REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
March 2000

3. REPORT TYPE AND DATES COVERED
Final Report (07-99 to 07-00)

4. TITLE AND SUBTITLE
Computer Simulation: A Methodology to Improve the Efficiency in the Brooke Army Medical Center Family Care Clinic
(A Patient Wait Case Study)

5. FUNDING NUMBERS

6. AUTHOR(S)
MAJ John F. Merkle, MBA, CHE

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Brooke Army Medical Center

8. PERFORMING ORGANIZATION REPORT NUMBER
3a-00

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
US ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL
BLDG 2841 MCCS-HRA US ARMY-BAYLOR PROGRAM IN HCA
3151 SCOTT RD SUITE 1412
FORT SAM HOUSTON TEXAS 78234-6135

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The executive leadership at Brooke Army Medical Center (BAMC) believes there are inefficiencies, characterized by poor access, high patient total time in the clinic, high patient wait time and inappropriate resource utilization in the BAMC primary care clinics. Computer simulation was selected to assist in reengineering the primary care clinics at BAMC to improve efficiency and patient satisfaction. The purpose of this study was to describe the current system and to evaluate the potential impact of process/resource changes in patient wait times, access and resource utilization at the BAMC Family Care Clinic (FCC). The base models were utilized to compare results of proposed process/resource changes. Alternate models were compared to the base models for the time the patient waits for the PCPs (Primary Care Providers), the total time a patient is in the clinic and resource utilization (e.g. PCPs, LVNs [Licensed Vocational Nurse] and exam rooms). Comparison of model outputs revealed that two alternate models were more efficient than the base model. Ultimately, these alternate models' multiple resources were optimized at 110, 120 and 130 percent of FY99 FCC visits to ascertain the best process/resource mix to improve access and patient wait times in the FCC.

14. SUBJECT TERMS
Computer Simulation; Primary Care; Efficiency

15. NUMBER OF PAGES
79

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

Running Head: Computer Simulation: BAMC FCC

Computer Simulation: A Methodology to Improve the Efficiency in the Brooke Army Medical Center Family Care Clinic (A Patient Wait Case Study)

A Graduate Management Project
Submitted to:

LTC Mark Perry, Ph.D., FACHE
Professor, U.S. Army - Baylor University
Graduate Program in Health Care Administration

24 March 2000

MAJ John F. Merkle, MBA, CHE
Administrative Resident
Brooke Army Medical Center
Fort Sam Houston, Texas 78234-6200
(210) 916-2662

ACKNOWLEDGEMENTS

I wish to acknowledge the contribution of many individuals who assisted me in my Graduate Management Project (GMP). It would have been impossible to complete my GMP without their assistance and support as well as many other people not mentioned.

Thank you Liz, Johnathan, Samantha, and Liam for your many sacrifices.

Thank you LTC Sandy White, for being a great mentor and preceptor.

Thank you Dr. Demouy for your advice, constant support, and never-ending instruction.

Thank you Stephanie Rozowski & Dawn Rusing for providing me data and the tools to transform this data into useful information.

Thank you Dr. Stith for the opportunity to study the Family Care Clinic.

Thank you Dr. Sauri and the rest of the Family Care Clinic professional staff for your continual assistance.

Thank you Dr. Perry for your advice and candor.

Thank you LTC Dawn Smith, COL Marty Fisher and the rest of the Brooke Army Medical Staff for your support.

Thank you to all the professional Baylor Staff for excellent learning experiences.

Thank you Lord for the great opportunity to participate in the U.S. Army-Baylor Program.

Abstract

The executive leadership at Brooke Army Medical Center (BAMC) believes there are inefficiencies, characterized by poor access, high patient total time in the clinic, high patient wait time and inappropriate resource utilization in the BAMC primary care clinics. The tool of computer simulation was selected to assist in reengineering the primary care clinics at BAMC to improve efficiency and patient satisfaction. This study focused specifically on the BAMC Family Care Clinic (FCC). The purpose of this study was to describe the current system and to evaluate the potential impact of process and resource changes in patient wait times, access and resource utilization at the BAMC Family Care Clinic (FCC). Base models were developed to replicate current FCC operations and tested for validity before creating all alternate models. The base models were utilized to compare results of proposed process and resource changes (alternate models). Alternate models were compared to the base model for the time the patient waits for the PCPs (Primary Care Providers), the total time a patient is in the clinic and resource utilization (e.g. PCPs, LVNs [Licensed Vocational Nurse] and exam rooms). Comparison of model outputs revealed that two alternate models generated lower patient wait times in the clinic than the base model. These alternate models' resources were individually changed to determine the effect on the models outputs. Ultimately, these alternate models' multiple resources were optimized at 110, 120 and 130 percent of FY99 FCC visits to ascertain the best process and resource mix to improve access and patient wait times in the FCC.

TABLE OF CONTENTS

ACKNOWLEDGMENTS ii

ABSTRACT iii

LIST OF TABLES vi

LIST OF FIGURES vii

INTRODUCTION 1
- Conditions Which Prompted the Study (Background) 1
- Statement of the Problem 3
- Literature Review 4
- Purpose 8
- Limitations and Assumptions 9

METHOD AND PROCEDURES 9
- Goals and Objectives of the Simulation 11
- Model Formulation and Planning 11
- Data Collection 15
- Model Development, Verification, Validation and Reliability 15
- Ethical Considerations 19

MODEL EXPERIMENTATION, ANALYSES AND RESULTS. 19
- Current FCC System 20
- Impact of Resource Changes 20
- Designing an Improved System (Optimization) 25

DISCUSSION 27
- Interpretation of Results 27
- Presentation of Results 31

CONCLUSION AND RECOMMENDATIONS 31

APPENDIX A: Tools Used in Acquiring Empirical Data 34
- A-1: FCC Time Study Sheet 34
- A-2: Input Variables Input Flow Timing Sheet 35

APPENDIX B: FCC Patient Information. 36
- B-1: Patient Demographics. 36
- B-2: Patient Utilization 38

APPENDIX C: FCC Floor Plan. 46

APPENDIX D: Statistical Analyses . . . 47
D-1: Validation of Oct 99 Status Quo Models to Empirical Data (wait times). 48
D-2: Validation of Oct 99 Status Quo Models to Empirical Data (total patients) 49
D-3: Validation of FY99 Status Quo Models to Empirical Data (total patients) 50
D-4: Reliability of FY99 Status Quo Models (Different Random Seeds) . . 51
D-5: Reliability of FY99 Status Quo Models (Multiple Iterations) . . . 53
D-6: Comparison of Alternative-One Models with FY99 Status Quo Models (wait times). . . . 55
D-7: Comparison of Alternative-Two Models with FY99 FCC Status Quo Models (wait times). . . . 56
D-8: Comparison of Alternative-Three Models with FY99 FCC Status Quo Models (wait times) . . . 57
D-9: Comparison of Alternative-Three Models with Alternative-One Models (wait times) . . . 58
D-10: Comparison of Alternative-Four Models with FY99 FCC Status Quo Models (wait times) . . . 59
D-11: Comparison of Alternative-Four Models with Alternative-One Models (wait times) . . . 60

APPENDIX E: Effects of Changing the Number of PCPs, LVNs, Exam Rooms and Appointments (Comparing Alternative-One Models and Alternative-Four Models) . . . 61
E-1: Time Patient is in the Clinic (Resource Changes). . . . 61
E-2: Resource Utilization (Resource Changes) . . . 64
E-3: Time Patient is in the Clinic (Changing Number of Appointments) . . 67
E-4: Resource Utilization (Changing Number of Appointments) . . . 68

APPENDIX F: Optimization of Alternative-One Models and Alternative-Four Models . . . 71
F-1: 110% of FY99 Appointments . . . 71
F-2: 120% of FY99 Appointments . . . 73
F-3: 130% of FY99 Appointments . . . 75

REFERENCES . . . 77

List of Tables

Table 1: Process Variables and Simulation "Inputs" 14

Table 2: Simulation "Output" Performance Measures 14

Table 3: Validation Results of BAMC Status Quo (Oct 99) Models. 18

Table 4: FY99 FCC Utilization. 20

Table 5: Simulation Factors Examined by the Modeler 20

Table 6: Description of Models Used in What-If Analysis 21

Table 7: Summary of Statistical Analyses and Utilization Results 22

Table 8: Optimization Results. 27

Table 9: Comparison of Optimization Models to Base Models 28

List of Figures

Figure 1: BAMC September Complaints by Area (Top 6) 3

Figure 2: Steps in a Simulation Study 10

Figure 3: BAMC FCC Patient Flow. 12

Introduction

Conditions Which Prompted the Study (Background)

Brooke Army Medical Center (BAMC), located at Fort Sam Houston in San Antonio Texas, serves 185,000 TRICARE beneficiaries in cooperation with nearby Wilford Hall Medical Center (Noyes, Harben, 1998). BAMC's staff provides inpatient/outpatient care, level one trauma and graduate medical education in a modern, state-of-the-art, 450-bed healthcare facility.

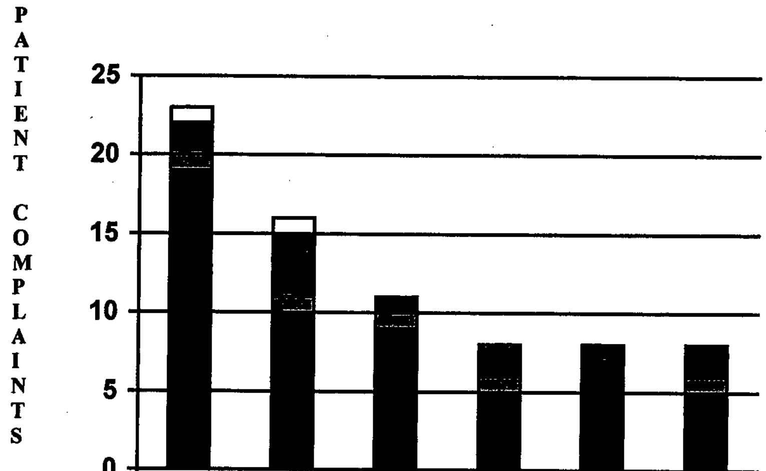
Due to healthcare advances and cost containment pressures, BAMC, like other major healthcare facilities, has shifted its focus from inpatient to outpatient care. BAMC has 58 outpatient specialty clinics, which recorded over 353,000 patient visits for fiscal year 1999 (FY99), and seven outpatient primary care clinics, which recorded over 276,000 patient visits for FY99 (Noyes, Harben, 1998; CHCS, October 1999). Only five BAMC primary care clinics enroll TRICARE beneficiaries (BAMC's TRICARE primary care clinics). Three of these primary care clinics are located in the main BAMC building: Pediatrics/Adolescent Medicine, Internal Medicine and the Adult Primary Care Network Clinic. The other two BAMC's TRICARE primary care clinics, General Medicine Clinic (for active duty only) and the Family Care Clinic (FCC), are collocated two miles away from the main BAMC building at the McWethy Troop Medical Clinic.

Traditionally, BAMC's TRICARE primary care clinics provided primary care to active duty personnel and their family members, military retirees under the age of 65 and their families as well as space available care to eligible beneficiaries over 65. Currently, in addition to providing care for these aforementioned healthcare recipients, these clinics have recently expanded their capabilities to support the primary care workload of an enrolled elderly population of TRICARE Senior Prime (TSP) beneficiaries. These TSP beneficiaries traditionally present with ailments related to chronic conditions thereby increasing the potential to consume more healthcare resources. Overall, these increases in patient load and severity mix have had a significant impact on the efficiency of operations in the primary care clinics (DeMouy, Rozowski, Rusing, 1999).

BAMC's TRICARE primary care clinics provide care for an enrolled beneficiary population of 34,936 (CHCS [Composite Health Care System], August 1999). The BAMC FCC provides primary care services to an enrolled beneficiary population of 9,800 (3,279 active duty family members, 2,166 retirees and their 2,968 family members and 1,387 TSP members under its current configuration) (CHCS, August 1999). BAMC FCC's nine primary care providers (PCPs) had over 44,200 patient visits for FY99 (CHCS, October 1999; Dr. Sauri, Personal Communication, October 1999). FCC's PCPs are comprised by a variety of military personnel, federal employees and contracted care providers, representing different levels of healthcare providers ranging from Family Practitioners, General Medical Officers, Physician Assistants or Nurse Practitioners (Dr. Sauri, Personal Communication, 19 October 1999).

Three of BAMC's TRICARE primary care clinics were among the top six areas of patient complaints for BAMC for the month of September 1999 (Figure 1) (BAMC Patient Representative Log, September 1999). The high number of complaints in the BAMC FCC in particular, in conjunction with the recent enrollment of TSP members have prompted the executive leadership to request a study which focused on improving efficiency and patient satisfaction at the FCC.

Figure 1: BAMC September Complaints by Area (Top 6)



	FCC	IMC	OPHTH	ORTHO	OB/GYN	APNC
☐ MISC	1	1	0	0	0	0
■ TELEPHONE	0	1	1	0	0	0
■ WAITING	0	1	0	1	0	0
■ QUALITY CARE	2	2	0	1	1	2
■ STAFF/COURTESY	1	1	1	1	0	1
■ ADMIN	4	1	0	2	4	4
■ ACCESS	15	9	9	3	3	1

(Adapted from BAMC September Patient Representative Report, 1999)

<u>Statement of the Problem</u>

Currently, the BAMC leadership believes there are inefficiencies in the present configurations of the primary care clinics. These inefficiencies are characterized by poor access, high total patient time in the clinic, high patient wait time and inappropriate resource utilization. These inefficiencies were caused when BAMC was required to shift primary focus from graduate medical education to primary care under TRICARE without changing its current organizational structure. Since the greatest number of complaints pertain to BAMC FCC, this study focused on the FCC. If resource inefficiencies do exist in the FCC, this study will aid in identifying where they exist. Additionally BAMC currently has no standard management tool to accurately predict the effect of resource allocation changes within the organization. Building a computer simulation model of the current FCC will allow the BAMC executive leadership to evaluate future proposed changes in the clinic in a less expensive, less disruptive and more timely manner.

Literature Review

The Department of Defense initiated the transition into managed care in the Military Health Service (MHS) on October 1, 1993. The overall goals of the program, called TRICARE, are to improve beneficiary access, ensure quality of care and control healthcare costs (Department of Defense, 1994). According to the current Army Surgeon General, LTG Blanck,

> "Managed Care" means managing the healthcare of each patient so that the right level of care is provided at the right time and at the right place...Often managed care means caring for patients on an outpatient basis as opposed to inpatient status when there is no difference in quality of outcome. (Blanck, 1997).

Primary care is key to the success of the MHS under TRICARE. Primary care is defined as the first level of care accessed by the patient (White, 1996). Comprehensive primary care also focuses on the elements of prevention, early intervention and wellness programs (Gapenski, 1996). The key player in the success of managed care is the patient care manager. In the MHS the PCP is the patient care manager. The ideal PCP not only provides comprehensive (broad range of services – acute and chronic disease management), coordinated (aware of patient's entire list of problems), continuous and accountable care but also is accessible to the patient (White, 1996). The PCP coordinates care for the patient throughout the MHS. Family practice/general medicine, internal medicine, pediatrics, emergency medicine and obstetrics/gynecology are provider categories generally defined as primary care (Kongstvedt, 1997; Booz Allen & Hamilton, 1998).

The appropriate staffing level for PCPs varies depending on the supported population demographics, utilization patterns and the overall mission of the health system. Based on research in 1995, in health systems with less than 80,000 members, the weighted mean PCP staffing ratio was 0.89:1,000 (1 PCP per 1,124 members) with a standard deviation of 0.68. For systems greater than 80,000 members the weighted mean PCP was 0.66:1,000 (1 PCP per 1,515) with a standard deviation of 0.51 (Kongstvedt, 1997). The AMEDD Fort Campbell Staffing Study and the Automated Staffing Assessment Model (ASAM) both consider provider non-patient time in developing their staffing ratios. Both of these systems found that Department of Defense (DoD) PCPs are unavailable for patient services approximately 10% of the time due to specific organizational requirements of the MHS (Booz Allen & Hamilton, 1998). While MHS PCP's time available for patient care is lower than their civilian counterparts, patient utilization rates are significantly higher (as much as 40% increase in demand factor) in MHS than in a civilian system due to the availability of "free care" (Newhouse, 1993).

In addition to enrollee demographics and utilization, a particular clinic's processes and activities can have an enormous effect on the required staffing and overall effectiveness of the clinic. Improving the overall process of patients moving through a clinic can reduce patient wait time and increase the overall access to a clinic. However, managers rarely have the time or resources to experiment with such process changes.

Computer simulation offers managers an accessible, less expensive, less disruptive and more timely means of evaluation (Benneyan, 1997). Simulation is one of the most widely used methods to evaluate, improve and optimize many types of processes. Simulation is an imitation of an actual process over time (Levy, Watford, Owen, 1989; Gogg, Mott, 1993; Benneyan et al., 1994; Benneyan, 1997). Simulation models imitate a system's behavior, referred to as "baselining", and are then used to evaluate possible changes in its structure, environment or underlying assumptions in the form of "what-if-analysis" (Benneyan et al., 1994; Bateman, Bowden, Gogg, Harrel, Mott, 1997).

Non-healthcare industries often employ simulation software to assist managers in decision making. Similarly, the advantages of simulation are receiving increased attention within the healthcare industry. The literature consistently notes simulation of patient flow provides invaluable information for senior and mid-level managers in problem solving activities (Benussi, Daris, Crevatin, Nedoclan, 1990; Mahacheck, 1992; Benneyan, Horowitz, Terceiro, 1994; Benneyan, 1997). Benneyan et al. (1994) recommend using computer simulation to test process and resource changes in an organization.

Numerous studies proclaim the advantages of simulation in identifying peak workload requirements and adjusting staffing patterns to increase providers' efficiency and decrease patient wait times (Bell, Warner, Cameron, 1985; Ammari, Abu Zahra, Dreesch, 1991, Benneyan et al., 1994; Hashimoto, Bell 1996; Allen, Ballash, Kimball, 1997; Benneyan, 1997). Simulation results typically identify the largest single challenge facing outpatient facilities is the time patients spend waiting to see a healthcare provider. Asezadeh (1997) noted that medical facilities could take advantage of outpatients' waiting periods, once identified, to disseminate preventive and other cost-effective healthcare information. Additionally, studies that modified clinics' operational procedures by incorporating simulation results report statistically significant benefits. For example, by incorporating simulation results into clinic operation, Hashimoto and Bell (1996) observed a decreased total time for patients in the clinic from a mean of 75.4 minutes (sd 34.2) to a mean of 57.1 minutes (sd 30.2) ($p<.001$, t test).

Simulation offers a practical alternative approach to problem solving. Because simulation models evaluate outcomes without actually making changes in the system, simulation modeling can allow the consideration of several alternatives before any resources, especially human, are expended. Healthcare is a dynamic service industry with high human involvement, sporadic workflow and high variability. Benneyan et el. (1994) points out that accountability for the variation of patient arrival times, staff shifts and breaks, queuing and treatment times is vital for accurate statistical results in a process which is dominated by interaction between human beings. A healthcare simulation program, like MedModel® version 4.2, is ideal for healthcare because its dynamic, stochastic (random) method can account for variability and randomness in a process over time and incorporate these attributes into the final analysis (ProModel® Corporation, 1998a).

The appropriate level of detail in a model is extremely important in achieving useful results. The simulator must choose the appropriate level to answer the objective (ProModel® Corporation, 1998a). As the model becomes more complex, it requires additional data and continuous verification. A simulator must understand there is an inverse relationship between model complexity and utility (ProModel® Corporation, 1998a). Once an appropriate simulation model is built, it repeats the process for the researcher to observe. Since simulation focuses on objective measures of the process, there is a decrease in the amount of researcher bias on the results of the study.

The amount of literature describing simulation applications to healthcare and patient scheduling is increasing substantially (Kalton, Singh, August, Parin, Othman, 1997; Benneyan, 1997). The use of simulation as a technique for evaluating military primary care facilities, like BAMC FCC, is also gaining momentum. In 1994 Reese developed a computer simulation to assess the effects of proposed changes on Martin Army Community Hospital Emergency Department. Two years later, an animated simulation was used to determine the optimal staffing and process configuration for the Heidelberg Medical Department Activity Family Practice Clinic (Ledlow, 1996; Ledlow, Bradshaw, 1999). In 1998 Fay used simulation to compare three Ireland Army Community Hospital Primary Care Clinics and ultimately recommended process and staffing changes. Similarly, computer simulation has been used to analyze staff utilization and patient waits to modify processes of Fort Monroe Health Clinic prior to facility occupation (Duray, 1998). Fulton, also in 1998, developed an outpatient model to assist in reengineering Bayne-Jones Army Community Hospital.

Purpose

The purpose of this study is to describe the current system and through the development of a simulation model to evaluate the potential impact of process and resource changes on patient wait times, access and resource utilization on the BAMC FCC. Additionally, building a computer simulation model of the current FCC provides the FCC leadership the capability to evaluate future proposed changes in the clinic in a more timely, less resource intensive manner. The terminal objective of this project is to determine resource levels and processes for the FCC that will improve operational efficiency. Efficiency, for this study, is defined as decreased patient total time in clinic, increased patient access (i.e. increased number of available appointments) and appropriate resource utilization.

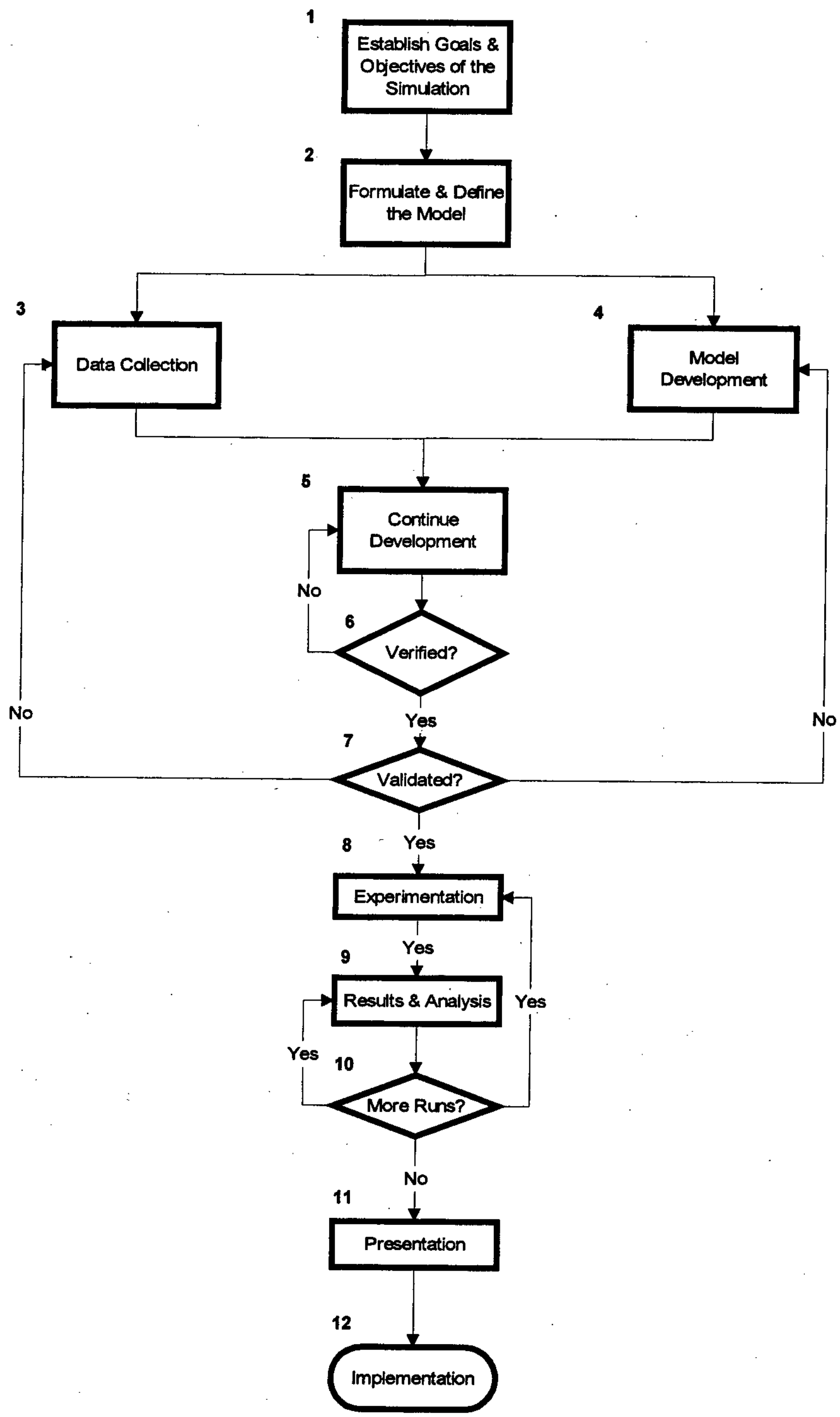
Limitations and Assumptions

As with any study, certain limitations and assumptions must be identified. The primary limitation of this study is that the simulation model can not replicate every variable or occurrence of the FCC system. The complexity of such a detailed model would actually decrease its utility. The major assumption governing this study was that a one-month time study of the FCC was sufficient to attain an accurate representation of the current system. A second assumption was that all data collected relating to workload and appointment scheduling were accurate. The following Department of Defense databases was utilized for data collection: Ambulatory Data System (ADS) and the Composite Health Care System (CHCS).

Method and Procedures

Even though each simulation is unique, past studies have shown a series of steps that lead to a successful simulation model. Steps common to successful simulation are: establish goals and objectives of the simulation; formulate and define the model; collect data; build, verify and validate the model; and experiment, analyze and present results (ProModel®, 1998c; Benneyan, 1997). This graduate management project followed the above format. Figure 2 is provided to illustrate the interrelationships between these steps.

Figure 2: Steps in a Simulation Study



(Adapted from Bateman, Bowden, Gogg, Harrell, Mott, 1997)

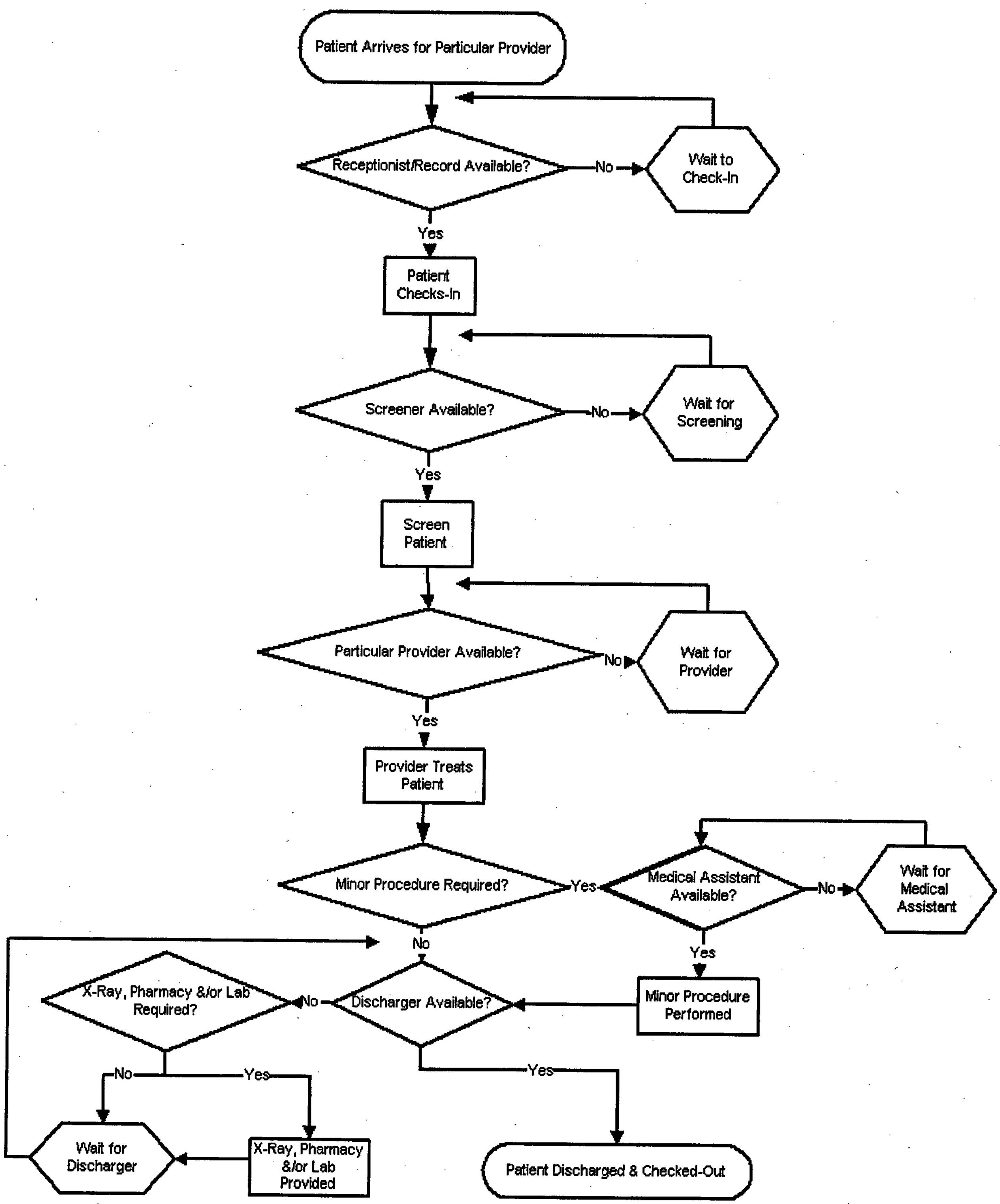
Goals and Objectives of the Simulation

The goal of this simulation was to generate information that can be used by the BAMC leadership to make appropriate decisions resulting in increased operational efficiency in the FCC. In order to attain this goal, the following objectives were established: (1) describe the current system, (2) evaluate the impact of process and resource changes on patient wait times, access and resource utilization, and (3) design an improved system for the FCC. The development of a MedModel® simulation model aided in achieving these objectives. Additionally, building a computer simulation model of the current FCC provided the FCC leadership the capability to evaluate future proposed changes in the clinic in a more timely, less resource intensive manner.

Model Formulation and Planning

Once the modeler and the FCC leadership agreed upon the simulation objectives, the next step was to determine a conceptual framework of the model. The first step in understanding a system, like the FCC, was to chart the flow of patients through the facility (Mahachek, 1992). The framework for the FCC model was developed through a patient flow diagram. The patient flow diagram was confirmed with the Chief, FCC and the Head Nurse, Department of Primary Care and Community Medicine (Figure 3).

Figure 3: BAMC FCC Patient Flow



The FCC patient flow process can be summarized as follows. Upon arrival, a patient checks in with the receptionist and/or records clerk and then waits in the waiting area. A screener escorts each patient to a screening room where vitals and general patient information are taken (e.g. height/weight & reason for appointment). After screening the patient is directed back to the waiting area. Once the primary provider is available, the PCP directs the patient to his or her exam room/office. After the appointment is complete the PCP directs the patient to the discharge area or to other ancillary care (e.g. medic for basic procedure, laboratory, x-rays or pharmacy) depending on the situation. A civilian nurse who is responsible for final coordination of patient treatments (e.g. discussing doctor treatment procedures, setting up follow on appointments and discharging the patient) staffs the discharge area. If this individual is not available the patient may wait for the discharger, get prescriptions filled or go to the laboratory.

At the FCC, appointments are conducted from 0730 to 1900 hours, Monday and Thursday and from 0730 to 1600 on Tuesday, Wednesday, and Friday. Physician appointments begin between 0730 and 0900 and are scheduled for fifteen minutes to forty minutes depending on the type of appointment and patient. Most providers take a short lunch break around 1200. Primary care appointments begin again for the majority of the providers at 1300 hours. Most provider appointments continue until 1600. On Monday and Thursday, two providers' appointments continue to 1900.

Creation of a flowchart assisted in the development of decision variables in the FCC process. In order to develop these models, certain process decision variables (variables that management has control over) as well as uncontrollable variables such as patient timeliness, had to be collected. Table 1 lists the primary "inputs" included in the FCC model.

Table 1: Process Variables and Simulation "Inputs"

Number of:	Distribution of Time for:
• Receptionists	• Patient Arrival
• Screeners	• Patient to Check-in
• Screening Rooms	• Screener to Screen Patient
• Providers	• Provider to Examine Patient
• Total Appointments	• Discharger to Discharge Patient
• Total Exam Rooms	
• Dischargers	General Facility Layout
• 91Bs	
• Education Nurses	

Table 2 lists the "output" performance measures that were collected from the FCC model. However, the modeler in conjunction with the FCC leadership determined the output performance measures in bold were the most relevant to increasing efficiency as defined in this study. Therefore only the output performance measures in bold were analyzed.

Table 2: Simulation "Output" Performance Measures

Patient Waits:	Location & Number of Patients:
• Total Patient Wait	• Waiting to Check-In
• Wait for Receptionists	• Checking-In
• Wait for Screening Room	• In Waiting Room
• Wait for Screeners	• Waiting for Screener
• Wait for Exam Room	• Being Screened
• Wait for Provider	• Waiting For Provider
• Wait for Discharger	• Being Examined
• **Total Time Until Seen By Provider**	• Waiting For Discharger
• **Total Time in FCC**	• Being Discharged (follow-up appt arranged)
Resource Utilization:	
• Receptionist Idle Time & Utilization	Total Number of Patients:
• **Screener Idle Time & Utilization**	• Arrived
• **Provider Idle Time & Utilization**	• In FCC
• Waiting Room Utilization	• **Departed**
• **Screening Room Utilization**	
• **Exam Room Utilization**	

Data Collection

Several ongoing methods were used to collect data for input variables of the model throughout the study. A time study was initiated on 1 October 1999 (Appendix A: Tools Used in Acquiring Empirical Data). Observations and personal interviews began in October and continued throughout the project. Interviews with the staff provided important information on daily work hours, personnel shifts and lunch breaks.

Historical data on clinic visits were collected from BAMC database systems (e.g. ADS and CHCS). The primary source was CHCS. Adhoc CHCS reports provided information for model inputs such as: the number of patients seen in the clinic by appointment type per month as well as the number of patients seen/appointments scheduled for each physician per month. In order to gather the needed data, Adhoc CHCS reports were run for BAMC FCC for Fiscal Year 1999 (Appendix B: FCC Patient Information).

The collected data was matched to an appropriate frequency distribution by using Stat::Fit®, a curve-fitting program in MedModel® version 4.2. These frequency distributions were placed into MedModel® to represent patient inter-arrival times, process duration times and probabilities of occurrences.

Model Development, Verification, Validation and Reliability

The models were built using version 4.2 of the MedModel® simulation software bought from ProModel® Corporation. MedModel® is computerized simulation software specifically designed to model medical processes. Six elements common to any MedModel® simulation model include entities, locations, arrivals, pathways, processes and resources. Entities are objects that have actions performed upon them (e.g. patients, medical charts, lab samples, x-ray, etc). Locations are the places where the activities associated with entities occur (e.g. treatment rooms). Arrivals describe patterns (e.g. frequency and time) related to when and how entities enter the system. Pathways represent the route entities take as they travel through the system (pathways can differ based on the type of entity – e.g., child vs. adult – and the actions performed on the entity). Processes are actions done to an entity (e.g. what action is performed, rules for prioritizing which entity is acted upon, identifying who performs the action, how long it takes and what happens to the entity when the action is completed). Resources perform processes on entities (e.g. physicians, nurse, etc.); resources limit the capacity of the system (ProModel®, 1998a; ProModel®, 1998c). Through MedModel® the modeler converted the actual workings of the system, shown in Figure 2, to these different elements in order to simulate actual FCC operations.

The Head Nurse, Department of Primary Care and Community Medicine provided the original floor plan of the McWethy TMC. This version was edited in Microsoft Paint© to reflect the present layout of the TMC (Appendix C). The programmer then imported the image to MedModel® simulation software and sized the image using the grid setting option to accurately depict the correct relative square footage of the TMC.

The actual development of the simulation was incremental, with process detail and complexity added in a stepwise fashion. After each process was modeled it was debugged (reconciled) and verified before the next process was added. Ultimately two BAMC FCC Status Quo Models evolved to sufficiently meet the study's first objective. One model simulated Monday and Thursday extended day operations while the other model simulated Tuesday, Wednesday, and Friday normal day operations.

A model is verified when it processes data as intended by the modeler and has the ability to generate output information that can satisfy the objectives of a study (Mahachek, 1992; Gogg et. el., 1993; Bateman et. el., 1997; ProModel®, 1998a). The flow of the patient (entity) in the BAMC FCC Status Quo Models were traced to verify the accuracy of the process, routing and frequency distributions; when an inconsistency was identified it was debugged. This verification process was continued throughout the study.

"Model validation establishes credibility in the model" (Gogg et. el. 1993). A valid model behaves like the actual system in a manner sufficient to address the stated problem (Bateman et. el., 1997; ProModel®, 1998a). Validation was accomplished in a stepwise manner, with each model segment being tested and validated before starting the next. When complete models were constructed, these aggregate FCC Status Quo Models' outputs were validated through statistical analysis that compared model outputs with data gathered through previous observations of the clinic. In past studies z and t-tests were used to determine if a significant statistical difference existed between the aggregate model outputs and previous empirical observations of clinic operations (Lowery, Martin, 1992; Ledlow, 1996; Duray, 1998; Fay, 1998). Likewise, a z-test was utilized to determine if the total time until seen by a PCP and total time in clinic produced from the FCC Status Quo Models (Oct 99) had a statistically significant difference from empirical wait times for October 1999. Additionally a t-test was employed to determine if total patient visits produced from the FCC Status Quo Models (Oct 99) had a statistically significant difference from the total patient visits in the FCC in October 1999. Table 3 shows the results of these statistical validations. Similarly, a z-test was used to validate the FCC Status Quo Models (FY99). The FY99 models' processes were based on the BAMC FCC Status Quo Models (Oct 99). The only variation in these models were that their arrival patterns were based on yearly data (FY99) instead of monthly data (Oct 99). The FY99 models were not validated on wait times because of lack of yearly wait time data. Appendix E demonstrates the processes and numbers utilized for all statistical validation results. The alpha level for statistical significance for these tests was .05. For validation purposes, there should not be a statistically significant difference between the empirical patient wait times and those obtained in the simulation models. From the results of these z/t-tests, and from conferring with Dr. Sauri, the modeler determined that there is no statistically significant or practical difference between the model and real patient wait times in the FCC.

Table 3: Validation Results of BAMC Status Quo Models (Oct 99)

PATIENT	MEAN		SAMPLE SIZE		RESULTS	
Total	Empirical	Model	Empirical	Model	Test	
In Clinic(time)	65.24	67.99	135	1382	1.22(z)	No statistically significant difference
Waiting for Provider(time)	21.44	18.19	146	1382	-0.074(z)	No statistically significant difference
Patients	117	124.99	21	21	1.47(t)	No statistically significant difference

Reliability is the ability of the model to consistently measure what it is designed to measure (Cooper, Schindler, 1998). Reliability looks at the variance of outputs produced from the model over time (Appendix D). The modeler ran the simulation for different iterations to determine the reliability of the model. Also the modeler changed the streams (sequences of independently cycling, random numbers used in conjunction with distributions [ProModel®, 1998c]) of the model and compared the results of different streams with z-tests to establish reliability of the model (Appendix D). From the results of the z-tests the modeler determined that the BAMC FCC Status Quo Models were reliable.

Ethical Considerations

Confidentiality and privacy are significant considerations when performing healthcare research. The Privacy Act and other patient protection policies require extreme diligence. Throughout this study, patient information was examined. All patient information involved in this study was collected in aggregate and only summary statistics were presented. Anonymity of all participants (patients and interviewees) was protected and used only with expressed permission. Appropriate recognition and source quotes are provided in all cases.

Model Experimentation, Analyses and Results

The model experimentation and analyses of results are provided to answer the objectives of this study: (1) describe the current system, (2) evaluate the impact of process and resource changes on patient wait times, access and resource utilization, and (3) design an improved system for the FCC (increased operational efficiency). Efficiency, for this study, is defined as decreased patient total time in clinic, increased patient access (i.e. increased number of available appointments) and appropriate resource utilization. In order to accomplish these efficiencies, a review of current operations was completed.

Current FCC System

The average time a patient waits to see a provider and the overall patient time in the current FCC system are 24.8 and 80.59 minutes, respectively. The utilization of PCPs, LVNs and exam rooms are 78.54, 49.67 and 46.41 percent of available time, respectively. Appendix B provides FCC patient information and Table 4 summarizes the FY99 FCC utilization by patient category.

Table 4: FY99 FCC Utilization

Enrollment Category	Number Enrolled	Visits	Utilization (Visits per year)
Tricare Prime	7,850	25,973	3.0308
Tricare Senior Prime	1,485	8,829	5.9495
Space A	0	7,396	4.0108
Active Duty	13	6	0.4615
Other Clinic	0	1,584	2.6893
TOTAL	9,348	43,788	3.9369

Note: Numbers based on end of FY99 Enrollment; therefore, patients may be enrolled during visit but not enrolled at end of FY99 and will be shown as Space A. Enrollment Data provided from Foundation Health. Visit Data provided from CHCS.

Impact of Resource Changes

The modeler then examined some preliminary what-if (imagineering) factors that may effect patients access, wait time and resource utilization (Table 5).

Table 5: Simulation Factors Examined by the Modeler

- Number of Exam Rooms
- Number of Screeners (LVNs) and Providers
- Number of Appointments
- Various Combinations of Above

The actual number and type of what-if analysis performed was constantly adjusted as needed to achieve the study objectives. Table 6 describes the different models used in the what-if analysis. What-if simulation outputs were tested for statistical significance (z-tests) as well as overall practicality (decreased overall time in clinic and minimal resource consumption). As suggested by Gogg et. el. (1993) and Bateman et. el. (1997), overall analysis was designed to maximize the usefulness of the information produced from simulation runs while minimizing the effort. Table 7 lists the major statistical analyses performed for the status quo and what-if models.

Table 6: Description of Models Used in What-If Analysis

Models	Description
Alternative-One Models	Combine the FCC & APNC resources at the TMC (ten PCPs, two interns, twenty exam rooms, two receptionists, two 91Bs, two education nurses and one discharger) for 100% of FY99 FCC visits.
Alternative-Two Models	Replicate one team (six PCPs and one intern) with the support of the rest of the FCC resources (fifteen exam rooms, two receptionists, two 91Bs, two education nurses and one discharger) for 50% of FY99 FCC visits.
Alternative-Three Models	Replicate one team (six PCPs, one intern) with the support of the rest of the FCC resources (fifteen exam rooms, two receptionists, two 91Bs, two education nurses and one discharger) with no screening rooms (process changed to accomplish screenings in exam rooms) for 50% of FY99 FCC visits.
Alternative-Four Models	Combine the FCC & APNC resources at the TMC with no screening rooms (process changed to accomplish screenings in exam rooms) for 100% of FY99 FCC visits.

Note: For each model types two models were built. One model simulated Monday and Thursday extended day operations while the other model simulated Tuesday, Wednesday and Friday normal day operations. All models replicated current FCC staff shift schedules.

The BAMC leadership recently directed that the FCC and the APNC be combined. This decision led to the first what-if-analysis, which studied the effects of the consolidation of these clinics. The Alternative-One Models were developed to represent the new allocation of resources in the McWethy Troop Medical Clinic. Overall the Alternative-One Models show the combination of the FCC and the APNC will have a positive impact on efficiency with regard to patient wait times (Appendix D-6). The average time a patient waits for a PCP and the overall time in the clinic will decrease 4.52 and 7.24 minutes, respectively, from the current FCC system (Table 7).

Table 7: Summary of Statistical Analyses

	Model	Empirical (OCT) Total Wait Time to See PCP	Empirical (OCT) Overall Time in Clinic	Empirical (Oct) Total Patient Visits	Empirical FY99 FCC Total Patient Visits	OCT99 FCC Status Quo Models Patients' Wait Time to See the PCP & Overall Time in Clinic	FY99 FCC Status Quo Models Patients' Wait for PCP (Model processes based on Oct99 Model with yearly patient load)
Validation	Oct99 FCC Status Quo Models	No Statistical Significant Difference Appendix D-1	No Statistical Significant Difference Appendix D-1	No Statistical Significant Difference Appendix D-1			
Validation	FY99 FCC Status Quo Models (Model Processes Based on Oct99 model with yearly patient load)				No Statistical Significant Difference Appendix D-3		24.8
Reliability	FY99 FCC Status Quo Models (Change in Streams)					No Statistical Significant Difference Appendix D-4	
Reliability	FY99 FCC Status Quo Models (Change in # of Iterations)					No Statistical Significant Difference Appendix D-5	
Experimentation	Alternative-One Models [Directed Change]						Positive Statistical Significant Difference (5.52 minute decrease in wait) Appendix D-6
Experimentation	Alternative-Two Models [Team Concept]						Positive Statistical Significant Difference (10.36 minute decrease in wait) Appendix D-7
Experimentation	Alternative-Three Models [Process Change with a Team Concept]						Negative Statistical Significant Difference (3.92 minute increase in wait) Appendix D-8
Experimentation	Alternative-Four Models [Process Change]						Negative Statistical Significant Difference (3.07 minute increase in wait) Appendix D-10

Note: Level of Significance = .05; Patient Visits exclude telephone consults; Utilization percentages only account for utilization i[illegible] models to replicate all activities.

Because the FCC staff was contemplating developing teams in the new FCC system, the modeler developed Alternative-Two Models to determine the effects of the team concept. This model replicated the work of only one team (six PCPs, one intern) with the support of the rest of the FCC resources (fifteen exam rooms, two receptionists, two 91Bs, two education nurses and one discharger). The Alternative-Two Models reveal the team concept will have a positive impact on efficiency in regards to patient wait times when compared to the current FCC system (Appendix D-7). The average time a patient waits for a PCP and the overall time in the clinic will decrease 10.36 and 7.13 minutes, respectively, from the current FCC system. However, the team concept does not improve the overall efficiency of the combined FCC/APNC, Alternative-One Models (Table 7).

To reiterate the terminal objective of this project was to determine resource levels and processes for the FCC that will improve efficiency. The modeler did some imagineering in an attempt to determine the optimal FCC structure. The modeler after discussion with PCPs developed the Alternative-Three Models that apply the same concepts as the Alternative-Two Models. However in the Alternative-Three Models, the present duties of the screeners (LVNs) changed to include preparing the patient for the PCPs in the exam rooms (enabling the PCPs to concentrate more on treating the patient and eliminating the use of a screening room for most patients). The Alternative-Three Models demonstrate that increasing the responsibilities of the LVNs will have a positive impact on efficiency in regards to patient wait times (Appendix D-8) when compared to the current FCC system. The average time a patient waits for a PCP and the overall time in the clinic will decrease 3.92 and 21.06 minutes, respectively, from the current FCC system. The Alternative-Three Models also improved efficiency in regards to wait times when compared to the Alternative-One Models. The average overall time a patient is in the clinic will decrease 12.82 minutes from the combined FCC/APNC system (Appendix D-9). The Alternative-Three Models gained efficiency in patient time in the clinic would allow the FCC to increase appointments by at least 30% before the patient time in clinic would reach the same level as the proposed combined FCC/APNC system (Alternative-One Models). Even though the Alternative-Three Models system would allow the clinic to increase patient appointments, it may be impractical due to the additional staff required to support this team system with today's budgetary constraints.

Therefore, the Alternative-Four Models were designed to determine the true effects of changing the screening process without increasing staff requirements. These models are based on the processes of the Alternative-One Models except with the change in the screening process. The present duties of the screeners (LVNs) changed to include preparing the patient for the PCPs in the exam rooms (enabling the PCPs to concentrate more on treating the patient and eliminating the use of a screening room for most patients). The Alternative-Four Models demonstrate that increasing the responsibilities of the LVNs will have a positive impact on efficiency in regards to patient wait times when compared to the current FCC system (Table 7). The average overall time a patient is in the clinic will decrease 8.82 minutes from the current FCC system (Appendix D-10). However, increasing the responsibility of the LVNs does not significantly improve the overall efficiency of the combined FCC/APNC (Alternative-One Models) in respect to the total time in clinic, a decrease of only .82 minutes (Appendix D-11).

The Alternative-One Models and the Alternative-Four Models were further analyzed to determine if changing the number of PCPs, LVNs, exam rooms or the number of appointments would increase the efficiency of either system. Appendix E-1 not only confirms the conceptual inverse relationship between the individual number of PCPs, LVNs or exam rooms and the total time a patient spends in the clinic but also illustrates the patient generally spends less time in clinic with the Alternative-Four Models. Appendix E-2 verifies the theoretical inverse relationship between the number of PCPs, LVNs or exam rooms and utilization of these resources. Appendix E-2 also demonstrates that Alternative-One Models have higher levels of PCPs utilization and lower levels of LVN and exam room utilization when compared to Alternative-Four Models. Appendices E-3 and E-4 confirm the direct relationship between increasing the amount of appointments and total time a patient is in the clinic as well as utilization of resources.

Designing an Improved System (Optimization)

Because this study was designed to improve the access in the FCC (Figure 1), the modeler used MedModel SimRunner2!® to attempt to improve the access and efficiency of both models. SimRunner2!® conducts various what-if analyses to determine the best way to perform operations (i.e. optimization). SimRunner2!® enables the modeler to optimize multiple factors simultaneously (ProModel®, 1998b). Because the modeler desired to increase access to the FCC, the modeler ran optimizations on the Alternative-One Models and Alternative-Four Models with increased appointments from FY99 (110, 120 and 130%). The modeler used the same input factors that were studied individually in Appendix E (12-20 PCPs, 4-12 LVNs and 20-32 Exam Rooms), to determine the optimal combinations of these multiple factors (resources) to attain the desired efficiencies. In order to maintain or preferably decrease the overall time the patient spent in the clinic, the modeler elected to minimize the average total time a patient is in the clinic as the optimization models' output. In order to accurately predict the objective function difference of 1.25 minutes with a statistical confidence level of 95 percent, the modeler ran 30 iterations of each potential combination of resources tested in SimRunner2!®. The modeler used Statistical Advantage, a component of SimRunner2!®, to determine the accuracy of SimRunner2!® objective function (average overall time a patient is in the clinic).

Table 8 summarizes the optimization results. The modeler determined the optimal solution from SimRunners2!® optimization results for each model by using the following practical significance criteria:

(1) Acceptable results must have an overall patient time in clinic of less than 70.59 minutes (a ten-minute decrease in time from current FCC operations).

(2) The lowest number of the PCPs utilized the better the solution (the most expensive resource).

(3) The lowest number of LVNs and exam rooms with the lowest PCPs and an acceptable overall time in clinic patient is the optimal solution.

Table 8: Optimization Results

	Time Patient is in the Clinic	# of PCPs/ Utilization	# of LVNs/ Utilization	# of Exam Rooms/ Utilization
Alternative-Four Models 1.1 Appendix F-1	66.27	12/68.79%	7/38.95%	20/50.46%
Alternative-One Models 1.1 Appendix F-1	69.86	14/65.26%	8/24.19%	26/29.43%
Alternative-Four Models 1.2 Appendix F-2	70.52	12/74.49%	12/23.03%	21/54.55%
Alternative-One Models 1.2 Appendix F-2	**No Acceptable Results**			
Alternative-Four Models 1.3 Appendix F-3	69.79	16/57.24%	12/24.72%	28/40.63%
Alternative-One Models 1.3 Appendix F-3	**No Acceptable Results**			

Note: Acceptable results must have an overall average patient time in clinic < 70.59 minutes. Overall average patient time in clinic has a +/- variance of 1.25 minutes with a confidence level of 95%. 1.1, 1.2 and 1.3 refer to the models simulating 110%, 120%, 130% of FY99 FCC visits, respectively.

Discussion

Interpretation of Results

According to FCC PCP Time Study (2000), only 79% of a PCPs' time is available for any type of patient care; therefore, any increase in direct patient care and decrease in indirect patient care time is crucial. Even though desirable, a 100% utilization rate of PCPs is not practical. Literature states a utilization rate of 70-80% of available time for patient care is as good as one could expect (Dawson, Ulgen, O'Conner and Sanchez, 1994; Ditch, 1997). Because the models do not account for all indirect patient care (e.g. reading charts, coordinating with other providers, etc.), the modeler reduced available patient care time by 5% of the PCPs time for indirect patient care, decreasing the desired appropriate utilization in the FCC models for the PCPs to 65-75%. Even though the modeler desired to maintain an approximate 65-75% PCP utilization rate in all models, the modeler was not able to achieve this rate with a 30% increase in patient visits in the Alternative-Four Models. However, the modeler still listed this scenario as a valid combination of resources due to the model's ability to increase visits by 30% and still decrease overall patient time in clinic by ten-minutes. Because the PCPs are the most expensive human resource, the appropriate LVN and exam room utilization rates were based on the highest rate that enabled the system to achieve a PCP utilization of 65-75%.

Table 9: Comparison of Optimization Models to Base Models

	FY99 FCC (Current)	Alternative-One Models (Directed Change)	Alternative-Four Models (Process Change)	Alternative-One Models 1.1	Alternative-Four Models 1.1	Alternative-Four Models 1.2	Alternative-Four Models 1.3
Average Daily Patient Census	146	146	146	161	161	175	190
Average Overall Time in Clinic	80.59	72.35	71.77	69.86	66.27	70.52	69.79
# of PCPs/ Utilization	11/76%	12/78%	12/66%	14/65%	12/69%	12/74%	16/57%
# of LVNs/ Utilization	4/50%	4/54%	4/69%	8/24%	7/39%	12/23%	12/25%
# of Exam Rooms/ Utilization	15/46%	20/43%	20/46%	26/29%	20/50%	21/55%	28/41%
Ratio of LVNs To PCPs	.36	.33	.33	.57	.58	1.0	.75
Ratio of Exam Rooms To PCPs	1.36	1.67	1.67	1.86	1.67	1.75	1.75

Note: Overall average patient time in clinic has a +/- variance of 1.25 minutes with a confidence level of 95%. 1.1, 1.2 and 1.3 refer to the models simulating 110%, 120%, 130% of FY99 FCC visits, respectively.

Table 9 compares the optimization models to base models. All models developed in this studied demonstrated the importance of having the appropriate amount and type of resources (i.e. PCPs and the appropriate ratio of exam rooms and LVNs to support the PCPs). The current FCC configuration has inappropriate resources to gain efficiency. Efficiency, for this study, was defined as decreased patient overall time in clinic, increased patient access (i.e. increased number of available appointments at the 110, 120 and 130% level) and appropriate resource utilization (65-75% of PCPs available time).

As seen in Table 9, additional PCPs and an appropriate number of exam rooms and LVNs supporting the PCPs are needed to gain optimal performance in the FCC. The BAMC leadership recently directed change of combining the FCC and the APNC will increase the number of PCPs and exam rooms which consequently will decrease the overall time a patient is in the FCC at McWethy Troop Medical Clinic. Nonetheless, to realize greater efficiencies (i.e. increasing the number of patients that the PCP can see as well as reduce the overall time a patient is in the clinic), the number of LVNs supporting the PCPs must also be increased. The FCC could gain even more efficiencies if the present duties of the screeners (LVNs) are changed to include preparing the patient in the exam rooms for the PCPs (enabling the PCPs to concentrate more on treating the patient and eliminating the use of a screening room for most patients).

Using the ratios listed in Table 9, the BAMC leadership has a method to determine the appropriate mix of resources to gain operational efficiency in the BAMC FCC with a constrained resource of PCPs, LVNs or exam rooms. For example, if the leadership wants to increase the FCC's capability up to 30% and changes the screening process but has a constrained resource of only fifteen PCPs available, the FCC would need twenty-five to twenty-six exam rooms and nine to fifteen LVNs (i.e. Exam Rooms = (# of PCPs) x (ratio of exam rooms to PCPs at a 10%-30% increase); LVNs = (# of PCPs) x (ratio of LVNs to PCPs at a 10%-30% increase)). Likewise if the constraining resource is the number of available exam rooms, the leadership can determine the appropriate amount of PCPs and LVNs (i.e. PCPs = (# of exam rooms) x ((ratio of exam rooms to PCPs at a 10%-30% increase)$^{-1}$); LVNs = (# of PCPs determined in above formula) x (ratio of LVNs to PCPs at a 10%-30% increase)).

The results of optimization demonstrate when varying the combination of multiple resources (PCPs, LVNs and exam rooms) that the Alternative-Four Models are consistently more efficient than the Alternative-One Models (Appendix F). In all cases (110, 120 and 130% of FY99 FCC visits), the Alternative-Four Models used fewer PCPs to achieve an acceptable time in the clinic for the patient (Table 8). These models used the PCPs more efficiently because the process was changed to increase the responsibilities of the LVNs to include preparing the patient in the exam room for the PCPs. This change in process will enable the PCPs to use more of their time in direct patient care (actual examination of the patient) and less time in preparing the patient for the exam.

Under all the Alternative-Four Models (i.e. 1.1,1.2 and 1.3), the exam rooms would have to be equipped to enable LVNs to screen patients in them. With this additional equipment and only three additional LVNs, the Alternative-Four Models 1.1 demonstrate that changing the screening process would enable the FCC to have an average of fifteen more visits daily as well as decrease the overall time a patient is in the clinic by an average of fourteen minutes from the current FCC configuration.

One finding that emerged in the study albeit not via the project's design was that increasing the number of exam rooms does not necessarily increase the productivity of PCPs. The actual location of these rooms is more essential to productivity. Increasing the number of exam rooms not in the proximity to the provider can decrease the productivity of the provider as well as decrease the efficiency of the system. Therefore the location of resources used by the PCP are key for the productivity of the provider and the efficiency of the system.

Presentation of Results

The modeler presented these results in a team fashion to key decision-makers and to personnel that may be affected by the results. In the presentations, the following was addressed with references to technical, operational and financial concerns: (1) Restatement of the Project Objectives; (2) Problem Solved; (3) Project Methodology; (4) Pros/Cons of Proposed Solution; and (5) Rejected Alternatives and Why (Gogg et. el., 1993).

Conclusions & Recommendations

To reiterate, the present configuration cannot support optimal performance in the FCC. Specifically, the models developed identified the need for one to five additional PCPs, four to eight LVNs, and five to thirteen exam rooms depending on the target capability and processes selected (Table 9). The anticipated directed consolidation of the FCC and the APNC will provide only one PCP and five exam rooms. Therefore, to gain the delta in resources needed to achieve optimal performance in the FCC, the BAMC leadership needs to examine the possibility of allocating more resources to the FCC (i.e. PCPs, LVNs and exam rooms). Due to the military's present resource constrained environment, the BAMC leadership may need to redirect resources, initiate resource sharing agreements or limit enrollment in the FCC to gain efficiency.

As stated earlier, the terminal objectives of this project were to determine resource levels and processes for the FCC that will improve efficiency. Efficiency, for this study, was defined as decreased patient overall time in clinic, increased patient access (i.e. increased number of available appointments at the 110, 120 and 130% level) and appropriate resource utilization (65-75% of PCPs available time).

As anticipated, the study findings identified several methods to improve the operational efficiency of BAMC FCC, specifically in the areas of access, patient wait times and resource utilization. By implementing the proposed process and resource changes of the Alternative-Four Models, the FCC can increase patient visits up to 30%, decrease patient total time in clinic by ten-minutes and increase PCPs' direct patient care utilization. In turn these resources and process changes are anticipated to improve the satisfaction of patients with BAMC FCC.

Before this study, BAMC did not have any standard management tool to determine the effect of changes of resource allocation in the FCC. The computer simulation models developed in this study will allow the BAMC executive leadership to evaluate future proposed changes in the clinic in a less expensive, less disruptive and more timely manner. Recommend that these models be used to further analyze the effect of increasing the number of exam rooms and to evaluate other proposed process changes to increase the use of PCPs for direct patient care as well as increase LVNs' responsibilities in the clinic. Likewise the procedures in this study can be used as a guide for completion of future studies of a similar nature in other BAMC TRICARE primary care clinics.

Overall, recommend BAMC leadership continue to support the use of computer simulation analysis. The ability of computer simulation to do "what-if" analyses without disrupting present processes and resources is invaluable. However, simulation is a resource intensive process that cannot be accomplished in a haphazard fashion. To effectively use computer simulation as a management decision-making tool, appropriate resources in the form of trained modelers, as well as allocation of time must be specifically provided to the project under study. Additionally, strongly recommend that individuals selected for training should be available to conduct simulation studies as a primary duty.

FCC Time Study Sheet

DATE: ________

Time Registration:	Time Screening:	Time Provider Visit:	Time Discharge/Check-Out:
Starts ________	Starts ________	Starts ________	Starts________
Ends ________	Ends ________	Ends ________	Ends ________

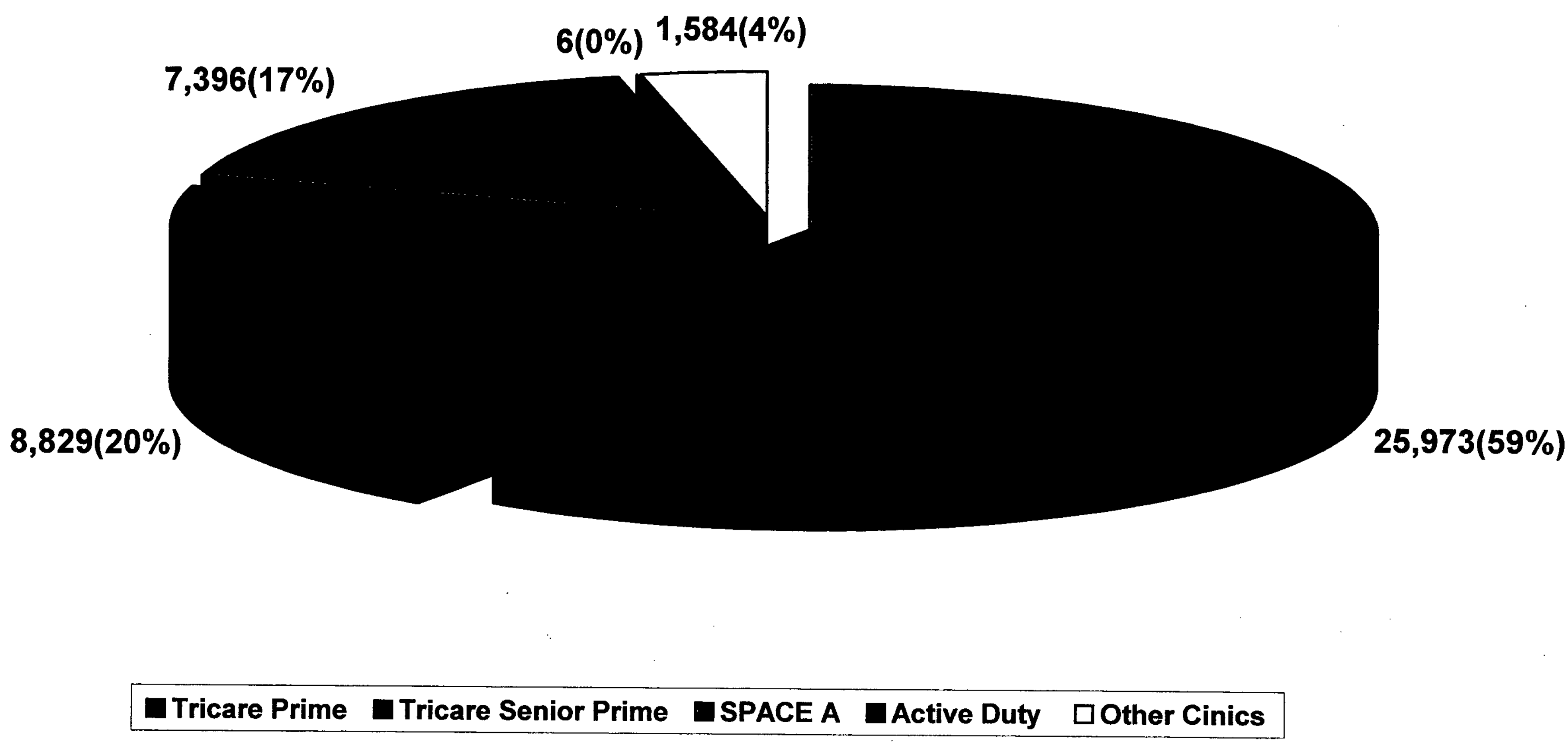
Provider
Type of Appointment
Time Patient Arrived

APPENDIX A-1

Input Variables Input Flow Timing Sheet

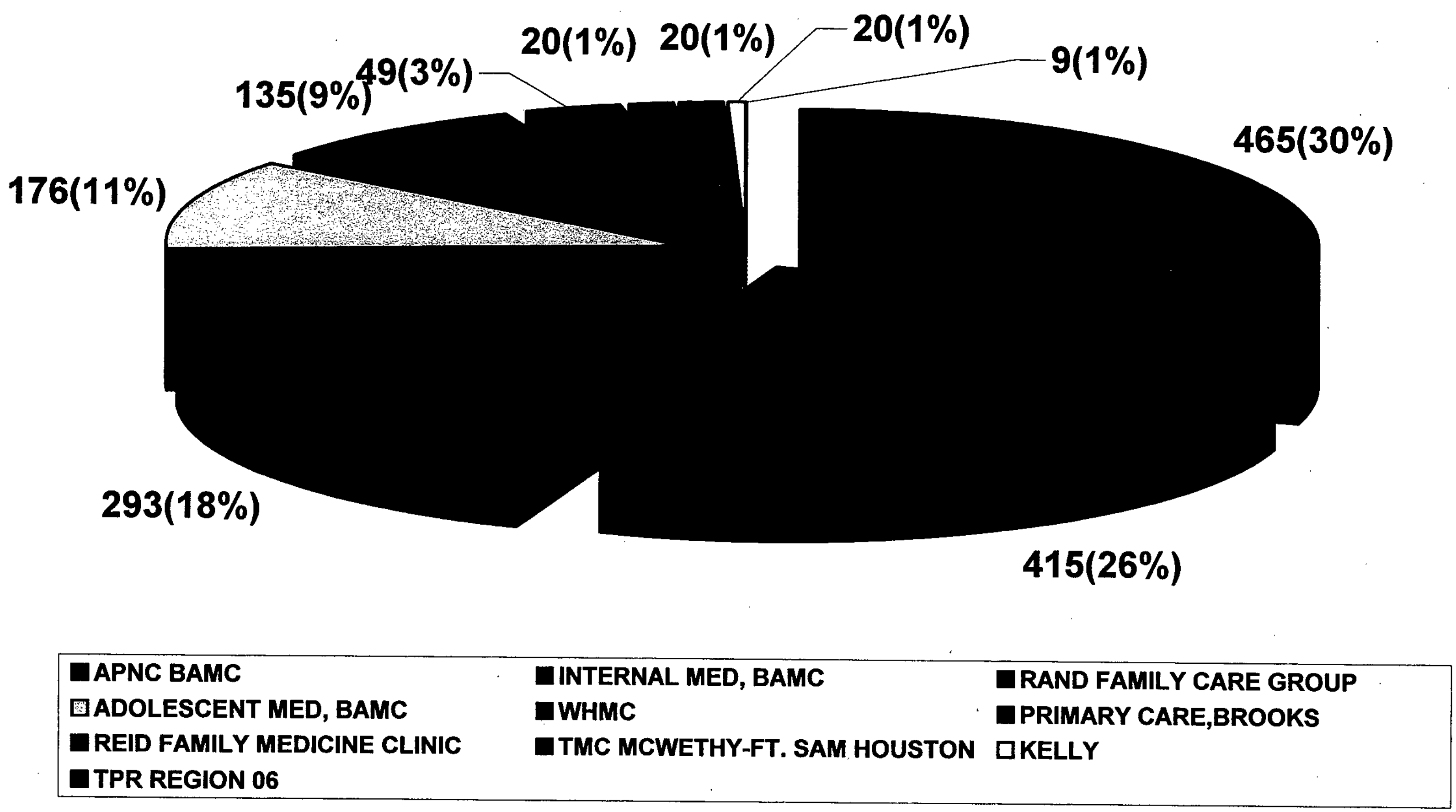
Date	#	PCPs	Appointment Type	Time	Time Before Appoint	Time Registration Starts	Time Ends	Reg Time	1ST Wait Time	Time Screening Starts	Time Screening Ends
Screening Time	2ND Wait	Time PCP Visit Starts	Time PCP Visit Ends	PCP Time	Time Check Out Starts	Time Check Out Ends	Discharge Time	Time See PCP Late	Total Time	Saw Nurse/Phar /Xray/Lab Before	Saw Nurse/Phar/ Xray/Lab After

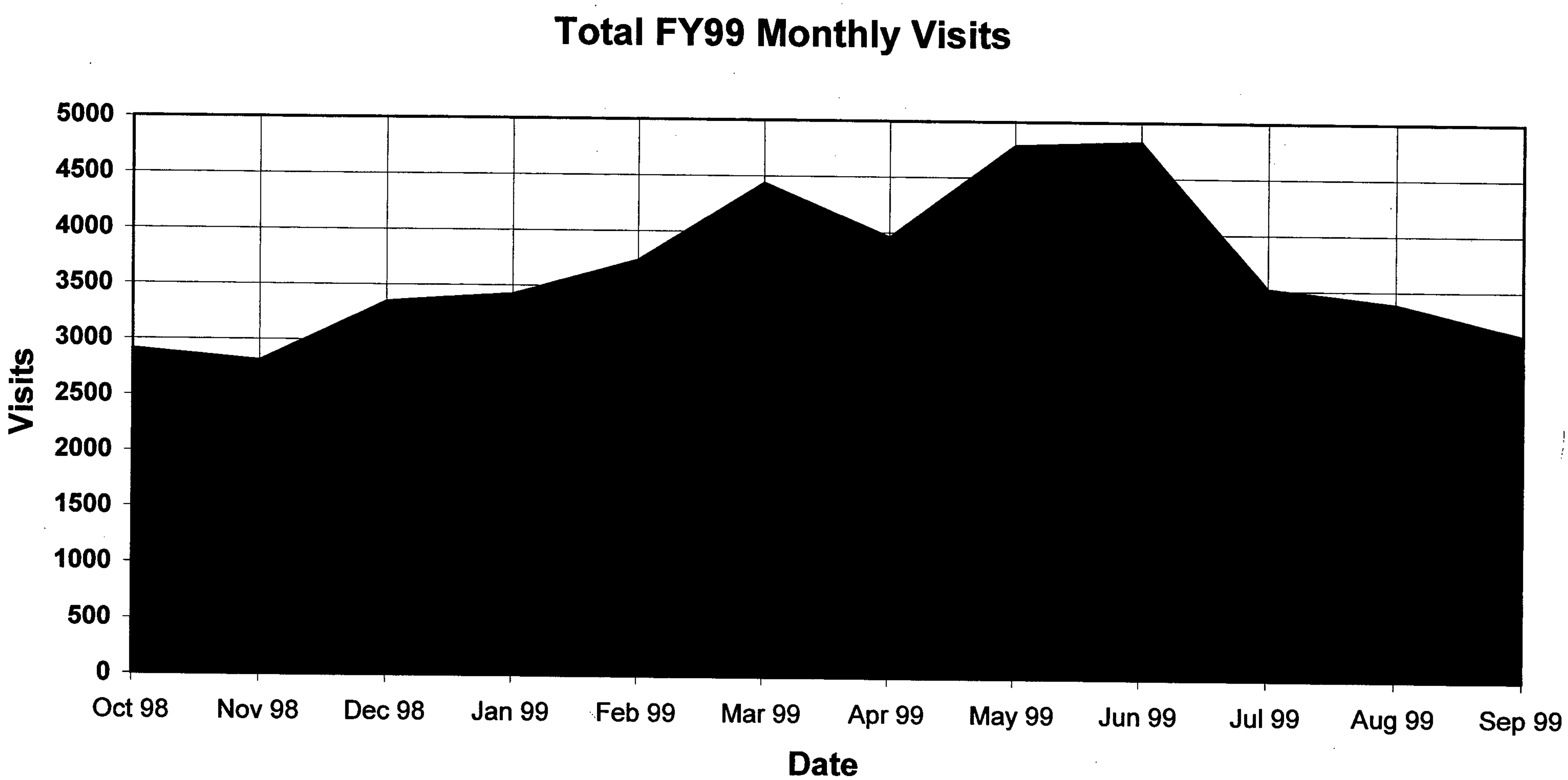
TOTAL FY99 FCC VISITS



APPRENDIX B-1

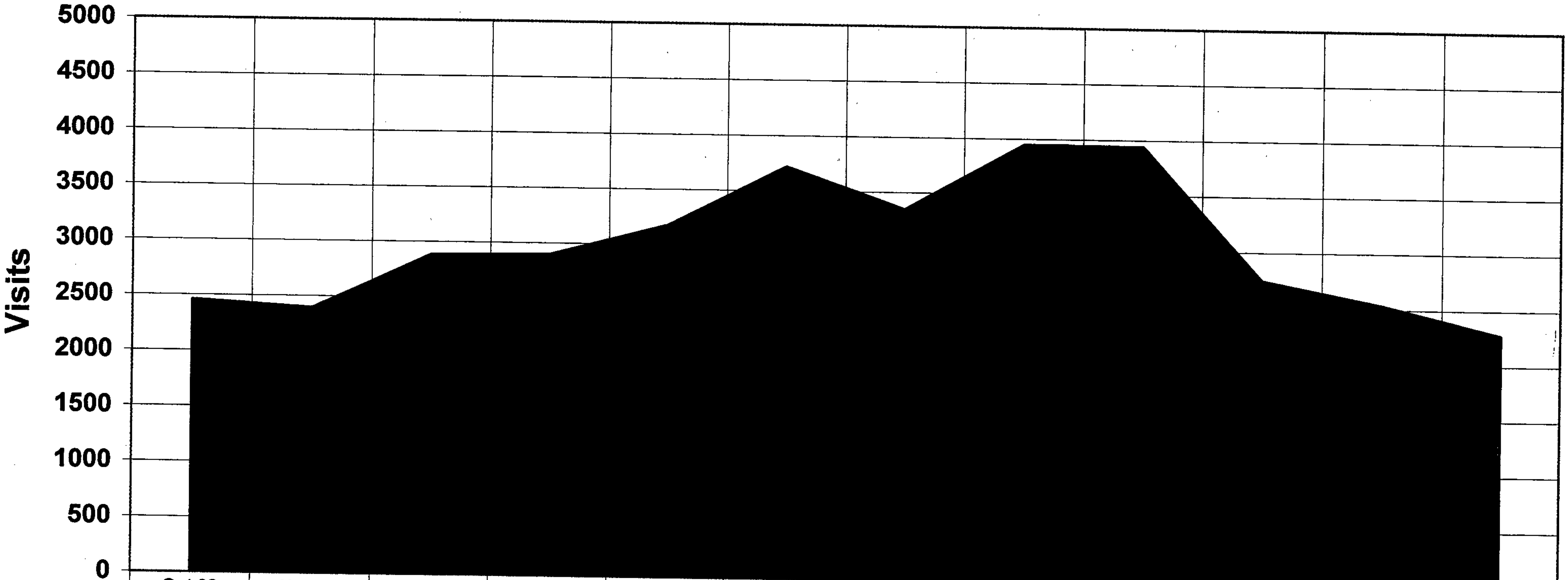
TOTAL FY99 FCC VISITS BY OTHER CLINIC ENROLLEES





APPRENDIX B-2

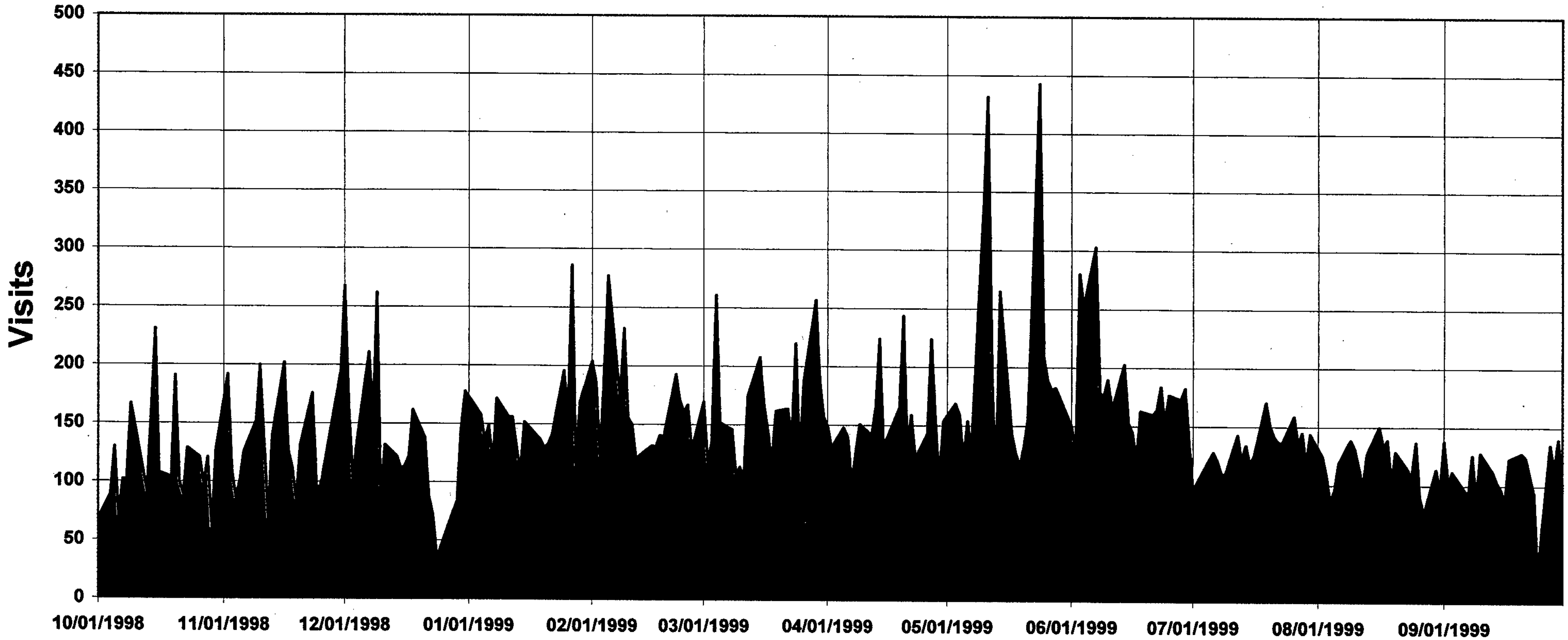
FY99 Monthly Visits without Telephone Consults



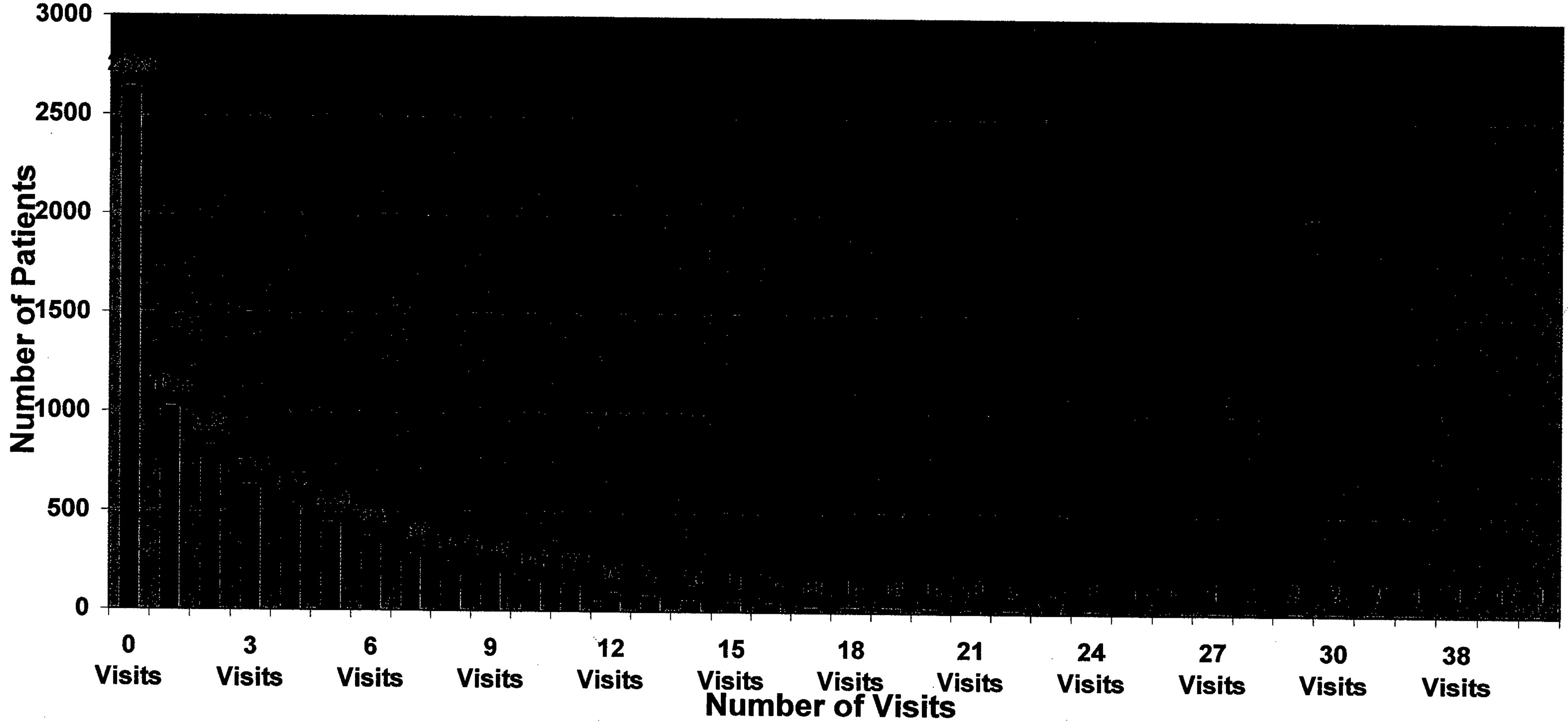
	Oct 98	Nov 98	Dec 98	Jan 99	Feb 99	Mar 99	Apr 99	May 99	Jun 99	Jul 99	Aug 99	Sep 99
Series1	2457	2393	2886	2901	3178	3720	3349	3948	3943	2747	2536	2280

APPRENDIX B-2

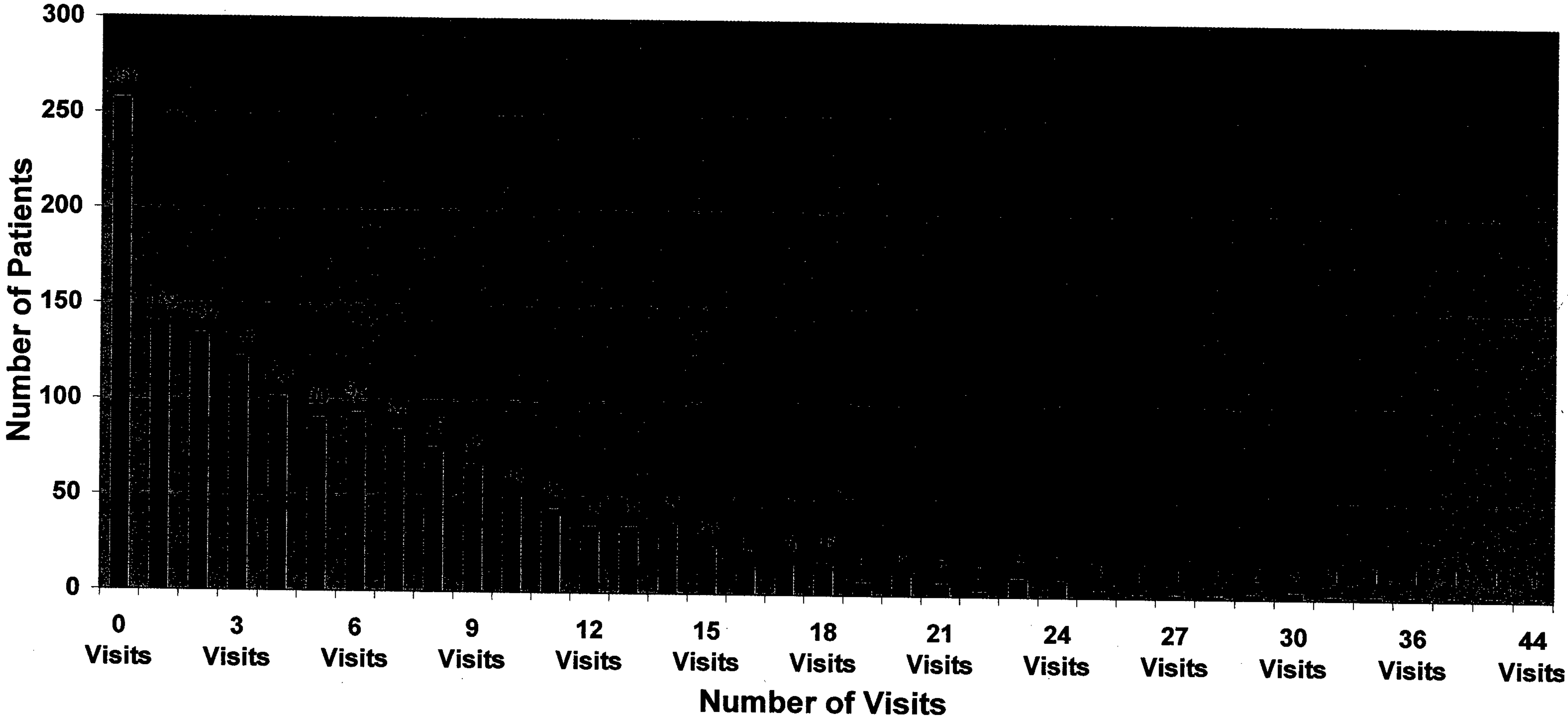
Total FY99 Daily Visits

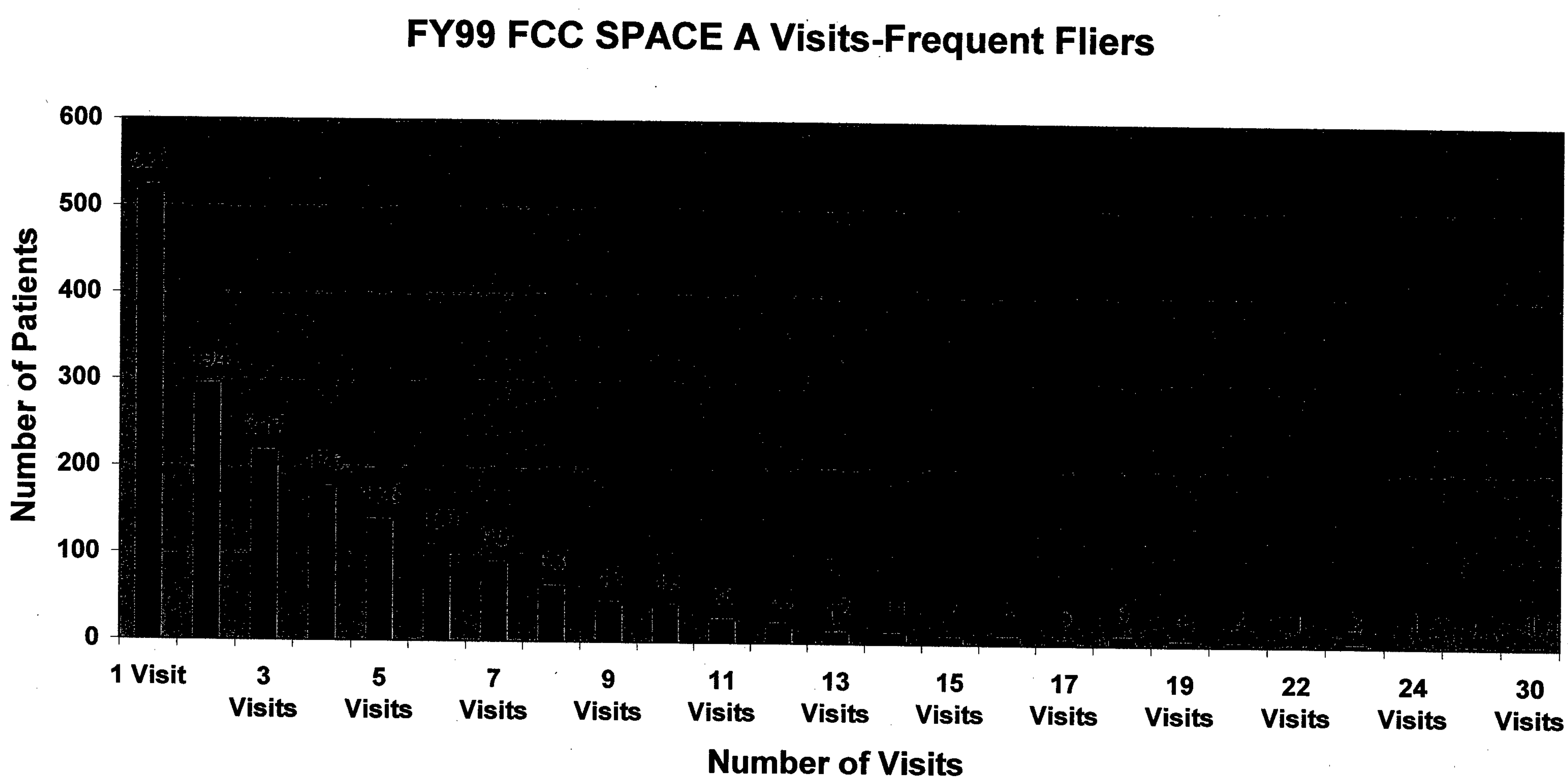


FY99 FCC TRICARE PRIME Visits-Frequent Fliers

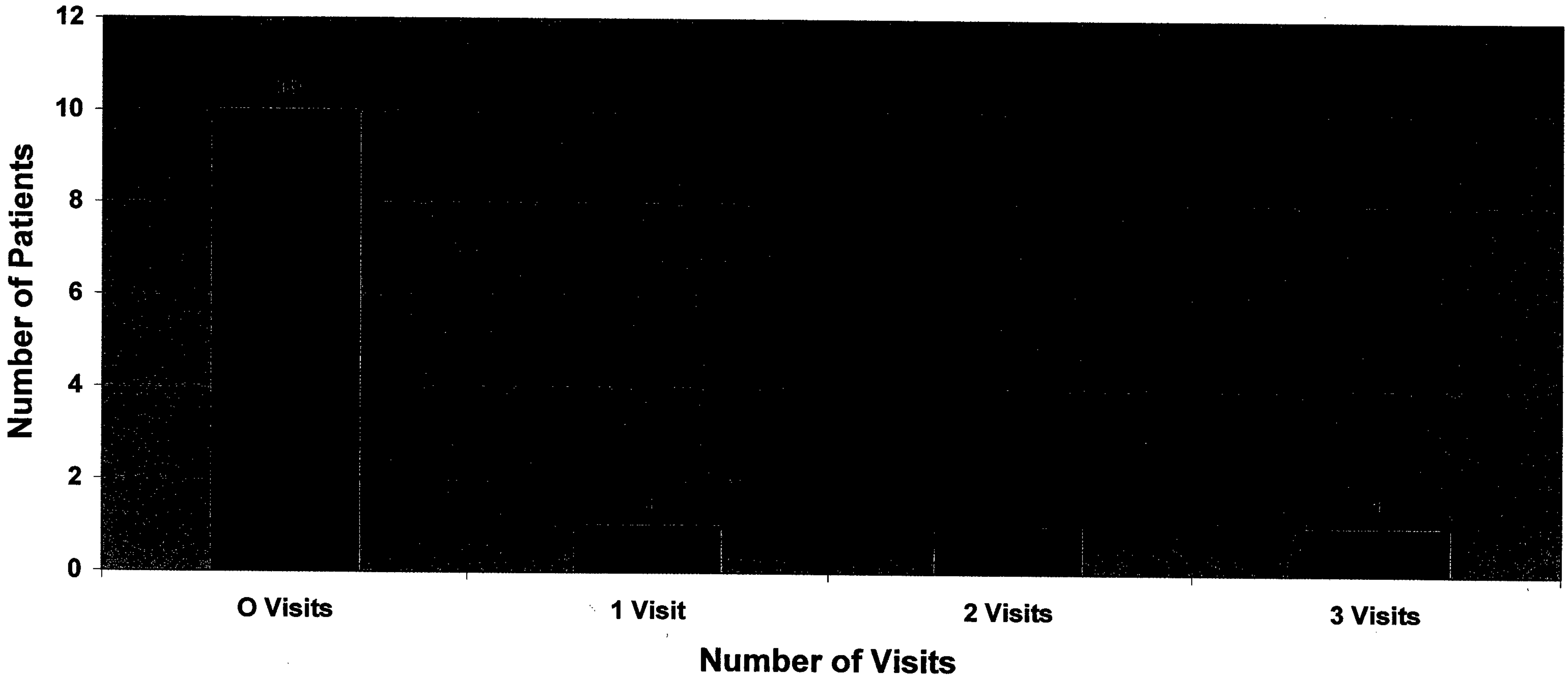


FY99 FCC TRICARE SENIOR PRIME Visits-Frequent Flier



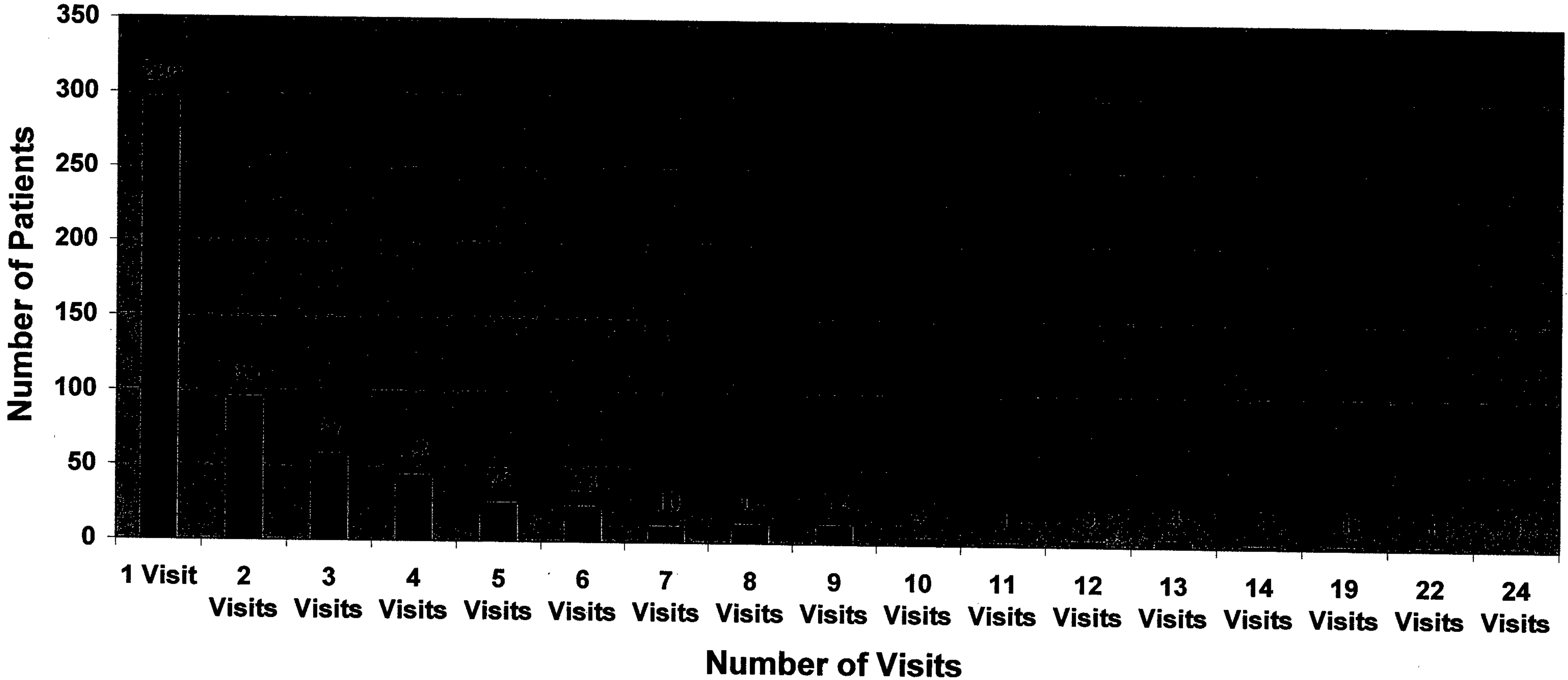

FY99 FCC SPACE A Visits-Frequent Fliers
Number of Patients
600
500
400
300
200
100
0
1 Visit
3 Visits
5 Visits
7 Visits
9 Visits
11 Visits
13 Visits
15 Visits
17 Visits
19 Visits
22 Visits
24 Visits
30 Visits
Number of Visits

FY99 FCC ACTIVE DUTY Visits - Frequent Fliers

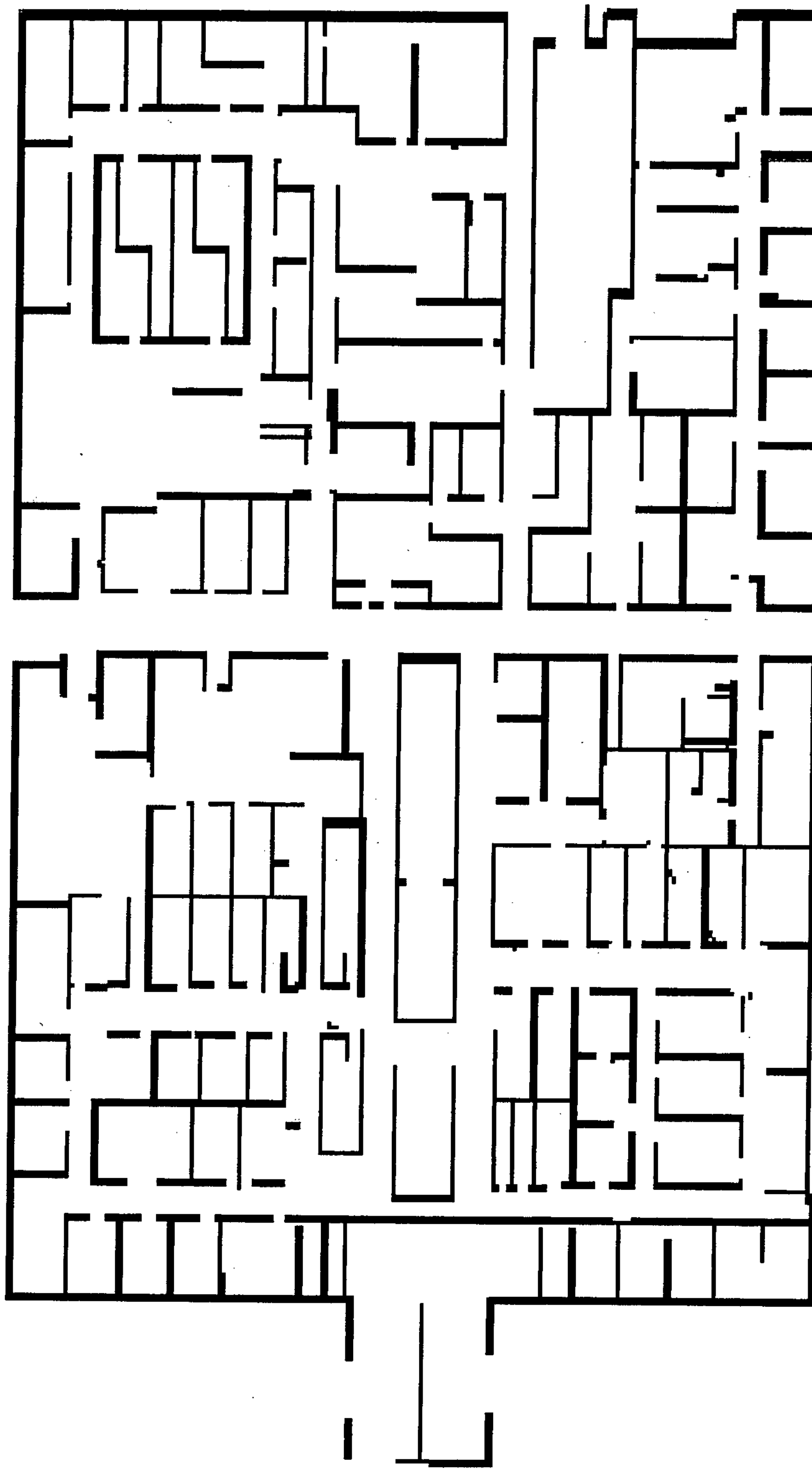


APPRENDIX B-2

FY99 FCC Visits By OTHER CLINIC ENROLLEES-Frequent Fliers



FCC Floor Plan



APPENDIX C

Statistical Analyses

Note: All statistical analysis numbers came directly from empirical time study data and MedModel® output numbers except for standard deviation numbers. Standard deviation numbers provided in MedModel® output are the standard deviation of the mean of each of the iterations. To determine a safe estimate of the standard deviations of the whole population, the modeler applied The Empirical Rule.

The Empirical Rule for distributions that are generally bell shaped is that:

About 68 percent of all data items lie within 1 standard deviation of the mean.

About 95 percent of all data lie within 2 standard deviation of the mean.

About 99.7 percent of all data lie within 3 standard deviation of the mean.

(Sanders, 1995)

The modeler used the maximum and minimum numbers provided in a MedModel® output and applied the empirical rule to determine a safe estimate of the standard deviation of MedModel® runs (e.g. (199.11-2.12)/6=32.83 the standard deviation of FCC Status Quo(M/Th).

APPENDIX D

Validation of Oct 99 Status Quo Models to Empirical Data (wait times)

TIME PATIENT WAITS TO BE EXAMED	M/TH	T/W/F	MONTH(OCT)
MEAN	17.84	18.41	18.19
MEDIAN	16.97	16.59	16.73
MIN	2.12	2.34	2.12
MAX	199.11	136.72	199.11
STD DEV	32.83	22.40	32.83
95% CI LOW	15	15.1	15.06
95% CI HIGH	20.67	21.73	21.33
SAMPLE SIZE	1019	1606	2625

TIME PATIENT IN CLINIC			
MEAN	66.58	68.86	67.99
MEDIAN	65.47	65.77	65.66
MIN	18.12	18.61	18.12
MAX	246.79	259.45	259.45
STD DEV	38.11	40.14	40.22
95% CI LOW	61.05	62.35	61.85
95% CI HIGH	72.11	75.38	74.13
SAMPLE SIZE	1019	1606	2625

TIME PATIENT WAITS TO BE EXAMED

Ho= There is no significant difference between the mean of the emperical total time a patient waits to see a PCP and the mean of the Oct 99 FCC Status Quo Models' total time a patient waits to see a PCP.

Level of Significance .05

H1= A significant difference exist between the mean of the emperical total time a patient waits to see a PCP and the mean of the Oct 99 FCC Status Quo Models' total time a patient waits to see a PCP.

		OBSERV	**.05 SIG =Z=+ OR -1.96**	**Z-TEST**	
18.19	MEAN	21.4384			
16.73	MEDIAN			EMPERICAL	MODEL
32.83	STD DEV	52.4724	SAMPLE SIZE	146	2625
15.06	95% CI LOW		MEAN	21.44	18.19
21.33	95% CI HIGH		STD DEV	52.47	32.83
2625	SAMPLE SIZE	146			

TR= -0.74

Fail To Reject Ho

TIME PATIENT IN SYSTEM

Ho= There is no significant difference between the mean of the emperical total time a patient is in the FCC and the mean of the Oct 99 FCC Status Quo Models' total time a patientis in the clinic.

Level of Significance .05

H1= A significant difference exist between the mean of the emperical total time a patient is in the FCC and the mean of the Oct 99 FCC Status Quo Models' total time a patient is in the clinic.

		OBSERV	**.05 SIG =Z=+ OR -1.96**	**Z-TEST**	
67.99	MEAN	65.2444			
65.66	MEDIAN			EMPERICAL	MODEL
40.22	STD DEV	24.619	SAMPLE SIZE	135	2625
61.85	95% CI LOW		MEAN	65.24	67.99
74.13	95% CI HIGH		STD DEV	24.62	40.22
2625	SAMPLE SIZE	135			

TR= 1.22

Fail to Reject Ho

APPENDIX D-1

Validation of Oct 99 Status Quo Models to Empirical Data (total patients)

TOTAL PATIENT VISITS LESS T-CONS FOR OCT 99	M/TH	T/W/F	MONTH(OCT)	Emperical (OCT)
MEAN	127.37	123.53	124.99	117
MEDIAN	126.5	123	124.33	
MIN	103	105	103.00	
MAX	153	154	154.00	
STD DEV	14.53	12.953	8.50	40.95
95% CI LOW	115.22	115.71	115.52	
95% CI HIGH	139.52	131.36	134.47	
SAMPLE SIZE	8	13	21.00	21
F-test	TR of 4.73 is >2.46			

Ho=There is no significant difference between the mean of the emperical total patients In October 1999 and the mean of the Oct 99 FCC Status Quo Models' total patients in October 1999 (within 10).

H1=There is a significant difference between the mean of the emperical total patients in October 1999 and the mean of the Oct 99 FCC Status Quo Models' total patients in October 1999 (within 10).

DF= 27.95985484 t.025= 2.0518

TR= 1.476175585 **TR of 1.476 is < t.025 of 2.0518; Fail to Reject Ho**

(Daniel, 1983)

Validation of FY99 Status Quo Models to Empirical Data (total patients)

TOTAL PATIENT VISITS LESS T-CONS FOR FY99	M/TH	T/W/F	FY99
MEAN	145.7	145.37	145.50
MEDIAN	144	146.00	145.20
MIN	123	114.00	114.00
MAX	177	175.00	177.00
STD DEV	11.57	12.09	10.50
95% CI LOW	143.33	143.34	143.34
95% CI HIGH	148.06	147.40	147.67
SAMPLE SIZE	100	149	249

Ho=There is no significant difference between the mean of the emperical total patients in FY99 and the mean of the FY99 FCC Status Quo Models' total patients in FY99.

TOTAL PATIENT VISITS LESS T-CONS FOR FY99

H1=There is a significant difference between the mean of the emperical total patients and the mean of the FY99 FCC Status Quo Models' total patients in FY99.

Level of Significance .05

		OBSER\	**.05 SIG =Z=+ OR -1.96**	**Z-TEST**	
145.50	MEAN	145.9			
145.20	MEDIAN			Emperical	FY99 Status Quo Models
10.50	STD DEV	52.68	SAMPLE SIZE	249	249
143.34	95% CI LOW		MEAN	145.94	145.50
147.67	95% CI HIGH		STD DEV	52.68	10.50
249	SAMPLE SIZE	249			

TR= 0.13

Fail To Reject Ho

Reliability of FY99 Status Quo Model (Different Random Seeds)

TIME PATIENT WAITS TO BE EXAMED	M/TH
MEAN	17.55
MEDIAN	16.86
MIN	2.81
MAX	152.42
STD DEV	24.94
95% CI LOW	14.77
95% CI HIGH	20.33
SAMPLE SIZE	948
TIME PATIENT IN CLINIC	
MEAN	67.24
MEDIAN	65.47
MIN	21.59
MAX	246.34
STD DEV	37.46
95% CI LOW	61.62
95% CI HIGH	72.85
SAMPLE SIZE	948

TIME PATIENT WAITS TO BE EXAMED

Ho= There is no significant difference between the mean of the FY99 FCC Status Qou Model's (Monday & Thursday with one set of seeds) total time a patient waits to see a PCP and the mean of the FY99 FCC Status Quo Model's (Monday & Thursday with another set of seeds) total time a patient waits to see a PCP.

H1= A significant difference exist between the mean of the FY99 FCC Status QouModel's (Monday & Thursday with one set of seeds) total time a patient waits to see a PCP and the mean of the FY99 FCC Status Qou Model's (Monday & Thursday with another set of seeds) total time a patient waits to see a PCP.

Level of Significance .05

		MODEL(8)
17.55	MEAN	17.84
16.86	MEDIAN	
24.94	STD DEV	32.83
14.77	95% CI LOW	
20.33	95% CI HIGH	
948	SAMPLE SIZE	1019

.05 SIG =Z=+ OI Z-TEST

	MODEL(8)	MODEL(s8)
SAMPLE SIZE	1019	948
MEAN	17.84	17.55
STD DEV	32.83	24.94

TR= 0.22

Fail To Reject Ho

TIME PATIENT IN SYSTEM

Ho= There is no significant difference between the mean of the FY99 FCC Status Qou Model's (Monday & Thursday with one set of seeds) total time a patient is in the FCC and the mean of the FY99 FCC Status Qou Model's (Monday & Thursday with another set of seeds) total time a patient is in the clinic.

H1= A significant difference exist between the mean of the FY99 FCC Status Qou Model's (Monday & Thursday with one set of seeds) total time a patient is in the FCC and the mean of the FY99 FCC Status Qou Model's (Monday & Thursday with another set of seeds) total time a patient is in the clinic.

Level of Significance .05

		MODEL(8)
67.24	MEAN	66.58
65.47	MEDIAN	
37.46	STD DEV	38.11
61.62	95% CI LOW	
72.85	95% CI HIGH	
948	SAMPLE SIZE	1019

.05 SIG =Z=+ OI Z-TEST

	MODEL(8)	MODEL(s8)
SAMPLE SIZE	1019	948
MEAN	66.58	67.24
STD DEV	38.11	37.46

TR= -0.39

Fail to Reject Ho

Reliability of FY99 Status Quo Model (Different Random Seeds)

TIME PATIENT WAITS TO BE EXAMINED

	T/W/F
MEAN	18.46
MEDIAN	17.14
MIN	2.26
MAX	345.68
STD DEV	57.24
95% CI LOW	15.50
95% CI HIGH	21.36
SAMPLE SIZE	1654

TIME PATIENT IN CLINIC

MEAN	68.85
MEDIAN	67.52
MIN	17.24
MAX	385.64
STD DEV	61.40
95% CI LOW	63.57
95% CI HIGH	74.13
SAMPLE SIZE	1654

TIME PATIENT WAITS TO BE EXAMINED

Ho= There is no significant difference between the mean of the FY99 FCC Status Qou Model's (Tuesday, Wenesday, & Friday with one set of seeds) total time a patient waits to see a PCP and the mean of the FY99 FCC Status Qou Model's (Tuesday, Wenesday, & Friday with another set of seeds) total time a patient waits for a PCP.

H1= A significant difference exist between the mean of the FY99 FCC Status Qou Model's (Tuesday, Wenesday, & Friday with one set of seeds) total time a patient waits to see a PCP and the mean of the FY99 FCC Status Qou Model's (Tuesday, Wenesday, & Friday with another set of seeds) total time a patient waits for a PCP.

Level of Significance .05

		MODEL(13)
18.46	MEAN	17.84
17.14	MEDIAN	
57.24	STD DEV	32.83
15.50	95% CI LOW	
21.36	95% CI HIGH	
1654	SAMPLE SIZE	1019

.05 SIG =Z=+ OR -1.96 **Z-TEST**

	MODEL(13)	MODEL(s13)
SAMPLE SIZE	1019	1654
MEAN	17.84	18.46
STD DEV	32.83	57.24

TR= -0.36

Fail To Reject Ho

TIME PATIENT IN SYSTEM

Ho= There is no significant difference between the mean of the FY99 FCC Status Qou Model's (Tuesday, Wenesday, & Friday with one set of seeds) total time a patient is in the FCC and the mean of the FY99 FCC Status Qou Model's (Tuesday, Wenesday, & Friday with another set of seeds) total time a patient is in the clinic.

H1= A significant difference exist between the mean of the FY99 FCC Status Qou Model's (Tuesday, Wenesday, & Friday with one set of seeds) total time a patient is in the FCC and the mean of the FY99 FCC Status Qou Model's (Tuesday, Wenesday, & Friday with another set of seeds) total time a patient is in the clinic.

Level of Significance .05

		MODEL(13)
68.85	MEAN	66.58
67.52	MEDIAN	
61.40	STD DEV	38.11
63.57	95% CI LOW	
74.13	95% CI HIGH	
1654	SAMPLE SIZE	1019

.05 SIG =Z=+ OR -1.96 **Z-TEST**

	MODEL(13)	MODEL(s13)
SAMPLE SIZE	1019	1654
MEAN	66.58	68.85
STD DEV	38.11	61.40

TR= -1.18

Fail to Reject Ho

Reliability of FY99 Status Quo Model (Multiple Iterations)

TIME PATIENT WAITS TO BE EXAMED	M/TH
MEAN	16.91
MEDIAN	16.11
MIN	2.02
MAX	199.11
STD DEV	30.55
95% CI LOW	15.81
95% CI HIGH	18.01
SAMPLE SIZE	3618
TIME PATIENT IN CLINIC	
MEAN	65.01
MEDIAN	64.46
MIN	18.12
MAX	246.79
STD DEV	38.11
95% CI LOW	62.78
95% CI HIGH	67.24
SAMPLE SIZE	3618

TIME PATIENT WAITS TO BE EXAMED

Ho= There is no significant difference between the mean of the FY99 FCC Status Qou Model's (Monday & Thursday ran 8 iterations) total time a patient waits to see a PCP and the mean of the FCC Model (Monday & Thursday ran 30 iterations) total time a patient waits for a PCP.

Level of Significance .05

H1= A significant difference exist between the mean of the FY99 FCC Status Qou Model's (Monday & Thursday ran 8 iterations) total time a patient waits to see a PCP and the mean of the FCC Model (Monday & Thursday ran 30 iterations) total time a patient waits for PCP.

		MODEL(8)
16.91	MEAN	17.84
16.11	MEDIAN	
30.55	STD DEV	32.83
15.81	95% CI LOW	
18.01	95% CI HIGH	
3618	SAMPLE SIZE	1019

.05 SIG =Z=+ OR -1.96 Z-TEST

	MODEL(8)	MODEL(30)
SAMPLE SIZE	1019	3618
MEAN	17.84	16.91
STD DEV	32.83	30.55

TR= 0.81

Fail To Reject Ho

TIME PATIENT IN SYSTEM

Ho= There is no significant difference between the mean of the FY99 FCC Status Qou Model's (Monday & Thursday ran 8 iterations) total time a patient is in the FCC and the mean of the FCC Model (Monday & Thursday ran 30 iterations) total time a patient is in the clinic.

Level of Significance .05

H1= A significant difference exist between the mean of the FY99 FCC Status Qou Model's (Monday & Thursday ran 8 iterations) total time a patient is in the FCC and the mean of the FCC Model (Monday & Thursday ran 30 iterations) total time a patient is in the clinic.

		MODEL(8)
65.01	MEAN	66.58
64.46	MEDIAN	
38.11	STD DEV	38.11
62.78	95% CI LOW	
67.24	95% CI HIGH	
3618	SAMPLE SIZE	1019

.05 SIG =Z=+ OR -1.96 Z-TEST

	MODEL(8)	MODEL(30)
SAMPLE SIZE	1019	3618
MEAN	66.58	65.01
STD DEV	38.11	38.11

TR= 1.16

Fail to Reject Ho

Reliability of FY99 Status Quo Model (Multiple Iterations)

TIME PATIENT WAITS TO BE EXAMED	**T/W/F**
MEAN	18.15
MEDIAN	16.74
MIN	1.99
MAX	168.44
STD DEV	27.74
95% CI LOW	16.47
95% CI HIGH	19.82
SAMPLE SIZE	3638
TIME PATIENT IN CLINIC	
MEAN	68.46
MEDIAN	65.32
MIN	17.31
MAX	296.66
STD DEV	46.56
95% CI LOW	64.89
95% CI HIGH	72.03
SAMPLE SIZE	3638

TIME PATIENT WAITS TO BE EXAMED

Ho= There is no significant difference between the mean of the FY99 FCC Status Qou Model's (Tuesday, Wednesday & Friday 13 iterations) total time a patient waits to see a PCP and the mean of the FCC Model (Tuesday, Wednesday & Friday ran 30 iterations) total time a patient waits for a PCP.

Level of Significance .05

H1= A significant difference exist between the mean of the FY99 FCC Status Qou Model's (Tuesday, Wednesday & Friday 13 iterations) total time a patient waits to see a PCP and the mean of the FCC Model (Tuesday, Wednesday & Friday ran 30 iterations) total time a patient waits for PCP.

		MODEL(8)
18.15	MEAN	18.41
16.74	MEDIAN	
27.74	STD DEV	22.40
16.47	95% CI LOW	
19.82	95% CI HIGH	
3638	SAMPLE SIZE	1606

.05 SIG =Z=+ OR -1.96 Z-TEST

	MODEL(13)	MODEL(30)
SAMPLE SIZE	1606	3638
MEAN	18.41	18.15
STD DEV	22.40	27.74

TR= 0.36

Fail To Reject Ho

TIME PATIENT IN SYSTEM

Ho= There is no significant difference between the mean of the FY99 FCC Status Qou Model's (Tuesday, Wednesday & Friday 13 iterations) total time a patient is in the FCC and the mean of the FCC Model (Tuesday, Wednesday & Friday ran 30 iterations) total time a patient is in the clinic.

Level of Significance .05

H1= A significant difference exist between the mean of the FY99 FCC Status Qou Model's (Tuesday, Wednesday & Friday 13 iterations) total time a patient is in the FCC and the mean of the FCC Model (Tuesday, Wednesday & Friday ran 30 iterations) total time a patient is in the clinic.

		MODEL(8)
68.46	MEAN	68.86
65.32	MEDIAN	
46.56	STD DEV	40.14
64.89	95% CI LOW	
72.03	95% CI HIGH	
3638	SAMPLE SIZE	1606

.05 SIG =Z=+ OR -1.96 Z-TEST

	MODEL(13)	MODEL(30)
SAMPLE SIZE	1606	3638
MEAN	68.86	68.46
STD DEV	40.14	46.56

TR= 0.32

Fail to Reject Ho

APPENDIX D-5

Comparison of Alternative-One Models with FY99 FCC Status Quo Models (wait times)

TIME PATIENT WAITS TO BE EXAMED	M/TH (Alt-1)	T/W/F (Alt-1)	Alternative-One Models	FY99 Status Quo Models (Base)	M/TH (Base)	T/W/F (Base)
MEAN	19.01	19.46	19.28	24.80	23.41	25.73
MEDIAN	18.46	18.72	18.62	22.80	21.91	23.39
MIN	1.67	1.59	1.59	1.3	1.93	1.3
MAX	319.98	299.98	319.98	370.4	241.1	370.4
STD DEV	53.05	49.73	53.07	61.52	39.86	61.52
95% CI LOW	18.39	18.91	18.70	23.47	22.24	24.29
95% CI HIGH	19.63	20.02	19.86	26.13	24.59	27.17
SAMPLE SIZE	14567	21683	36250	36231	14570	21661
TIME PATIENT IN CLINIC						
MEAN	71.2	73.13	72.35	80.59	78.72	81.84
MEDIAN	70.15	72.38	71.48	78.11	76.64	79.1
MIN	17.62	15.95	15.95	17.57	17.79	17.57
MAX	334.2	324.42	334.20	391.53	287.9	391.53
STD DEV	52.76	51.41	53.04	62.33	45.02	62.33
95% CI LOW	69.97	72.09	71.24	78.40	76.55	79.64
95% CI HIGH	72.43	74.17	73.47	82.77	80.9	84.03
SAMPLE SIZE	14567	21683	36250	36231	14570	21661

TIME PATIENT WAITS TO BE EXAMED

Ho= There is no significant statistical difference between the mean of the FY 99 FCC Status Quo Models' total time a patient waits to see a PCP and the mean of the Alternative-One Models' total time a patient waits to see a PCP.

H1= A significant statistical difference exist between the mean of the FY 99 FCC Status Quo Models' total time a patient waits to see a PCP and the mean of the Alternative-One Models' total time a patient waits to see a PCP.

Level of Significance .05

		FY99 Base
19.28	MEAN	24.80
18.62	MEDIAN	22.80
53.07	STD DEV	61.52
18.70	95% CI LOW	23.47
19.86	95% CI HIGH	26.13
36250	SAMPLE SIZE	36250

.05 SIG =Z=+ OR -1.96 Z-TEST

	FY99 Base	Alt-1
SAMPLE SIZE	36250	36250
MEAN	24.80	19.28
STD DEV	61.52	53.07

TR= 12.93

Reject Ho

TIME PATIENT IN SYSTEM

Ho= There is no significant statistical difference between the mean of the FY 99 FCC Status Quo Models' mean total time a patient is in the FCC and the mean of the Alternative-One Moedls' total time a patient is in the clinic.

H1= A significant statistical difference exist between the mean of the FY 99 FCC Status Quo Models' mean total time a patient is in the FCC and the mean of the Alternative-One Models' total time a patient is in the clinic.

Level of Significance .05

		FY99 Base
72.35	MEAN	80.59
71.48	MEDIAN	78.11
53.04	STD DEV	62.33
71.24	95% CI LOW	78.40
73.47	95% CI HIGH	82.77
36250	SAMPLE SIZE	36231

.05 SIG =Z=+ OR -1.96 Z-TEST

	FY99 Base	Alt-1
SAMPLE SIZE	36231	36250
MEAN	80.59	72.35
STD DEV	62.33	53.04

TR= 19.15

Reject Ho

Comparison of Alternative-Two Models with FY99 Status Quo Models (wait times)

TIME PATIENT WAITS TO BE EXAMED	M/TH (Alt-2)	T/W/F (Alt-2)	Alternative-Two Models	FY99 FCC STATUS QUO (Base)	M/TH (Base)	T/W/F (Base)
MEAN	14.1	14.67	14.44	24.80	23.41	25.73
MEDIAN	13.99	14.02	14.01	22.80	21.91	23.39
MIN	1.32	1.61	1.66	1.3	1.93	1.3
MAX	186.76	279.21	268.46	370.4	241.1	370.4
STD DEV	30.91	46.27	44.47	61.52	39.86	61.52
95% CI LOW	13.8	14.28	14.09	23.47	22.24	24.29
95% CI HIGH	14.41	15.06	14.80	26.13	24.59	27.17
SAMPLE SIZE	7250	10792	18042	36231	14570	21661
TIME PATIENT IN CLINIC						
MEAN	69.82	75.91	73.46	80.59	78.72	81.84
MEDIAN	68.85	74.62	72.30	78.11	76.64	79.1
MIN	18.09	15.49	18.09	17.57	17.79	17.57
MAX	294.1	337.41	337.41	391.53	287.9	391.53
STD DEV	46.00	53.65	53.22	62.33	45.02	62.33
95% CI LOW	68.71	74.7	72.29	78.40	76.55	79.64
95% CI HIGH	70.93	77.13	74.64	82.77	80.9	84.03
SAMPLE SIZE	7250	10792	18042	36231	14570	21661

TIME PATIENT WAITS TO BE EXAMED

Ho= There is no significant statistical difference between the mean of the FY99 FCC Status Quo Models' total time a patient waits to see a PCP and the mean of the Alternative-Two Models' total time a patient waits to see a PCP.

Level of Significance .05

H1= A significant statistical difference exist between the mean of the FY99 FCC Status Quo Models' total time a patient waits to see a PCP and the mean of the AlternativeTwo Models' total time a patient waits to see a PCP.

		FY99 Base	.05 SIG =Z=+ OR -1.96		
14.44	MEAN	24.80			
14.01	MEDIAN	22.80			
44.47	STD DEV	61.52			
14.09	95% CI LOW	23.47			
14.80	95% CI HIGH	26.13			
18042	SAMPLE SIZE	36231			

Z-TEST

	FY99 Base	Alt-2
SAMPLE SIZE	36231	18042
MEAN	24.80	14.44
STD DEV	61.52	44.47

TR= 22.39

Reject Ho

TIME PATIENT IN SYSTEM

Ho= There is no significant statistical difference between the mean of the FY99 FCC Status Quo Models' mean total time a patient is in the FCC and the mean of the Alternative-Two Models' total time a patient is in the clinic.

Level of Significance .05

H1= A significant statistical difference exist between the mean of the FY99 FCC Status Quo Models' mean total time a patient is in the FCC and the mean of the Alternative-Two Models' total time a patient is in the clinic.

		FY00 Base	.05 SIG =Z=+ OR -1.96
73.46	MEAN	80.59	
72.30	MEDIAN	78.11	
53.22	STD DEV	62.33	
72.29	95% CI LOW	78.40	
74.64	95% CI HIGH	82.77	
18042	SAMPLE SIZE	36231	

Z-TEST

	FY00 Base	Alt-2
SAMPLE SIZE	36231	18042
MEAN	80.59	73.46
STD DEV	62.33	53.22

TR= 13.86

Reject Ho

Comparison of Alternative-Three Models with FY99 FCC Status Quo Models (wait times)

TIME PATIENT WAITS TO BE EXAMED	M/TH (Alt-3)	T/W/F (Alt-3)	Alternative-Three Models	FY99 STATUS QUO MODEL (BASE)	M/TH (Base)	T/W/F(Base)
MEAN	19.87	21.55	20.88	24.80	23.41	25.73
MEDIAN	19.53	20.44	20.07	22.80	21.91	23.39
MIN	1.06	0.92	0.92	1.3	1.93	1.3
MAX	182.33	186.27	186.27	370.4	241.1	370.4
STD DEV	30.21	30.89	30.89	61.52	39.86	61.52
95% CI LOW	19.36	20.84	20.25	23.47	22.24	24.29
95% CI HIGH	20.38	22.26	21.50	26.13	24.59	27.17
SAMPLE SIZE	7250	10792	18042	36231	14570	21661
TIME PATIENT IN CLINIC						
MEAN	57.88	60.63	59.53	80.59	78.72	81.84
MEDIAN	57.68	59.97	59.05	78.11	76.64	79.1
MIN	16.62	13.48	13.48	17.57	17.79	17.57
MAX	215.62	98.23	215.62	391.53	287.9	391.53
STD DEV	33.17	14.13	33.69	62.33	45.02	62.33
95% CI LOW	57.12	59.7	58.66	78.40	76.55	79.64
95% CI HIGH	58.63	61.56	60.38	82.77	80.9	84.03
SAMPLE SIZE	7250	10792	18042	36231	14570	21661

TIME PATIENT WAITS TO BE EXAMED

Ho= There is no significant statistical difference between the mean of the FY99 FCC Status Quo models' total time a patient waits to see a PCP and the mean of the Alternatie-Three Models' total time a patient waits to see a PCP.

Level of Significance .05

H1= A significant statistical difference exist between the mean of the FY99 FCC Status Quo total time a patient waits to see a PCP and the mean of the Alternative-Three Models' total time a patient waits to see a PCP.

Alt-3		FY99 Base	.05 SIG =Z=+ OR -1.96	Z-TEST FY99 Base	Alt-3
20.88	MEAN	24.80			
20.07	MEDIAN	22.80			
30.89	STD DEV	61.52	SAMPLE SIZE	36231	18042
20.25	95% CI LOW	23.47	MEAN	24.80	20.88
21.50	95% CI HIGH	26	STD DEV	61.52	30.89
18042	SAMPLE SIZE	36231			

TR= 9.89

Reject Ho

TIME PATIENT IN SYSTEM

Ho= There is no significant statistical difference between the mean of the FY99 FCC Status Quo Models' mean total time a patient is in the FCC and the mean of the Alternative-Three Models' total time a patient is in the clinic.

Level of Significance .05

H1= A significant statistical difference exist between the mean of the AFY99 FCC Status Quo Models' mean total time a patient is in the FCC and the mean of the Alternative-Three Models' total time a patient is in the clinic.

Alt-3		FY99 Base	.05 SIG =Z=+ OR -1.96	Z-TEST FY99 Base	Alt-3
59.53	MEAN	80.59			
59.05	MEDIAN	78.11			
33.69	STD DEV	62.33	SAMPLE SIZE	36231	18042
58.66	95% CI LOW	78.40	MEAN	80.59	59.53
60.38	95% CI HIGH	82.77	STD DEV	62.33	33.69
18042	SAMPLE SIZE	36231			

TR= 51.06

Reject Ho

Comparison of Alternative-Three Models with Alternative-One Models (wait times)

TIME PATIENT WAITS TO BE EXAMED	M/TH (Alt-3)	T/W/F (Alt-3)	Alternative-Three Models	Alternative-One Models	M/TH (Alt-1)	T/W/F(Alt-1)
MEAN	19.87	21.55	20.88	19.28	19.01	19.46
MEDIAN	19.53	20.44	20.07	18.62	18.46	18.72
MIN	1.06	0.92	0.92	1.3	1.67	1.59
MAX	182.33	186.27	186.27	370.4	319.98	299.98
STD DEV	30.21	30.89	30.89	61.52	53.05	49.73
95% CI LOW	19.36	20.84	20.25	18.70	18.39	18.91
95% CI HIGH	20.38	22.26	21.50	19.86	19.63	20.02
SAMPLE SIZE	7250	10792	18042	36250	14567	21683
TIME PATIENT IN CLINIC						
MEAN	57.88	60.63	59.53	72.35	71.2	73.13
MEDIAN	57.68	59.97	59.05	71.48	70.15	72.38
MIN	16.62	13.48	13.48	17.57	17.62	15.95
MAX	215.62	98.23	215.62	391.53	334.2	324.42
STD DEV	33.17	14.13	33.69	62.33	52.76	51.41
95% CI LOW	57.12	59.7	58.66	71.24	69.97	72.09
95% CI HIGH	58.63	61.56	60.38	73.47	72.43	74.17
SAMPLE SIZE	7250	10792	18042	36250	14567	21683

TIME PATIENT WAITS TO BE EXAMED

Ho= There is no significant statistical difference between the mean of the Alternative-One Models' total time a patient waits to see a PCP and the mean of the Alternatie-Three Models' total time a patient waits to see a PCP.

H1= A significant statistical difference exist between the mean of the Alternative-One Models' total time a patient waits to see a PCP and the mean of the Alternative-Three Models' total time a patient waits to see a PCP.

Level of Significance .05

		Alt-1
20.88	MEAN	19.28
20.07	MEDIAN	18.62
30.89	STD DEV	61.52
20.25	95% CI LOW	18.70
21.50	95% CI HIGH	20
18042	SAMPLE SIZE	36250

.05 SIG =Z=+ OR -1.96

Z-TEST

	Alt-1	Alt-3
SAMPLE SIZE	36250	18042
MEAN	19.28	20.88
STD DEV	61.52	30.89

TR= -4.02

Reject Ho

TIME PATIENT IN SYSTEM

Ho= There is no significant statistical difference between the mean of the Alternative-One Models' mean total time a patient is in the FCC and the mean of the Alternative-Three Models' total time a patient is in the clinic.

H1= A significant statistical difference exist between the mean of the Alternative-One Models' mean total time a patient is in the FCC and the mean of the Alternative-Three Models' total time a patient is in the clinic.

Level of Significance .05

		Alt-1
59.53	MEAN	72.35
59.05	MEDIAN	71.48
33.69	STD DEV	62.33
58.66	95% CI LOW	71.24
60.38	95% CI HIGH	73.47
18042	SAMPLE SIZE	36250

.05 SIG =Z=+ OR -1.96

Z-TEST

	Alt-1	Alt-3
SAMPLE SIZE	36250	18042
MEAN	72.35	59.53
STD DEV	62.33	33.69

TR= 31.11

Reject Ho

APPENDIX D-9

Comparison of Alternative-Four Models with FY99 Status Quo Models (wait times)

TIME PATIENT WAITS TO BE EXAMED	M/TH (Alt-4)	T/W/F (Alt-4)	Alternative-Four Models	FY99 FCC Status Quo Model (Base)	M/TH (Base)	T/W/F (Base)
MEAN	27.5	28.12	27.87	24.80	23.41	25.73
MEDIAN	26.68	27.3	27.05	22.80	21.91	23.39
MIN	0.65	0.68	0.68	1.3	1.93	1.3
MAX	198.55	251.98	251.98	370.4	241.1	370.4
STD DEV	32.98	41.88	41.88	61.52	39.86	61.52
95% CI LOW	26.53	27.23	26.95	23.47	22.24	24.29
95% CI HIGH	28.47	29.01	28.79	26.13	24.59	27.17
SAMPLE SIZE	14567	21683	36250	36231	14570	21661
TIME PATIENT IN CLINIC						
MEAN	71.2	72.16	71.77	80.59	78.72	81.84
MEDIAN	70.05	71.77	71.08	78.11	76.64	79.1
MIN	14.83	16.75	16.75	17.57	17.79	17.57
MAX	249.78	313.42	249.78	391.53	287.9	391.53
STD DEV	39.16	49.45	38.84	62.33	45.02	62.33
95% CI LOW	69.8	70.89	70.45	78.40	76.55	79.64
95% CI HIGH	72.61	73.44	73.11	82.77	80.9	84.03
SAMPLE SIZE	14567	21683	36250	36231	14570	21661

TIME PATIENT WAITS TO BE EXAMED

Ho= There is no significant statistical difference between the mean of the FY99 FCC Status Quo Models' total time a patient waits to see a PCP and the mean of the Alternative-four Models' total time a patient waits to see a PCP.

Level of Significance .05

H1= A significant statistical difference exist between the mean of the FY99 FCC Status Quo Models' total time a patient waits to see a PCP and the mean of the Alternative-Four Models' total time a patient waits to see a PCP.

		FY99 Base
27.87	MEAN	24.80
27.05	MEDIAN	22.80
41.88	STD DEV	61.52
26.95	95% CI LOW	23.47
28.79	95% CI HIGH	26
36250	SAMPLE SIZE	36231

.05 SIG =Z=+ OR -1.96 **Z-TEST**

	FY99 Base	Alt-4
SAMPLE SIZE	36231	36250
MEAN	24.80	27.87
STD DEV	61.52	41.88

TR= -7.86

Reject Ho

TIME PATIENT IN SYSTEM

Ho= There is no significant statistical difference between the mean of the FY99 FCC Status Quo Models' mean total time a patient is in the FCC and the mean of the Alterantive-Four Models' total time a patient is in the clinic.

Level of Significance .05

H1= A significant statistical difference exist between the mean of the FY99 Status Quo Models' mean total time a patient is in the FCC and the mean of the Alternative-Four Models' total time a patient is in the clinic.

		FY99 Base
71.77	MEAN	80.59
71.08	MEDIAN	78.11
38.84	STD DEV	62.33
70.45	95% CI LOW	78.40
73.11	95% CI HIGH	82.77
36250	SAMPLE SIZE	36231

.05 SIG =Z=+ OR -1.96 **Z-TEST**

	FY99 Base	FY00 (Alt-4)
SAMPLE SIZE	36231	36250
MEAN	80.59	71.77
STD DEV	62.33	38.84

TR= 22.84

Reject Ho

Comparison of Alternative-Four Models with Alternative-One Models (wait times)

TIME PATIENT WAITS TO BE EXAMED	M/TH (Alt-1)	T/W/F (Alt-4)	Alternative-Four Models	Alternative-One Models	M/TH (Alt-1)	T/W/F (Alt-1)
MEAN	27.5	28.12	27.87	19.28	19.01	19.46
MEDIAN	26.68	27.3	27.05	18.62	18.46	18.72
MIN	0.65	0.68	0.68	1.3	1.67	1.59
MAX	198.55	251.98	251.98	370.4	319.98	299.98
STD DEV	32.98	41.88	41.88	61.52	53.05	49.73
95% CI LOW	26.53	27.23	26.95	18.70	18.39	18.91
95% CI HIGH	28.47	29.01	28.79	19.86	19.63	20.02
SAMPLE SIZE	14567	21683	36250	36250	14567	21683
TIME PATIENT IN CLINIC						
MEAN	71.2	72.16	71.77	72.35	71.2	73.13
MEDIAN	70.05	71.77	71.08	71.48	70.15	72.38
MIN	14.83	16.75	16.75	17.57	17.62	15.95
MAX	249.78	313.42	249.78	391.53	334.2	324.42
STD DEV	39.16	49.45	38.84	62.33	52.76	51.41
95% CI LOW	69.8	70.89	70.45	71.24	69.97	72.09
95% CI HIGH	72.61	73.44	73.11	73.47	72.43	74.17
SAMPLE SIZE	14567	21683	36250	36250	14567	21683

TIME PATIENT WAITS TO BE EXAMED

Ho= There is no significant statistical difference between the mean of the Alterantive-One Models' total time a patient waits to see a PCP and the mean of the Alternative-Four Models' total time a patient waits to see a PCP.

Level of Significance .05

H1= A significant statistical difference exist between the mean of the Alternative-One Models' total time a patient waits to see a PCP and the mean of the Alternative-Four Models' total time a patient waits to see a PCP.

		Alt-1
27.87	MEAN	19.28
27.05	MEDIAN	18.62
41.88	STD DEV	61.52
26.95	95% CI LOW	18.70
28.79	95% CI HIGH	20
36250	SAMPLE SIZE	36250

.05 SIG =Z=+ OR -1.96 **Z-TEST**

	Alt-1	Alt-4
SAMPLE SIZE	36250	36250
MEAN	19.28	27.87
STD DEV	61.52	41.88

TR= -21.98

Reject Ho

TIME PATIENT IN SYSTEM

Ho= There is no significant statistical difference between the mean of the Alterantive-One Models' mean total time a patient is in the FCC and the mean of the Alternative-Four Models' total time a patient is in the clinic.

Level of Significance .05

H1= A significant statistical difference exist between the mean of the Alternaitve-One Models' mean total time a patient is in the FCC and the mean of the Alternative-Four Models' total time a patient is in the clinic.

		Alt-1
71.77	MEAN	72.35
71.08	MEDIAN	71.48
38.84	STD DEV	62.33
70.45	95% CI LOW	71.24
73.11	95% CI HIGH	73.47
36250	SAMPLE SIZE	36250

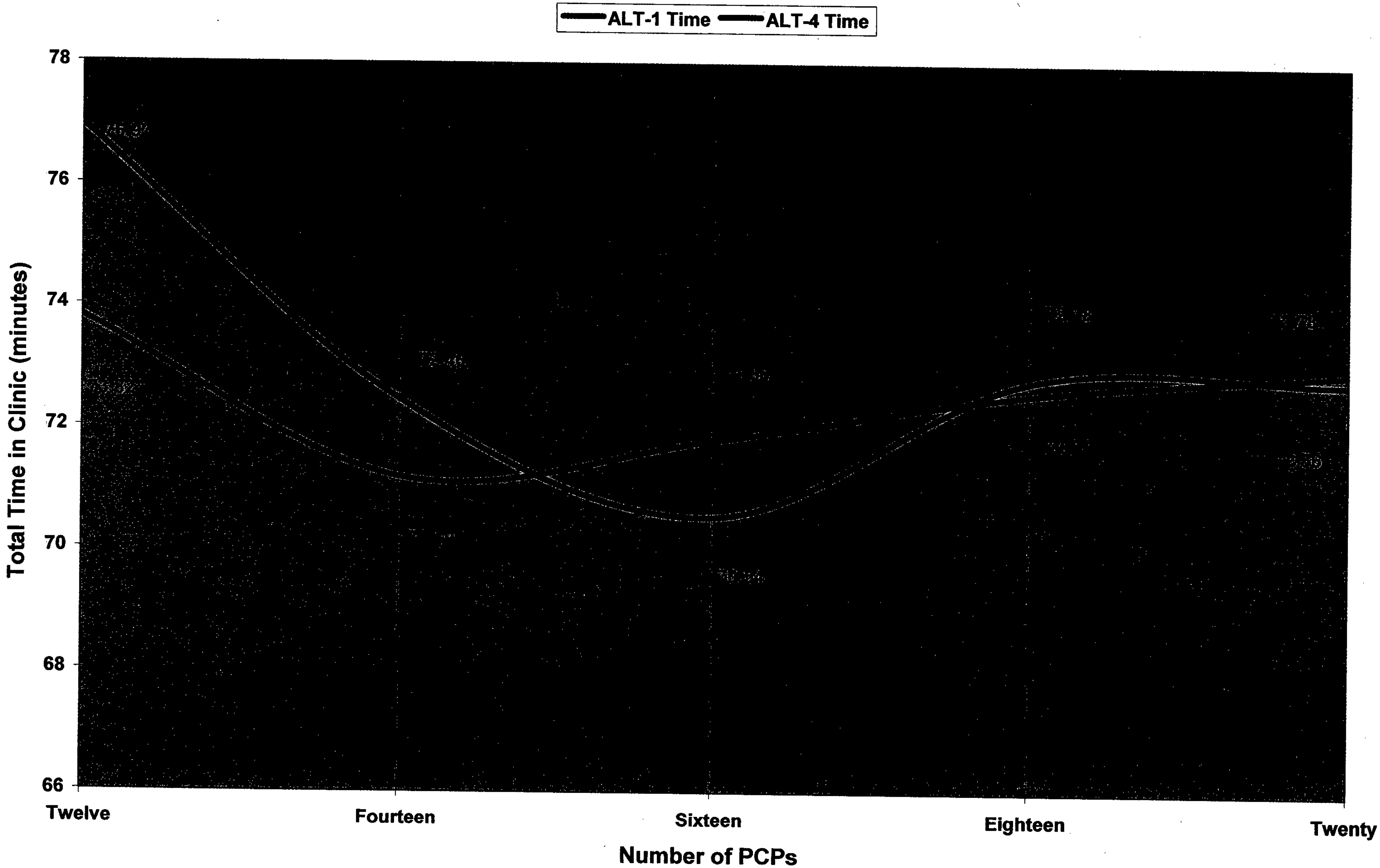
.05 SIG =Z=+ OR -1.96 **Z-TEST**

	Alt-1	Alt-4
SAMPLE SIZE	36250	36250
MEAN	72.35	71.77
STD DEV	62.33	38.84

TR= 1.50

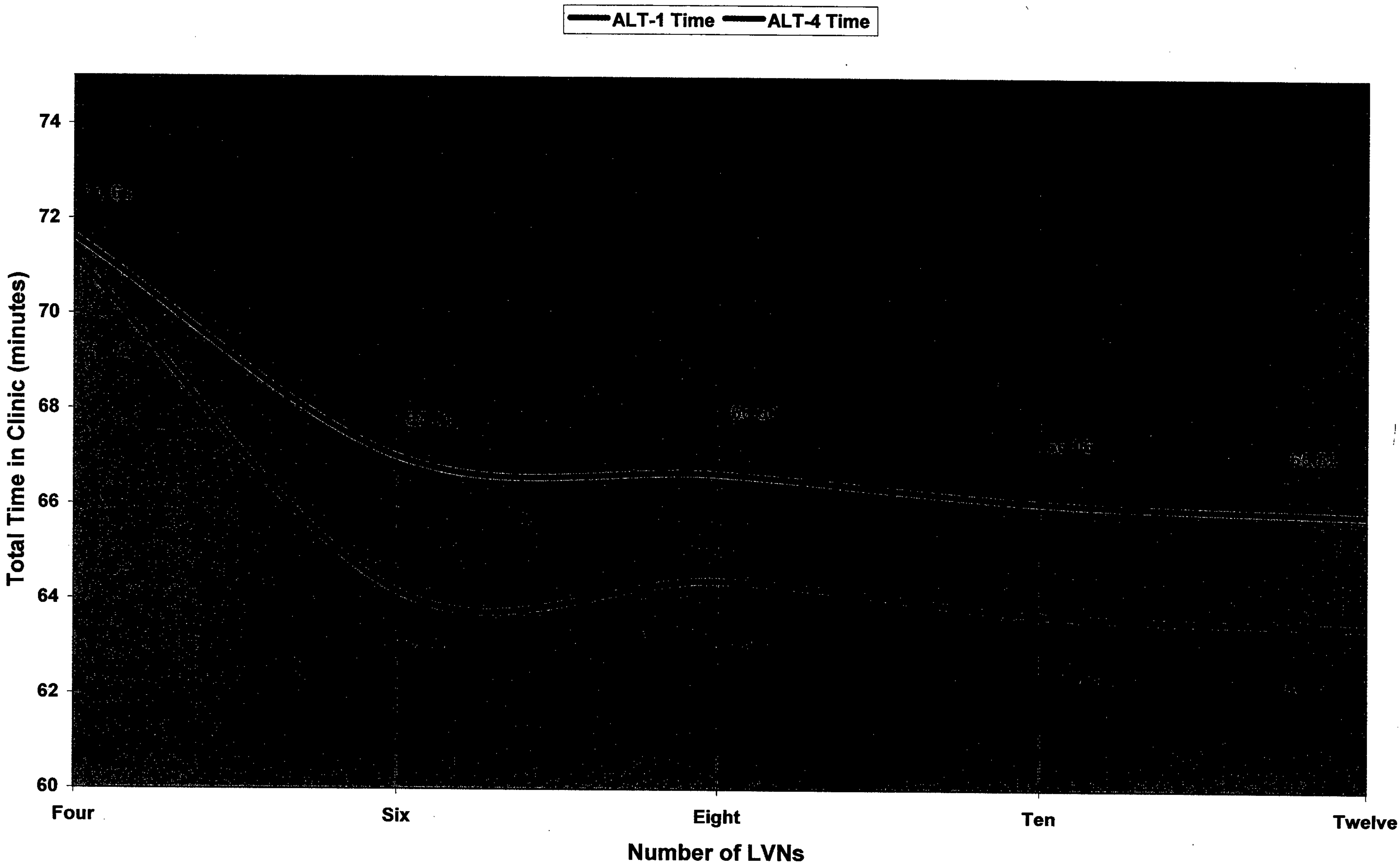
Fail to Reject Ho

Comparison of Alternative-One and Alternative-Four Models PCPs Effect on Total Time Patient is in the Clinic

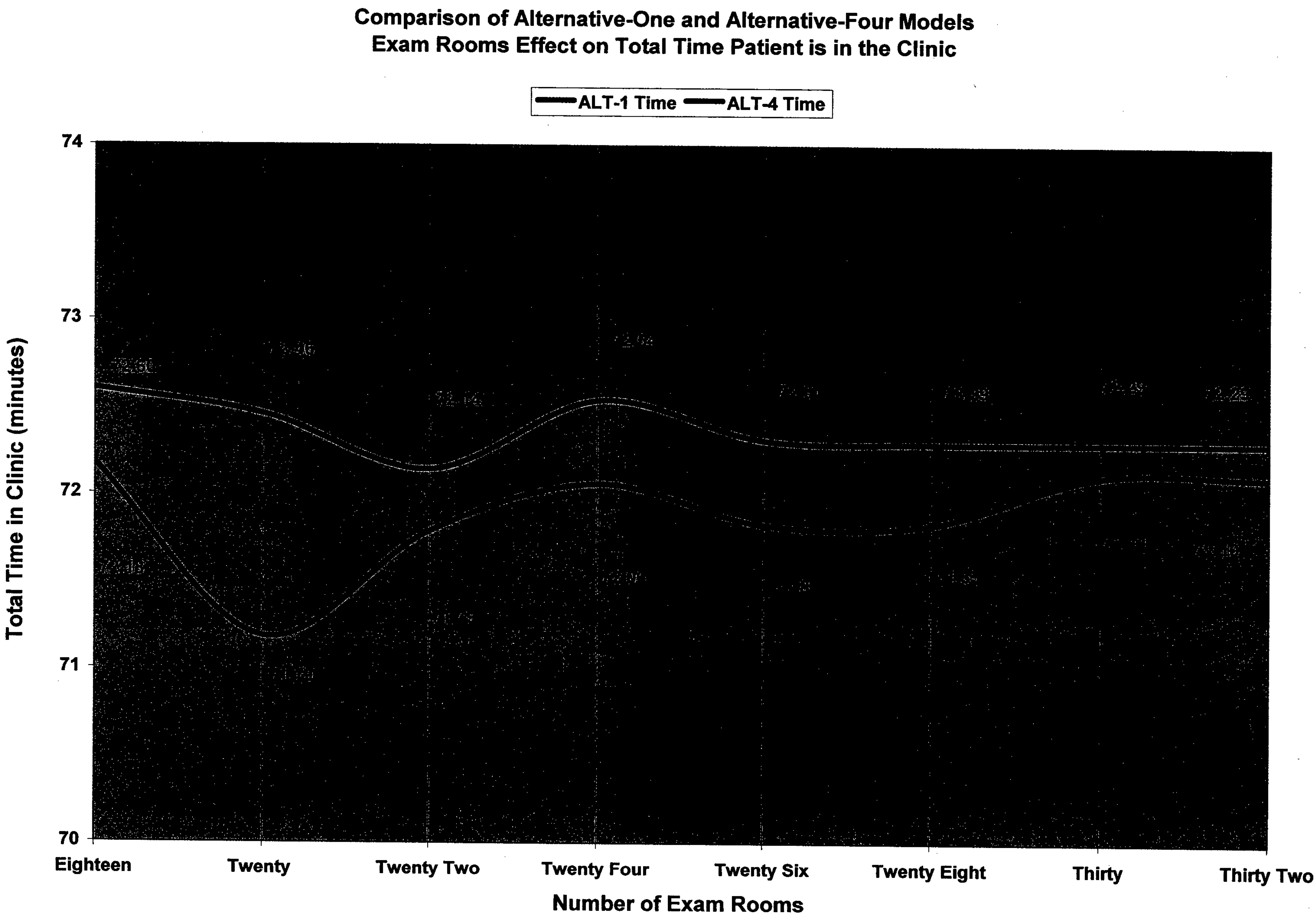


APPENDIX E-1

Comparison of Alternative-One and Alternative-Four Models
LVNs Effect on Total Time Patient is in the Clinic

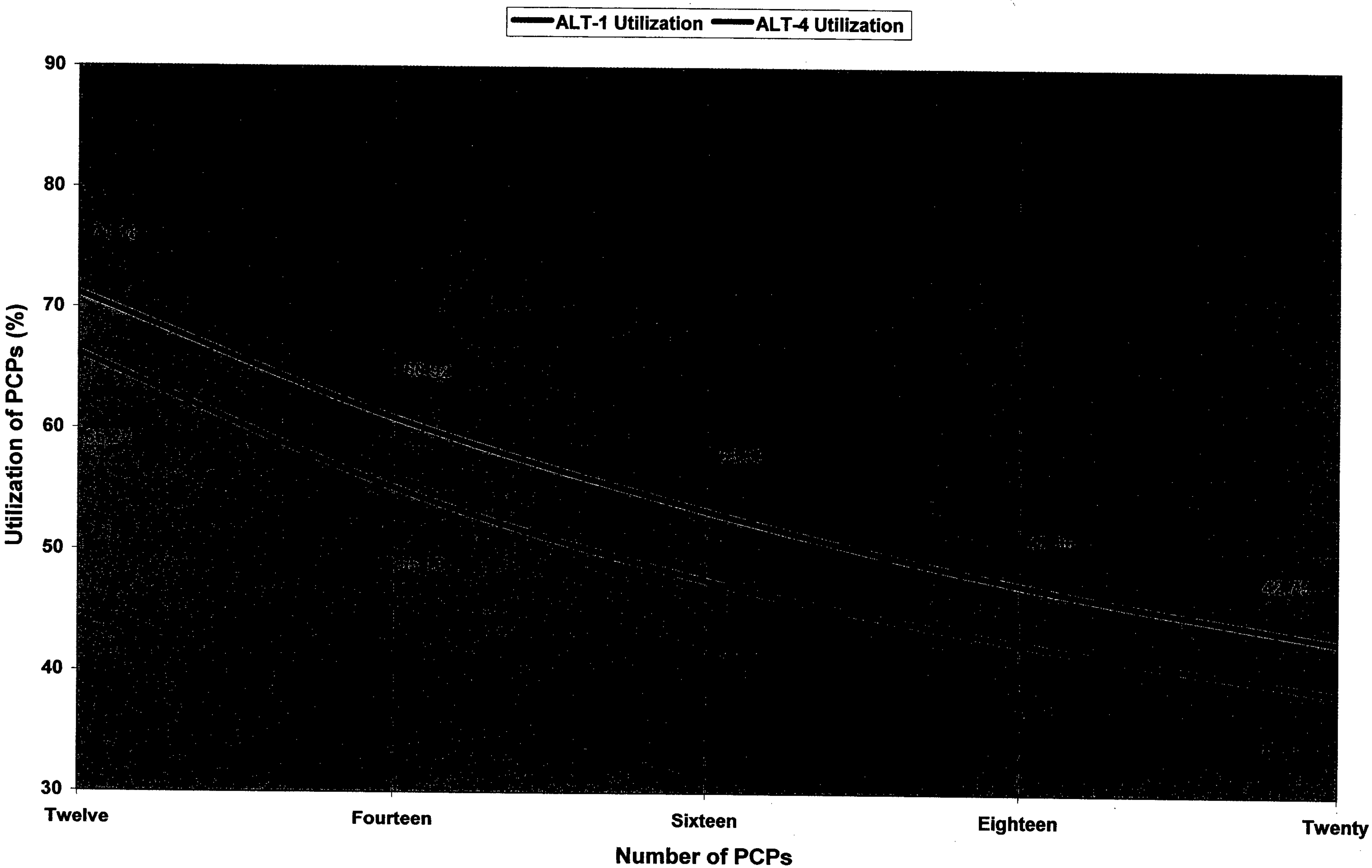


APPENDIX E-1

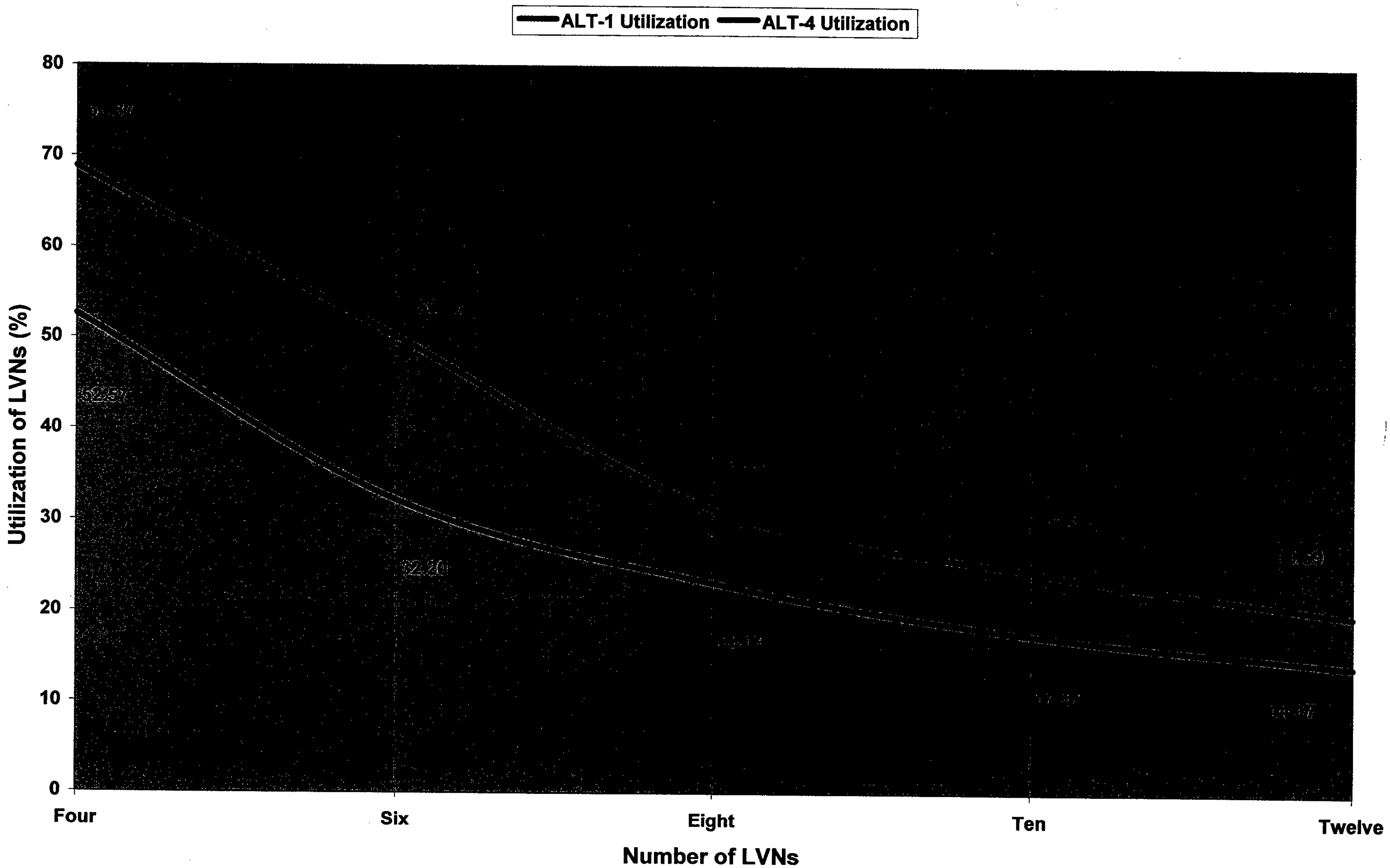

Comparison of Alternative-One and Alternative-Four Models
Exam Rooms Effect on Total Time Patient is in the Clinic
ALT-1 Time
ALT-4 Time
Total Time in Clinic (minutes)
74
73
72
71
70
Eighteen
Twenty
Twenty Two
Twenty Four
Twenty Six
Twenty Eight
Thirty
Thirty Two
Number of Exam Rooms

APPENDIX E-1

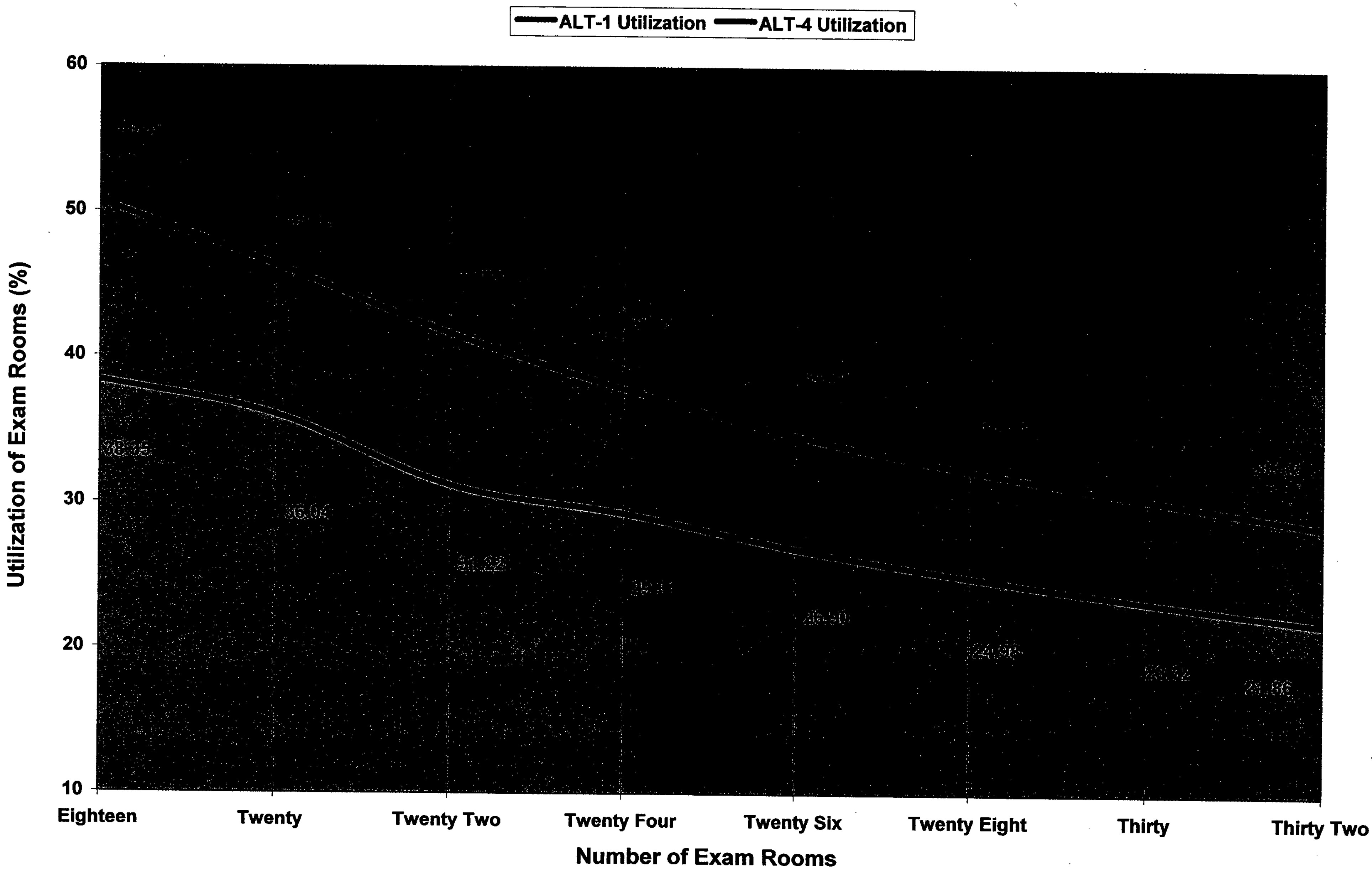
Comparison of Alternative-One and Alternative-Four Models
PCPs Effect on Utilization of PCPs



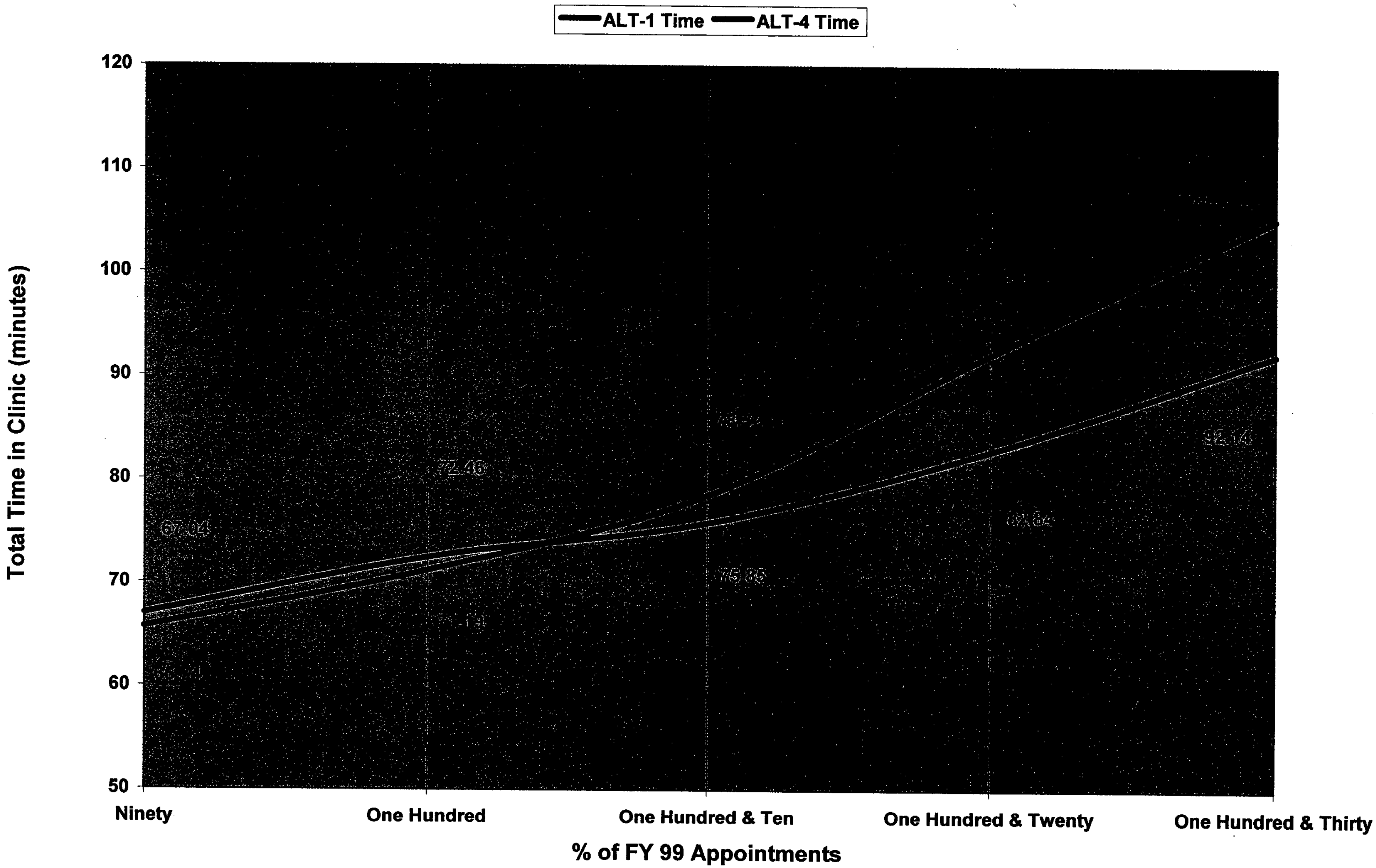
Comparison of Alternative-One and Alternative-Four Models
LVNs Effect on Utilization of PCPs



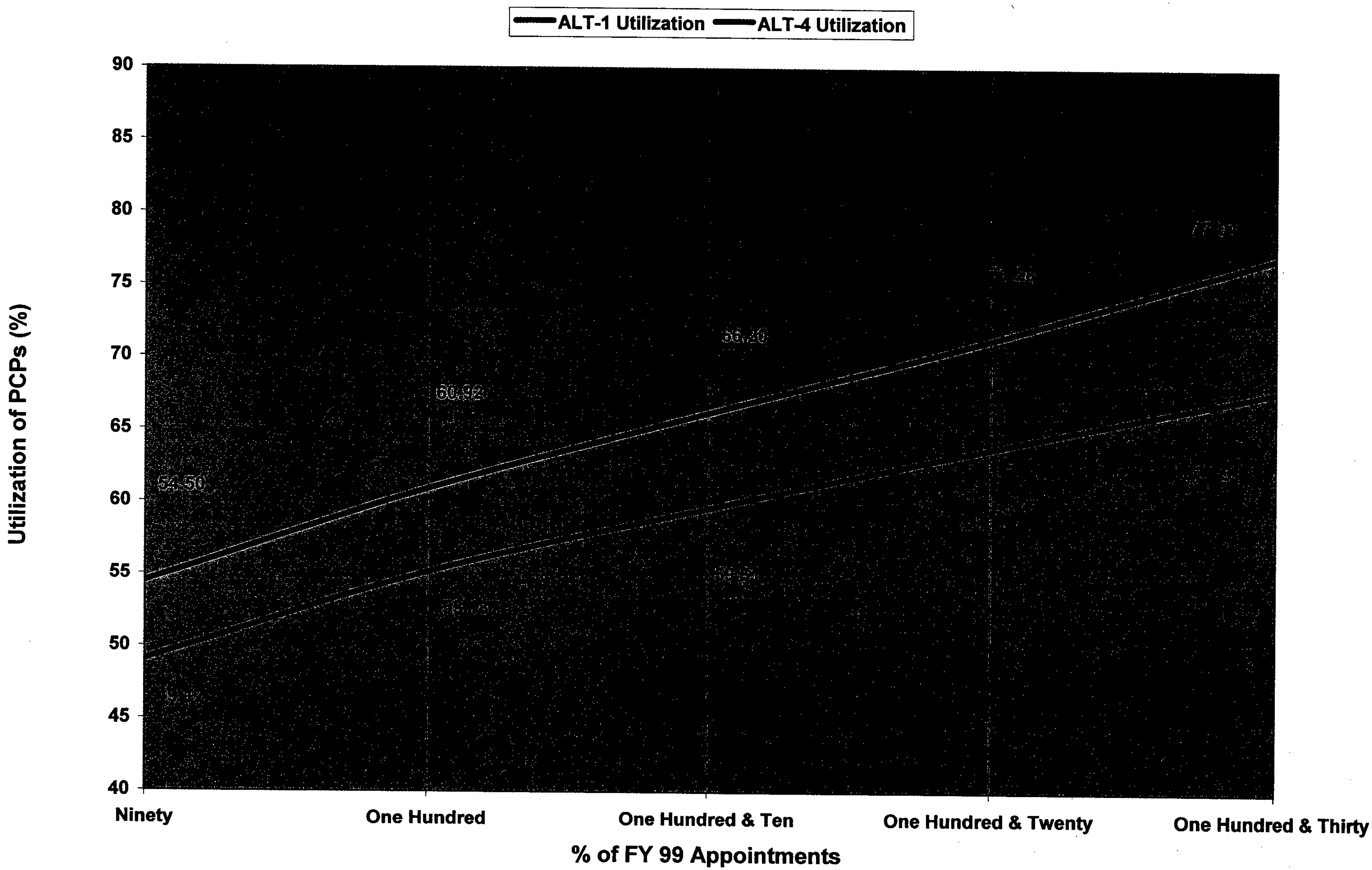
Comparison of Alternative-One and Alternative-Four Models
Exam Rooms Efect on Utilization of Exam Rooms



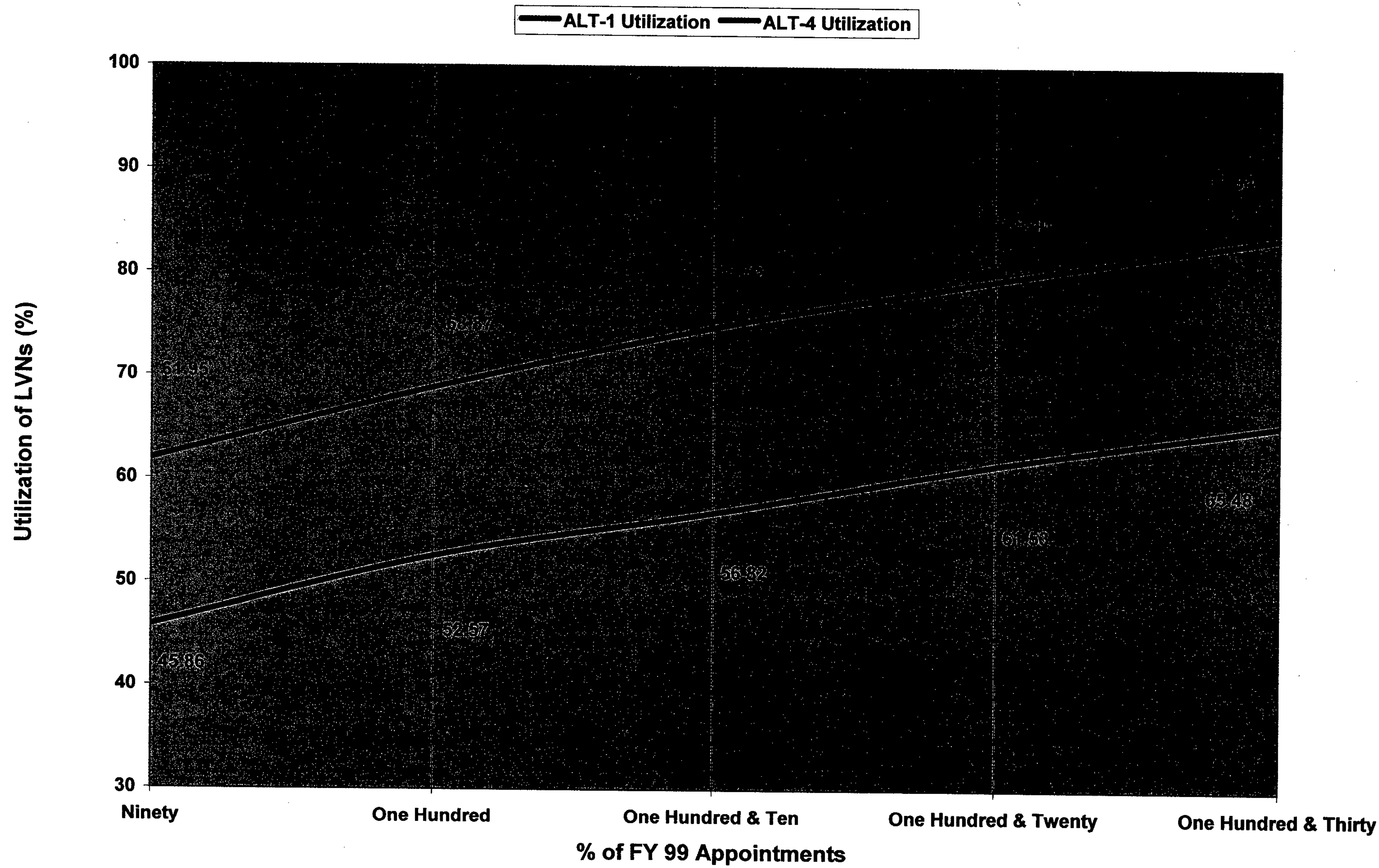
Comparison of Alternative-One and Alternative-Four Models
% of FY 99 Appointments Effect on Total Time Patient is in the Clinic



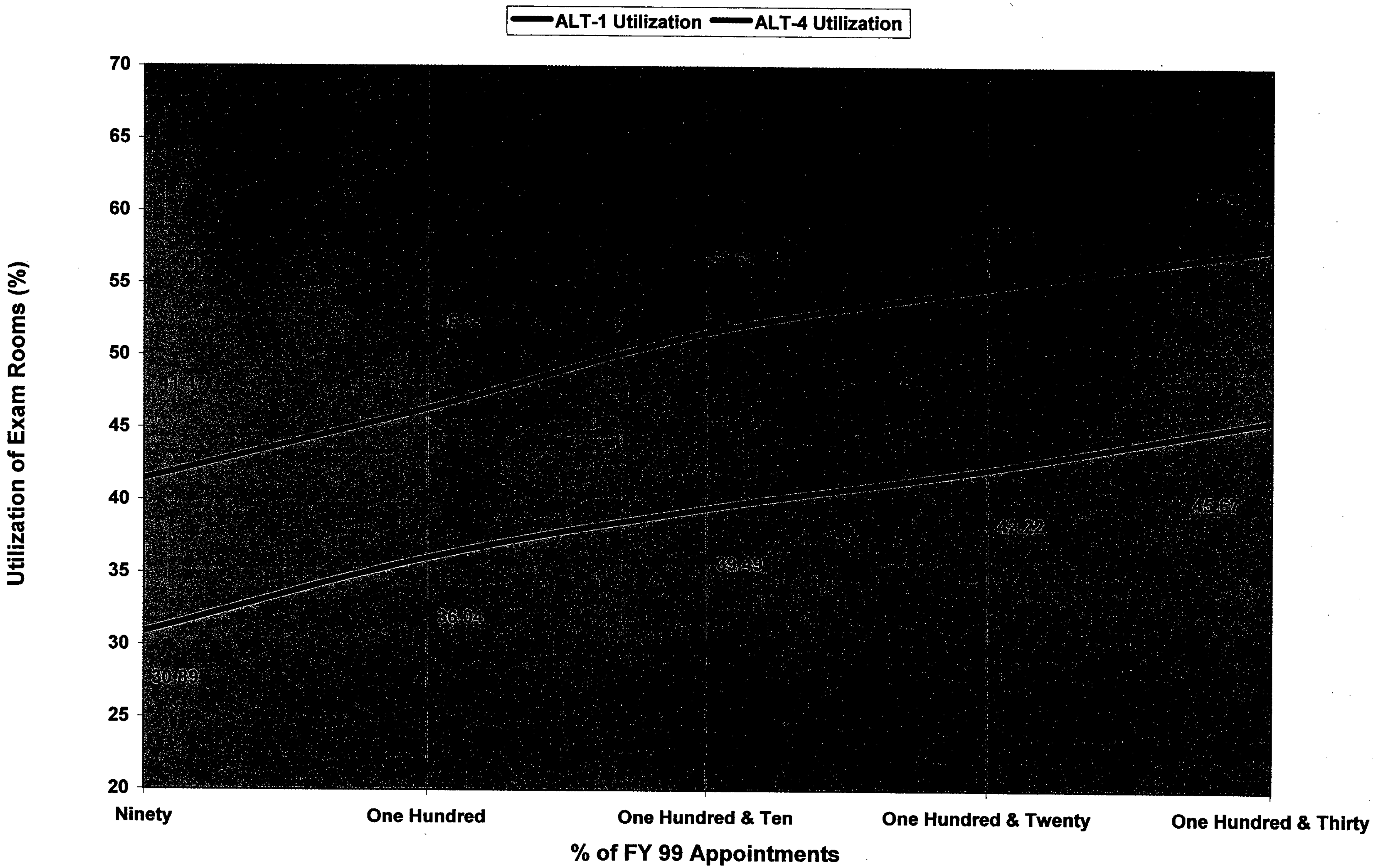
Comparison of Alternative-One and Alternative-Four Models
% of FY 99 Appointments Effect on Utilization of PCPs



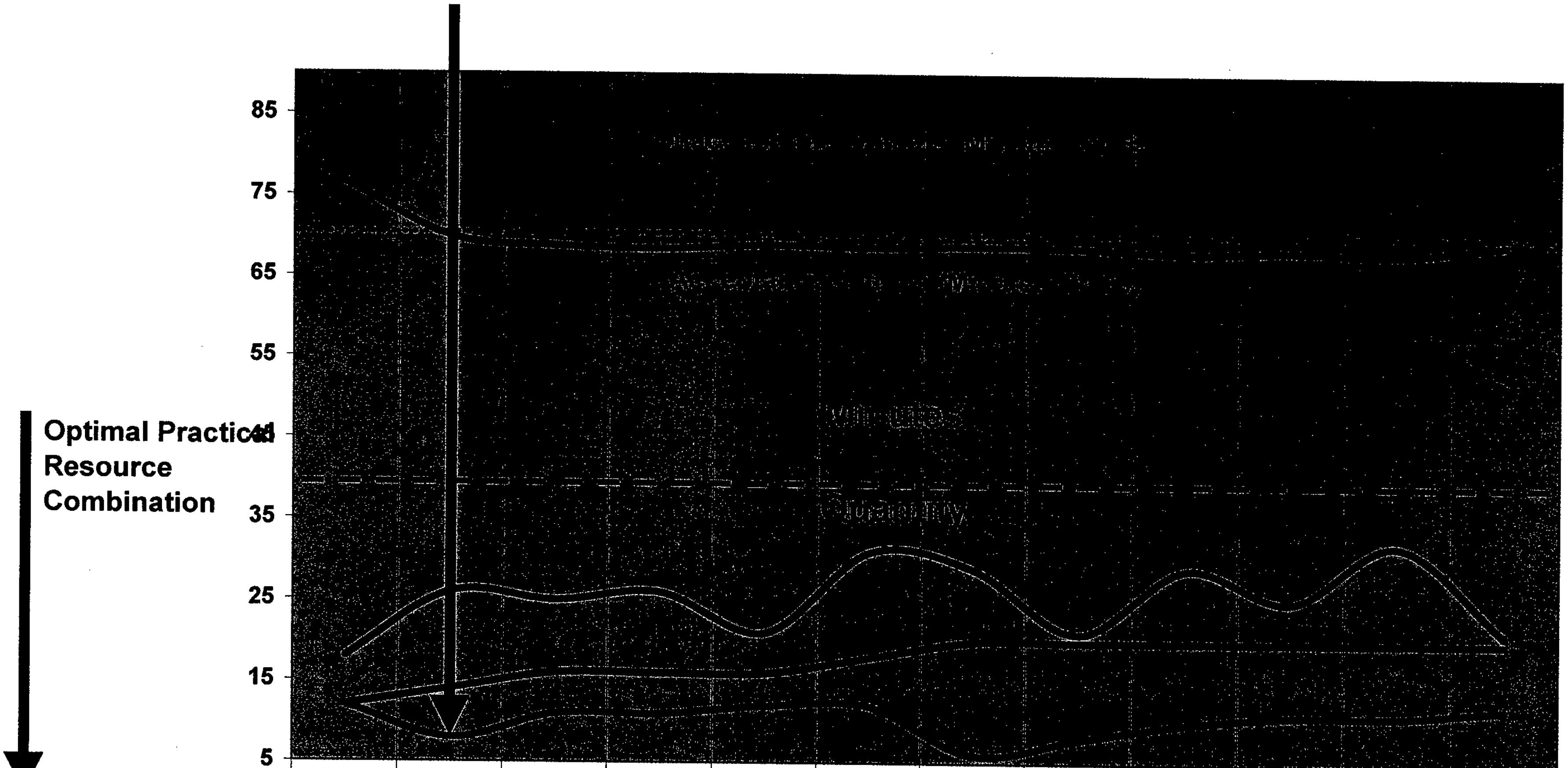
Comparison of Alternative-One and Alternative-Four Models
% of FY 99 Appointments Effect on Utilization of LVNs



Comparison of Alternative-One and Alternative-Four Models
% of FY 99 Appointments Effect on Utilization of Exam Rooms

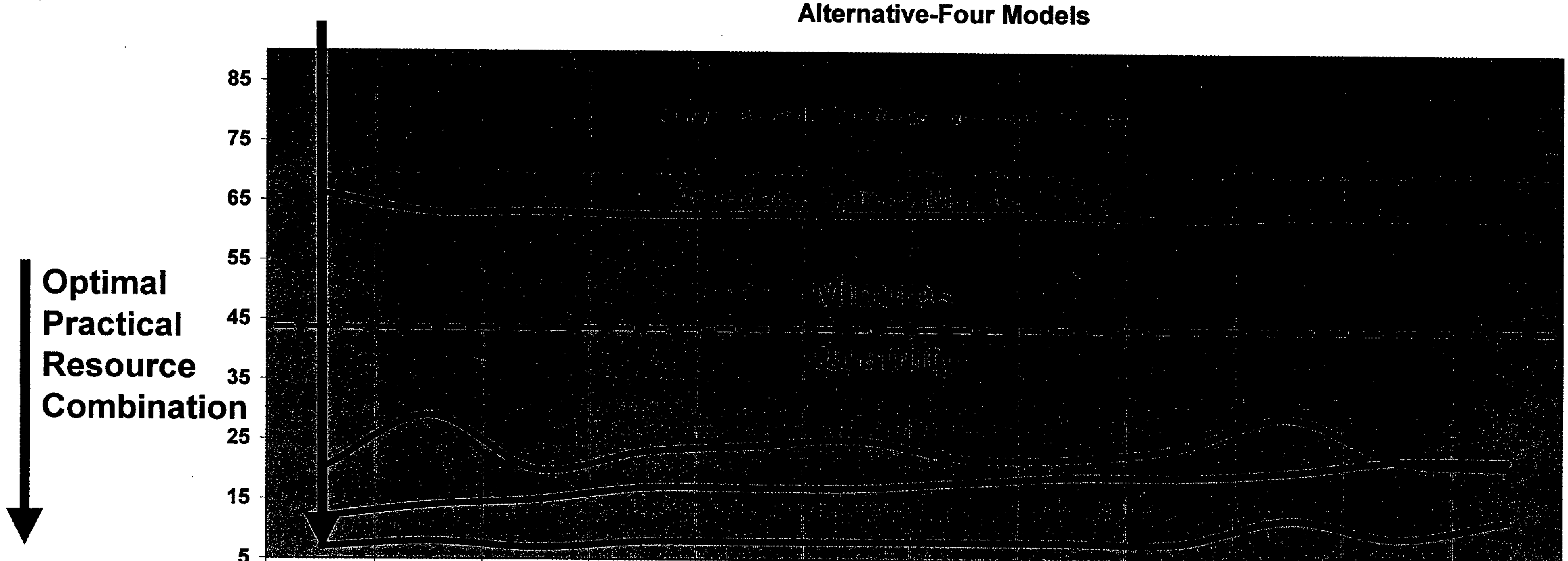


Optimal Combinations of Multiple Resources for 110% of FCC FY 99 Appointments with Alternative-One Models



	1	2	3	4	5	6	7	8	9	10	11	12
PCPs	12	14	16	16	16	18	20	20	20	20	20	20
LVNs	12	8	11	11	12	12	6	8	10	11	11	12
Exam Rooms	18	26	25	26	21	31	29	21	29	25	32	21
Total Time in Clinic	76.43	69.86	68.8	68.45	68.96	68.69	68.9	68.73	68.11	68.45	68.11	69.41

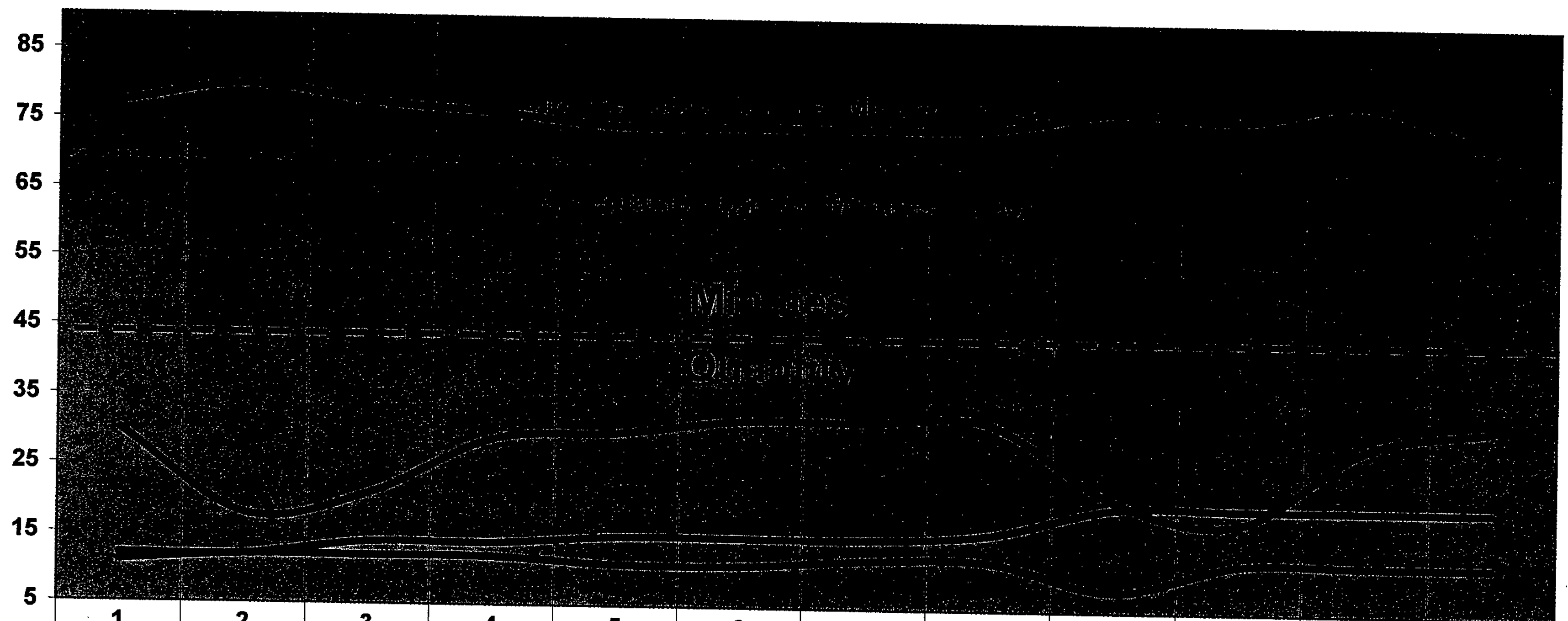
Optimal Combinations of Multiple Resources for 110% of FCC FY 99 Appointments with Alternative-Four Models



	1	2	3	4	5	6	7	8	9	10	11	12
PCPs	12	14	15	17	17	17	18	19	19	20	22	22
LVNs	7	8	7	8	8	8	8	8	8	12	9	12
Exam Rooms	20	29	20	23	24	25	22	22	24	29	22	21
Total Time in Clinic	66.27	63.17	63.25	62.74	62.88	62.79	62.94	62.83	62.24	62.87	62.87	62.87

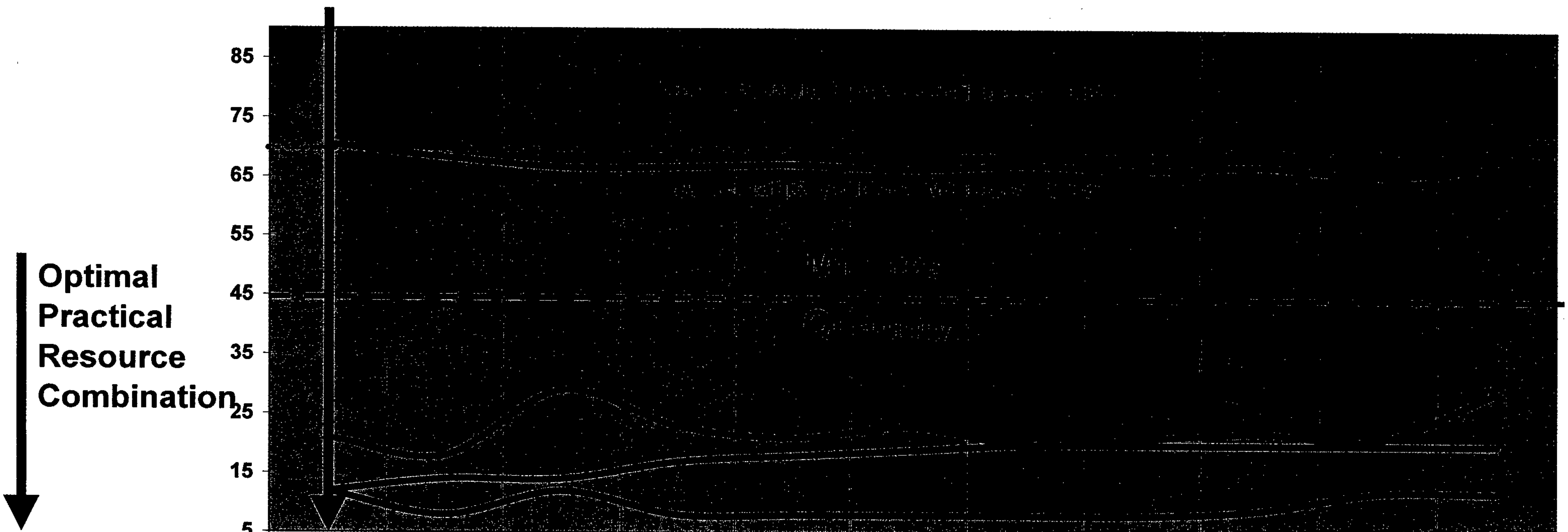
Optimal Combinations of Multiple Resources for 120% of FCC FY 99 Appointments with Alternative-One Models

No Acceptable Options
(Time<70.59)



	1	2	3	4	5	6	7	8	9	10	11	12
PCPs	12	12	14	14	15	15	15	16	20	20	20	20
LVNs	11	12	12	12	11	11	12	12	8	12	12	12
Exam Rooms	30	18	21	29	30	32	32	32	21	18	29	32
Total Time in Clinic	77.38	80	77.69	76.3	74.51	74.51	74.51	74.71	77.35	76.43	78.85	72.58

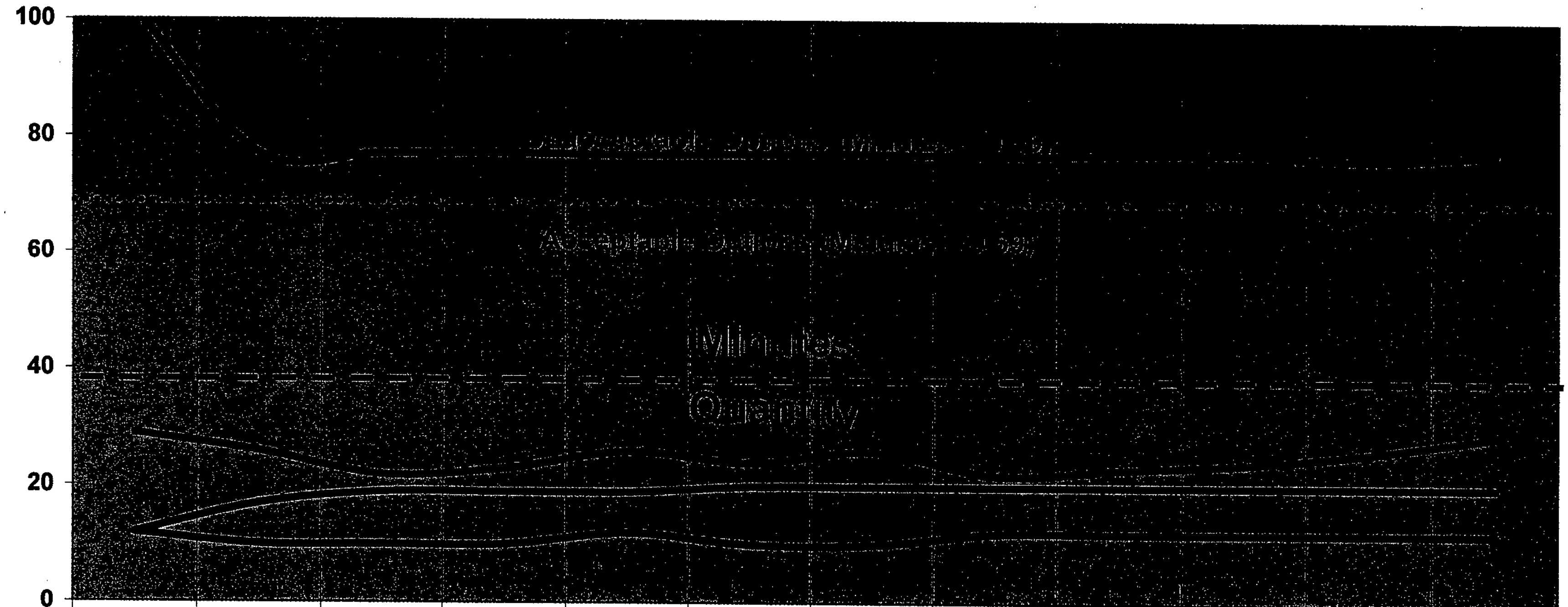
Optimal Combinations of Multiple Resources for 120% of FCC FY 99 Appointments with Alternative-Four Models



	1	2	3	4	5	6	7	8	9	10	11
PCPs	12	14	14	17	18	19	20	20	20	20	20
LVNs	12	8	12	8	8	8	8	8	9	12	12
Exam Rooms	21	18	29	23	21	23	20	21	22	21	29
Total Time in Clinic	70.52	68.34	66.63	66.7	67.13	66.41	67.17	66.41	67.06	65.56	67.08

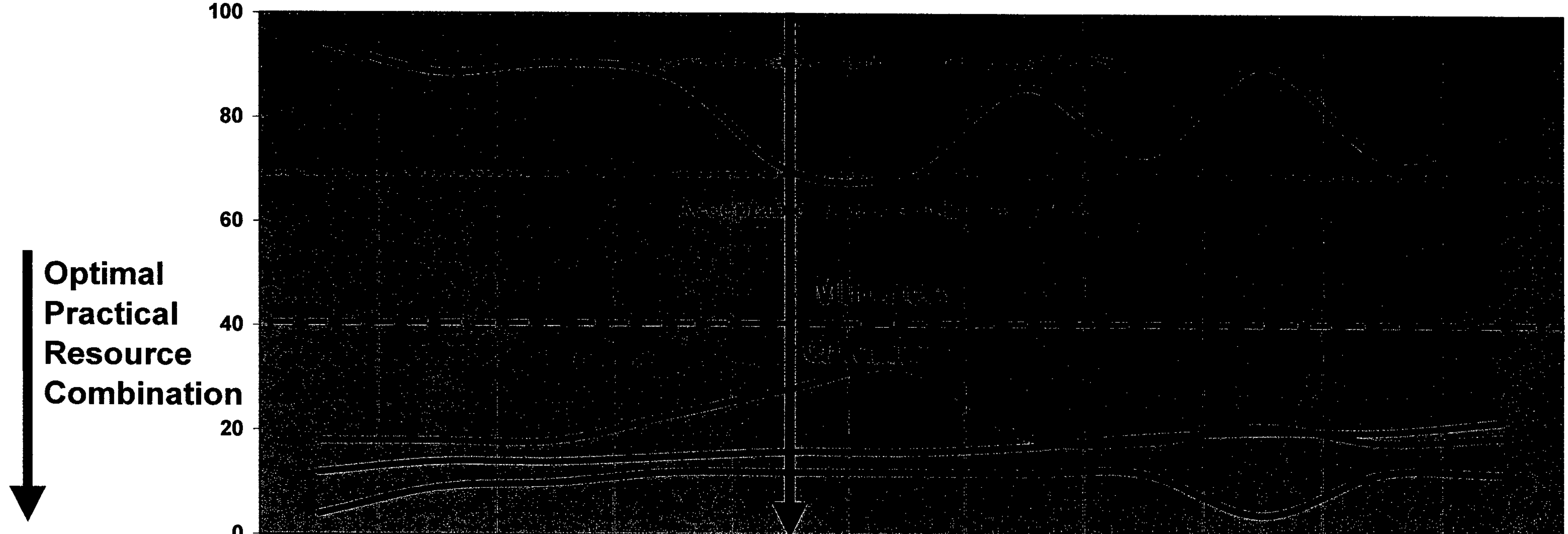
Optimal Combinations of Multiple Resources for 130% of FCC FY 99 Appointments with Alternative-One Models

No Acceptable Options
(Time<70.59)



	1	2	3	4	5	6	7	8	9	10	11	12
PCPs	12	17	19	19	19	20	20	20	20	20	20	20
LVNs	12	10	10	10	12	10	10	12	12	12	12	12
Exam Rooms	29	26	22	23	26	24	26	22	23	24	26	29
Total Time in Clinic	101.74	77.22	77.13	77.3	76.97	77.18	77.33	76.91	77.26	77.39	76.32	77.47

Optimal Combinations of Multiple Resources for 130% of FCC FY 99 Appointments with Alternative-Four Models



	1	2	3	4	5	6	7	8	9	10	11
PCPs	12	14	14	15	16	16	17	19	20	20	22
LVNs	4	9	10	12	12	12	12	12	4	12	12
Exam Rooms	18	18	18	23	28	32	19	18	21	18	19
Total Time in Clinic	94.58	88.8	90.44	87.51	69.79	69.79	85.94	73.21	90.11	72.91	77.09

References

Allen, P., Ballash, D., Kimball, G. (1997). Simulation Provides Suprising Staffing and Operation Improvements at Family Practice Clinics. Proceedings of the 1997 Annual HIMSS Conference. Vol. 4, 211-227.

Ammari, N., Abu Zahra N., Dreesch, N. (1991). Streamlining Clinic Management. World Health forum 1991; 12(9): 479-482.

Asefdeh, S. (1997). Patient flow Analysis in a Children's Clinic. International Journal of Quality Health Care Apr 9(2): 143-147.

Bateman, R., Bowden, R., Gogg, T., Harrel, C., Mott, J. (Ed.). (1997). System Improvement Using Simulation (5th ed.). Orem, Utah: ProModel® Corporation.

Bell, M., Warner J., Cameron A. (1985). Patient Flow Patterns in a Recovery room and Implications for Staffing. Journal of Sociological Medicine. 1985 Jan;78(1): 35-38.

Benneyan, J. (1997). An Introduction to Using Computer Simulation in Healthcare: Patient Wait Case Study. Journal of the Society for Health Systems, 5(3), 1-15.

Benneyan, J., Horowitz, M., Terceiro, M. (1994). Using Computer Simulation to Help Reduce Patient Waits. Proceedings of the 1994 Annual HIMSS Conference. Vol. 1, 323-342.

Benussi, G., Mathews, L., Daris, F., Crevatin, E., Nedoclan, G. (1990) Improving Patient flow in an Ambulatory Care through Computerized Evaluation Techniques. Rev Epidemiol Sante Publique 1990; 38(3): 221-226.

Blanck, R. R. LTG (1997, Feb). Surgeon General reaffirms commitment to quality healthcare for Army's people. Retrieved September 27, 1999 from the World Wide Web: http://dtic.mil:80/cgi-bin/multiga...;esn=FT%5fTEXT%20HTML%200;ct=text/html

Booz Allen & Hamilton (1998). AMEDD Maximally Fort Campbell Staffing Study. 25 March.

Cooper D., Schindler, P. (1998). Business Research Methods (6th ed.), Boston: Irwin-McGraw-Hill.

Daniel, W. (1983). Biostatistics: A Foundation for Analysis in the Health Services, United States: John Wiley & Sons, Inc.

Dawson, K., Ulgen, O., O'Conner, K., Sanchez, P. (1994). How to conduct a Successful Emergency Center Staffing Simulation Study. Proceedings of the 1994 Annual HIMSS Conference, 3, 273-289.

Ditch, D. (1997). Using Simulation as a Foundation for Mult-Objective BPR: Ambulatory Admitting. Proceedings of the 1994 Annual HIMSS Conference, 4, 81-94.

Department of Defense (Health Affairs) (1994). Policy guidelines for implementing managed care reforms in the military health system. 10 January.

Duray, P. (1998). Productivity Improvement through Computer Simulation: Analysis of Staff Utilization Prior to facility Occupation Unpublished master's graduate management project, U.S. Army-Baylor University Graduate Program in Health Care Administration, Fort Sam Houston, Texas

Fay, M. (1998). Simulation Models of three Ireland community Hospital Primary Care Clinics Unpublished master's graduate management project, U.S. Army-Baylor University Graduate Program in Health Care Administration, Fort Sam Houston, Texas.

Fulton, L. (1998). Strategic Analysis and Associated Management Products supporting the Reengineering of Bayne-Jones Army Community Hospital: Consultative Products and Findings Unpublished master's graduate management project, U.S. Army-Baylor University Graduate Program in Health Care Administration, Fort Sam Houston, Texas

Gapenski, L. (1996). Understanding Health Care Financial Management (2 ed.). Chicago: Health Administration Press/Association of University programs in Health Administration

Gogg, T., Mott J., (1993). Introduction to Simulation. Proceedings of the 1993 Winter simulation Conference, 9-17.

Hashimoto, F., Bell S. (1996). Improving Outpatient Staffing and Scheduling with Computer Simulation. Journal of General Medicine. Mar; 11(3): 1732-1743.

Kalton, A., Singh, M., August, D., Parin, C., Othman, E. (1997). Using Simulation to Improve the Operational Efficiency of a Multi-Disciplinary Clinic. Journal of the Society for Health Systems, 5 (3), 43-62.

Kongstvedt, P. (Ed.). (1997). Essentials of Managed Health Care (2nd ed.). Gatihersburg, Maryland: Aspen Publishers, Inc.

Ledlow, G. (1996). Animated Simulation: Optimal Family Practice Clinic Staffing and Process Configuration DTIC AD A324-224.

Ledlow, G., Bradshaw, D. (1999). Animated Simulation: A valuable Decision Support Tool for Practice Improvement. Journal of Healthcare Management, 44 (2), 91-101.

Levy, J., Watford, B., & Owen, V. (1989). Simulation Analysis of an Outpatient Services Facility. Journal of the Society for Health Systems, 1 (2), 35-49.

Lowery, J., Martin, J. (1992). Design and Validation of a Critical care Simulation Model. Journal of the Society for Health Systems, 3 (3), 15-36.

Mahachek, A. (1992). An Introduction to Patient Flow Simulation for Health Care Managers. Journal of the Society for Health Systems, 3 (3), 73-81.

Newhouse, J. (1993). Free for All? Lessons from RAND Health Insurance Experiment Group. Cambridge: Harvard University Press.

Noyes, H., Harben, J. (Ed.). (Spring 1998). The Mercury. Fort Sam Houston, Texas: Public Affairs Office, HQ MEDCOM .

ProModel® Corporation. (1998a). MedModel® Course 1 Training Workbook. Utah.

ProModel® Corporation. (1998b). SimRunner2!® Plus Statistical Advantage: Simulation Analysis and Optimization Software, User's Guide: ProModel® Software. Utah.

ProModel® Corporation. (1998c). User's Guide version 4.1: MedModel® Healthcare Simulation Software. Utah.

Reese, T. (1994). Development of a Computer Simulation Model for a Community Hospital Emergency Department DTIC AD A292-899.

Sanders, D. (1995). Statistics: A First Course (5th Ed.) McGraw-Hill. Boston.

White, R., (1996). The Role of Primary Care. In R. H. Rubin, C. Voss, D. J. Derksen, A. Gately & R. Quenzer (Eds.), Medicine a Primary Care Approach (pp. 1-4). Philadelphia: W. B. Saunders Company.