the solution, testing and then evaluating the results. The problem at hand for this project is described in the background section and specifically defined in the Section 3 Problem Statement. The problem at hand for the VA CBOC situation is to create a planning tool to aid in resource scheduling; this issue was identified by complexities arising in current scheduling given specialist schedules, finite numbers of providers and rooms, as well as a transition to a PACT model. (ABET, 2008)

The methodology section of the report outlines the steps taken in the solution process that meet the planning criteria for the ABET design process. This demonstrates that the first step in the solution was to define the problem by determining user needs as well as data collection; this step not only allows for the problem to be defined, but analyzes the problem to ensure all aspects of the situation are discovered. In addition, this step included literature reviews to understand similar types of problems and the solutions that were found; this enabled the team to consider multiple alternative methods of solution including linear programming, simulation, and combination models, to determine the best model type of the situation at hand. The next three steps include the three designs created; the linear programming model, the simulation model, and finally the user interface. Testing is performed in the following step as the model is both validated and verified which is to ensure that the models are not only working as expected from a mathematical standpoint, but also match operations at the Worcester CBOC. Verification and validation provide a loop back to model revisions when discrepancies arise, thus meeting the testing and evaluation steps in the ABET process. The final step in the model process is the final implementation, which is a reflection of further evaluating the results to complete the project.

12 Conclusions & Future Recommendations

This report outlined the creation, testing, and implementation of an executable planning tool ProSkedge. ProSkedge, a linear programming-based planning tool, was created to be modifiable by the user to reflect varying operating states in a health clinic environment. The user is allowed to adjust provider preferences, provider time away, specialist schedules, room requirements, number of exam rooms (available), and the number of exam rooms utilized by nurses and health technicians. Other inputs that can be altered include clinic, administrative, and triage requirements, length of morning and afternoon periods, appointment length per patient type, and patient mix percentages. ProSkedge runs linear programming models through Visual Basic macros using these inputs to output a feasible schedule to the user. This model was verified through an Arena-based simulation model and validated through interviews and meetings with CBOC staff.

Scenario analysis, performed by ProSkedge and an Arena-based simulation model, proved that increasing the number of available providers had the greatest impact on patient throughput. Other factors that notably contributed to an increase in patient throughput included lengthening the workday by one hour and adding a partial or full-day Saturday clinic. The addition of new examination rooms poses a potential opportunity to improve patient throughput. However, it would also require an increase in number of providers for maximum benefit. An additional finding of the scenario analysis demonstrated that changing patient mix to include a greater percentage of new patients had a significant negative impact on throughput. It is therefore suggested that the CBOC experiment with inputs, such as number of providers available, using ProSkedge to maintain a desired patient throughput in the event of a patient mix change.

Additional recommendations beyond the implementation of ProSkedge to aid in the operational and human factors related concerns faced by the CBOC can be suggested. These recommendations include limiting the number of rooms to which providers are assigned, standardizing exam room layout, providing adjustable office equipment, performing time studies to identify more efficient patient scheduling policies, and offering templates and checklists so that providers may ensure all steps are completed and that encounter notes are in a standard format.

13 Future Model Improvements

ProSkedge was originally designed with the Worcester CBOC in mind. Minor alterations were made to allow the model to be more dynamic and usable in other similar clinics. Still, improvements can be made to allow for a more dynamic tool and applicability to other clinics of a much larger size and with other constraints. The improvements detailed below were not implemented in this version of ProSkedge because they would require computer programming expertise beyond the levels of the project team.

- **Ability to add additional periods to the week**
  Currently, ProSkedge only adds and deletes providers and specialists within a set planning period of ten periods (five days with two periods each). Adding additional periods would allow the user to test the impact of changes such as Saturday clinics without modifying the linear program directly.

- **Ability to personalize names in lieu of "Provider #" and "Specialist #"**
  ProSkedge lists providers and specialists by number because the Visual Basic macro must search the Excel sheets to determine how many providers and specialists are currently being represented. If another method of counting the number of providers and specialists shown in the model is determined and implemented, the names of providers and specialists can be added to eliminate any confusion between which provider is represented by which number in the model.

- **Ability to schedule/assign providers to specific exam rooms**
  The Worcester CBOC currently requires nurses to assign providers to exam rooms during their scheduled periods. While ProSkedge will ensure that no more providers than available rooms are scheduled, it does not use that information to assign the providers to exam rooms.

- **Ability to schedule nurses**
  ProSkedge currently can schedule up to 15 providers. However, the nurses at the Worcester CBOC utilize rooms as well and also host nurse visits with patients when a provider is unnecessary. ProSkedge handles this by allowing the user to assign a number of the total exam rooms to be used for nurse use for any purpose other than a patient visit with a provider. It would be beneficial for the model to be able to incorporate nurses as another decision variable constrained by the issues that surround nurse scheduling.

- **Implement LP in an optimization programming language to allow for more variables**
  Microsoft Excel, and Solver in particular, have limits on the number of decision variables and other constraints which may prohibit the advancement of ProSkedge. Therefore, it is suggested that the linear program described in this report be programmed using a true optimization language (open-source optimization languages exist) and developed as a standalone application not built within Microsoft Excel. This will bypass the limits set within Excel.

Glossary

AAP: American Academy of Pediatrics

ACU: Ambulatory care unit

CBOC: Community Based Outpatient Clinic

FIFO: First-in, first-out

LP: Linear Programming

PACT: Patient Aligned Care Team

PCMH: Patient-Centered Medical Home

ProSkedge: Name of provider schedule planning tool developed during this project meant as an abbreviation for Provider Schedule

VA: Department of Veterans Affairs

VB: Visual Basic

VHA: Veterans Health Administration

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A Methods Matrix

	Method	Problem Example	Objective[1]	How	Advantages	Disadvantages
Optimization	Linear Programming	Activity analysis problem – choose the intensities with which the various activities are to be operated to maximize the value of the output to the company subject to the given resources[2]	Minimizing or maximizing an objective function	Quickly determines the implications of information and impact of variation	Great computational power because of its mathematical base; accurate approximation of fundamental relationships	Difficult to incorporate probability and to address business risk; non-linear effects are not modeled accurately; unable to deal with uncertainty without many assumptions
	Decomposition Methods	No examples found	Break down a large problem into a smaller solvable problems	Iterative technique	Can handle non-linearities; can integrate different levels of planning	Unable to handle uncertainly well
	Dynamic Programming	Can be applied to health care in areas such as cancer screening, dosing strategies, and hospital admissions[3]	Optimize in stages over one variable	Recursive relation to solve optimization	Capacity constraints make calculations simpler; can incorporate uncertainty in demand and in fixed/variable costs	Unable to treat uncertain capacity constraints because installed/operable capacity must be fixed; data is not helpful in assessing the kinds of decisions under different conditions in time
	Stochastic Programming	How to plan operations such that staff and equipment are being scheduled most efficiently[4]	Maximize or minimize an objective function when parameters depend on random states	4 sub-methods: 1) two stage programming with recourse, 2) change constrained programming, 3) stochastic programming via distributional analysis, 4) expected value/variance criterion in quadratic programming	Can incorporate uncertainty/variation into LP problems	Cannot handle too many constraints because it can become too large to solve; non-linear feasible regions and multivariate probability distributions may cause problems

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A. Methods Matrix (continued)

	Method	Problem Example	Objective	How	Advantages	Disadvantages
Simulation	System Dynamics	Model the interactions between staff and patients to design programs[5]	Analyze the effect of something over time	By analyzing the effect of feedbacks to describe interactions	Use to determine optimal capacity levels and to hypothesize on the effect of changing variables in different scenarios	Can be very data-intensive and detailed; output requires careful validation
	Scenario Analysis	No stand-alone example	Analyze problems over time under different conditions	Requires judgment to hypothesize discrete futures with a different assumptions	Helpful in the projection of long range and highly uncertain environments; most suitable for situations where crucial factors can be identified but not easily predicted, where uncertainty is high and future events are unlikely to be affected by historical events	Difficult to predict interacting future events; too many factors lead to speculation
	Sensitivity Analysis	Investigate the possible improvement of a cancer screening model[6]	Examine which factors affect performance the most	Identifies most important variables	Validates results of optimization	Looking at variables in isolation does not consider probability of relationships; no attempt to analyze risk
	Probabilistic Risk Analysis	Model risks and identify known hazards that threaten patient safety[7]	Examines optimization under subjective probability	Considers correlations among uncertainties by assigning probabilities to critical inputs	Permits a thorough analysis of alternative options; possible to analyze risk and uncertainty realistically	Time consuming; difficult to obtain probability assessments; does not reflect decision maker's preferences
Decision Analysis		Program evaluation; effectiveness analysis[8]	To make the best choice among many potential options	Uses many decision-theoretic techniques	Permits a thorough analysis of alternative options; incorporates decision maker's judgments	Time consuming; probabilities and utilities are difficult to obtain

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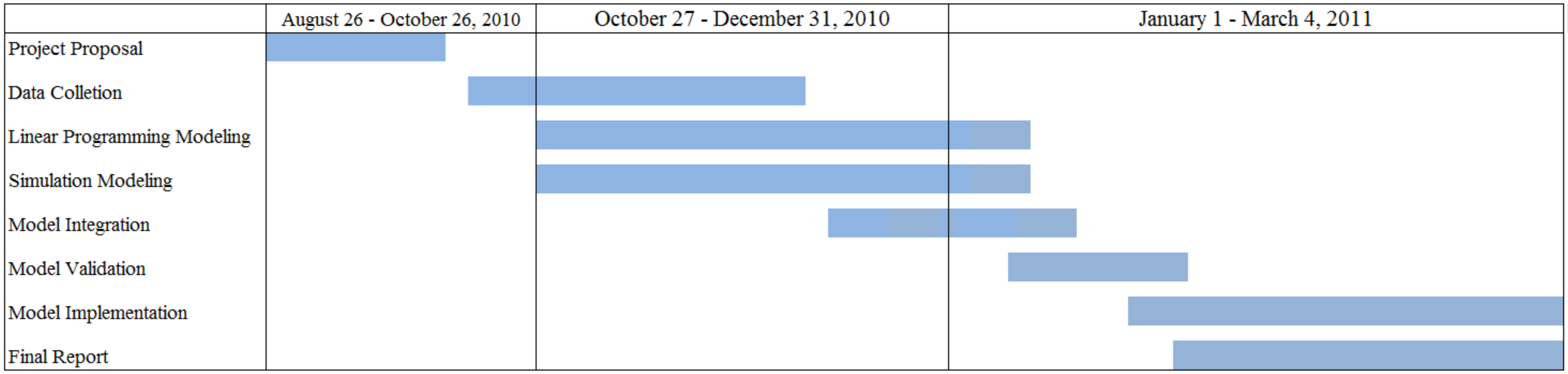
B Methods Matrix with VA Project Requirements

	Method	Flexible	Handle changes in condition	Incorporate provider schedules	Allowing for non-traditional visit types	Handle physician room sharing	Handle change in patient type
Optimization	Linear Programming	No	Yes	No	No	Yes	No
	Decomposition Methods	No	Yes	No	No	Yes	No
	Dynamic Programming	No	Yes	No	Yes	Yes	Yes
	Stochastic Programming	Yes	Yes	Yes	Yes	Yes	Yes
Simulation	System Dynamics	Yes	Yes	Yes	Yes	Yes	Yes
	Scenario Analysis	Yes	Yes	Yes	Yes	Yes	Yes
	Sensitivity Analysis	Yes	Yes	Yes	Yes	Yes	Yes

C Gantt Chart - Schedule for Methodology



D Simulation Model Screenshots

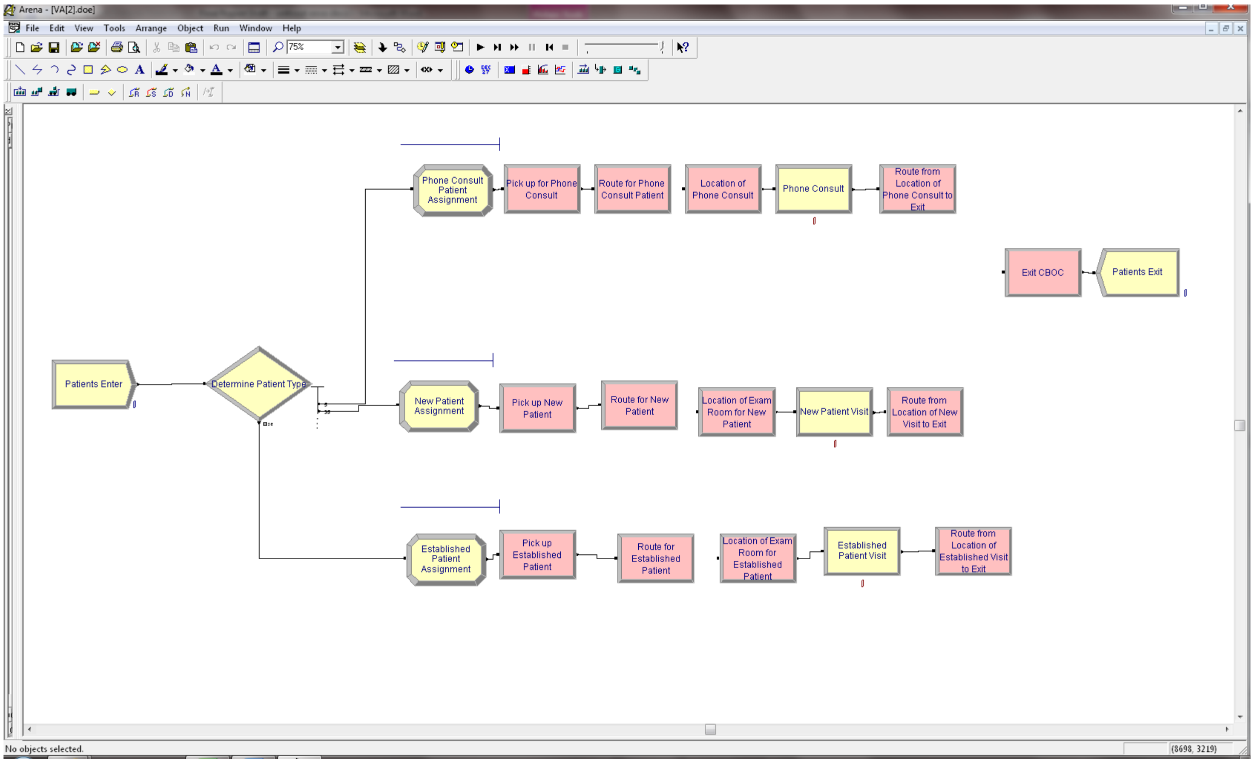


Figure D-1. Simulation Module

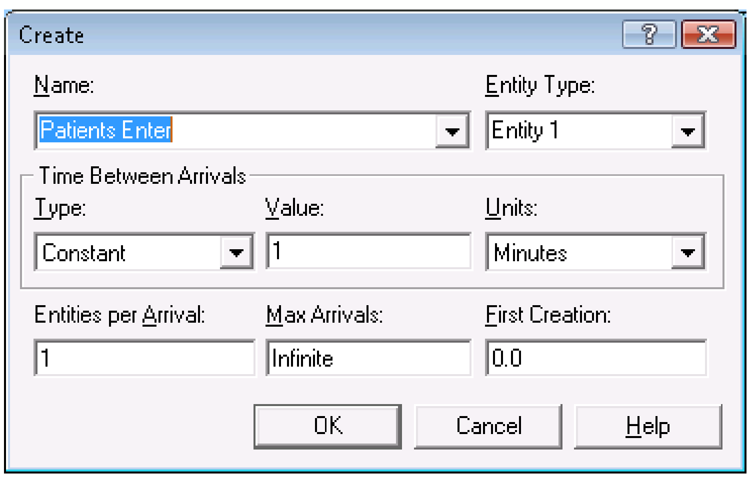


Figure D-2. Create Module for Patients to Enter

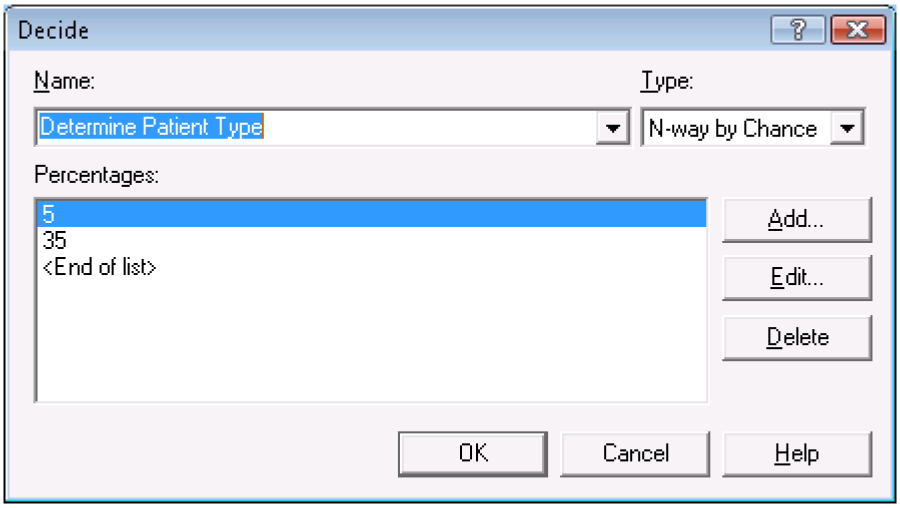


Figure D-3. Decide Module to Determine Patient Type

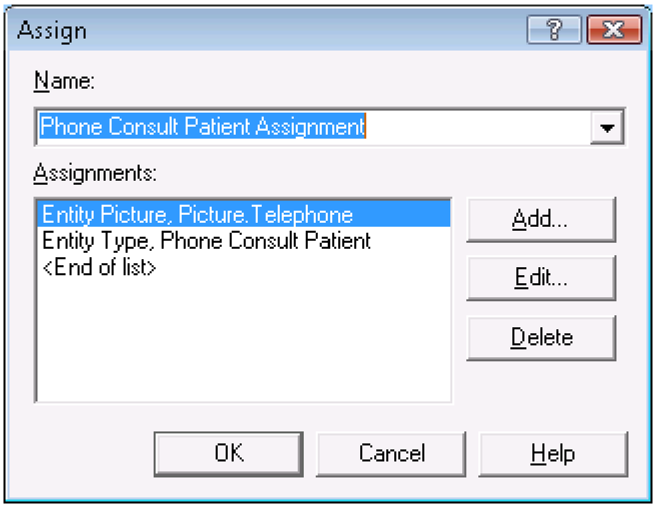


Figure D-4. Phone Consult Patient Assignment

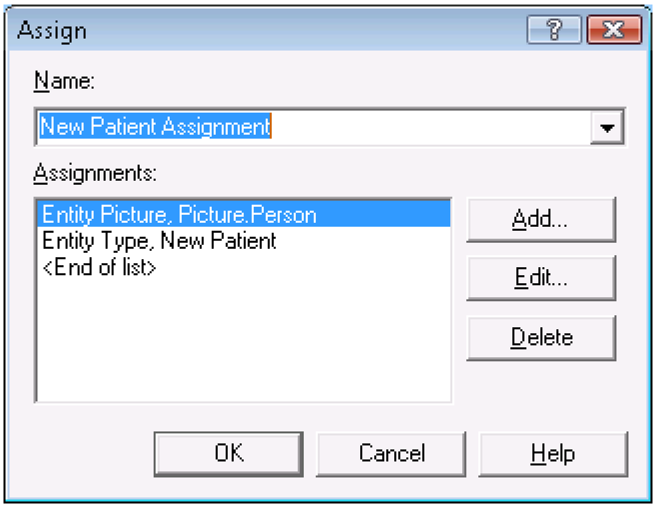


Figure D-5. New Patient Assignment

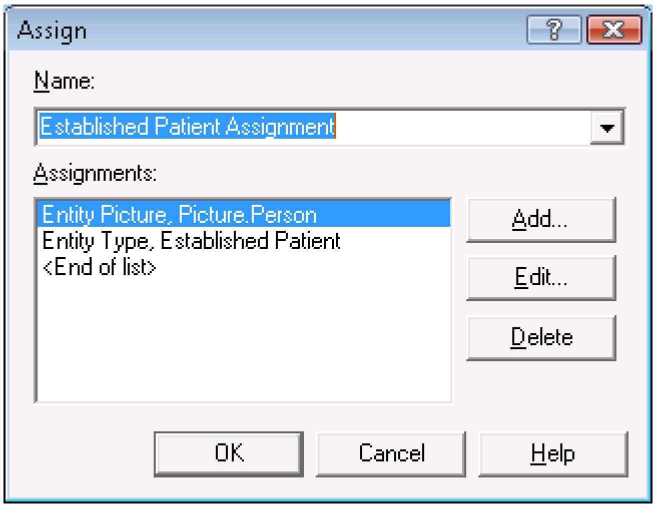


Figure D-6. Established Patient Assignment

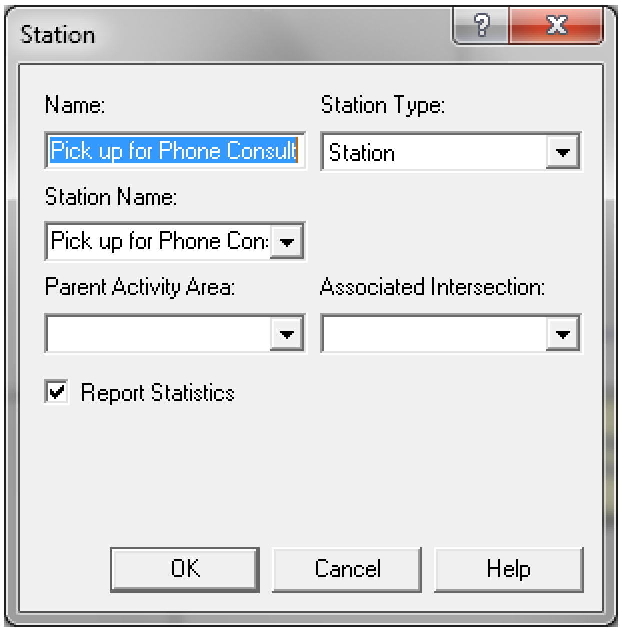


Figure D-7. Pick Up for Phone Consult Station

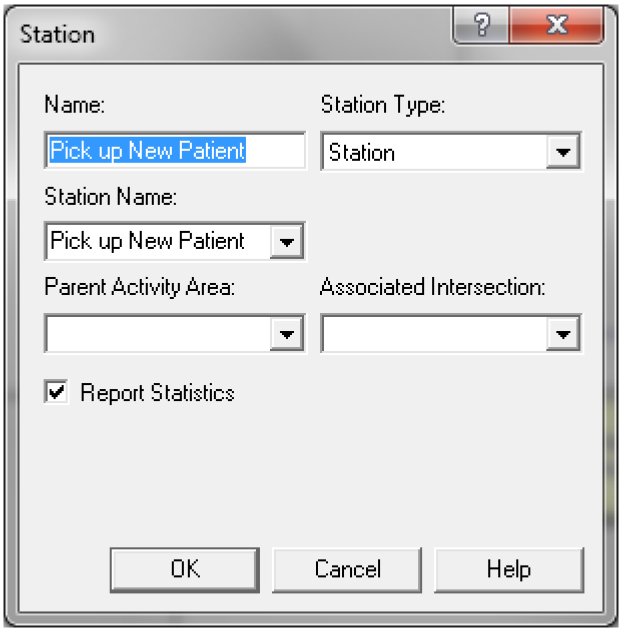


Figure D-8. Pick Up for New Patient Station

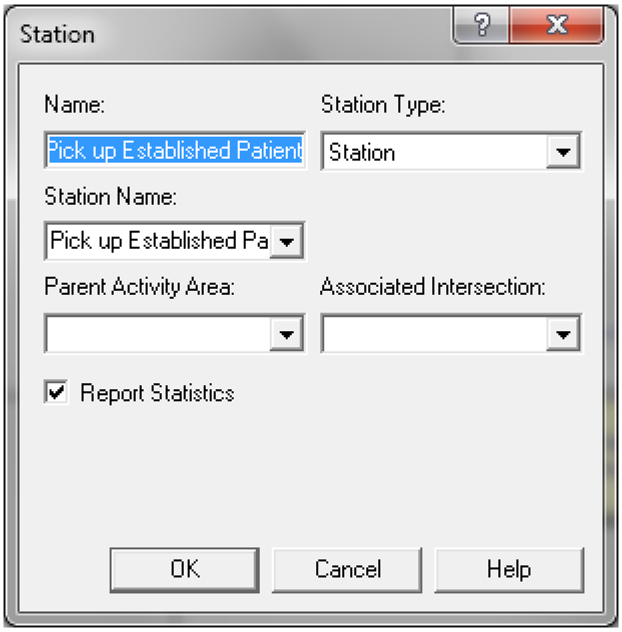


Figure D-9. Pick Up for Established Patient

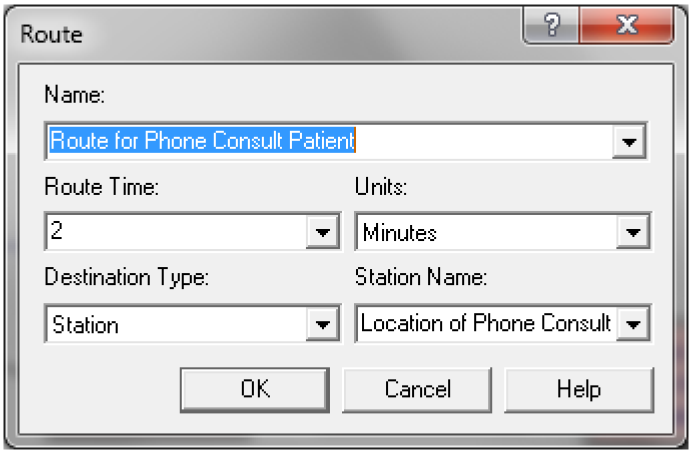


Figure D-10. Route for Phone Consult Patient

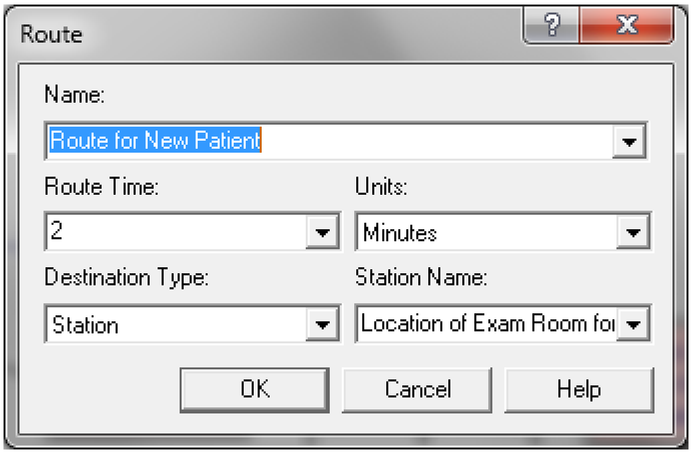


Figure D-11. Route for New Patient

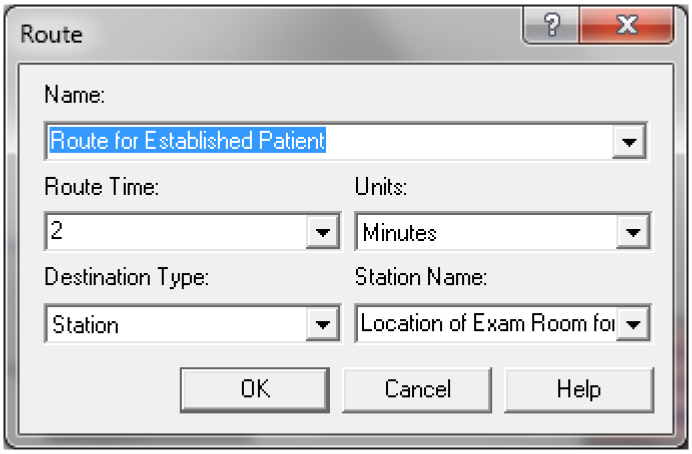


Figure D-12. Route for Established Patient

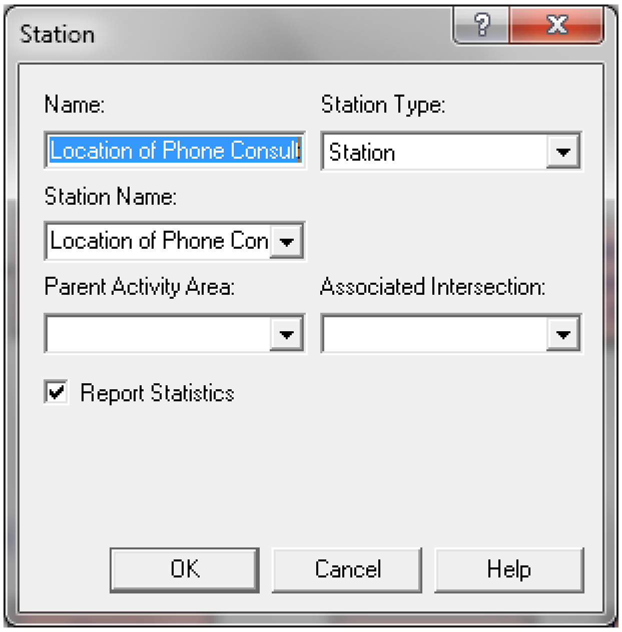


Figure D-13. Location of Phone Consult

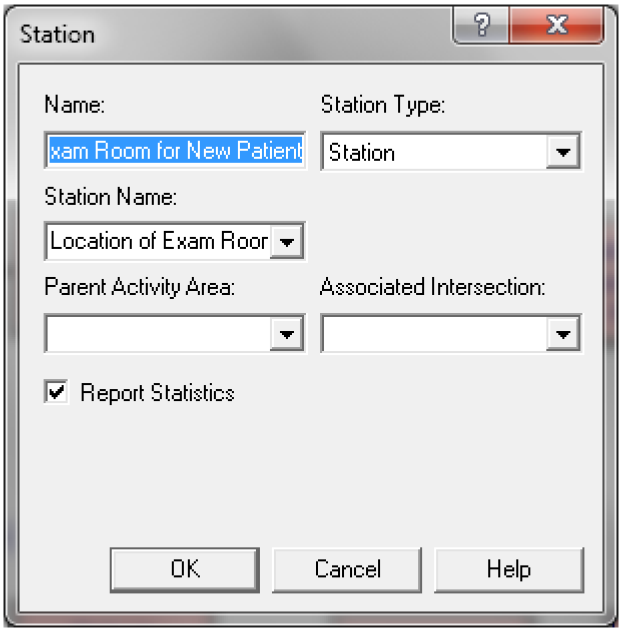


Figure D-14. Location of Exam Room for New Patient

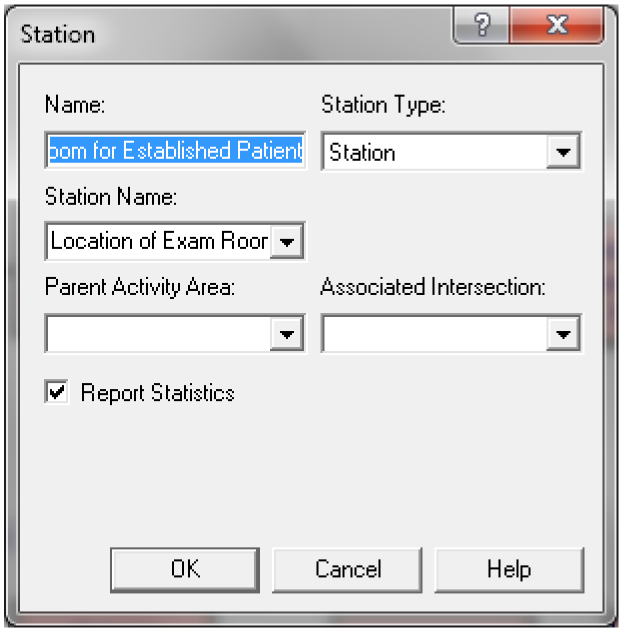


Figure D-15. Location of Exam Room for Established Patient

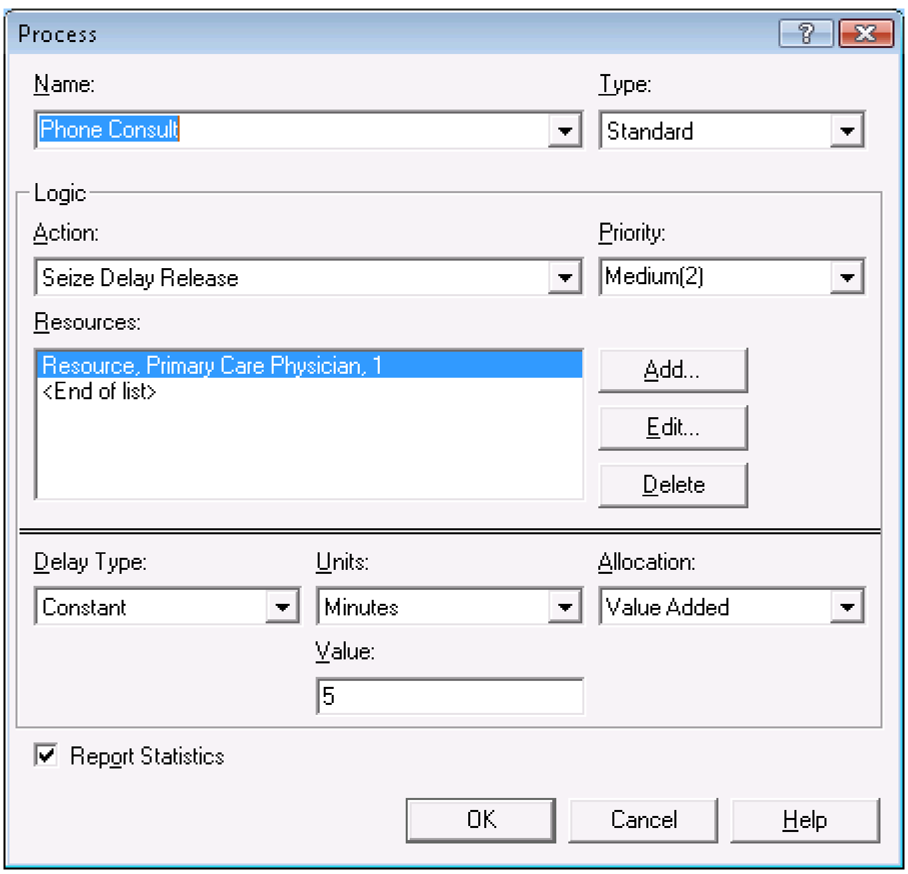


Figure D-16. Process Module for Phone Consult

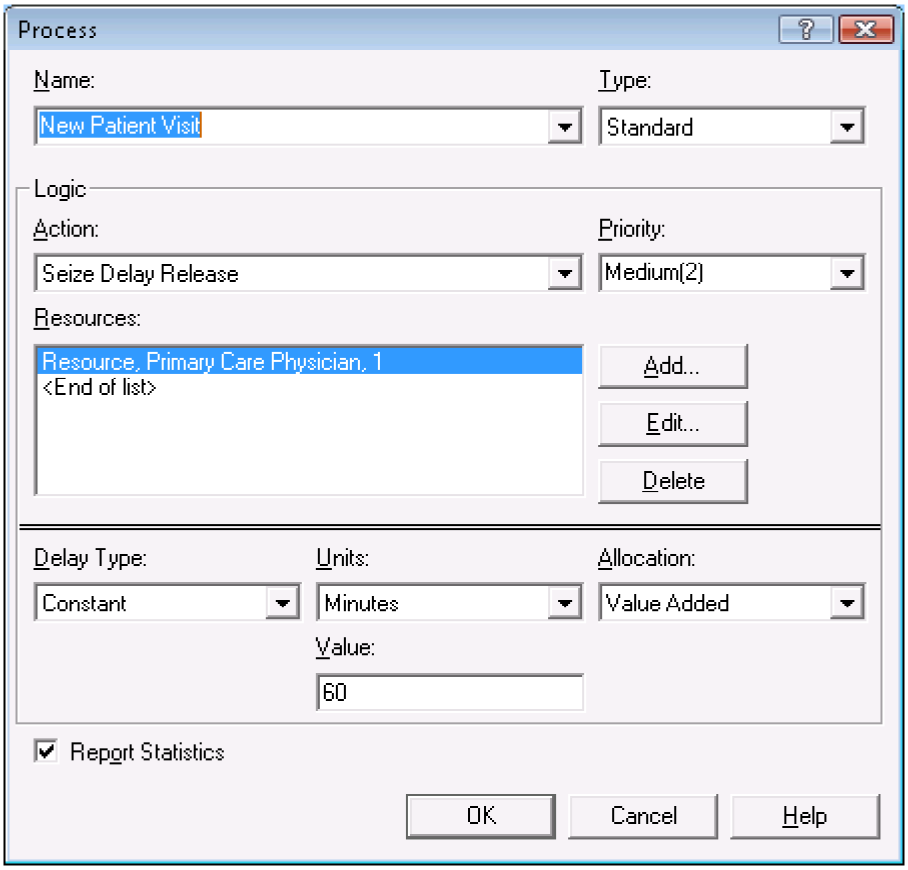


Figure D-17. Process Module for New Patient Visit

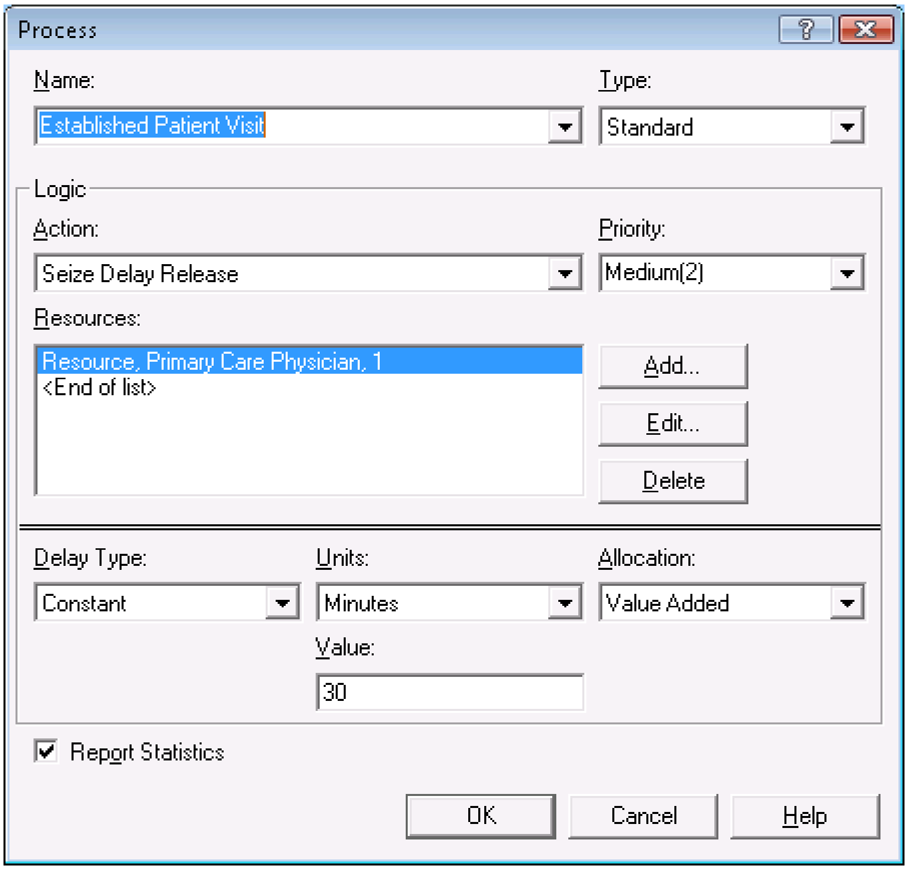


Figure D-18. Process Module for Established Patient Visit

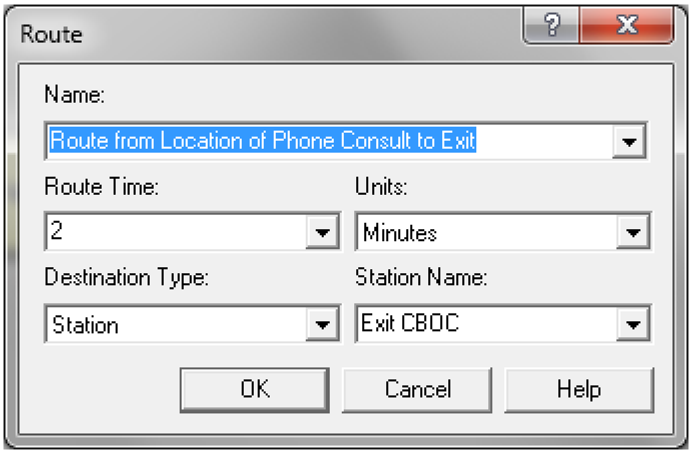


Figure D-19. Route from Location of Phone Consult to Exit

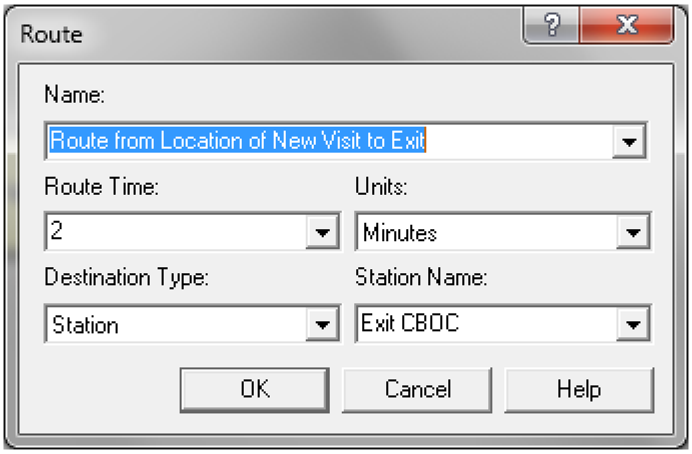


Figure D-20. Route Location of New Visit to Exit

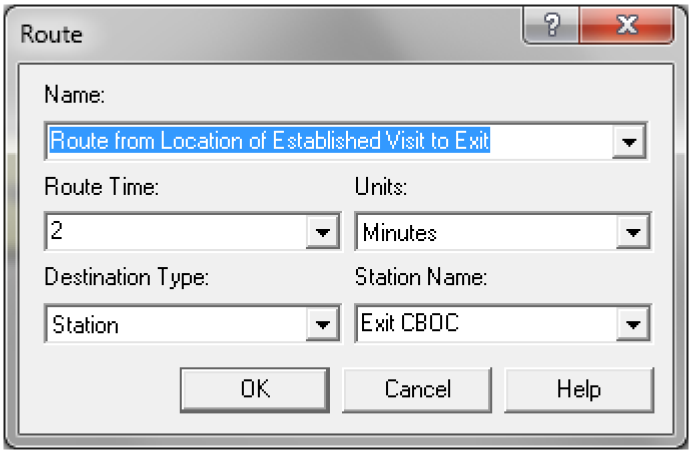


Figure D-21. Route from Location of Established Visit to Exit

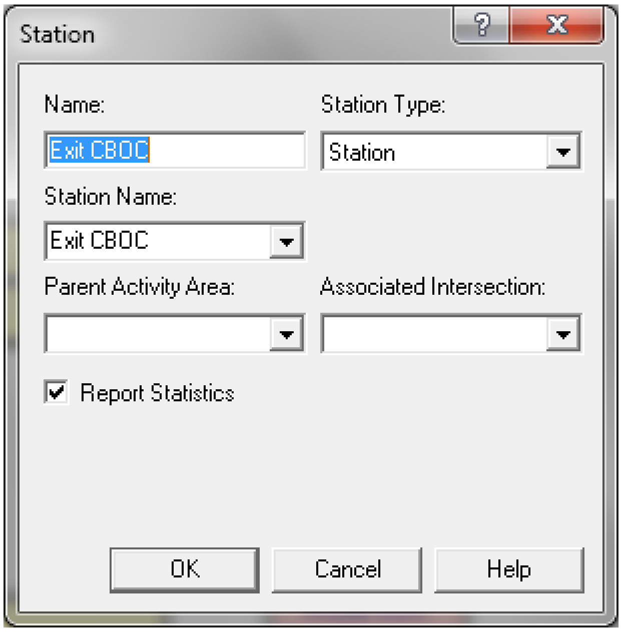


Figure D-22. Exit Station

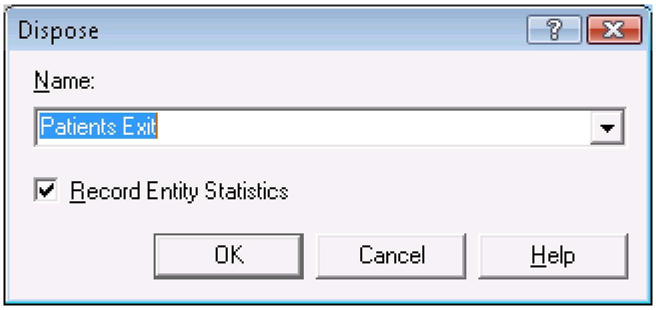


Figure D-23. Exit Module

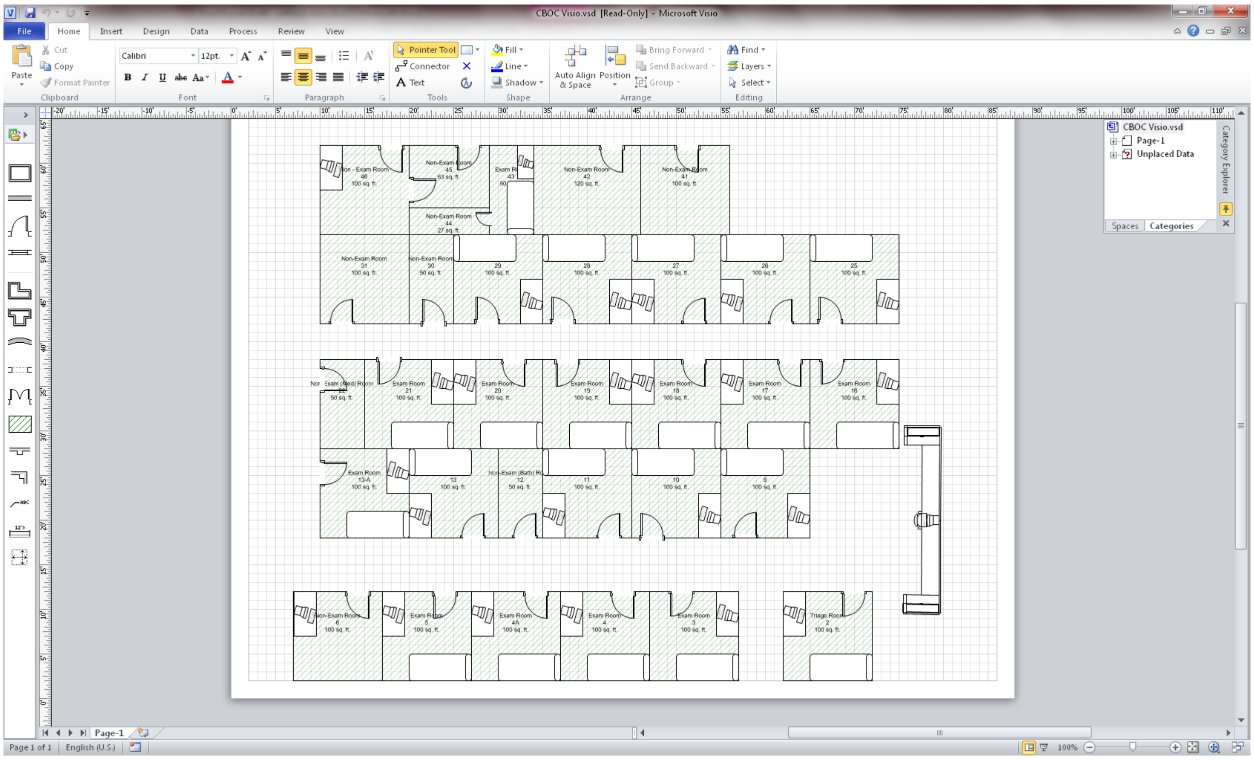


Figure D-24. CBOC Facility Layout Created in Visio

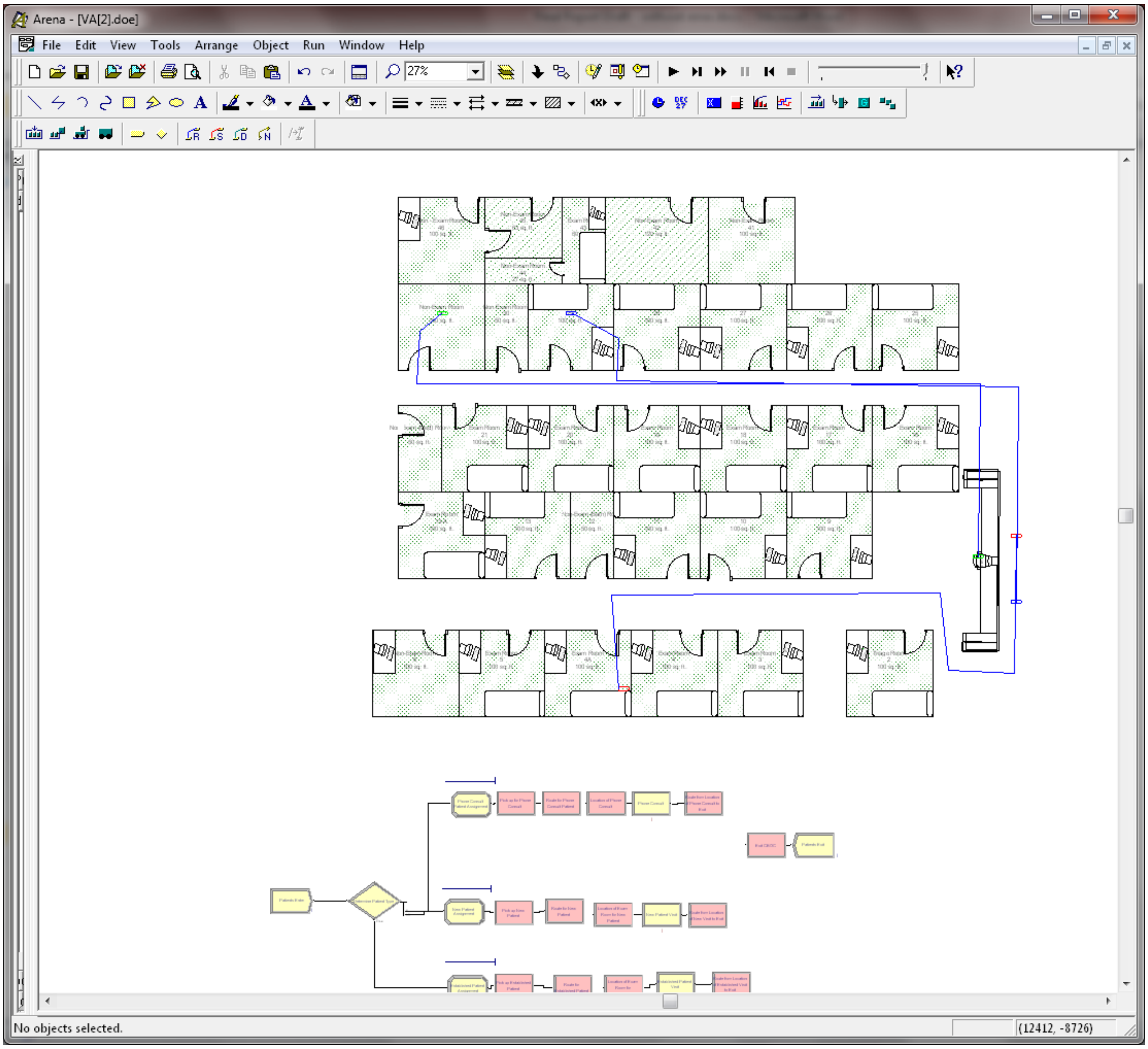


Figure D-25. Overall Simulation Model Screenshot

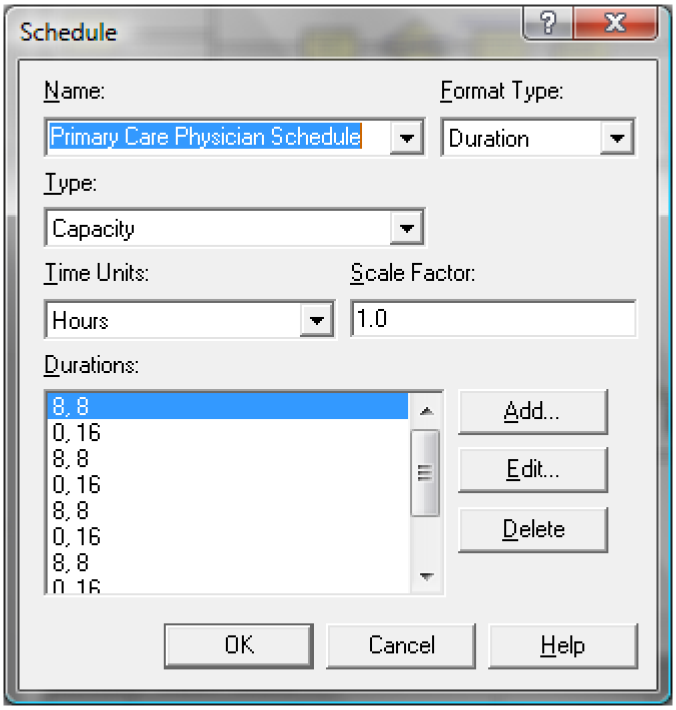


Figure D- 26. Primary Care Provider Schedule

E Scenario Analysis Results

Base Model

1. The linear programming model output (schedule)
2. The linear programming model results (throughput)
3. The Arena simulation model report

Base Model - Linear Programming Model Output (Schedule)

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
Week 1	Provider 1	1	0	1	0	1	0	1	1	1	1
	Provider 2	0	0	1	0	1	1	1	1	1	1
	Provider 3	0	1	0	1	0	1	1	1	1	1
	Provider 4	0	1	0	0	1	1	1	1	1	1
	Provider 5	1	1	1	0	0	1	1	1	1	1
	Provider 6	1	0	1	1	1	1	1	1	1	0
	Provider 7	1	0	0	1	1	1	1	1	1	1
	Provider 8	0	1	0	1	1	1	1	1	1	1
Week 2	Provider 1	1	0	1	1	1	1	1	1	1	0
	Provider 2	1	0	1	0	1	1	1	1	1	1
	Provider 3	1	1	0	0	1	1	1	1	1	1
	Provider 4	0	1	1	1	1	1	1	1	1	0
	Provider 5	0	1	1	0	0	1	1	1	1	1
	Provider 6	0	0	0	1	1	1	1	1	1	1
	Provider 7	0	1	0	0	1	1	1	1	1	1
	Provider 8	1	0	0	1	0	1	1	1	1	1
Week 3	Provider 1	1	0	1	0	1	0	1	1	1	1
	Provider 2	0	0	1	0	1	1	1	1	1	1
	Provider 3	0	1	0	1	0	1	1	1	1	1
	Provider 4	0	1	0	0	1	1	1	1	1	1
	Provider 5	1	1	1	0	0	1	1	1	1	1
	Provider 6	1	0	1	1	1	1	1	1	1	0
	Provider 7	1	0	0	1	1	1	1	1	1	1
	Provider 8	0	1	0	1	1	1	1	1	1	1
Week 4	Provider 1	1	0	1	1	1	1	1	1	1	0
	Provider 2	1	0	1	0	1	1	1	1	1	1
	Provider 3	1	1	0	0	1	1	1	1	1	1
	Provider 4	0	1	1	1	1	1	1	1	1	0
	Provider 5	0	1	1	0	0	1	1	1	1	1
	Provider 6	0	0	0	1	1	1	1	1	1	1
	Provider 7	0	1	0	0	1	1	1	1	1	1
	Provider 8	1	0	0	1	0	1	1	1	1	1

Base Model - Linear Programming Model Results (Throughput)

Week 1	Throughput Objective
New Patients	110.9433962
Established Patients	190.1886792
Phone Patients	15.8490566
Week 2	Throughput Objective
New Patients	110.9433962
Established Patients	190.1886792
Phone Patients	15.8490566
Week 3	Throughput Objective
New Patients	110.9433962
Established Patients	190.1886792
Phone Patients	15.8490566
Week 4	Throughput Objective
New Patients	110.9433962
Established Patients	190.1886792
Phone Patients	15.8490566
Full Month	
New Patients	443.7735849
Established Patients	760.754717
Phone Patients	63.39622642
	1267.924528 total patients can be seen ideally.

Base Model

Replications: 100 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	1,225

Base Model

Replications: 100 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.5000	0.00	0.5000	0.5000	0.5000	0.5000
New Patient	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Phone Consult Patient	0.08333333	0.00	0.08333333	0.08333333	0.08333333	0.08333333

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	70.5133	0.28	67.1211	74.1315	0.00	139.50
New Patient	70.1608	0.24	67.1227	72.5229	0.00	139.02
Phone Consult Patient	70.0592	1.14	59.1412	86.5121	0.00	139.72

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
New Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
Phone Consult Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	71.0800	0.28	67.6878	74.6982	0.5667	140.07
New Patient	71.2274	0.24	68.1894	73.5896	1.0667	140.08
Phone Consult Patient	70.2092	1.14	59.2912	86.6621	0.1500	139.87

Other

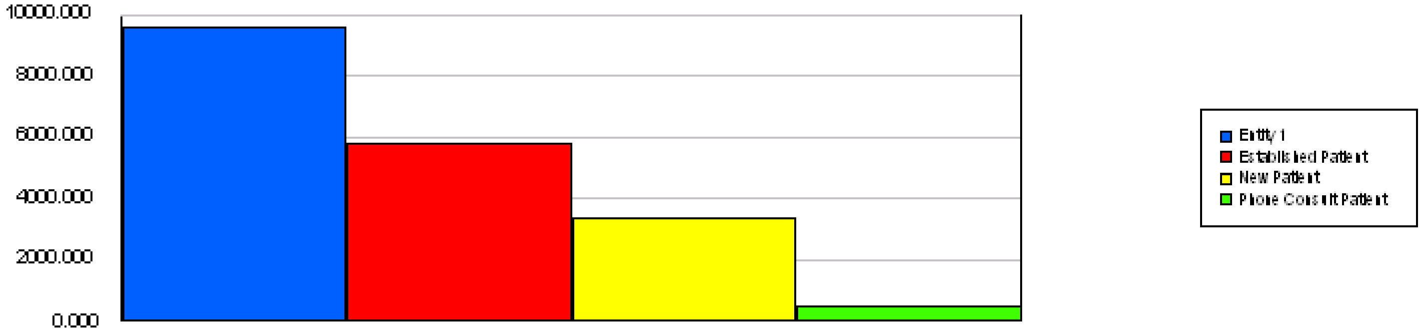
Base Model

Replications: 100 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	9600.00	0.00	9600.00	9600.00
Established Patient	5767.46	9.32	5634.00	5877.00
New Patient	3354.66	8.67	3268.00	3472.00
Phone Consult Patient	477.88	3.57	429.00	525.00



Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	9600.00	0.00	9600.00	9600.00
Established Patient	737.52	4.99	660.00	805.00
New Patient	425.85	2.44	393.00	456.00
Phone Consult Patient	61.4900	1.76	42.0000	79.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
Established Patient	2521.97	4.84	2462.81	2579.10	0.00	5143.00
New Patient	1467.51	4.86	1412.60	1535.66	0.00	3019.00
Phone Consult Patient	208.43	1.86	184.30	235.38	0.00	463.00

Base Model

Replications: 100 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	70.7171	0.28	67.1211	74.4845	0.00	139.88
New Patient Visit.Queue	70.5317	0.23	67.2932	73.0606	0.00	139.80
Phone Consult.Queue	70.0821	1.14	59.1412	86.5121	0.00	139.87

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	2518.31	4.83	2459.43	2575.52	0.00	5136.00
New Patient Visit.Queue	1464.05	4.85	1409.21	1531.99	0.00	3016.00
Phone Consult.Queue	208.28	1.86	184.17	235.23	0.00	463.00

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	0.8915	0.00	0.8871	0.8934	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	5.0099	0.00	4.9365	5.0603	0.00	8.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	4.7973	0.01	4.7063	4.8904	0.00	8.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1.0443	0.00	1.0334	1.0542

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1229.38	3.25	1196.00	1267.00

Scenario 1: Extend the clinic hours: increase the afternoon block by one hour (from 3 to 4 hours) for all providers each day of the week

Scenario 1 - Linear Programming Model Output (Schedule)

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
Week 1	Provider 1	0	0	1	1	1	1	0	1	1	1
	Provider 2	1	0	0	1	1	0	1	1	1	1
	Provider 3	0	0	0	1	1	1	1	1	1	1
	Provider 4	0	0	1	0	1	1	1	1	1	1
	Provider 5	0	1	1	1	0	1	1	1	1	1
	Provider 6	1	1	1	0	0	1	1	1	1	1
	Provider 7	1	1	0	1	0	1	1	1	1	1
	Provider 8	1	1	0	1	0	1	1	1	1	1
Week 2	Provider 1	1	0	1	1	1	1	1	1	1	0
	Provider 2	1	0	1	0	1	1	1	1	1	1
	Provider 3	1	1	0	0	1	1	1	1	1	1
	Provider 4	0	1	1	1	1	1	1	1	1	0
	Provider 5	0	1	1	0	0	1	1	1	1	1
	Provider 6	0	0	0	1	1	1	1	1	1	1
	Provider 7	0	1	0	0	1	1	1	1	1	1
	Provider 8	1	0	0	1	0	1	1	1	1	1
Week 3	Provider 1	0	1	1	0	0	1	1	1	1	1
	Provider 2	0	0	0	1	1	1	1	1	1	1
	Provider 3	0	1	0	1	0	1	1	1	1	1
	Provider 4	0	1	1	1	0	0	1	1	1	1
	Provider 5	1	0	1	1	1	0	1	1	1	1
	Provider 6	1	0	0	1	1	1	1	1	1	1
	Provider 7	1	1	0	0	1	1	1	1	1	1
	Provider 8	1	0	1	0	1	1	1	1	1	1
Week 4	Provider 1	1	1	0	0	1	1	1	1	1	1
	Provider 2	1	1	1	1	1	0	0	1	1	1
	Provider 3	1	0	1	0	1	1	1	1	1	1
	Provider 4	1	1	0	1	1	0	1	1	1	1
	Provider 5	0	0	0	1	1	1	1	1	1	1
	Provider 6	0	0	1	0	1	1	1	1	1	1
	Provider 7	0	0	1	1	1	1	1	0	1	1
	Provider 8	0	1	1	1	1	1	0	0	1	1

Scenario 1 - Linear Programming Model Results (Throughput)

Week 1	Throughput Objective
New Patients	126.7924528
Established Patients	217.3584906
Phone Patients	18.11320755
Week 2	Throughput Objective
New Patients	126.7924528
Established Patients	217.3584906
Phone Patients	18.11320755
Week 3	Throughput Objective
New Patients	126.7924528
Established Patients	217.3584906
Phone Patients	18.11320755
Week 4	Throughput Objective
New Patients	126.7924528
Established Patients	217.3584906
Phone Patients	18.11320755
Full Month	
New Patients	507.1698113
Established Patients	869.4339623
Phone Patients	72.45283019
	1449.056604 total patients can be seen ideally.

Values Across All Replications

Scenario One: Extend the clinic hours by one hour for all providers for each day of the week: increase the afternoon block by one hour (from 3 to 4 hours) for all providers for everyday

Replications: 100 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	1,372

Scenario One: Extend the clinic hours by one hour for all providers for each day of the week: increase the afternoon block by one hour (from 3 to 4 hours) for all providers for everyday

Replications: 100 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.5000	0.00	0.5000	0.5000	0.5000	0.5000
New Patient	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Phone Consult Patient	0.08333333	0.00	0.08333333	0.08333333	0.08333333	0.08333333

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	80.4606	0.29	76.6394	83.7834	0.00	157.00
New Patient	80.1788	0.22	77.2865	82.7555	0.00	156.55
Phone Consult Patient	80.2917	1.17	68.5589	96.7593	0.00	157.27

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
New Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
Phone Consult Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	81.0273	0.29	77.2060	84.3500	0.5667	157.57
New Patient	81.2455	0.22	78.3532	83.8222	1.0667	157.62
Phone Consult Patient	80.4417	1.17	68.7089	96.9093	0.1500	157.42

Other

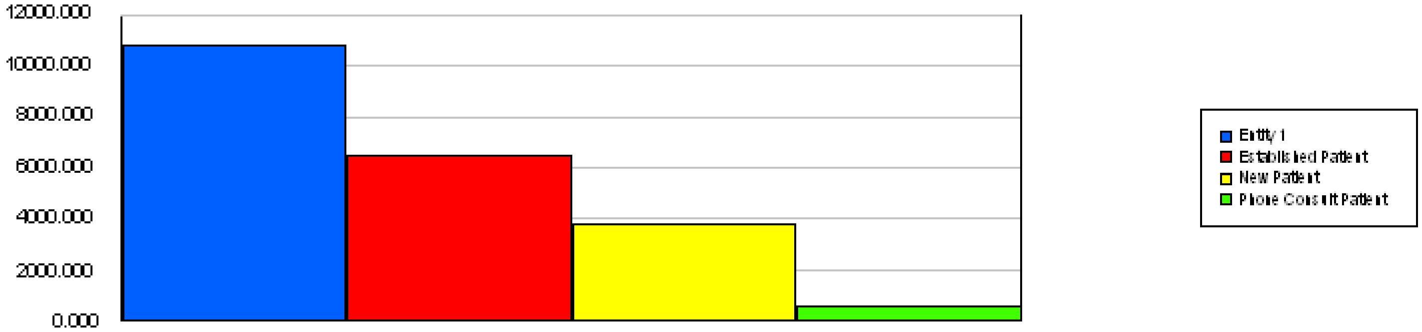
Scenario One: Extend the clinic hours by one hour for all providers for each day of the week: increase the afternoon block by one hour (from 3 to 4 hours) for all providers for everyday

Replications: 100 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	10800.00	0.00	10800.00	10800.00
Established Patient	6487.91	9.57	6351.00	6585.00
New Patient	3773.19	9.30	3659.00	3903.00
Phone Consult Patient	538.90	4.18	484.00	599.00



Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	10800.00	0.00	10800.00	10800.00
Established Patient	825.75	5.27	759.00	889.00
New Patient	477.38	2.66	442.00	517.00
Phone Consult Patient	69.1000	1.89	47.0000	91.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
Established Patient	2843.45	5.24	2778.45	2895.96	0.00	5786.00
New Patient	1654.86	4.99	1602.06	1721.86	0.00	3406.00
Phone Consult Patient	235.13	1.96	208.91	262.07	0.00	520.00

Values Across All Replications

Scenario One: Extend the clinic hours by one hour for all providers for each day of the week: increase the afternoon block by one hour (from 3 to 4 hours) for all providers for everyday

Replications: 100 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	80.7361	0.28	77.0147	84.0167	0.00	157.62
New Patient Visit.Queue	80.6261	0.23	77.7835	83.2651	0.00	157.60
Phone Consult.Queue	80.3545	1.18	68.5589	97.0095	0.00	157.32

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	2839.79	5.23	2775.02	2892.17	0.00	5779.00
New Patient Visit.Queue	1651.41	4.99	1598.71	1718.16	0.00	3402.00
Phone Consult.Queue	234.99	1.96	208.78	261.93	0.00	519.00

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	0.8888	0.00	0.8886	0.8941	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	4.9903	0.01	4.9407	5.0583	0.00	8.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	4.7774	0.01	4.7191	4.8630	0.00	8.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1.0446	0.00	1.0350	1.0578

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1378.09	3.35	1341.00	1422.00

Scenario 2: The addition of one examination room

Scenario 2 - Linear Programming Model Output (Schedule)

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
Week 1	Provider 1	0	0	1	1	1	1	0	1	1	1
	Provider 2	1	0	0	1	1	0	1	1	1	1
	Provider 3	0	0	0	1	1	1	1	1	1	1
	Provider 4	0	0	1	0	1	1	1	1	1	1
	Provider 5	0	1	1	1	0	1	1	1	1	1
	Provider 6	1	1	1	0	0	1	1	1	1	1
	Provider 7	1	1	0	1	0	1	1	1	1	1
	Provider 8	1	1	0	1	0	1	1	1	1	1
Week 2	Provider 1	1	0	1	1	1	1	1	1	1	0
	Provider 2	1	0	1	0	1	1	1	1	1	1
	Provider 3	1	1	0	0	1	1	1	1	1	1
	Provider 4	0	1	1	1	1	1	1	1	1	0
	Provider 5	0	1	1	0	0	1	1	1	1	1
	Provider 6	0	0	0	1	1	1	1	1	1	1
	Provider 7	0	1	0	0	1	1	1	1	1	1
	Provider 8	1	0	0	1	0	1	1	1	1	1
Week 3	Provider 1	0	1	1	0	0	1	1	1	1	1
	Provider 2	0	0	0	1	1	1	1	1	1	1
	Provider 3	0	1	0	1	0	1	1	1	1	1
	Provider 4	0	1	1	1	0	0	1	1	1	1
	Provider 5	1	0	1	1	1	0	1	1	1	1
	Provider 6	1	0	0	1	1	1	1	1	1	1
	Provider 7	1	1	0	0	1	1	1	1	1	1
	Provider 8	1	0	1	0	1	1	1	1	1	1
Week 4	Provider 1	1	1	0	0	1	1	1	1	1	1
	Provider 2	1	1	1	1	1	0	0	1	1	1
	Provider 3	1	0	1	0	1	1	1	1	1	1
	Provider 4	1	1	0	1	1	0	1	1	1	1
	Provider 5	0	0	0	1	1	1	1	1	1	1
	Provider 6	0	0	1	0	1	1	1	1	1	1
	Provider 7	0	0	1	1	1	1	1	0	1	1
	Provider 8	0	1	1	1	1	1	0	0	1	1

Scenario 2 - Linear Programming Model Results (Throughput)

Week 1	Throughput Objective	
New Patients	109.3584906	
Established Patients	187.4716981	
Phone Patients	15.62264151	
Week 2	Throughput Objective	
New Patients	110.9433962	
Established Patients	190.1886792	
Phone Patients	15.8490566	
Week 3	Throughput Objective	
New Patients	109.3584906	
Established Patients	187.4716981	
Phone Patients	15.62264151	
Week 4	Throughput Objective	
New Patients	109.3584906	
Established Patients	187.4716981	
Phone Patients	15.62264151	
Full Month		
New Patients	439.0188679	
Established Patients	752.6037736	
Phone Patients	62.71698113	
	1254.339623	total patients can be seen ideally.

Values Across All Replications

Scenario Two: The addition of one examination room

Replications: 100 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	1,373

Scenario Two: The addition of one examination room

Replications: 100 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.5000	0.00	0.5000	0.5000	0.5000	0.5000
New Patient	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Phone Consult Patient	0.08333333	0.00	0.08333333	0.08333333	0.08333333	0.08333333

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	80.6105	0.30	77.2609	84.3558	0.00	157.08
New Patient	80.4280	0.23	77.4406	83.4937	0.00	156.40
Phone Consult Patient	80.2472	1.17	67.3292	97.4150	0.00	157.13

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
New Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
Phone Consult Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	81.1772	0.30	77.8276	84.9224	0.5667	157.65
New Patient	81.4947	0.23	78.5073	84.5604	1.0667	157.47
Phone Consult Patient	80.3972	1.17	67.4792	97.5650	0.1500	157.28

Other

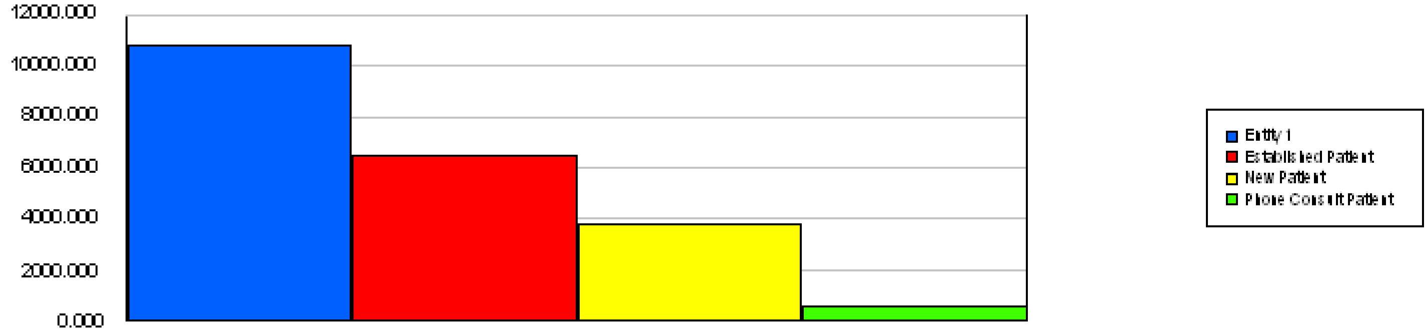
Scenario Two: The addition of one examination room

Replications: 100 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	10800.00	0.00	10800.00	10800.00
Established Patient	6487.91	9.57	6351.00	6585.00
New Patient	3773.19	9.30	3659.00	3903.00
Phone Consult Patient	538.90	4.18	484.00	599.00



Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	10800.00	0.00	10800.00	10800.00
Established Patient	826.30	5.19	742.00	889.00
New Patient	478.21	2.61	445.00	514.00
Phone Consult Patient	68.9600	1.87	47.0000	89.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
Established Patient	2843.90	5.21	2782.01	2895.95	0.00	5779.00
New Patient	1655.17	5.02	1601.57	1724.62	0.00	3402.00
Phone Consult Patient	235.17	1.96	208.63	262.13	0.00	520.00

Values Across All Replications

Scenario Two: The addition of one examination room

Replications: 100 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	80.7107	0.30	77.4527	84.5444	0.00	157.52
New Patient Visit.Queue	80.6284	0.24	77.4406	83.9540	0.00	157.50
Phone Consult.Queue	80.2654	1.17	67.3292	97.4150	0.00	157.15

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	2840.25	5.21	2778.64	2892.35	0.00	5777.00
New Patient Visit.Queue	1651.72	5.01	1598.21	1720.95	0.00	3401.00
Phone Consult.Queue	235.03	1.96	208.51	261.98	0.00	520.00

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	0.8866	0.00	0.8830	0.8886	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	4.9891	0.00	4.9394	5.0328	0.00	8.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	4.7607	0.00	4.7267	4.8019	0.00	8.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1.0480	0.00	1.0391	1.0560

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1375.84	3.03	1345.00	1413.00

Scenario 3: The addition of two examination rooms

Scenario 3 - Linear Programming Model Output (Schedule)

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
Week 1	Provider 1	0	0	1	1	1	1	0	1	1	1
	Provider 2	1	0	0	1	1	0	1	1	1	1
	Provider 3	0	0	0	1	1	1	1	1	1	1
	Provider 4	0	0	1	0	1	1	1	1	1	1
	Provider 5	0	1	1	1	0	1	1	1	1	1
	Provider 6	1	1	1	0	0	1	1	1	1	1
	Provider 7	1	1	0	1	0	1	1	1	1	1
	Provider 8	1	1	0	1	0	1	1	1	1	1
Week 2	Provider 1	1	0	1	1	1	1	1	1	1	0
	Provider 2	1	0	1	0	1	1	1	1	1	1
	Provider 3	1	1	0	0	1	1	1	1	1	1
	Provider 4	0	1	1	1	1	1	1	1	1	0
	Provider 5	0	1	1	0	0	1	1	1	1	1
	Provider 6	0	0	0	1	1	1	1	1	1	1
	Provider 7	0	1	0	0	1	1	1	1	1	1
	Provider 8	1	0	0	1	0	1	1	1	1	1
Week 3	Provider 1	0	1	1	0	0	1	1	1	1	1
	Provider 2	0	0	0	1	1	1	1	1	1	1
	Provider 3	0	1	0	1	0	1	1	1	1	1
	Provider 4	0	1	1	1	0	0	1	1	1	1
	Provider 5	1	0	1	1	1	0	1	1	1	1
	Provider 6	1	0	0	1	1	1	1	1	1	1
	Provider 7	1	1	0	0	1	1	1	1	1	1
	Provider 8	1	0	1	0	1	1	1	1	1	1
Week 4	Provider 1	1	1	0	0	1	1	1	1	1	1
	Provider 2	1	1	1	1	1	0	0	1	1	1
	Provider 3	1	0	1	0	1	1	1	1	1	1
	Provider 4	1	1	0	1	1	0	1	1	1	1
	Provider 5	0	0	0	1	1	1	1	1	1	1
	Provider 6	0	0	1	0	1	1	1	1	1	1
	Provider 7	0	0	1	1	1	1	1	0	1	1
	Provider 8	0	1	1	1	1	1	0	0	1	1

Scenario 3 - Linear Programming Model Results (Throughput)

Week 1	Throughput Objective
New Patients	109.3584906
Established Patients	187.4716981
Phone Patients	15.62264151
Week 2	Throughput Objective
New Patients	110.9433962
Established Patients	190.1886792
Phone Patients	15.8490566
Week 3	Throughput Objective
New Patients	109.3584906
Established Patients	187.4716981
Phone Patients	15.62264151
Week 4	Throughput Objective
New Patients	109.3584906
Established Patients	187.4716981
Phone Patients	15.62264151
Full Month	
New Patients	439.0188679
Established Patients	752.6037736
Phone Patients	62.71698113
	1254.339623 total patients can be seen ideally.

The linear programming results for Scenario 3 are precisely the same as the results for Scenario 2. For this reason, a simulation model report was not created. These scenarios output identical provider schedules because of the constraints placed on each provider for administrative and triage time; that is, the addition of 2 additional exam rooms does not increase throughput more than the addition of 1 room because there are not sufficient providers available to use the rooms given other scheduling constraints.

Scenario 4: Increase of 5% more new patients, 5% less established patients

Scenario 4 - Linear Programming Model Output (Schedule)

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
Week 1	Provider 1	0	0	1	1	1	1	0	1	1	1
	Provider 2	1	0	0	1	1	0	1	1	1	1
	Provider 3	0	0	0	1	1	1	1	1	1	1
	Provider 4	0	0	1	0	1	1	1	1	1	1
	Provider 5	0	1	1	1	0	1	1	1	1	1
	Provider 6	1	1	1	0	0	1	1	1	1	1
	Provider 7	1	1	0	1	0	1	1	1	1	1
	Provider 8	1	1	0	1	0	1	1	1	1	1
Week 2	Provider 1	1	0	1	1	1	1	1	1	1	0
	Provider 2	1	0	1	0	1	1	1	1	1	1
	Provider 3	1	1	0	0	1	1	1	1	1	1
	Provider 4	0	1	1	1	1	1	1	1	1	0
	Provider 5	0	1	1	0	0	1	1	1	1	1
	Provider 6	0	0	0	1	1	1	1	1	1	1
	Provider 7	0	1	0	0	1	1	1	1	1	1
	Provider 8	1	0	0	1	0	1	1	1	1	1
Week 3	Provider 1	0	1	1	0	0	1	1	1	1	1
	Provider 2	0	0	0	1	1	1	1	1	1	1
	Provider 3	0	1	0	1	0	1	1	1	1	1
	Provider 4	0	1	1	1	0	0	1	1	1	1
	Provider 5	1	0	1	1	1	0	1	1	1	1
	Provider 6	1	0	0	1	1	1	1	1	1	1
	Provider 7	1	1	0	0	1	1	1	1	1	1
	Provider 8	1	0	1	0	1	1	1	1	1	1
Week 4	Provider 1	1	1	0	0	1	1	1	1	1	1
	Provider 2	1	1	1	1	1	0	0	1	1	1
	Provider 3	1	0	1	0	1	1	1	1	1	1
	Provider 4	1	1	0	1	1	0	1	1	1	1
	Provider 5	0	0	0	1	1	1	1	1	1	1
	Provider 6	0	0	1	0	1	1	1	1	1	1
	Provider 7	0	0	1	1	1	1	1	0	1	1
	Provider 8	0	1	1	1	1	1	0	0	1	1

Scenario 4 - Linear Programming Model Results (Throughput)

Week 1	Throughput Objective	
New Patients	120.4363636	
Established Patients	165.6	
Phone Patients	15.05454545	
Week 2	Throughput Objective	
New Patients	122.1818182	
Established Patients	168	
Phone Patients	15.27272727	
Week 3	Throughput Objective	
New Patients	120.4363636	
Established Patients	165.6	
Phone Patients	15.05454545	
Week 4	Throughput Objective	
New Patients	120.4363636	
Established Patients	165.6	
Phone Patients	15.05454545	
Full Month		
New Patients	483.4909091	
Established Patients	664.8	
Phone Patients	60.43636364	
	1208.727273	total patients can be seen ideally.

Scenario Four: Increase of 5% more new patients, 5% less established patients

Replications: 100 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	1,323

Scenario Four: Increase of 5% more new patients, 5% less established patients

Replications: 100 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.5000	0.00	0.5000	0.5000	0.5000	0.5000
New Patient	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Phone Consult Patient	0.08333333	0.00	0.08333333	0.08333333	0.08333333	0.08333333

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	81.0331	0.37	76.0020	84.7835	0.00	157.65
New Patient	80.9782	0.22	78.5819	83.5663	0.00	157.22
Phone Consult Patient	81.0060	1.20	68.2563	95.7207	0.00	157.92

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
New Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
Phone Consult Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	81.5998	0.37	76.5687	85.3502	0.5667	158.22
New Patient	82.0448	0.22	79.6486	84.6329	1.0667	158.28
Phone Consult Patient	81.1560	1.20	68.4063	95.8707	0.1500	158.07

Other

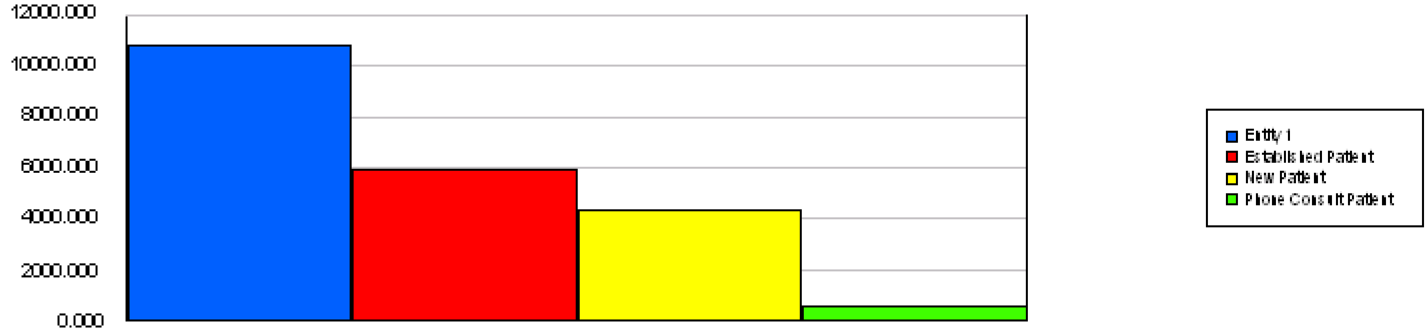
Scenario Four: Increase of 5% more new patients, 5% less established patients

Replications: 100 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	10800.00	0.00	10800.00	10800.00
Established Patient	5944.54	9.20	5814.00	6068.00
New Patient	4316.56	9.13	4211.00	4440.00
Phone Consult Patient	538.90	4.18	484.00	599.00



Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	10800.00	0.00	10800.00	10800.00
Established Patient	729.34	4.62	659.00	791.00
New Patient	527.45	2.49	495.00	558.00
Phone Consult Patient	66.7000	1.84	45.0000	87.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
Established Patient	2619.16	5.27	2550.44	2682.25	0.00	5324.00
New Patient	1903.58	5.11	1848.34	1971.39	0.00	3885.00
Phone Consult Patient	236.42	1.97	210.06	264.30	0.00	522.00

Scenario Four: Increase of 5% more new patients, 5% less established patients

Replications: 100 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	81.1507	0.37	76.1120	84.9854	0.00	158.15
New Patient Visit.Queue	81.2167	0.21	78.5819	83.5663	0.00	158.20
Phone Consult.Queue	81.0458	1.20	68.2563	95.7207	0.00	157.95

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	2615.90	5.27	2547.41	2679.00	0.00	5323.00
New Patient Visit.Queue	1899.74	5.10	1844.64	1967.37	0.00	3883.00
Phone Consult.Queue	236.28	1.97	209.94	264.15	0.00	522.00

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	0.8872	0.00	0.8830	0.8886	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	4.9937	0.00	4.9458	5.0338	0.00	8.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	4.7565	0.00	4.7204	4.7963	0.00	8.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1.0499	0.00	1.0372	1.0621

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1326.30	2.67	1300.00	1360.00

Scenario 5: Increase of 10% more new patients, 10% less established patients

Scenario 5 - Linear Programming Model Output (Schedule)

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
Week 1	Provider 1	0	0	1	1	1	1	0	1	1	1
	Provider 2	1	0	0	1	1	0	1	1	1	1
	Provider 3	0	0	0	1	1	1	1	1	1	1
	Provider 4	0	0	1	0	1	1	1	1	1	1
	Provider 5	0	1	1	1	0	1	1	1	1	1
	Provider 6	1	1	1	0	0	1	1	1	1	1
	Provider 7	1	1	0	1	0	1	1	1	1	1
	Provider 8	1	1	0	1	0	1	1	1	1	1
Week 2	Provider 1	1	0	1	1	1	1	1	1	1	0
	Provider 2	1	0	1	0	1	1	1	1	1	1
	Provider 3	1	1	0	0	1	1	1	1	1	1
	Provider 4	0	1	1	1	1	1	1	1	1	0
	Provider 5	0	1	1	0	0	1	1	1	1	1
	Provider 6	0	0	0	1	1	1	1	1	1	1
	Provider 7	0	1	0	0	1	1	1	1	1	1
	Provider 8	1	0	0	1	0	1	1	1	1	1
Week 3	Provider 1	0	1	1	0	0	1	1	1	1	1
	Provider 2	0	0	0	1	1	1	1	1	1	1
	Provider 3	0	1	0	1	0	1	1	1	1	1
	Provider 4	0	1	1	1	0	0	1	1	1	1
	Provider 5	1	0	1	1	1	0	1	1	1	1
	Provider 6	1	0	0	1	1	1	1	1	1	1
	Provider 7	1	1	0	0	1	1	1	1	1	1
	Provider 8	1	0	1	0	1	1	1	1	1	1
Week 4	Provider 1	1	1	0	0	1	1	1	1	1	1
	Provider 2	1	1	1	1	1	0	0	1	1	1
	Provider 3	1	0	1	0	1	1	1	1	1	1
	Provider 4	1	1	0	1	1	0	1	1	1	1
	Provider 5	0	0	0	1	1	1	1	1	1	1
	Provider 6	0	0	1	0	1	1	1	1	1	1
	Provider 7	0	0	1	1	1	1	1	0	1	1
	Provider 8	0	1	1	1	1	1	0	0	1	1

Scenario 5 - Linear Programming Model Results (Throughput)

Week 1	Throughput Objective	
New Patients	130.7368421	
Established Patients	145.2631579	
Phone Patients	14.52631579	
Week 2	Throughput Objective	
New Patients	132.6315789	
Established Patients	147.3684211	
Phone Patients	14.73684211	
Week 3	Throughput Objective	
New Patients	130.7368421	
Established Patients	145.2631579	
Phone Patients	14.52631579	
Week 4	Throughput Objective	
New Patients	130.7368421	
Established Patients	145.2631579	
Phone Patients	14.52631579	
Full Month		
New Patients	524.8421053	
Established Patients	583.1578947	
Phone Patients	58.31578947	
	1166.315789	total patients can be seen ideally.

Values Across All Replications

Scenario Five: Increase of 10% more new patients, 10% less established patients

Replications: 100 Time Units: Hours

Key Performance Indicators

System

	Average
Number Out	1,107

Scenario Five: Increase of 10% more new patients, 10% less established patients

Replications: 100 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.5000	0.00	0.5000	0.5000	0.5000	0.5000
New Patient	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Phone Consult Patient	0.08333333	0.00	0.08333333	0.08333333	0.08333333	0.08333333

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	72.4267	0.33	67.4025	75.9062	0.00	141.32
New Patient	72.1084	0.19	69.6586	75.5827	0.00	140.90
Phone Consult Patient	72.0981	1.17	59.0170	87.2524	0.00	141.52

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
New Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
Phone Consult Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	72.9934	0.33	67.9692	76.4728	0.5667	141.88
New Patient	73.1751	0.19	70.7252	76.6494	1.0667	141.97
Phone Consult Patient	72.2481	1.17	59.1670	87.4024	0.1500	141.67

Other

Values Across All Replications

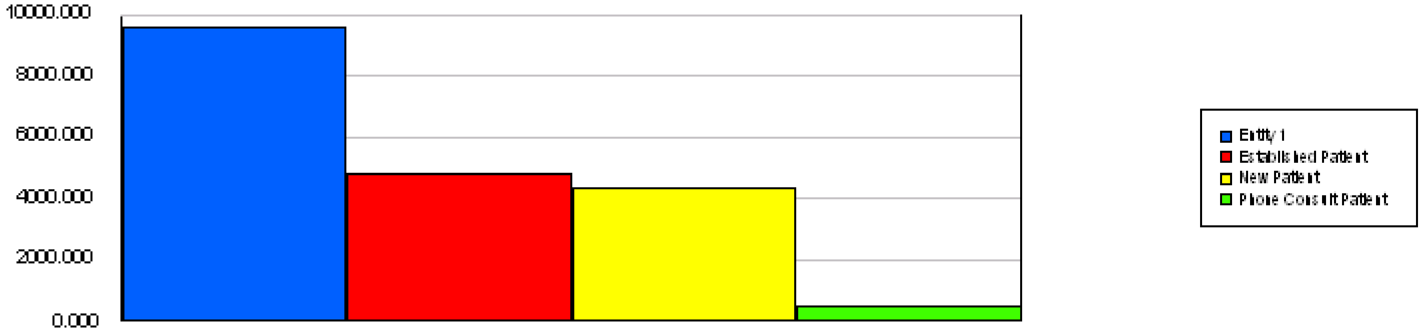
Scenario Five: Increase of 10% more new patients, 10% less established patients

Replications: 100 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	9600.00	0.00	9600.00	9600.00
Established Patient	4804.35	9.57	4662.00	4925.00
New Patient	4317.77	9.24	4219.00	4444.00
Phone Consult Patient	477.88	3.57	429.00	525.00



Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	9600.00	0.00	9600.00	9600.00
Established Patient	555.73	4.27	504.00	604.00
New Patient	495.90	2.30	468.00	520.00
Phone Consult Patient	55.7800	1.70	36.0000	73.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
Established Patient	2133.19	4.95	2072.36	2195.70	0.00	4359.00
New Patient	1917.59	4.97	1860.52	1974.65	0.00	3936.00
Phone Consult Patient	211.66	1.89	186.85	238.85	0.00	470.00

Scenario Five: Increase of 10% more new patients, 10% less established patients

Replications: 100 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	72.6964	0.33	67.6673	76.4342	0.00	141.82
New Patient Visit.Queue	72.6684	0.18	70.3821	76.1079	0.00	141.78
Phone Consult.Queue	72.1408	1.18	59.0170	87.2524	0.00	141.52

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	2130.33	4.95	2069.66	2192.82	0.00	4359.00
New Patient Visit.Queue	1913.47	4.97	1856.45	1970.42	0.00	3930.00
Phone Consult.Queue	211.52	1.89	186.73	238.71	0.00	470.00

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	0.8871	0.00	0.8871	0.8871	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	4.8821	0.01	4.8164	4.9718	0.00	8.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	4.6434	0.01	4.5750	4.7292	0.00	8.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1.0514	0.00	1.0394	1.0665

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1113.70	2.71	1086.00	1147.00

Scenario 6: The addition of a full-staffed Saturday AM block

This model could not be run in the linear programming model given the addition of the new day period. For this reason, there are no linear programming results to compare to for model verification. The schedule for this scenario was based off the “Base Model” schedule – a four hour Saturday block was added for all providers. All providers is defined by the 8 current providers at the Worcester CBOC.

Scenario 6 - Linear Programming Model Output (Schedule) – n/a

Scenario 6 - Linear Programming Model Results (Throughput) – n/a

Scenario Six – Addition of an AM clinic for 4 providers

Replications: 100 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	96

Scenario Six – Addition of an AM clinic for 4 providers

Replications: 100 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.5000	0.00	0.5000	0.5000	0.5000	0.5000
New Patient	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Phone Consult Patient	0.08166667	0.00	0.00	0.08333333	0.00	0.08333333

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	6.6569	0.10	5.4545	7.8598	0.00	13.8167
New Patient	6.5128	0.08	5.3448	7.4603	0.00	13.3333
Phone Consult Patient	6.7066	0.41	0.00	11.4833	0.00	14.1500

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
New Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
Phone Consult Patient	0.06533333	0.00	0.00	0.06666667	0.00	0.06666667

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	7.2236	0.10	6.0212	8.4265	0.5667	14.3833
New Patient	7.5794	0.08	6.4115	8.5270	1.0667	14.4000
Phone Consult Patient	6.8536	0.41	0.00	11.6333	0.00	14.3000

Other

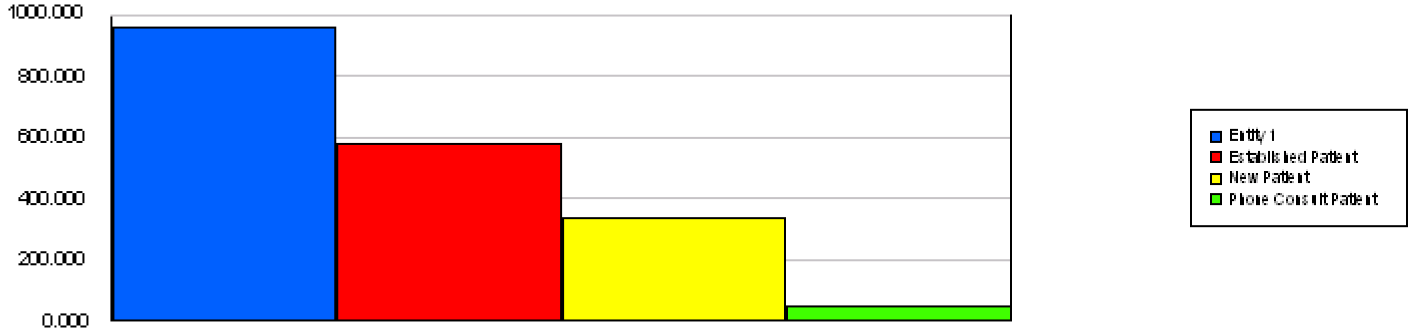
Scenario Six – Addition of an AM clinic for 4 providers

Replications: 100 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	960.00	0.00	960.00	960.00
Established Patient	577.60	3.21	533.00	611.00
New Patient	334.72	3.06	301.00	378.00
Phone Consult Patient	47.6800	1.41	33.0000	67.0000



Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	960.00	0.00	960.00	960.00
Established Patient	57.5300	1.42	42.0000	75.0000
New Patient	32.6200	0.70	23.0000	40.0000
Phone Consult Patient	5.4400	0.46	0.00	11.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
Established Patient	259.76	1.66	238.20	279.20	0.00	555.00
New Patient	152.15	1.66	131.21	174.79	0.00	340.00
Phone Consult Patient	21.5877	0.72	14.2625	31.1208	0.00	57.0000

Scenario Six – Addition of an AM clinic for 4 providers

Replications: 100 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	6.8662	0.10	5.5241	8.2069	0.00	14.2167
New Patient Visit.Queue	6.9920	0.09	5.3448	8.0083	0.00	14.3167
Phone Consult.Queue	6.7066	0.41	0.00	11.4833	0.00	14.1500

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	256.61	1.65	234.99	275.60	0.00	554.00
New Patient Visit.Queue	149.26	1.64	128.18	171.95	0.00	337.00
Phone Consult.Queue	21.4487	0.72	14.1635	30.9083	0.00	57.0000

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	0.9964	0.00	0.9964	0.9964	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	3.9854	0.00	3.9854	3.9854	0.00	4.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	4.0000	0.00	4.0000	4.0000	4.0000	4.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	0.9964	0.00	0.9964	0.9964

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	99.60	0.85	91.0000	108.00

Scenario 7: The addition of a Saturday AM block for 4 providers

This model could not be run in the linear programming model given the addition of the new day period. For this reason, there are no linear programming results to compare to for model verification. The schedule for this scenario was based off the "Base Model" schedule – a four hour Saturday block was added for 4 providers, or half of the current total providers available at the Worcester CBOC.

Scenario 7 - Linear Programming Model Output (Schedule) – n/a

Scenario 7 - Linear Programming Model Results (Throughput) – n/a

Scenario Seven – Addition of an AM clinic for 8 providers

Replications: 100 Time Units: Hours

Key Performance Indicators

System

	Average
Number Out	191

Scenario Seven – Addition of an AM clinic for 8 providers

Replications: 100 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.5000	0.00	0.5000	0.5000	0.5000	0.5000
New Patient	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Phone Consult Patient	0.08333333	0.00	0.08333333	0.08333333	0.08333333	0.08333333

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	5.9655	0.07	5.0218	6.9269	0.00	12.3000
New Patient	5.7265	0.05	5.0068	6.5048	0.00	11.8667
Phone Consult Patient	5.9997	0.26	2.8233	10.8333	0.00	12.5667

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
New Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
Phone Consult Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	6.5322	0.07	5.5884	7.4936	0.5667	12.8667
New Patient	6.7932	0.05	6.0735	7.5714	1.0667	12.9333
Phone Consult Patient	6.1497	0.26	2.9733	10.9833	0.1500	12.7167

Other

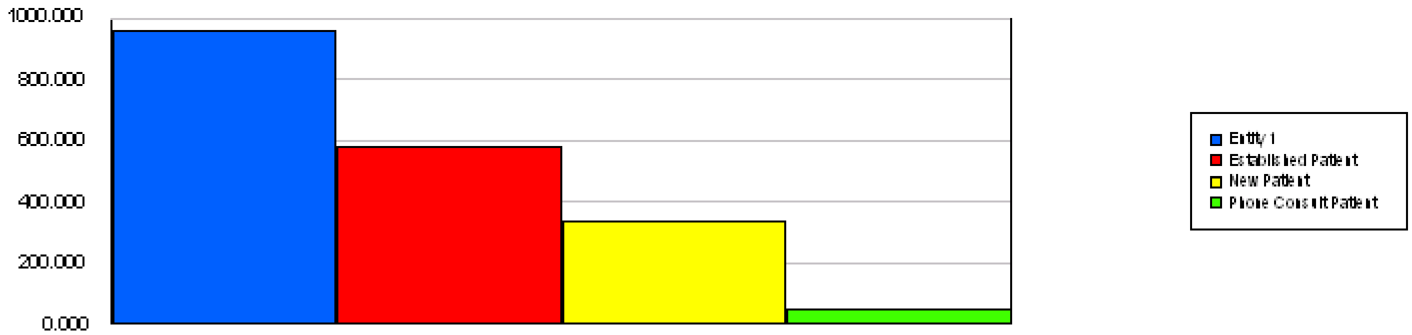
Scenario Seven – Addition of an AM clinic for 8 providers

Replications: 100 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	960.00	0.00	960.00	960.00
Established Patient	577.60	3.21	533.00	611.00
New Patient	334.72	3.06	301.00	378.00
Phone Consult Patient	47.6800	1.41	33.0000	67.0000



Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	960.00	0.00	960.00	960.00
Established Patient	115.68	1.78	95.0000	139.00
New Patient	65.0200	0.91	54.0000	75.0000
Phone Consult Patient	10.5000	0.68	4.0000	19.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
Established Patient	231.56	1.43	211.11	250.04	0.00	501.00
New Patient	136.60	1.51	115.89	158.67	0.00	303.00
Phone Consult Patient	18.9399	0.61	13.0646	27.4083	0.00	53.0000

Scenario Seven – Addition of an AM clinic for 8 providers

Replications: 100 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	6.1615	0.07	5.2616	7.0175	0.00	12.7000
New Patient Visit.Queue	6.1404	0.05	5.5303	6.7765	0.00	12.7000
Phone Consult.Queue	5.9997	0.26	2.8233	10.8333	0.00	12.5667

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	226.43	1.41	206.13	245.00	0.00	495.00
New Patient Visit.Queue	131.55	1.48	111.26	153.46	0.00	301.00
Phone Consult.Queue	18.7641	0.61	12.9312	27.1521	0.00	53.0000

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	0.9942	0.00	0.9936	0.9943	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	7.9538	0.00	7.9490	7.9542	0.00	8.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	8.0000	0.00	8.0000	8.0000	8.0000	8.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	0.9942	0.00	0.9936	0.9943

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	199.24	1.13	187.00	211.00

Scenario 8: The addition of a Saturday AM & PM block for 4 providers

This model could not be run in the linear programming model given the addition of the new day period. For this reason, there are no linear programming results to compare to for model verification. The schedule for this scenario was based off the "Base Model" schedule – two blocks (4 hour AM and 3 hour PM) blocks were added for 4 providers, or half of the current total providers available at the Worcester CBOC.

Scenario 8 - Linear Programming Model Output (Schedule) – n/a

Scenario 8 - Linear Programming Model Results (Throughput) – n/a

Scenario Eight: The addition of a Saturday AM & PM block for 4 providers

Replications: 100 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	1,344

Scenario Eight: The addition of a Saturday AM & PM block for 4 providers

Replications: 100 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.5000	0.00	0.5000	0.5000	0.5000	0.5000
New Patient	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Phone Consult Patient	0.08333333	0.00	0.08333333	0.08333333	0.08333333	0.08333333

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	86.6829	0.33	82.8414	91.2029	0.00	169.57
New Patient	86.3567	0.26	83.4775	89.8336	0.00	169.18
Phone Consult Patient	86.4651	1.27	72.2342	102.95	0.00	169.97

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
New Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
Phone Consult Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	87.2495	0.33	83.4081	91.7696	0.5667	170.13
New Patient	87.4234	0.26	84.5441	90.9002	1.0667	170.25
Phone Consult Patient	86.6151	1.27	72.3842	103.10	0.1500	170.12

Other

Scenario Eight: The addition of a Saturday AM & PM block for 4 providers

Replications: 100 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	11520.00	0.00	11520.00	11520.00
Established Patient	6920.63	10.04	6801.00	7022.00
New Patient	4025.22	9.72	3903.00	4140.00
Phone Consult Patient	574.15	4.37	522.00	632.00

Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	11520.00	0.00	11520.00	11520.00
Established Patient	808.97	5.12	733.00	872.00
New Patient	467.52	2.59	434.00	504.00
Phone Consult Patient	67.6700	1.88	46.0000	89.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
Established Patient	3067.04	5.37	3002.84	3120.74	0.00	6216.00
New Patient	1784.92	5.24	1729.71	1856.38	0.00	3671.00
Phone Consult Patient	253.73	2.06	225.70	281.10	0.00	557.00

Scenario Eight: The addition of a Saturday AM & PM block for 4 providers

Replications: 100 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	86.8978	0.33	82.8414	91.2029	0.00	170.02
New Patient Visit.Queue	86.7788	0.26	84.0066	89.8336	0.00	170.00
Phone Consult.Queue	86.5016	1.27	72.2342	102.95	0.00	169.97

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	3063.59	5.37	2999.62	3117.34	0.00	6212.00
New Patient Visit.Queue	1781.70	5.24	1726.59	1852.95	0.00	3669.00
Phone Consult.Queue	253.59	2.06	225.57	280.96	0.00	557.00

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	0.8987	0.00	0.8955	0.9007	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	4.5799	0.00	4.5217	4.6352	0.00	8.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	4.3933	0.00	4.3086	4.4595	0.00	8.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1.0425	0.00	1.0311	1.0521

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1348.71	3.16	1308.00	1385.00

Scenario 9: The addition of a full-staffed*** Saturday AM & PM block

This model could not be run in the linear programming model given the addition of the new day period. For this reason, there are no linear programming results to compare to for model verification. The schedule for this scenario was based off the “Base Model” schedule – two blocks (4 hour AM and 3 hour PM) blocks were added for 8 providers, or all of the current total providers available at the Worcester CBOC.

Scenario 9 - Linear Programming Model Output (Schedule) – n/a

Scenario 9 - Linear Programming Model Results (Throughput) – n/a

Scenario Nine: The addition of a fully-staffed Saturday AM & PM block

Replications: 100 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	1,473

Scenario Nine: The addition of a fully-staffed Saturday AM & PM block

Replications: 100 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.5000	0.00	0.5000	0.5000	0.5000	0.5000
New Patient	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Phone Consult Patient	0.08333333	0.00	0.08333333	0.08333333	0.08333333	0.08333333

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	85.6023	0.30	81.5193	90.1551	0.00	167.27
New Patient	85.2457	0.23	82.0465	88.7006	0.00	166.88
Phone Consult Patient	85.4815	1.24	71.2015	101.90	0.00	167.25

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
New Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
Phone Consult Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	86.1690	0.30	82.0860	90.7217	0.5667	167.83
New Patient	86.3124	0.23	83.1132	89.7672	1.0667	167.95
Phone Consult Patient	85.6315	1.24	71.3515	102.05	0.1500	167.40

Other

Scenario Nine: The addition of a fully-staffed Saturday AM & PM block

Replications: 100 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	11520.00	0.00	11520.00	11520.00
Established Patient	6920.63	10.04	6801.00	7022.00
New Patient	4025.22	9.72	3903.00	4140.00
Phone Consult Patient	574.15	4.37	522.00	632.00

Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	11520.00	0.00	11520.00	11520.00
Established Patient	886.97	5.30	803.00	951.00
New Patient	512.29	2.62	482.00	551.00
Phone Consult Patient	74.1900	1.87	51.0000	96.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
Established Patient	3029.03	5.37	2968.11	3083.09	0.00	6141.00
New Patient	1763.03	5.16	1709.87	1832.11	0.00	3627.00
Phone Consult Patient	250.56	2.02	223.31	277.15	0.00	550.00

Scenario Nine: The addition of a fully-staffed Saturday AM & PM block

Replications: 100 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	85.7970	0.30	81.5193	90.5253	0.00	167.75
New Patient Visit.Queue	85.5924	0.24	82.5479	88.7006	0.00	167.70
Phone Consult.Queue	85.5035	1.23	71.2015	101.90	0.00	167.53

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	3025.36	5.36	2964.70	3079.48	0.00	6139.00
New Patient Visit.Queue	1759.57	5.16	1706.51	1828.41	0.00	3625.00
Phone Consult.Queue	250.42	2.02	223.18	277.00	0.00	550.00

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	0.8988	0.00	0.8955	0.9007	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	5.0192	0.00	4.9722	5.0564	0.00	8.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	4.8284	0.00	4.7601	4.8945	0.00	8.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1.0395	0.00	1.0318	1.0460

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1477.78	3.12	1442.00	1515.00

Scenario 10: Increase the number of providers by 1 to 9 total providers

Scenario 1 - Linear Programming Model Output (Schedule)

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
Week 1	Provider 1	0	0	1	1	1	0	1	1	1	1
	Provider 2	0	0	0	1	1	1	1	1	1	1
	Provider 3	0	0	0	1	1	1	1	1	1	1
	Provider 4	0	0	1	1	0	1	1	1	1	1
	Provider 5	1	0	1	1	1	1	1	0	1	1
	Provider 6	0	1	0	1	1	1	1	1	1	1
	Provider 7	1	1	1	0	1	1	1	0	1	1
	Provider 8	1	1	1	1	1	0	1	0	1	1
	Provider 9	1	1	0	1	1	1	1	0	1	1
Week 2	Provider 1	1	0	0	1	1	1	1	1	1	1
	Provider 2	1	0	0	1	1	1	1	1	1	1
	Provider 3	1	1	1	0	0	1	1	1	1	1
	Provider 4	1	1	0	1	1	1	1	1	1	0
	Provider 5	0	0	0	1	1	1	1	1	1	1
	Provider 6	0	0	1	1	1	1	1	1	0	1
	Provider 7	0	1	1	0	1	1	0	1	1	1
	Provider 8	0	0	1	0	1	1	1	1	1	1
	Provider 9	0	1	0	1	1	1	1	0	1	1
Week 3	Provider 1	0	0	1	1	1	0	1	1	1	1
	Provider 2	0	0	0	1	1	1	1	1	1	1
	Provider 3	0	0	0	1	1	1	1	1	1	1
	Provider 4	0	0	1	1	0	1	1	1	1	1
	Provider 5	1	0	1	1	1	1	1	0	1	1
	Provider 6	0	1	0	1	1	1	1	1	1	1
	Provider 7	1	1	1	0	1	1	1	0	1	1
	Provider 8	1	1	1	1	1	0	1	0	1	1
	Provider 9	1	1	0	1	1	1	1	0	1	1
Week 4	Provider 1	1	0	0	1	1	1	1	1	1	1
	Provider 2	1	0	0	1	1	1	1	1	1	1
	Provider 3	1	1	1	0	0	1	1	1	1	1
	Provider 4	1	1	0	1	1	1	1	1	1	0
	Provider 5	0	0	0	1	1	1	1	1	1	1
	Provider 6	0	0	1	1	1	1	1	1	0	1
	Provider 7	0	1	1	0	1	1	0	1	1	1
	Provider 8	0	0	1	0	1	1	1	1	1	1
	Provider 9	0	1	0	1	1	1	1	0	1	1

Scenario 10 - Linear Programming Model Results (Throughput)

Week 1	Throughput Objective
New Patients	126
Established Patients	216
Phone Patients	18
Week 2	Throughput Objective
New Patients	123
Established Patients	211
Phone Patients	18
Week 3	Throughput Objective
New Patients	126
Established Patients	216
Phone Patients	18
Week 4	Throughput Objective
New Patients	126
Established Patients	216
Phone Patients	18
Full Month	
New Patients	501
Established Patients	859
Phone Patients	72
	1432 total patients can be seen ideally.

Scenario Ten: The addition of one full-time provider

Replications: 100 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	1,363

Scenario Ten: The addition of one full-time provider

Replications: 100 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.5000	0.00	0.5000	0.5000	0.5000	0.5000
New Patient	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Phone Consult Patient	0.08333333	0.00	0.08333333	0.08333333	0.08333333	0.08333333

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	69.5673	0.26	66.8013	72.7540	0.00	137.27
New Patient	69.1697	0.19	66.7741	72.0840	0.00	136.90
Phone Consult Patient	69.4263	1.02	59.0078	84.9589	0.00	137.48

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
New Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
Phone Consult Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	70.1339	0.26	67.3680	73.3207	0.5667	137.83
New Patient	70.2364	0.19	67.8407	73.1506	1.0667	137.97
Phone Consult Patient	69.5763	1.02	59.1578	85.1089	0.1500	137.63

Other

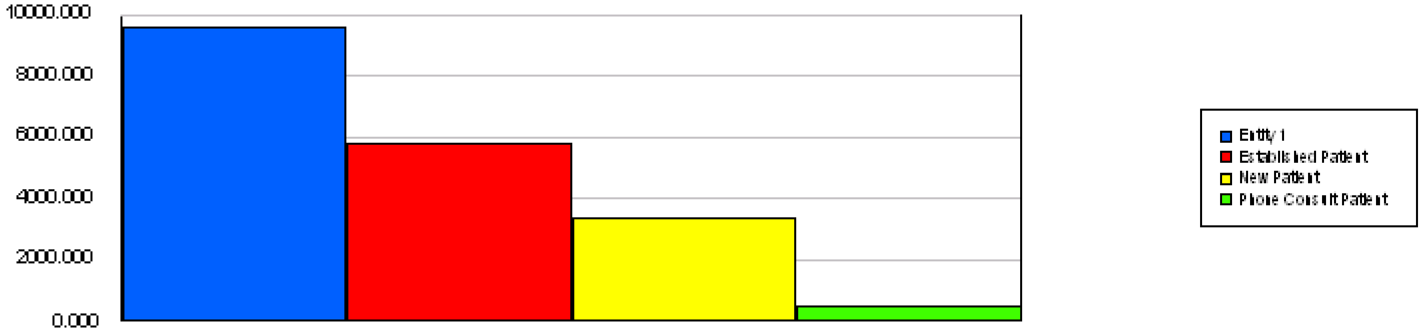
Scenario Ten: The addition of one full-time provider

Replications: 100 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	9600.00	0.00	9600.00	9600.00
Established Patient	5767.46	9.32	5634.00	5877.00
New Patient	3354.66	8.67	3268.00	3472.00
Phone Consult Patient	477.88	3.57	429.00	525.00



Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	9600.00	0.00	9600.00	9600.00
Established Patient	821.08	5.31	745.00	893.00
New Patient	473.51	2.64	438.00	513.00
Phone Consult Patient	68.7000	1.87	47.0000	89.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
Established Patient	2481.97	4.93	2422.68	2538.43	0.00	5062.00
New Patient	1444.53	4.72	1392.11	1507.84	0.00	2973.00
Phone Consult Patient	205.07	1.83	181.79	231.59	0.00	453.00

Values Across All Replications

Scenario Ten: The addition of one full-time provider

Replications: 100 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	69.8830	0.26	66.8851	73.1699	0.00	137.68
New Patient Visit.Queue	69.7832	0.20	67.5039	72.2186	0.00	137.65
Phone Consult.Queue	69.4878	1.04	59.0078	84.9589	0.00	137.68

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	2478.02	4.93	2419.02	2534.57	0.00	5055.00
New Patient Visit.Queue	1440.76	4.71	1388.45	1503.79	0.00	2968.00
Phone Consult.Queue	204.93	1.82	181.66	231.43	0.00	453.00

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	0.8871	0.00	0.8871	0.8871	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	5.5827	0.01	5.4875	5.6781	0.00	9.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	5.3371	0.01	5.2146	5.4292	0.00	9.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1.0460	0.00	1.0345	1.0614

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1371.56	3.52	1337.00	1413.00

Scenario 11: Increase the number of providers by 2 to 10 total providers

Scenario 11 - Linear Programming Model Output (Schedule)

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
Week 1	Provider 1	0	0	1	0	1	1	1	1	1	1
	Provider 2	0	1	0	0	1	1	1	1	1	1
	Provider 3	0	1	0	1	0	1	1	1	1	1
	Provider 4	1	0	1	0	1	1	0	1	1	1
	Provider 5	1	0	1	0	1	1	1	1	1	1
	Provider 6	0	0	1	1	1	1	1	1	1	1
	Provider 7	0	1	0	1	1	1	1	1	1	1
	Provider 8	1	0	1	1	1	0	1	1	1	1
	Provider 9	1	0	0	1	1	1	1	1	1	1
	Provider 10	0	1	1	0	1	1	1	1	1	1
Week 2	Provider 1	1	0	1	1	0	1	1	1	1	1
	Provider 2	1	1	1	0	0	1	1	1	1	1
	Provider 3	1	1	1	0	0	1	1	1	1	1
	Provider 4	1	1	0	0	1	1	1	1	1	1
	Provider 5	0	0	0	1	1	1	1	1	1	1
	Provider 6	0	0	0	1	1	1	1	1	1	1
	Provider 7	0	0	0	1	1	1	1	1	1	1
	Provider 8	1	0	1	0	0	1	1	1	1	1
	Provider 9	1	0	0	1	0	1	1	1	1	1
	Provider 10	1	1	0	1	0	1	0	1	1	1
Week 3	Provider 1	0	0	1	0	1	1	1	1	1	1
	Provider 2	0	1	0	0	1	1	1	1	1	1
	Provider 3	0	1	0	1	0	1	1	1	1	1
	Provider 4	1	0	1	0	1	1	0	1	1	1
	Provider 5	1	0	1	0	1	1	1	1	1	1
	Provider 6	0	0	1	1	1	1	1	1	1	1
	Provider 7	0	1	0	1	1	1	1	1	1	1
	Provider 8	1	0	1	1	1	0	1	1	1	1
	Provider 9	1	0	0	1	1	1	1	1	1	1
	Provider 10	0	1	1	0	1	1	1	1	1	1
Week 4	Provider 1	1	0	1	1	0	1	1	1	1	1
	Provider 2	1	1	1	0	0	1	1	1	1	1
	Provider 3	1	1	1	0	0	1	1	1	1	1
	Provider 4	1	1	0	0	1	1	1	1	1	1
	Provider 5	0	0	0	1	1	1	1	1	1	1
	Provider 6	0	0	0	1	1	1	1	1	1	1
	Provider 7	0	0	0	1	1	1	1	1	1	1
	Provider 8	1	0	1	0	0	1	1	1	1	1
	Provider 9	1	0	0	1	0	1	1	1	1	1
	Provider 10	1	1	0	1	0	1	0	1	1	1

Scenario 11 - Linear Programming Model Results (Throughput)

Week 1	Throughput Objective
New Patients	141
Established Patients	241
Phone Patients	20
Week 2	Throughput Objective
New Patients	135
Established Patients	232
Phone Patients	19
Week 3	Throughput Objective
New Patients	141
Established Patients	241
Phone Patients	20
Week 4	Throughput Objective
New Patients	141
Established Patients	241
Phone Patients	20
Full Month	
New Patients	558
Established Patients	955
Phone Patients	79

1592 total patients can be seen ideally.

Scenario Eleven: The addition of two full-time providers

Replications: 100 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	1,493

Scenario Eleven: The addition of two full-time providers

Replications: 100 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.5000	0.00	0.5000	0.5000	0.5000	0.5000
New Patient	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Phone Consult Patient	0.08333333	0.00	0.08333333	0.08333333	0.08333333	0.08333333

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	68.1449	0.26	64.1261	71.4266	0.00	135.25
New Patient	67.7479	0.20	65.2195	71.3142	0.00	134.82
Phone Consult Patient	68.2083	0.95	55.4094	80.8236	0.00	135.47

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
New Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667
Phone Consult Patient	0.06666667	0.00	0.06666667	0.06666667	0.06666667	0.06666667

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	0.00	0.00	0.00	0.00	0.00	0.00
New Patient	0.00	0.00	0.00	0.00	0.00	0.00
Phone Consult Patient	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient	68.7115	0.26	64.6928	71.9932	0.5667	135.82
New Patient	68.8145	0.20	66.2862	72.3809	1.0667	135.88
Phone Consult Patient	68.3583	0.95	55.5594	80.9736	0.1500	135.62

Other

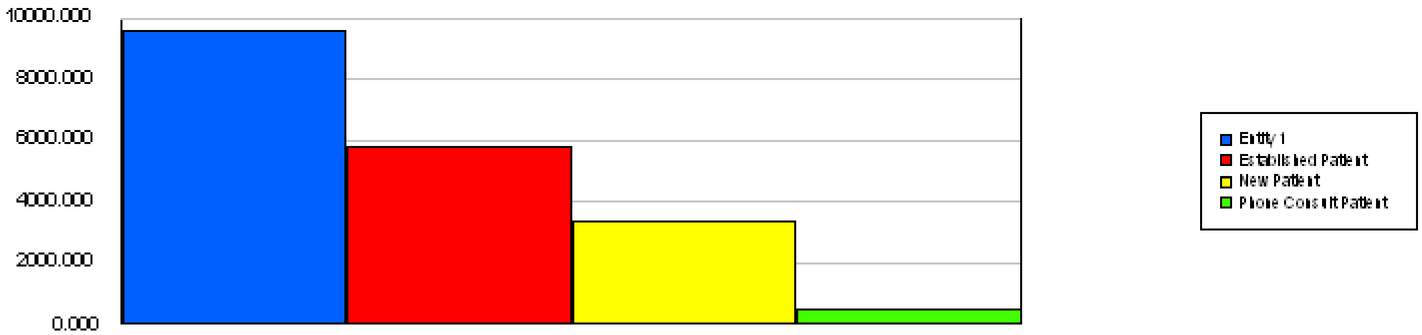
Scenario Eleven: The addition of two full-time providers

Replications: 100 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	9600.00	0.00	9600.00	9600.00
Established Patient	5767.46	9.32	5634.00	5877.00
New Patient	3354.66	8.67	3268.00	3472.00
Phone Consult Patient	477.88	3.57	429.00	525.00



Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	9600.00	0.00	9600.00	9600.00
Established Patient	898.97	5.38	810.00	960.00
New Patient	518.48	2.80	487.00	557.00
Phone Consult Patient	75.3500	1.88	51.0000	96.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
Established Patient	2441.81	4.91	2388.42	2494.31	0.00	4969.00
New Patient	1421.38	4.65	1370.58	1484.32	0.00	2919.00
Phone Consult Patient	201.72	1.78	179.10	226.98	0.00	446.00

Scenario Eleven: The addition of two full-time providers

Replications: 100 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	68.4544	0.25	64.4355	71.7014	0.00	135.62
New Patient Visit.Queue	68.3673	0.19	65.8934	71.7792	0.00	135.62
Phone Consult.Queue	68.2544	0.94	55.4094	80.8236	0.00	135.47

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Established Patient Visit.Queue	2437.60	4.91	2384.54	2490.14	0.00	4964.00
New Patient Visit.Queue	1417.32	4.64	1366.63	1479.98	0.00	2915.00
Phone Consult.Queue	201.57	1.78	178.96	226.81	0.00	446.00

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	0.8871	0.00	0.8822	0.8871	0.00	1.0000

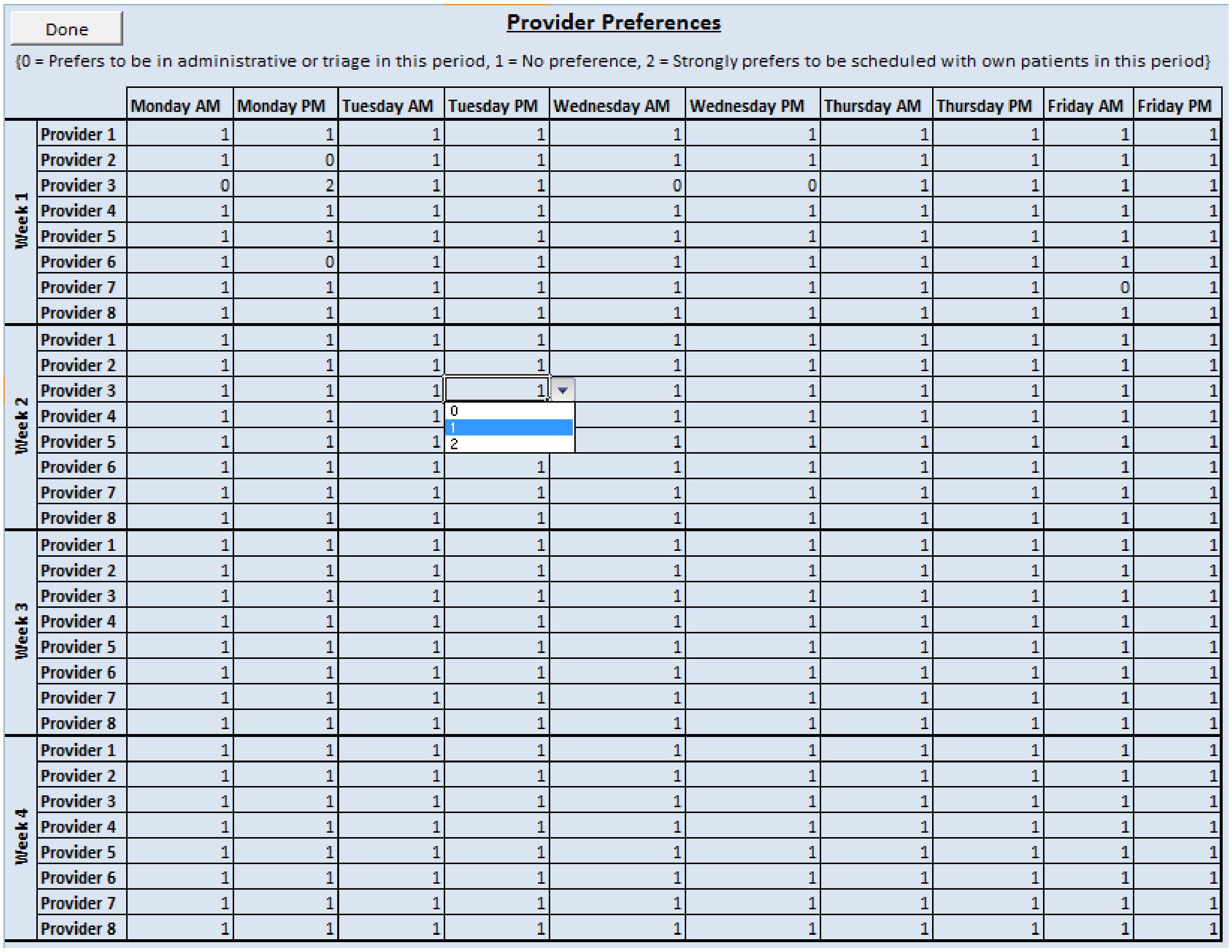
Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	6.1103	0.01	5.9958	6.2176	0.00	10.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Primary Care Physician	5.8436	0.01	5.7172	5.9609	0.00	10.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1.0457	0.00	1.0324	1.0572

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Primary Care Physician	1501.88	3.54	1461.00	1549.00

F User Interface Screenshots



Done

Provider Preferences

{0 = Prefers to be in administrative or triage in this period, 1 = No preference, 2 = Strongly prefers to be scheduled with own patients in this period}

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
Week 1	Provider 1	1	1	1	1	1	1	1	1	1	1
	Provider 2	1	0	1	1	1	1	1	1	1	1
	Provider 3	0	2	1	1	0	0	1	1	1	1
	Provider 4	1	1	1	1	1	1	1	1	1	1
	Provider 5	1	1	1	1	1	1	1	1	1	1
	Provider 6	1	0	1	1	1	1	1	1	1	1
	Provider 7	1	1	1	1	1	1	1	1	0	1
	Provider 8	1	1	1	1	1	1	1	1	1	1
Week 2	Provider 1	1	1	1	1	1	1	1	1	1	1
	Provider 2	1	1	1	1	1	1	1	1	1	1
	Provider 3	1	1	1	1	1	1	1	1	1	1
	Provider 4	1	1	1	0	1	1	1	1	1	1
	Provider 5	1	1	1	1 2	1	1	1	1	1	1
	Provider 6	1	1	1	1	1	1	1	1	1	1
	Provider 7	1	1	1	1	1	1	1	1	1	1
	Provider 8	1	1	1	1	1	1	1	1	1	1
Week 3	Provider 1	1	1	1	1	1	1	1	1	1	1
	Provider 2	1	1	1	1	1	1	1	1	1	1
	Provider 3	1	1	1	1	1	1	1	1	1	1
	Provider 4	1	1	1	1	1	1	1	1	1	1
	Provider 5	1	1	1	1	1	1	1	1	1	1
	Provider 6	1	1	1	1	1	1	1	1	1	1
	Provider 7	1	1	1	1	1	1	1	1	1	1
	Provider 8	1	1	1	1	1	1	1	1	1	1
Week 4	Provider 1	1	1	1	1	1	1	1	1	1	1
	Provider 2	1	1	1	1	1	1	1	1	1	1
	Provider 3	1	1	1	1	1	1	1	1	1	1
	Provider 4	1	1	1	1	1	1	1	1	1	1
	Provider 5	1	1	1	1	1	1	1	1	1	1
	Provider 6	1	1	1	1	1	1	1	1	1	1
	Provider 7	1	1	1	1	1	1	1	1	1	1
	Provider 8	1	1	1	1	1	1	1	1	1	1

Figure F-1. Provider Preferences Input Page

Done

Time Away

Set to 0 for any time in which the provider has approved vacation time or is scheduled for routine time away from this facility.

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
Week 1	Provider 1	1	1	1	1	1	1	1	1	1	1
	Provider 2	1	1	1	1	1	1	1	1	1	1
	Provider 3	1	1	1	1	1	1	1	1	1	1
	Provider 4	1	1	1	1	1	1	1	1	1	1
	Provider 5	1	1	1	1	1	1	1	1	1	1
	Provider 6	1	1	1	1	0 1	1	1	1	1	1
	Provider 7	1	1	1	1	1	1	1	1	1	1
	Provider 8	1	1	1	1	1	1	1	1	1	1
Week 2	Provider 1	1	1	1	1	1	1	1	1	1	1
	Provider 2	1	1	1	1	1	1	1	1	1	1
	Provider 3	1	1	1	1	1	1	1	1	1	1
	Provider 4	1	1	1	1	1	1	1	1	1	1
	Provider 5	1	1	1	1	1	1	1	1	1	1
	Provider 6	1	1	1	1	1	1	1	1	1	1
	Provider 7	1	1	1	1	1	1	1	1	1	1
	Provider 8	1	1	1	1	1	1	1	1	1	1
Week 3	Provider 1	1	1	1	1	1	1	1	1	1	1
	Provider 2	1	1	1	1	1	1	1	1	1	1
	Provider 3	1	1	1	1	1	1	1	1	1	1
	Provider 4	1	1	1	1	1	1	1	1	1	1
	Provider 5	1	1	1	1	1	1	1	1	1	1
	Provider 6	1	1	1	1	1	1	1	1	1	1
	Provider 7	1	1	1	1	1	1	1	1	1	1
	Provider 8	1	1	1	1	1	1	1	1	1	1
Week 4	Provider 1	1	1	1	1	1	1	1	1	1	1
	Provider 2	1	1	1	1	1	1	1	1	1	1
	Provider 3	1	1	1	1	1	1	1	1	1	1
	Provider 4	1	1	1	1	1	1	1	1	1	1
	Provider 5	1	1	1	1	1	1	1	1	1	1
	Provider 6	1	1	1	1	1	1	1	1	1	1
	Provider 7	1	1	1	1	1	1	1	1	1	1
	Provider 8	1	1	1	1	1	1	1	1	1	1

Figure F-2. Time Away Input Page

Done

Specialist Schedules

Set to 0 or 1: {0 = Is not scheduled, 1 = Is scheduled}

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
Week 1	Specialist 1	1	1	0	0	0	0	0	0	0	0
	Specialist 2	1	1	0	0	1	0	0	0	0	0
	Specialist 3	1	0	0	0	0	0	0	0	0	0
	Specialist 4	1	1	0	0	0	0	0	0	0	0
	Specialist 5	0	0	0	[illegible]	0	0	0	0	1	1
Week 2	Specialist 1	1	1	0	0	0	0	0	0	0	0
	Specialist 2	1	1	0	0	1	0	0	0	0	0
	Specialist 3	1	0	0	0	0	0	0	0	0	0
	Specialist 4	0	0	0	0	0	0	1	1	0	0
	Specialist 5	0	0	0	0	0	0	0	0	1	1
Week 3	Specialist 1	1	1	0	0	0	0	0	0	0	0
	Specialist 2	1	1	0	0	1	0	0	0	0	0
	Specialist 3	1	0	0	0	0	0	0	0	0	0
	Specialist 4	1	1	0	0	0	0	0	0	0	0
	Specialist 5	0	0	0	0	0	0	0	0	1	1
Week 4	Specialist 1	1	1	0	0	0	0	0	0	0	0
	Specialist 2	1	1	0	0	1	0	0	0	0	0
	Specialist 3	1	0	0	0	0	0	0	0	0	0
	Specialist 4	0	0	0	0	0	0	1	1	0	0
	Specialist 5	0	0	0	0	0	0	0	0	1	1

Figure F-3. Specialist Schedules Input Page

Done

Room Requirements

How many rooms does a provider or specialist require? It does not matter if the provider/specialist is scheduled. The number will most likely be the same for all cells in a row.

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
All Weeks	Provider 1	1	1	1	1	1	1	1	1	1	1
	Provider 2	2	2	2	2	2	2	2	2	2	2
	Provider 3	2	2	2	2	2	2	2	2	2	2
	Provider 4	2	2	2	2	2	2	2	2	2	2
	Provider 5	2	2	[illegible]	2	2	2	2	2	2	2
	Provider 6	2	2	[illegible]	2	2	2	2	2	2	2
	Provider 7	2	2	[illegible]	2	2	2	2	2	2	2
	Provider 8	1	1	1	1	1	1	1	1	1	1
	Specialist 1	2	2	2	2	2	2	2	2	2	2
	Specialist 2	2	2	2	2	2	2	2	2	2	2
	Specialist 3	2	2	2	2	2	2	2	2	2	2
	Specialist 4	2	2	2	2	2	2	2	2	2	2
	Specialiat 5	2	2	2	2	2	2	2	2	2	2

Figure F-4. Room Requirements Input Page

Done

Number of Rooms

How many rooms are available for exams?

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
Week 1	Number of Rooms	21	21	21	21	21	21	21	21	21	21
Week 2	Number of Rooms	21	21	21	21	21	21	21	21	21	21
Week 3	Number of Rooms	21	21	21	21	21	21	21	21	21	21
Week 4	Number of Rooms	21	21	21	21	21	21	21	21	21	21

Figure F-5. Number of Rooms Input Page

Done

Utilization of Rooms by Nurses & Health Techs

How many EXAM ROOMS that could be used for patient appointments are expected to be utilized by nurses or health techs for other purposes?

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
Week 1	Number of Rooms	0	0	0	0	0	0	0	0	0	0
Week 2	Number of Rooms	0	0	0	0	0	0	0	0	0	0
Week 3	Number of Rooms	0	0	0	0	0	0	0	0	0	0
Week 4	Number of Rooms	0	0	0	0	0	0	0	0	0	0

Figure F-6. Nurse Use of Rooms

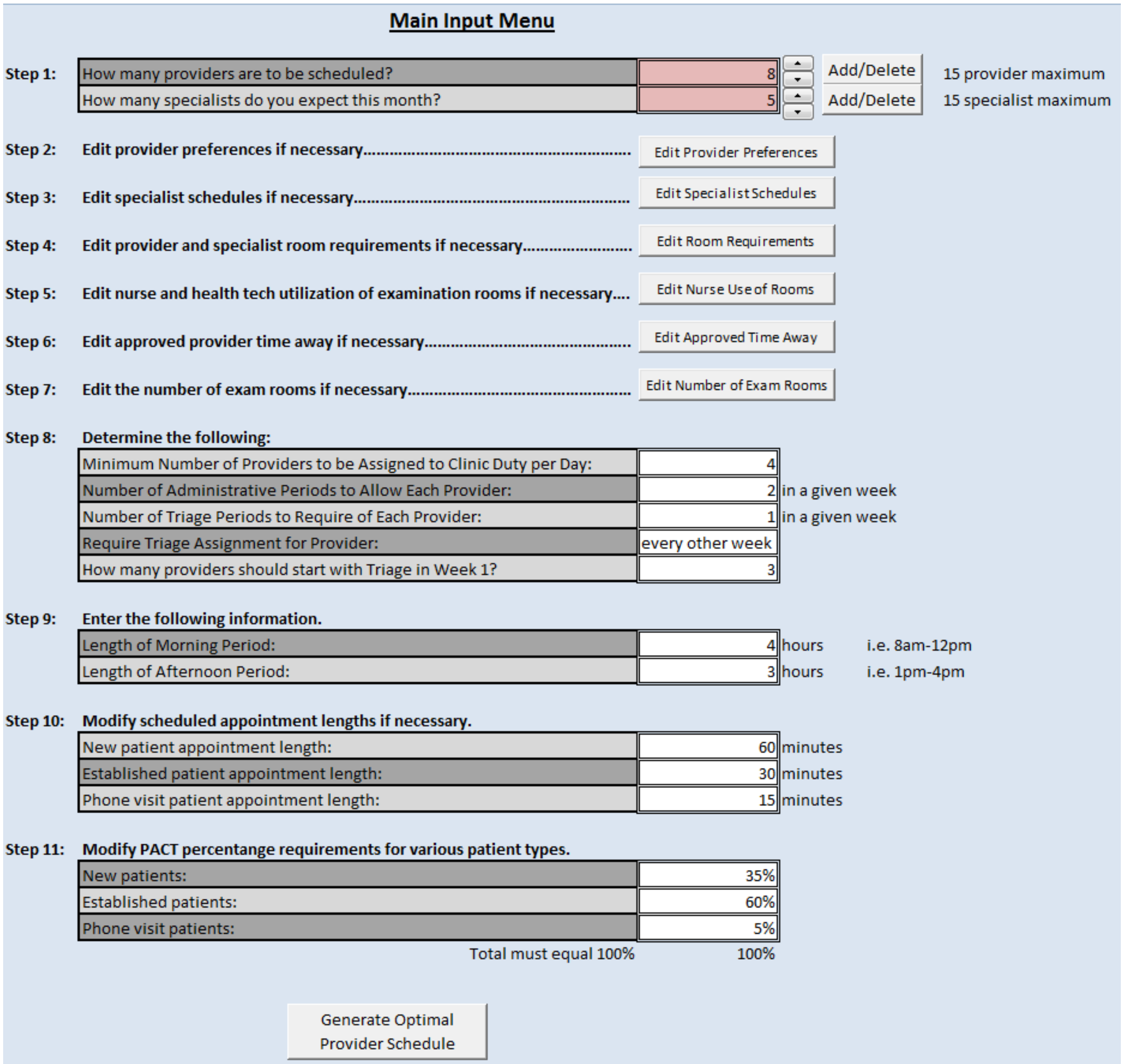


Figure F-7. Output, Model 1 All Weeks

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Optimal Provider Schedule

Throughput Results

		Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
Week 1	Provider 1	0	0	1	0	1	1	1	1	1	1
	Provider 2	0	0	1	0	1	1	1	1	1	1
	Provider 3	0	0	0	1	1	1	1	1	1	1
	Provider 4	1	0	1	0	1	1	1	1	1	1
	Provider 5	1	1	1	0	0	1	1	1	1	1
	Provider 6	1	1	0	1	0	1	1	1	1	1
	Provider 7	1	1	0	1	0	1	1	1	1	1
	Provider 8	0	1	0	1	1	1	1	1	1	1
Week 2	Provider 1	1	1	1	0	1	1	0	1	1	1
	Provider 2	1	0	1	0	1	1	1	1	1	1
	Provider 3	1	1	0	0	1	1	1	1	1	1
	Provider 4	0	0	0	1	1	1	1	1	1	1
	Provider 5	0	0	0	1	1	1	1	1	1	1
	Provider 6	0	0	1	1	0	1	1	1	1	1
	Provider 7	0	1	1	0	1	1	0	1	1	1
	Provider 8	1	1	0	1	0	1	0	1	1	1
Week 3	Provider 1	0	0	1	0	1	1	1	1	1	1
	Provider 2	0	0	1	0	1	1	1	1	1	1
	Provider 3	0	0	0	1	1	1	1	1	1	1
	Provider 4	1	0	1	0	1	1	1	1	1	1
	Provider 5	1	1	1	0	0	1	1	1	1	1
	Provider 6	1	1	0	1	0	1	1	1	1	1
	Provider 7	1	1	0	1	0	1	1	1	1	1
	Provider 8	0	1	0	1	1	1	1	1	1	1
Week 4	Provider 1	1	1	1	0	1	1	0	1	1	1
	Provider 2	1	0	1	0	1	1	1	1	1	1
	Provider 3	1	1	0	0	1	1	1	1	1	1
	Provider 4	0	0	0	1	1	1	1	1	1	1
	Provider 5	0	0	0	1	1	1	1	1	1	1
	Provider 6	0	0	1	1	0	1	1	1	1	1
	Provider 7	0	1	1	0	1	1	0	1	1	1
	Provider 8	1	1	0	1	0	1	0	1	1	1

Figure F-8. Output, Model 1 All Weeks

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Patient Throughput Objectives

With the patient mix requirement of:	35% new patients	**approximately 444 new patients can be seen in a month,**
	60% established patients	**approximately 761 established patients can be seen in a month,**
	5% phone visits	**approximately 63 phone visit patients can be seen in a month,**
		for an ideal aproximate patient throughout value of 1268 patients per month.

Figure F-9. Output, Model 2

G How to Use ProSkedge

These instructions are based on Microsoft Office Excel 2007.

1. Install Excel Solver Add-in
    a. Open a new Excel spreadsheet.
    b. Click on the Microsoft Office Button and click Excel Options.
    c. Click the Add-ins button on the left.
    d. In the Manage box, select Excel Add-Ins and then Go.
    e. In the Add-Ins Available box, select the checkbox next to the Solver Add-in and then click OK.
2. Open ProSkedge.
3. Enable Macros
    a. If macros are not enabled, enable macros.
4. Modify inputs in ProSkedge using the buttons or input numbers into the WHITE cells. Use the arrow buttons when provided.
5. Select GENERATE OPTIMAL SCHEDULE and wait for the schedule output to show.