Computer Simulation of a U.S. Army Prosthodontic Service

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Abstract

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Introduction

During the past 10 to 15 years, significant social and political forces have forced the U.S. Army Dental Care System (ADCS) to undergo tremendous changes in terms of management philosophy and organizational structure. The "rightsizing" of the U.S. military establishment, decreased numbers of dental school graduates, increased competition for qualified dental professionals among civilian and government employers, and the focus on cost, quality, and access in the health care industry are some of the major causes for the recent changes in the ADCS. The end result is an organization that has sought new ways to maximize quality and cost efficiency in an environment of decreasing resources.

With the fall of the "Iron Curtain" and the subsequent disintegration of a major military threat, the U.S. government has reduced significantly the size of its military forces. In turn, the Military Health System (MHS) has reduced accordingly, as has the ADCS. In 1984, the ADCS had 1743 active duty dental officers. By June of 1997, the ADCS's personnel strength had dropped to 1084 dental officers (M.J. Carino, personal communication, October 7, 1997).

The reduced staffing and funding within the armed services initiated a significant change in philosophy for the ADCS, in which the focus of Army dentistry shifted from treating active duty and other than active duty patients to treating active duty personnel only. In place of space-available care at Army facilities, Congress passed a bill that authorized a government subsidized dental insurance program, the TRICARE Family Member Dental Plan, for family members of active duty service members. Congress also recently passed a bill that authorized a non-government subsidized dental insurance program for retirees and their family members. The exclusion of other than active duty patients created a more limited patient pool and dental practice experience for Army dentists, by eliminating pediatric dentistry and geriatric dentistry cases.

Since 1985, the ADCS has experienced a significant decline in the recruitment and retention of dental officers. In 1996, the ADCS achieved only 45% of its accession goal, and retained 40% fewer retirement eligible officers than in 1988 (M.J. Carino, personal communication, October 7, 1997). The decline can be attributed to the decrease in dental school enrollment, the brighter economic prospects in the civilian sector versus the military setting, and the resistance to joining, or remaining, with an organization that is drawing down in size. Although the overall reduction in the Army's requirements for dental officers mitigated the effects of a dental officer shortage, the ADCS experienced an increasingly critical shortage of general dentists, forcing other specialists to provide general dentistry support and creating longer waiting periods for specialty care.

One specialty area which has seen significant manpower reductions is prosthodontics. The inventory of prosthodontists in the U.S. Army has steadily decreased over the past 15 years from 164 to 97. The ADCS reduced the number of prosthodontic training programs from four to one, and the number of residents trained per year from eight to three.

Another significant factor affecting the ADCS has been the increasing emphasis (Department of Defense (DoD) wide) on the readiness of the force, specifically, dental readiness. The Department of Defense monitors the dental readiness of the armed forces through a dental classification system, which categorizes individuals on a scale of 1 to 4. Class 1 individuals have no dental disease. Class 2 individuals have some dental problems, which will not cause a dental emergency within the next twelve months. Class 3 individuals have dental conditions that will likely result in a dental emergency within the next twelve months. Individuals whose dental condition is unknown are considered Class 4. The Office of the Assistant Secretary of Defense for Health Affairs (ASD(HA)) recently changed the percent requirement for all service members to be in dental classification 1 or 2, from 90% to 95%. The emphasis to get soldiers into dental class 1 or 2 has resulted in a perceived decreased quality of practice which emphasizes primarily annual exams and limited restorative procedures associated with Class 3 conditions (L. Rouse, personal communication, May 20, 1996).

Conditions Which Prompted the Study

Constrained budgets and increased competition have forced healthcare organizations, the ADC System included, to evaluate their present business practices and strive to become more efficient. During the early 1990s, the Army Medical Department began using Total Quality Management practices and Business Process Reengineering to improve the cost and quality of, and access to Army Medicine. In the fall of 1996, the senior leaders of the ADCS established a process action team to address the issue of providing quality care and maintaining dental readiness in an environment of shrinking resources. The senior leaders of the ADCS directed the team to evaluate the current business processes within the ADCS, identify areas for improvement, and develop an overall business process reengineering plan. The process action team, also known as the "HIT Team", conducted detailed evaluations of clinic business practices, visited comparable civilian dental clinics (e.g. Salem-Winston clinic), and consulted with several professional practice management organizations. The HIT Team determined that although the ADCS provides quality dental care, "practice patterns…remain inconsistent and inefficient at a time when the civilian delivery system is advancing clinically and administratively." (Lambert, Nasser, & Wineman, 1997)

The HIT Team consolidated its observations and findings and developed the Dental Care Reengineering Initiative (DCRI). Lambert et al. (1997) stated that the objective of the DCRI is to "improve business practices and clinical efficiencies in the Army Dental Care System." The goals of the DCRI are to: (1) surpass the DoD standard of 95% Class 1 and 2; (2) establish a benchmark for oral health wellness as measured by the ratio of Class 1s per 1000 servicemembers in the population; 3) be the provider of choice for the population served as measured by satisfaction surveys; (4) improve the quality and scope of practice and work environment of the workforce as measured by worker satisfaction surveys; and (5) demonstrate long term cost effectiveness by reducing dependency on contract dental support, eliminating excess capacity, and meeting stated goals at capitiation rates equal to, or below, the Dental Command average. (Lambert et al., 1997)

To accomplish this, the DCRI proposes utilizing treatment teams based on the dental health care delivery model that is widely used in the private sector. The DCRI evolved from the ADCS's "Concept and Feasibility Plan for the Implementation of a Team Dental Health Care Delivery Model" and it was approved by the ADCS Board of Directors in February 1997. The DCRI concept was approved by The Surgeon General of the Army in March 1997 and by the ASD (HA) in April 1997.

Beta testing of the DCRI concept began at five CONUS installations in August 1997: Fort Stewart, Fort Bragg, Fort Campbell, Fort Bliss, and Fort Hood (Lambert, Nasser, & Wineman, 1997). Within each clinic, dental treatment teams were formed, consisting of one dentist, the equivalent of three dental assistants, a dental hygienist, and a treatment coordinator. Each team was responsible for the dental care of a panel of 1200 to 1500 patients. A recent, unpublished paper used simulation to validate the design and composition of the dental treatment team (Gebhart, Grimes, and Wong, (1997).

Because the team organization is geared primarily towards the general dentistry practice, the DCRI identified a need to determine the appropriate team composition for other dental specialties, e.g. prosthodontics. The results of this investigator's study, and parallel studies, will be used to develop a comprehensive dental clinic model, which could then be used to answer questions concerning staffing requirements and maximum patient load capacities for entire units.

Problem Statement

The ADCS is currently evaluating and reengineering its clinical practices in order to improve clinical efficiencies, maintain a high standard of dental care, and ensure dental officers have a professionally diverse and rewarding dental practice. Recent focus has been aimed at identifying and validating the optimal dentist:assistant staffing ratios for ADCS general dentistry teams. A study is needed to evaluate the existing dental:assistant staffing ratios and practice configurations of the ADCS prosthodontic services.

Literature Review

Dental staffing.

During the 1960s, the dental community became increasingly interested in improving dental practice productivity. Concern over the potential nation-wide shortage of dentists stimulated investigations, which used time motion studies to investigate dental operations. Prior to the 1960s, dentistry was predominately a "stand up" profession, dentists treated patients while standing, with minimal support staff. Klein (1944) initially reported the benefits of using dental assistants to improve productivity and reduce work related stress. A subsequent study demonstrated the positive effects of seated operators (dentist and assistant) using four-handed dentistry techniques and the delegation of duties (e.g. passing instruments, changing burs, arranging/adjusting dental equipment, preparing dental filling materials, making preliminary impressions, and placing rubber dams) (Kilpatrick, 1971). Later studies conducted in the 1970s advocated the use of expanded-function dental assistants (also called dental therapy assistants) in improving dental practice productivity (Abramowitz, & Berg, 1973; Pelton, Embry, Overstreet, & Dilworty, 1973). In addition to the duties performed by traditional dental assistants, expanded function dental assistants could also select and place matrix bands, place and contour permanent filling materials, and place temporary fillings (Redig, Snyder, Nevitt, & Tocchini, 1974).

The majority of the early studies regarding dental auxiliary-to-dentist ratios dealt primarily with the use of expanded function dental assistants. However, one study by Kilpatrick (1971) examined the effects of varying dental assistant-to-dentist ratios on productivity and found one and two dental assistants will improve productivity by 15% and 29%, respectively. Waterman's (1969) and Arnold's (1969) studies reported dental assistants can decrease working times by as much as 68% - 70% (as cited in Kilpatrick, 1971). Marizi (1973) and Feldstein (1969), in studies conducted at the macro level, determined that practice productivity would increase with additional dental assistants (as cited in Lipscomb & Scheffler, 1975). Boulier's (1974) study estimated an optimal assistant-to-dentist ratio of 1.5:1 (as cited in Lipscomb & Schefler, 1975). Ganssle (1995) reported several advantages to having assistant-to-dentist ratios of greater than 1:1.

In order to maximize the use of available dental assistant support, dentists also require multiple dental treatment rooms. King, Brunner, and Mangelsdorf (1982) surveyed 147 U.S. Army dental clinics and determined that dentist productivity was significantly higher when dentists used multiple treatment rooms. In 1978, Parker determined that dental officers using two operatories were more productive when they were supported by two dental assistants.

While review of the literature reveals many articles on the subject of dentist to dental assistant ratios, the issue of determining the ideal provider to assistant ratio for a prosthodontic practice/service is not addressed well. In 1972, Hickey and Boucher identified the need to evaluate the scope of duties, which could be performed by expanded duty dental assistants in prosthodontics. The authors proposed several duties, however, did not provide suggestions for staffing ratios.

Simulation.

According to Law and Kelton (1991), "Simulation is one of the most widely used techniques in operations research and management science…". Companies within the manufacturing industry used computer simulation as a means of evaluating alternative methods of production without the financial risk of actually investing exorbitant amounts of time, money, and manpower in full scale testing of each alternative method. Simulation allows an organization to test and analyze numerous "What if?" scenarios, without the risk and expense of actual on-site testing. Other advantages of computer simulation are that it: (1) costs less than actual implementation and testing of each alternative; (2) causes less disruption of the current operations; (3) leads to greater focus on, and increased understanding of, the current processes; (4) is a more timely method (accelerate time) of evaluating the effects of a multitude of variables; (5) has an enhanced ability to incorporate process variability in the simulation and outcomes analysis, (6) has a greater ability to test an almost unlimited number of variations/combinations of variables; and (7) gives observers the ability to visualize the application of alternative processes. (Alessandra, A.J., Grazman, T.E., Parameswaran, R., &

Yavas, Y., 1978; Benneyan, J.C., Horowitz, M.L., & Terriceiro, M.B., 1994; Kalton, A.G., Singh, M.R., August, D.A., Parin, C.M., & Othman, E.J., 1997; and Law, A.M., & Kelton, W.D., 1991). In addition, simulation can assist organizations avoid "unanticipated process barriers and glitches during and actual pilot (program) …(which) can hurt process change acceptance in the minds of internal customers and cause less than optimal service quality perception in the eyes of the external customers." (Cirillo and Wise, 1996) Potential problems with using computer simulation are that it: (1) requires substantial amounts of time, cost, and effort to develop an accurate model; and (2) requires computer hardware with a capacity large enough to process huge loads of data. (Benneyan et al., 1994)

The introduction of diagnostic related groups, the prospective payment system, and managed care have all had an impact on the operation of health care organizations and facilities. Forced to focus on the "bottomline", health care managers became more prudent, which affected their decisions regarding manpower, facilities, and organizational structure. As efficiency and cost savings became significant influencing forces, and as the health care industry became more focused on Total Quality Improvement and process reengineering, health care organizations needed a tool that would allow them to accurately evaluate alternative means of providing health care. Simulation is that tool.

However, the simulation process must be carefully conducted, and investigators must recognize its limitations (Figure 1). "The science of simulation is a learned art, and there is no substitute for both knowledge and experience." (Benneyan et al., 1994) There are several reasons why simulation can fail: [Banks & Carson, 1989 (as cited in Benneyan, 1997); Branson & Krall (1997); Keller, Harrell, & Levy, 1991; Law & Kelton, 1991; and Law & McComas, 1989].

- organizational resistance to change;
- incomplete understanding of simulation;
- insufficient understanding of statistical concepts, experimental design ;
- unclear problem statement and objective;
- insufficient involvement of the decision-makers in the process;
- incomplete understanding of the process being studied;
- not capturing appropriate process dependencies and relationships;
- inappropriate level of detail;
- inaccurately recording randomness;
- inaccurate/incomplete data collection;
- inadequate development of probability distributions;
- misuse of animation;
- improper/lack of model verification and validation.

The literature is replete with examples of how computer simulation modeling can be used to evaluate and solve various management issues within the health care industry. General uses of simulation include research, education and training, decision-making, and planning. Investigators have used simulation to determine hospital bed capacities, outpatient clinic scheduling, facility planning, equipment purchasing, manpower staffing and utilization, emergency services planning, and community health policy planning.

Kalton et al. (1997) used simulation modeling to evaluate the operation of a breast care center, identify problem areas, and recommend corrective actions. In 1994, Benneyan et al. modeled the Harvard Community Health Plan's pediatric health center, in an effort to identify ways to reduce patient wait times. Simulation was used in conjunction with Total Quality

Management procedures and principles, specifically, evaluating and analyzing the impact of proposed process changes. Ditch and Hendershott (1997) used simulation to validate alternative practices developed by a business process reengineering effort at a Fallon Healthcare facility. In 1996, Huebner and Miller described the use of simulation to analyze and validate business process reengineering proposals at an outpatient clinic. Levy, Watford, and Owen (1989) used simulation in determining the facility design requirements for a planned outpatient services center. Standridge and Delcher, (1978) developed a simulation model for use in planning future health care policies for the State of Indiana. In 1992, Dankbar, Shellum, and Bennet used simulation models to compare and evaluate the effectiveness of laboratory equipment made by different companies. Wilt and Goddin (1989) modeled a proposed outpatient diagnostic center and determined optimal staffing levels and patient flow processes. Allen et al., (1997) used simulation to determine optimal staffing levels, room configurations, and patient scheduling policies for a planned family practice clinic.

This investigator located only two manuscripts, both unpublished, which discussed the use of simulation in dental manpower studies. Gebhart, Grimes, and Wong (1997) used simulation to study various dentist to assistant staffing ratios, and determined the optimal configuration for a general dentistry team to be one dentist to three assistants. Clouse, Schmidt, and Sarthou (1997) created a dental clinic model and compared staff utilization with and without a central sterilization room.

<u>Purpose</u>

The purpose of this project is to determine the optimal dentist to assistant staffing ratio, process configuration, and dental room configuration for a typical prosthodontic service in the ADCS. The impact on productivity and patient wait times will be evaluated using different combinations of assistants and dental treatment rooms assigned to a prosthodontist. Some process alternatives involve the use of assistants with expanded capabilities. The enabling objectives are:

- To determine the performance capability of the current prosthdontic clinical practices (Baseline Prosthodontic Model).
- To develop alternative prosthodontic staffing ratios.
- To determine alternative process and dental treatment room (DTR) configurations.
- To compare current and proposed staffing ratios and DTR configurations. Identify the optimal alternatives based on productivity, wait times, and cost.

Models Simulated

Three models were simulated, two of which, incorporated characteristics of a DCRI general dentistry practice and recommendations from surveyed prosthodontists. The Baseline Prosthodontic Model reflects the current prosthodontic service staffing (two DTRs and one dental assistant) and process configuration. The Additional Assistant Model simulates the current prosthodontic service with an additional DTR and one additional assistant. The Expanded Function Model takes the Baseline Prosthodontic Model and incorporates an additional expanded function dental assistant and an extra DTR.

Hypotheses

Ho: There is no significant difference between the Baseline Prosthodontic Model and empirical data.

Ha: There is a significant difference between the Baseline Prosthodontic Model and empirical data.

Ho: There is no significant difference (patients treated) between the Baseline Prosthodontic Model and Additional Assistant Model (additional chair, assistant, and part-time sterilization assistant).

Ha: There is a significant difference (patients treated) between the Baseline Prosthodontic Model and Additional Assistant Model (additional chair, assistant, and part-time sterilization assistant).

Ho: There is no significant difference (patients treated) between the Baseline Prosthodontic Model and Expanded Functions Model (additional chair, assistant, and part-time sterilization assistant, and process modifications).

Ha: There is a significant difference (patients treated) between the Baseline Prosthodontic Model and Expanded Functions Model (additional chair, assistant, and part-time sterilization assistant, and process modifications).

Materials and Methods

Modeling Software

This investigator chose to model a prosthodontic service located at the Schofield Barracks Dental Clinic, Schofield Barracks, Hawaii, because the clinic is similar to the ones being used as DCRI beta sites, and it is representative of the more modern clinics in the ADCS. The student version of MedModel 3.5 Healthcare Simulation software was used to develop and evaluate the different models. MedModel 3.5 Healthcare Simulation software has the benefits of animation and a built-in statistical analysis program. The student version is limited to 20 locations, 5 entity types, 5 resource types, 5 attributes, 10 RTI parameters, 0 input files, 0 prompt statements, and 0 external subroutines. The advantages of stochastic, discrete-event computer simulation modeling over analytical modeling include: (1) the ability to model complex systems;

and (2) the ability to incorporate and analyze real-world variance. Figure 1 outlines the general steps in conducting a simulation study.

Model Development

One of the initial steps was to develop a realistic alternative process configuration, specifically, what duties could be delegated to dental assistants and expanded function dental assistants. One-hundred and four surveys were sent to prosthodontists, and their assistants, within the ADCS (Appendix B). The surveys asked respondents to list those duties which could be feasibly delegated to dental assistants, assuming the organization could provide the appropriate training.

Description of the Prosthodontic Service

The majority of the ADCS's prosthodontic services contain one to two prosthodontists, each assigned one dental assistant. Currently, the role of the typical dental assistant is limited to dental operatory preparation, patient preparation, chairside assisting duties, and general administrative duties. There are a few dental assistants, who, through additional training, inherent skill, and self-motivation, assume extra responsibility to make preliminary impressions, recement provisional restorations, and make provisional restorations. The majority of specialists, to include prosthodontists, generally maintain their own appointment books.

Prosthodontic patients fall into two broad categories of treatment, fixed prosthodontics and removable prosthodontics, each having a different set of treatment processes. Patients requiring fixed prosthodontic care will have, on average, three to four appointments per treatment: preliminary appointment, centric jaw relation record appointment, preparation appointment, and insertion/cementation appointment. Patients requiring removable prosthodontic care usually average five appointments per treatment: evaluation appointment, final impression appointment, framework/baseplate try-in and centric jaw record appointment, wax try-in appointment, and insertion appointment. Several of the treatment processes can be delegated to auxiliaries, depending on the skill, past training, and motivation of the individual.

The majority of prosthodontic patients have scheduled appointments, while a small number of patients walk-in with an acute dental emergency. Patients arrive prior to their scheduled appointment time, check in at the front desk, and wait in the reception area until the dentist is ready to see them. The dental assistant prepares the DTR, escorts the patient from the waiting area to the DTR, seats the patient in the dental chair, prepares the patient for treatment, and notifies the dentist that the patient is ready. The dentist goes to the DTR, performs the scheduled procedure(s), and fills out the record. The dental assistant cleans and dismisses the patient, and prepares the DTR for the next patient. (Figure 2)

Survey Responses

Out of the 104 surveys sent, 60 surveys were completed, and returned. Of the 60 respondents, their mean years of dental experience and mean years of prosthodontic experience were 17.9 and 8.7, respectively. Just over 58% of the respondents were board certified. Over 88% of the respondents used only one dental assistant, while 44.3% used just one DTR. In response to the question about the ideal assistant to prosthodontist ratio, 28.3% of the prosthodontists recommended a one-to-one ratio, while 50% recommended a two-to-one ratio. Almost 77% of the respondents recommended two DTRs per prosthodontist.

The majority of respondents allow their assistants to assist with tooth shade selection, clean the DTRs, and take vital signs. Under the proper conditions, the majority of respondents would allow their assistants to assist with tooth shade selection, make provisional restorations, cement provisional restorations, remove provisional restorations, clean and polish prepared teeth, make diagnostic impressions, make impression trays, take vital signs, and clean the DTR. Several respondents would like to have their assistants make entries in dental treatment records.

Models

Based on the survey results, this investigator developed an alternative prosthodontic model that delegated to the assistant, the following duties: (1) making provisional restorations; (2) cementing provisional restorations; (3) taking vital signs and verifying the medical history; (4) making diagnostic impressions; (5) cleaning and polishing prepared teeth for RPDs; and (6) cleaning the operatory. Out of the six major categories of appointments (i.e. fixed prosthodontic procedures, removable partial denture procedures, complete denture procedures, implants, temporomandibular disorders, and other), only fixed and removable partial denture procedures were amenable to significant delegation of duties. In addition, these two categories made up the majority of procedures in a prosthodontic practice (69.3%). On the basis of these two observations, this investigator opted to develop three new process configurations, fixed procedures, removable partial denture procedures (tooth preparation), and prosthodontic examinations. The resulting alternative process configurations for both fixed and removable partial denture procedures releases the prosthodontist after the impression/try-in stage, allowing the assistant to complete the procedure and freeing the prosthodontist to conduct other activities. The third alternative process configuration, examinations, delegates the diagnostic impression procedures to the assistant. (Figure 3)

The resulting three models were: (1) the Baseline Prosthodontic Model, which consisted of one assistant and two DTRs; (2) the Additional Assistant Model, which added an additional DTR, assistant, and part-time sterilization assistant; and (3) the Expanded Function Model, which included the extra resources added to the AAM and incorporated the new process modifications.

Data collection

This investigator collected data from three full-time prosthodontists stationed in the Honolulu, Hawaii area. All three prosthodontists were board-eligible and in the process of attaining board certification. An orientation briefing was provided to both the prosthodontists and their assistants, describing the purpose of the study, and the importance of their roles as data collectors. Data collection sheets and instructions were provided to the participants (Appendix C).

The three prosthodontic teams manually collected empirical data for one month, recording patient interarrival (time measured from the arrival of one patient and the arrival of the next patient) and wait times, elapsed times for the different procedures, and patient dismissal times. Patient treatment data was also collected, however, patient identification information was excluded. The data was processed using the Stat::Fit program, which produced treatment time distributions for all categories of patients.

The model, process configuration, and process improvement were developed closely with representatives of the prosthodontic services. Using techniques recommended by previous studies, the model was verified by comparing empirical data with data generated by the model (Dawson, K.A., Ulgen, O.M., O'Conner, K., and Sanchez, P.A., 1994; Lowery, J.C. and Martin, J.B.). The face validity of the model was confirmed by two ADCS board-certified prosthodontists, who together had 30 years of clinical experience.

The model was run for 250 cycles, representing a year's worth of full-time clinical practice. To identify the maximum capacity of each model, the arrival rates were increased for each run. The start and end times for each run were 0730 hours and 1630 hours, respectively. The results were compiled and the following performance measures (outputs) were evaluated: patient waiting time, total time in clinic, number of fixed prosthodontic patients treated, number of removable prosthodontic patients treated, number of examination patients treated, dentist utilization rates, dental assistant utilization rate. Through the use of SPSS 7.0 for Windows, the statistical significance of the results was determined by an analysis of variance (ANOVA) test. The significance level was set at $p \leq 0.05$. The Bonferroni pairwise multiple comparison test was used to determine differences between experimental means.

Assumptions

- The collected data are accurate and representative of a typical ADCS prosthodontic service.
- All prosthodontists and assistants work at equivalent rates.
- Expanded function assistants provide comparable care, in terms of quality and quantity, as dentists.
- Additional staffing requirements will be filled.
- Additional DTRs will be available.
- Two hundred and fifty repetitions represent one year's operation.

Results

This investigator evaluated the results to compare patient wait times, productivity, and staff utilization between the different models. Waiting room times and total times in the clinic measured the patient wait times for the models. The total number of patients treated reflected the productivity of the models, while the percent utilization of dentists and assistants measured the staff utilization rates of the models.

Table 1 provides the descriptive statistics for the three prosthodontic models. As expected, the BPM performed poorly in comparison to the other two models. Except for the number of exam patients treated and the dental assistant utilization percentage, the BPM ranked third compared to the AAM and the EFM. By adding extra assistants and DTRS, and by incorporating modifications into the treatment process, this investigator realized significant improvements in the experimental models (i.e. the AAM and the EFM) with regard to patient wait times, productivity and cost effectiveness. The results from the ANOVA (Table 2) indicate the differences in mean values between the groups were statistically significant ($p \leq 0.05$). Tables 3 through 11 show the results of the Bonferroni pairwise multiple comparison test, which revealed what pairs of results had mean differences that were statistically significant.

The addition of extra assistants and DTRs to the BPM significantly improved patient waiting room times for the AAM and the EFM, on the order of 21 to 2 1/2 times, respectively. Total times in the clinic improved with the additional resources and especially with the process modifications included in the EFM. Interestingly, the AAM performed better than the EFM in the area of patient waiting room times and total time in clinic for exam patients, however the mean differences were not statistically significant (Tables 3 & 6).

The number of appointed patients were increased for all three models to determine the model's maximum production capacity. The EFM demonstrated significantly improved production capacity, compared to the other two models. The differences were especially evident for fixed patients, in which the EFM out performed the other two models by a 1.9 to 2.0 increase. With regards to patients requiring removable prosthodontic treatment, the AAM and EFM produced results that were not significantly different. Surprisingly, the AAM ranked third in the total number of exam patients treated.

The AAM produced the highest prosthodontist utilization rate (95.17%), followed by the EFM (83.49%) and the BPM (79.86%). Conversely, the BPM produced the highest dental assistant utilization rate (97.52%), followed by the EFM (62.24%) and the AAM (52.64%). All results regarding resource utilization rates were statistically significant (Tables 10 and 11).

Discussion

Overall, the results of this study conform to the investigator's expectations with regard to observing improvements in the areas of patient wait times, productivity, and staff utilization for the AAM and the EFM. Intuitively, one would expect to see decreased patient wait times and increased productivity, while maintaining acceptable staff utilization rates, as additional resources are added to the BPM, and as treatment processes become more efficient. However, the results do not show a direct correlation between modifications and the observed improvements (i.e., the AAM did not rank second in all areas, and the EFM did not rank first in all categories).

Compared to the BPM, the AAM and EFM had significantly lower patient waiting room times, with the AAM having slightly lower values. The additional resources were identical for the AAM and EFM models, however, the process modifications in the EFM created slightly longer waiting rooms. One reason for the slightly longer EFM waiting room times is the fact that dental assistants were tasked to spend more time in direct patient care and were not readily available to escort patients from the waiting room to the DTR. Another explanation is that the process modifications in the EFM enabled more patients to be seated simultaneously as they were being treated by both prosthodontists and dental assistants, thereby blocking additional patients from being seated. The important finding was that the patients in the AAM and the EFM spent less time in the clinic waiting for treatment and being treated, which can make a positive impact on overall customer satisfaction.

The increase in productivity (number of patients seem) is largely attributed to the additional resources given to, and the process modifications made to, the basic prosthodontic practice. The greatest improvements occurred with patients requiring fixed prosthodontic treatment, which can be attributed to the fact that more fixed treatment practices are amenable to delegation to dental assistants. These results correlate well with the results from the practice survey, in which the respondents were more apt to delegate fixed procedures than other prosthodontic procedures. Previous studies on the effects of adding expanded function dental assistants to general dentistry practices indicated a 15% to 62% improvement in terms of patients seen per day, depending on the actual number of additional resources used (Pelton et al., 1973; and Redig et al., 1974). These results are comparable with this study's finding of a 9% to 45% increase in patients seen, for the AAM and EFM, respectively.

The prosthodontist utilization results from the EFM and the BPM met realistic expectations for utilization rates prosthodontists, while dental assistant utilization rates were high in the BPM, and relatively low for the other two models. From a theoretical business management perspective, one would prefer 100% utilization of all resources, however, in actual operations, this goal is unrealistic and undesirable. A 100% utilization rate would place undue stress and fatigue on personnel, create excessive patient wait times as patients wait for the next available resource, and render resources incapable of effectively reacting to inherent variation in daily functions. Currently, there are no standards for prosthodontist or dental assistant utilization rates. In Templin's study of emergency rooms, the investigator determined the target staff utilization rate to be in the 70% to 80% range (as cited in Dawson et al., 1994). Twenty to thirty percent of non-direct patient care time would allow resources to conduct required administrative duties, complete dental laboratory procedures, and take requisite morning and afternoon breaks.

Clearly, the use of the sterilization assistant contributed to the performance improvements seen in the AAM and the EFM. By taking care of sterilization duties and infection control responsibilities, the sterilization assistant allowed the chair-side dental assistant to concentrate on, and perform more direct patient care duties. The result was decreased patient treatment times and increased productivity. Conversely, the use of sterilization assistants reduced the observed utilization rates for chair-side dental assistants.

In order for a prosthodontic service to employ the EFM, practice managers will have to modify current scheduling practices. Jameson (1996) describes a method for scheduling that can improve productivity, reduce stress, and minimize chaotic patient flow during the work day. In her article, Jameson recommends identifying a specific daily production goal, preparing procedure analysis sheets, entering appropriate information for each appointment, delegating duties to the appropriate levels, varying the procedures throughout the day, and preblocking the appointment book at specified times for certain procedures.

Another crucial factor for successful implementation of the EFM is the availability of qualified prosthodontic expanded function dental assistants. In the late 1970s, the ADCS terminated its program for training expanded function general dentistry assistants, so the numbers of dental assistants with higher skill levels has dwindled over the past 20 years. Most prosthodontists rely on closely monitored on-the-job training to develop dental assistants who can effectively perform patient treatment procedures requiring greater skills, while at the same time maintain quality care equal to, or greater than that provided by the prosthodontist.

As with any change in practice, many prosthodontists will need to modify their personal biases regarding what duties can and can not be delegated to dental assistants. In order to successfully implement these changes, the senior leadership will need to effectively communicate the importance of changing the traditional prosthodontic practices and involve the prosthodontists in developing training standards and programs for expanded function dental assistants. Until every prosthodontist feels comfortable with the skills and abilities of the expanded functions dental assistant, the prosthodontic service can not fully realize the efficiency and productivity potential of the EFM.

The results from the present study were limited by the types of prosthodontic procedures that could be modeled, the amount and quality of data collected, and the small sample size of ADCS prosthodontists who provided the data. This investigator encountered some difficulties in gaining staff compliance in filling out survey forms. Potential reasons behind the difficulty and/or reluctance to provide data include: (1) personnel were too busy treating patients, (2) personnel were suspicious about how the information would be used, and (3) personnel were indifferent to making changes to the present system.

Future studies should focus on improving the dental assistant utilization rates, while at the same time, preserving the improvements gained in the EFM. From a cost perspective, it is more advantageous to maximize use of the more expensive resource (i.e. dentists versus assistants), however, the results from the EFM indicate there is room to improve the process and increase utilization of the dental assistants. Modifications to the EFM could include reducing the number of assistants, reducing the number of DTRs, and combinations of both.

In order to develop more realistic data with which to make more accurate business decisions, future studies should incorporate realistic cost data, in terms of resource costs and production benefits. Results from these studies could then be used to predict and compare the cost/benefit of Army prosthodontists and contract, civilian prosthodontists. Although the results of this study reflected greater productivity (i.e., more patients treated) with higher ratios of dental assistants to dentists, optimal staffing ratios cannot be determined without considering the higher costs for the additional personnel. Further investigations in this area should focus on a cost-benefit analysis of training and resourcing additional expanded–function prosthodontic dental assistants.

Conclusions and Recommendations

The results of this study indicate that adding more dental assistants and DTRs, and at the same time, delegating more duties to the dental assistant, can improve the productivity of a prosthodontic service. The staffing, configuration, and process modifications in the Expanded Functions Model should theoretically enable a Dental Activity's prosthodontic service to evaluate and treat more patients requiring prosthodontic care, compared to the current prosthodontic practice configuration and process. However, the success of the Expanded Functions Model depends on: (1) the skills, ability, and motivation of the dental assistant; (2) the ability to acquire and provide additional dental assistants; and (3) the ability to provide the necessary funding for the potentially higher GS ratings. Other potential obstacles to introducing and implementing the Expanded Functions Model include: organizational resistance to change and the limited availability of DTRs.

This study's results can be used to develop future staffing requirements for ADCS prosthodontic services. Prior to ADCS-wide implementation of these findings, the ADCS should re-validate the models by using data from other prosthodontic services within the ADCS. As part of the DCRI, these results can be combined with other past and ongoing simulation studies to develop a comprehensive dental clinic model. Future ADCS studies in the area of simulation modeling can attempt to determine the maximum patient capacities for dental clinics of varying staff configurations, servicing patient populations of varying levels of dental health. Although there are other influencing factors, improving the performance of the ADCS's prosthodontic services can reduce the number of soldiers requiring prosthodontic treatment, and increase the number of Class 1 soldiers.

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Appendix A

Abbreviations

ADCS	Army Dental Care System
ANOVA	Analysis of Variance
ASD(HA)	Assistant Secretary of Defense, Health Affairs
CD	Complete Denture
CONUS	Continental United States
DCRI	Dental Care Reengineering Initiative
DoD	Department of Defense
DTR	Dental Treatment Room
MHS	Military Health System
RPD	Removable Partial Denture

Appendix B

Sample Process Configuration Survey

MCHK-DCA-A 14 November 1997

MEMORANDUM FOR All U.S. Army Prosthodontists

SUBJECT: Prosthodontic Practice Survey

1. Please complete the attached survey and return it using the enclosed pre-addressed envelope. The results of the survey will be used to assist in making recommendations for improving the dental assistant:prosthodontist staffing ratio. Please return the completed survey NLT 15 December 1997.

2. As part of the requirements of the U.S. Army-Baylor University Graduate Program in Healthcare Administration, I must complete a graduate management project (GMP). Using computer simulation software, MedModel, I am studying the use of, and optimal staffing levels for prosthodontic dental assistants. Your responses and comments will be invaluable in providing legitimate, real-world data input for this project.

3. Thank you for taking the time and effort to complete this survey. If you have any questions, feel free to write, call, or email me at:

436-B Halawa View Loop
Honolulu, HI 96818

(808) 433-3611 (W)
(808) 834-1006 (H)

email: wongted@gte.net

Encl
as

M. TED WONG
Lieutenant Colonel, Dental Corps
Administrative Resident

Prosthodontic Practice Survey

Instructions: Please answer the following questions. Feel free to clarify responses as needed. Return the completed survey using the attached pre-addressed envelope, NLT 15 December 1997.

Administrative Data:

	Fixed	CD	RPD	Implant	TMD	Other
Practice description (%):	____	____	____	____	____	____

Number of years experience as a dentist: _____

Number of years experience as a prosthodontist: _____

Board certified? Yes _____ No _____

1. How many assistants do you use? Full-time _____ Part-time _____

2. How much experience does your assistant(s) possess?

	Asst	Asst 2	Asst 3
Number of years as a dental assistant:	_____	_____	_____
Number of years as a prosthodontic dental assistant:	_____	_____	_____

3. How long have you and your dental assistant been working together?

Number of years:	_____	_____	_____

4. How many dental operatories do you use? _____

5. How do you use multiple chairs, if any? (i.e. Do you use all chairs for any procedure, or do you use one chair primarily for exams and emergencies, or do you use on chair for fixed procedures and another for removable, etc …?

6 What is your vision of an ide a l dental assistant to prosthodontist staffing ratio, and dental operatory to prosthodontist ratio?

Assistant:prosthodontist __________ Operatory:prosthodontist __________

7. Circle the procedures/duties that your assistant(s) perform:

Fixed:
select tooth shade
place retraction cord
make final impressions
make provisional restorations
cement provisional restorations
clean operatory
fill out records
remove provisionals and clean preparations
CJR
others___________
____
____
____

CD:
select tooth shade and mold
contour wax rims
CJR
POT
others_______________
____
____
____
____
____
____
____

RPD:
select tooth shade and mold
clean/polish teeth before and after final impressions
CJR
POT
others_______________
____

____
____

Misc:
prepare operatory
seat patient
obtain vital signs, check med hx
preliminary impressions
fabricate trays

Others_______________
____
____
____
____
____
____

8. Circle the procedures/duties that you would like a dental assistant to perform:

Fixed:
select tooth shade
place retraction cord
make final impressions
make provisional restorations
cement provisional restorations
clean operatory
fill out records
remove provisionals and clean preparations
CJR
others___________
____
____
____

CD:
select tooth shade and mold
contour wax rims
CJR
POT
others_______________
____
____
____
____
____
____
____

RPD:
select tooth shade and mold
clean/polish teeth before and after final impressions
CJR
POT
others_______________
____
____
____

Misc:
prepare operatory
seat patient
obtain vital signs, check med hx
preliminary impressions
fabricate trays

Others_______________
____
____
____
____
____
____

Appendix C

Sample Data Collection Sheets

C-1

Sample Exam Data Collection Sheet

Patient #	Fix/Rem/CD (F/R/C)	Date (MM/DD)	Arrival Time (ex. 0730)	Scheduled or Walk-in	Prelim Imp (minutes)	Exam (minutes)	Other (minutes)	Clean up (minutes)	Departure Time (ex. 0930)

C-2

Sample Fixed Data Collection Sheet

Patient #	Procedure (# of unitsFPD)	Date (MM/DD)	Arrival Time (ex. 0730)	Seat Pnt/Prep (minutes)	Impression (minutes)	Provisionals (minutes)	POI/Dismiss (minutes)	Departure Time	Clean Up (min)

Appendix D

Survey Responses

Appendix D-1

Fixed Prosthodontic Procedures

Procedure	Presently delegated to assistant(s).	Would like to delegate to assistant(s).
Seat patient.	Yes	Yes
Take vital signs, review medical history	Yes	Yes
Diagnostic impressions	Yes	Yes
Chairside assisting	Yes	Yes
Place retraction cord and make impressions	No	No
Make and cement provisionals	No	Yes
Clean and prepare operatory	Yes	Yes
Remove provisionals and clean teeth	No	Yes
Post-cementation cleaning	Yes	Yes
Fill out record, tick sheets	No	Yes

Appendix D-2

Removable Prosthodontic Procedures

Procedure	Presently delegated to assistant(s).	Would like to delegate to assistant(s).
Seat patient.	Yes	Yes
Take vital signs, review medical history	Yes	Yes
Diagnostic impressions	Yes	
Chairside assisting	Yes	Yes
Polish and clean teeth before and after impressions	No	Yes
Fill out record, tick sheets	No	Yes
Select tooth shade and mold	No	Yes
Make centric jaw recoreds	No	No

Appendix D-3

Complete Denture Prosthodontic Procedures

Procedure	Presently delegated to assistant(s).	Would like to delegate to assistant(s).
Seat patient.	Yes	Yes
Vital signs, review medical history	Yes	Yes
Diagnostic impressions	Yes	Yes
Chairside assisting	Yes	Yes
Select tooth shade and mold	No	Yes
Clean and prepare operatory	Yes	Yes
Fill out record, tick sheets	No	Yes
Contour wax rims	No	No
Make centric jaw records	No	No

Appendix E

Dental Clinic Floor Plan

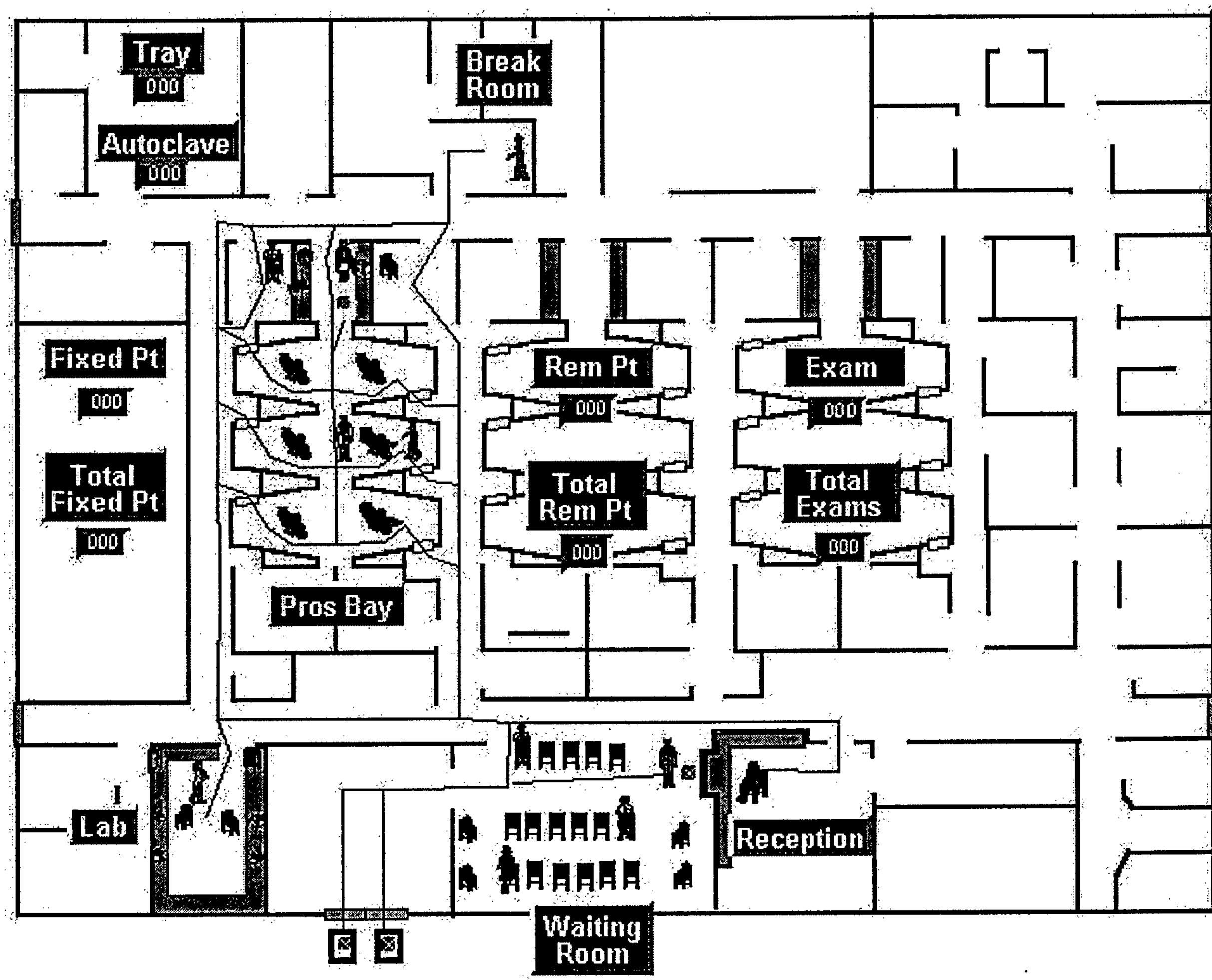

Table 1.

Descriptive Statistics for Scenarios 1-3

	MODEL	Base	Additional Assistant	Expanded Function
Waiting Room Time	Mean	21.54	0.97	2.27
	Std. Deviation	19.42	1.13	2.91
Total Time in Clinic, Fixed	Mean	123.19	105.46	72.21
	Std. Deviation	39.99	20.92	12.22
Total Time in Clinic, Removable	Mean	104.91	91.21	88.11
	Std. Deviation	32.40	28.80	23.40
Total Time in Clinic, Exam	Mean	57.34	48.96	50.80
	Std. Deviation	21.85	13.49	9.43
Total Patients, Fixed	Mean	4.06	4.65	8.68
	Std. Deviation	0.28	0.77	1.33
Total Patients, Removable	Mean	2.76	3.82	3.94
	Std. Deviation	1.07	0.48	0.28
Total Patients, Exam	Mean	6.65	6.20	7.00
	Std. Deviation	0.78	0.92	0.83
Utilization, DDS 1	Mean	79.86	95.17	83.48
	Std. Deviation	4.59	4.36	7.92
Utilization, Assistant 1	Mean	97.52	52.64	62.24
	Std. Deviation	3.14	2.07	4.20

Table 2.

ANOVA Results for Scenarios 1-3

		Sum of Squares	df	Mean Square	F	Sig.
Waiting Room Time	Between Groups	66352.97	2	33176.49	257.25	.000
	Within Groups	96337.87	747	128.97		
Total Time in Clinic, Fixed	Between Groups	334877.90	2	167439.00	229.78	.000
	Within Groups	544336.90	747	728.70		
Total Time in Clinic, Removable	Between Groups	39139.30	2	19569.65	24.27	.000
	Within Groups	595794.80	739	806.22		
Total Time in Clinic, Exam	Between Groups	9691.13	2	4845.56	19.43	.000
	Within Groups	186302.50	747	249.40		
Total Patients, Fixed	Between Groups	3163.45	2	1581.72	1948.66	.000
	Within Groups	606.34	747	0.81		
Total Patients, Removable	Between Groups	210.64	2	105.32	218.03	.000
	Within Groups	360.83	747	0.48		
Total Patients, Exam	Between Groups	79.69	2	39.84	55.56	.000
	Within Groups	535.72	747	0.72		
Utilization, DDS 1	Between Groups	32053.25	2	16026.63	467.16	.000
	Within Groups	25626.97	747	34.31		
Utilization, Assistant 1	Between Groups	279265.50	2	139632.80	13190.19	.000
	Within Groups	7907.82	747			

Table 3.

Post Hoc Test for Models 1-3 (Bonferroni) – Waiting Room Total Wait Time

DEPENDENT VARIABLE	MODEL	MODEL	MEAN DIFFERENCE
Waiting Room Total Wait Time	1	2	20.5707(*)
		3	19.2716(*)
	2	1	-20.5707(*)
		3	-1.2991
	3	1	-19.2716(*)
		2	1.2991

* Indicates the mean difference is significant at the 0.05 level.

Table 4.

Post Hoc Test for Models 1-3 (Bonferroni) – Total Time in Clinic - Fixed Patients

DEPENDENT VARIABLE	MODEL	MODEL	MEAN DIFFERENCE
Total Time in Clinic –	1	2	17.7293(*)
Fixed Patients		3	50.9778(*)
	2	1	-17.7293(*)
		3	33.2486(*)
	3	1	-50.9778(*)
		2	-33.2486(*)

* Indicates the mean difference is significant at the 0.05 level.

Table 5.

Post Hoc Test for Models 1-3 (Bonferroni) – Total Time in Clinic - Removable Patients

DEPENDENT VARIABLE	MODEL	MODEL	MEAN DIFFERENCE
Total Time in Clinic -	1	2	13.7017(*)
Removable Patients		3	16.8032(*)
	2	1	-13.7017(*)
		3	
	3	1	-16.8032(*)
		2	

* Indicates the mean difference is significant at the 0.05 level.

Table 6.

Post Hoc Test for Models 1-3 (Bonferroni) – Total Time in Clinic-Exam Patients

DEPENDENT VARIABLE	MODEL	MODEL	MEAN DIFFERENCE
Total Time in Clinic -	1	2	8.3758(*)
Exam Patients		3	6.5397(*)
	2	1	-8.3758(*)
		3	
	3	1	-6.5397(*)
		2	

* Indicates the mean difference is significant at the 0.05 level.

Table 7.

Post Hoc Test for Models 1-3 (Bonferroni) – Total Fixed Patients Treated

DEPENDENT VARIABLE	MODEL	MODEL	MEAN DIFFERENCE
Total Fixed Patients	1	2	-.5960(*)
		3	-4.6240(*)
	2	1	.5960(*)
		3	-4.0280(*)
	3	1	4.6240(*)
		2	4.0280(*)

* Indicates the mean difference is significant at the 0.05 level.

Table 8.

Post Hoc Test for Models 1-5 (Bonferroni) – Total Removable Patients Treated

DEPENDENT VARIABLE	MODEL	MODEL	MEAN DIFFERENCE
Total Removable Patients	1	2	-1.0640(*)
		3	-1.1760(*)
	2	1	1.0640(*)
		3	-0.112
	3	1	1.1760(*)
		2	0.112

* Indicates the mean difference is significant at the 0.05 level.

Table 9.

Post Hoc Test for Models 1-3 (Bonferroni) – Total Exam Patients Treated

DEPENDENT VARIABLE	MODEL	MODEL	MEAN DIFFERENCE
Total Exam Patients	1	2	.4520(*)
		3	-.3440(*)
	2	1	-.4520(*)
		3	-.7960(*)
	3	1	.3440(*)
		2	.7960(*)

* Indicates the mean difference is significant at the 0.05 level.

Table 10.

Post Hoc Test for Models 1-3 (Bonferroni) - Dentist Utilization

DEPENDENT VARIABLE	MODEL	MODEL	MEAN DIFFERENCE
Dentist Utilization	1	2	-15.3196(*)
		3	-3.6222(*)
	2	1	15.3196(*)
		3	11.6974(*)
	3	1	3.6222(*)
		2	-11.6974(*)

* Indicates the mean difference is significant at the 0.05 level.

Table 11.

Post Hoc Test for Models 1-3 (Bonferroni) - Assistant Utilization

DEPENDENT VARIABLE	MODEL	MODEL	MEAN DIFFERENCE
Assistant Utilization	1	2	44.8803(*)
		3	35.2819(*)
	2	1	-44.8803(*)
		3	-9.5984(*)
	3	1	-35.2819(*)
		2	9.5984(*)

* Indicates the mean difference is significant at the 0.05 level.

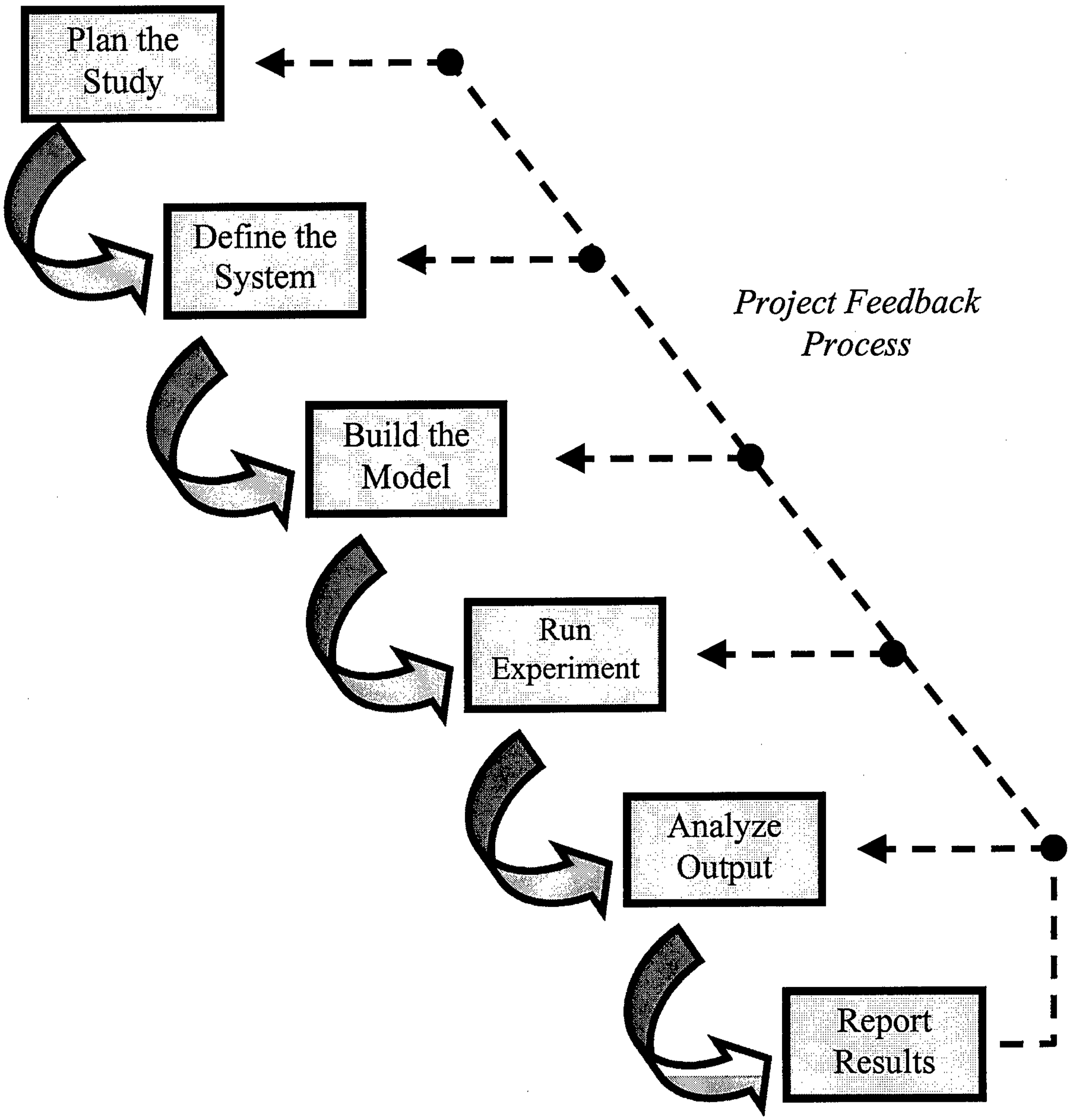

Figure 1. Simulation Process. The steps involved with conducting a simulation study.

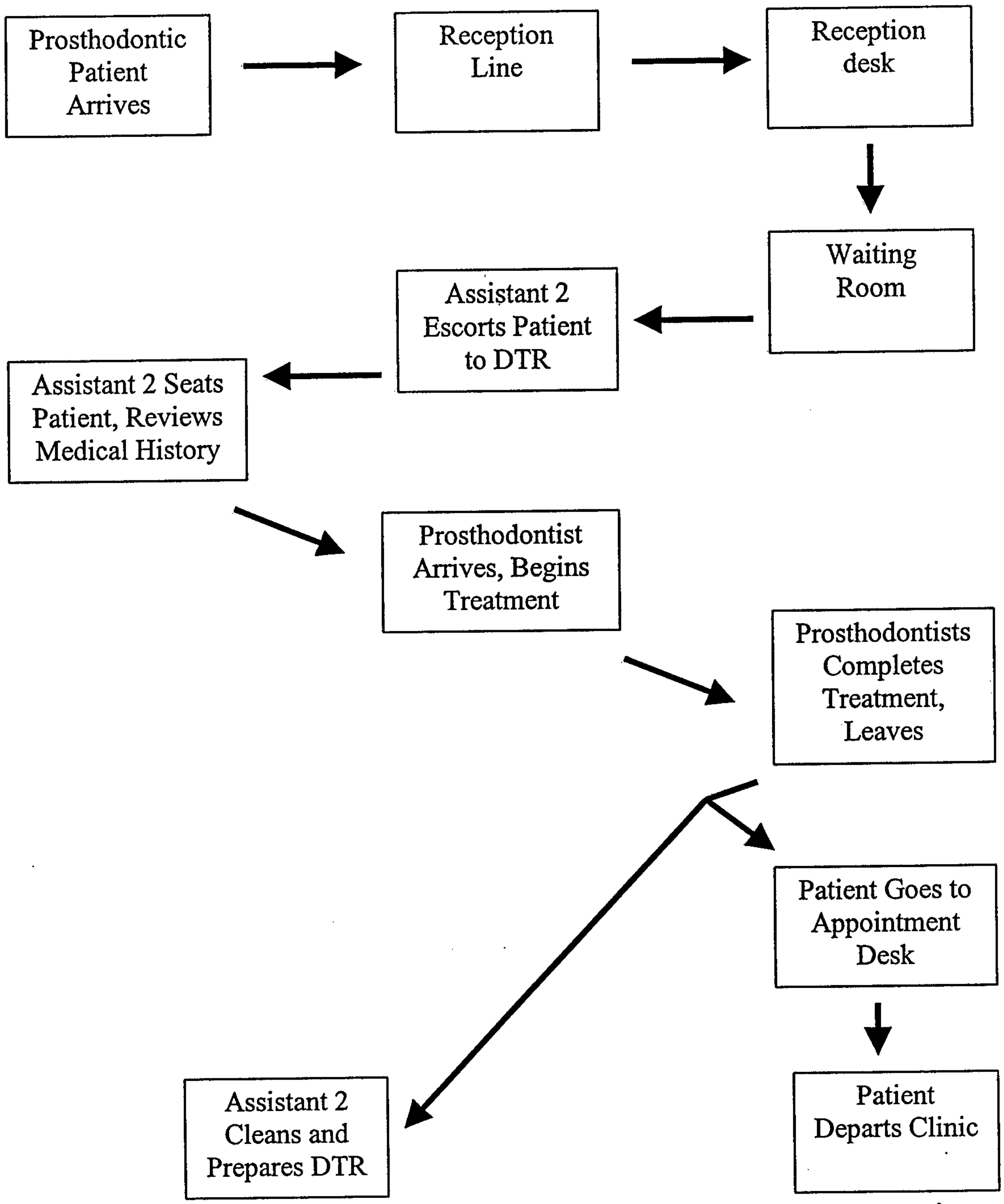

Figure 2. Traditional Prosthodontic Patient Flow. The patient flow process for a traditional prosthodontic practice.

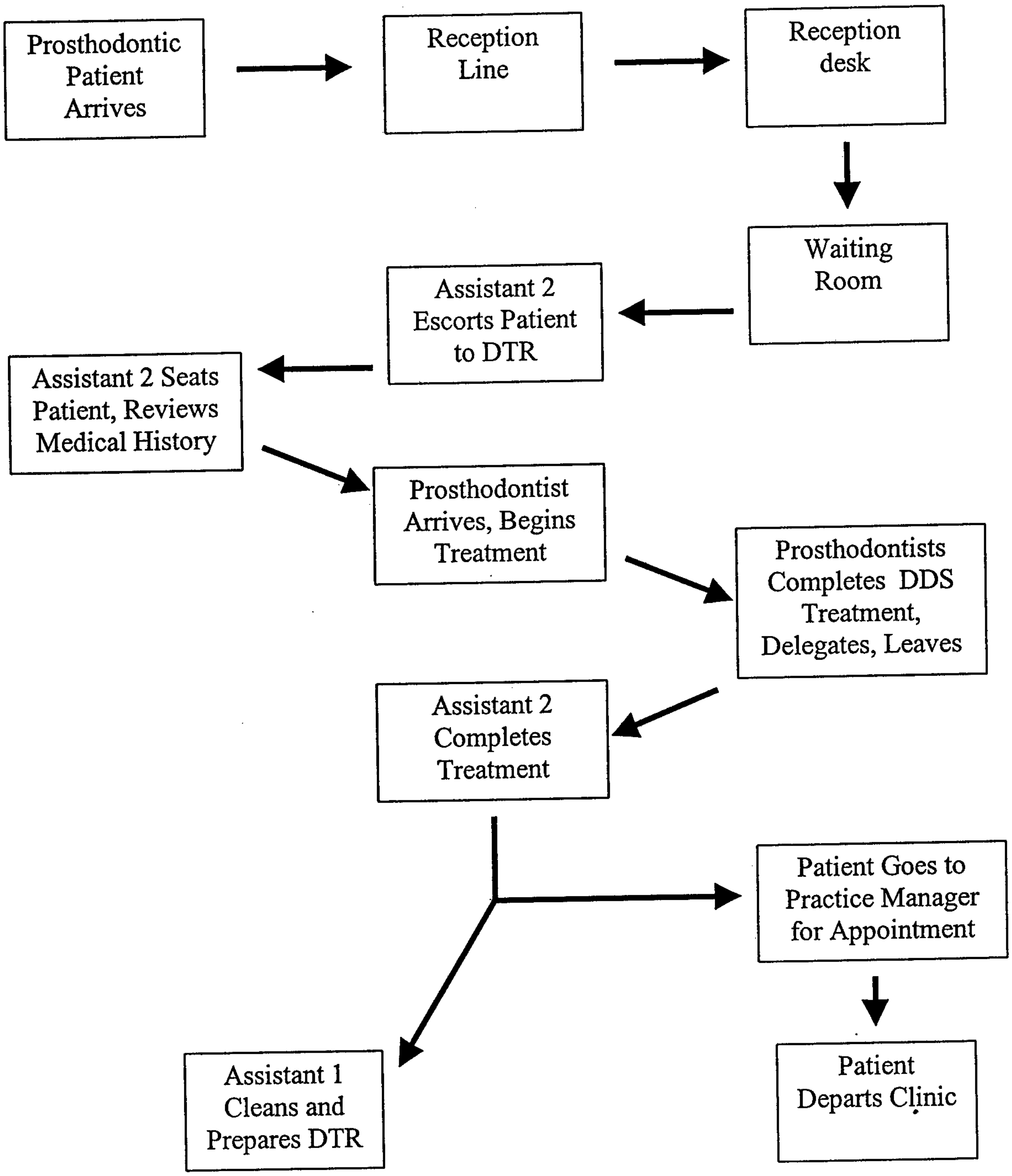

Figure 3. Proposed Prosthodontic Patient Flow. The patient flow process for the Expanded Function Model.