Running Head: IMPROVING OPERATIONAL EFFICIENCY AT THE BREAST CENTER

GRADUATE MANAGEMENT PROJECT

Using Simulation Software to Improve Operational Efficiency at Region Nine Tricare's Breast Health Referral Center

(A Look at Examination Room Requirements and Staffing Issues)

Submitted to:

FACULTY: U.S. ARMY-BAYLOR UNIVERSITY MASTERS OF HEALTHCARE ADMINISTRATION PROGRAM
APRIL 1998

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DISTRIBUTION STATEMENT A
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DTIC QUALITY INSPECTED 1

20000112 103

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
April 1998

3. REPORT TYPE AND DATES COVERED
FINAL REPORT (07-97 TO 07-98)

4. TITLE AND SUBTITLE
Using Simulation Software to Improve Operational Efficiency at RNT's Breast Health Center

5. FUNDING NUMBERS

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Office of the Lead Agent
Tricare Southern California
34800 Bob Wilson Drive, San Diego, CA 92134

8. PERFORMING ORGANIZATION REPORT NUMBER
32d-98

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 HOUST 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)

As the Military Health System implements managed care concepts throughout all military treatment facilities, administrators and providers are realizing that the care provided within military facilities must be equivalent to the civilian network in terms of quality, patient satisfaction, and cost-effectiveness. Consequently, Naval Medical Center San Diego opened a new Breast Health Center to offer comprehensive care for all region nine beneficiaries. A computer model of the clinic was built to help providers determine the optimal mix of space and providers. Twenty-seven model variations were built and the impact of each model on patient waiting time, examination room utilization, and provider utilization were reviewed by the clinic providers. From the created models, a combination of two or three staff members, six residents, and six examination rooms were selected.

14. SUBJECT TERMS
Simulation, Patient Waiting Time, Clinic Efficiency, Provider/Exam Room Utilization

15. NUMBER OF PAGES
65

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

ACKNOWLEDGEMENTS

I would like to recognize several individuals who provided extensive assistance, guidance, and support throughout the development of my Graduate Management Project. Without them, I could not have achieved this much in such a short time. My deepest thanks and gratitude are extended to:

Lu Keller and the entire staff at MedModel (especially Jeff and Debbie) for their constant technical support. If it were not for their untiring devotion and dedication to helping modelers out in the field, this project would not have been completed. Their sincerity and genuine desire to help is unparalleled. Thank you for standing by my side!

LCOL(sel) Mark Perry, MS, USA, Ph.D. for his willingness to answer all my questions and for giving me guidance whenever he felt I needed some. Always willing to offer his opinion, he helped me realize the need for an expanded project goal and is the reason this project will help so many people.

CDR Wyatt Smith, MC, USNR for his patience and understanding as I toiled over the enormous amount of data generated by the MedModel program. He has a true vision of 'what can be' and I am inspired by his never-ending goal to always find better ways to conduct business - better for our beneficiaries and our providers.

MAJ Donna Shahbaz, MS, USA for her constant support and belief in my abilities.

To each of you, thank you!

ABSTRACT

As the Military Health System (MHS) implements managed care concepts throughout all military treatment facilities, administrators and providers are realizing that the care provided within military facilities must be equivalent to the civilian network in terms of quality, patient satisfaction, and cost-effectiveness. The care must be equivalent if the MHS is going to survive the next decade of change and increasing competition. Consequently, in 1997 Naval Medical Center San Diego opened a new Breast Health Referral Center for all Region Nine beneficiaries in response to a challenge put forth by the Assistant Secretary of Defense for Health Affairs (ASD(HA)) with respect to Breast Cancer.

Being a teaching facility, the new clinic experienced long patient delays and low provider utilization rates largely due to a shortage of examination rooms. Consequently, the teaching mission was diminished. As a result, an analysis of current clinic operations was conducted and a model mirroring clinical processes was built using MedModel software. The objective was to determine the appropriate number of examination rooms for the Breast Health Center which were required to maintain clinic efficiency, as defined by minimal patient waiting time, high utilization of examination rooms, and high utilization of providers, while still supporting the teaching mission of the clinic.

After building the base model, the original project objective was expanded to include the appropriate mix of staff and resident providers who should staff the clinic because in reality a different mix of providers worked in the clinic each day. Clinic staff members concluded that a combination of two or three staff members, six residents, and six examination rooms would result in optimal efficiency, given certain constraints that couldn't be overcome.

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INTRODUCTION

Conditions Which Prompted the Study

Global Issues

A commitment has been made in the United States to search for more effective methods of providing health care through better management of health resources. This commitment comes from intense fiscal pressures plaguing the health care industry, which have shifted the focus like never before to the financial bottom line. Consequently, managed care techniques such as the use of primary care gatekeepers, utilization management, utilization review, critical pathways, and case management have been employed in most health care systems (Kongstvedt 1996). In addition, a tremendous shift from inpatient care to the use of outpatient centers has swept the nation.

Responding to similar financial constraints, the Military Health System (MHS) began implementing managed care concepts throughout all military treatment facilities with the advent of Tricare. Like the civilian health network, the MHS has realized that health care resources need to be managed through a network of primary care managers in order to be cost-effective and produce beneficial results for the patient. In addition, the MHS, as well as the administrators, providers, and support personnel who work within this system, have realized the care provided within military facilities must be equivalent to the civilian network in terms of quality, patient satisfaction, efficiency, and cost-effectiveness. The care must be equivalent if the MHS is to survive the next decade of change and increasing competition. Simply shifting care to the less expensive outpatient setting is not enough. As TRICARE is implemented nationwide and beneficiaries are encouraged to enroll in TRICARE Prime, patient satisfaction will become more

important than ever before. In addition, military healthcare professionals must focus on preventive measures and apply innovative solutions to the problems encountered by both patients and staff.

An Innovative Step

In support of this endeavor, in Fiscal Year 1996 Congress directed the Assistant Secretary of Defense for Health Affairs (ASD(HA)) to develop and implement a Breast Cancer Prevention, Education, and Diagnosis Initiative for women beneficiaries of the MHS. Support was generated for this endeavor because nearly 18,000 new cases of breast cancer are diagnosed in the MHSS each year. Experts believe that education and a heightened focus on monthly breast self-examinations, clinical examinations, and mammograms are the best strategy for decreasing breast cancer mortality. Aside from being the most commonly diagnosed cancer among American women, breast cancer is the leading cause of cancer deaths for women aged 15-54 years and the second leading cause of cancer deaths among all women in the United States (Department of Defense – BPR: 1255271-001). In addition, breast cancer affects not only the women who develop the disease and undergo treatment, but also their spouses, families, employers, and peers. "In the case of women who are either on active duty or in a reserve status, breast cancer is a readiness issue. The actual treatment for breast cancer, plus the loss of work time, has a significant and far-reaching impact economically and emotionally on the military and the Nation" (Department of Defense - BPR:1255271-001, p1-1). In response to the challenge put forth by ASD(HA), Region Nine TRICARE (RNT) formed a Regional Action Team (RAT) to recommend the best utilization of money allocated for the Breast Cancer Initiative. Led by a senior physician specialist in oncology, the action team included representation from medical and radiological

oncology, radiation therapy, surgery, nursing, and medical administration. The proposal submitted to Health Affairs was for a Breast Health Center providing comprehensive breast care for all beneficiaries of RNT. This multi-disciplinary breast health center would replace an existing Breast Tumor Clinic (BTC) at Naval Medical Center San Diego (NMCSD). In addition, it would provide comprehensive, multi-disciplinary diagnosis and treatment of both benign and malignant breast diseases for the estimated 235,497 female beneficiaries eighteen years or older within region nine (Defense Medical Information System Report – October 1997).

The Original Breast Tumor Clinic

NMCSD's original BTC was established in 1992 because of a growing referral base and the inherent problems identified with traditional treatment processes. Previously, patients passed through a succession of several clinics such as radiology, surgery, oncology, and radiation therapy. The original BTC was composed of one full-time nurse and a part-time clerk. Utilizing the General Surgery Department's clinic appointment desk, administrative personnel, and examination rooms on a part-time basis, the clinic drew on rotating physician subspecialists to provide services. On average, a staff general surgeon treated twelve patients two days a week (no medical teaching was conducted). Patients were referred to the clinic only after the diagnoses of cancer had been established. Providing professional consultation by a combination of medical subspecialties during any visit, patients were provided an opportunity to ask questions and discuss both treatment options and consequences. In addition, a tumor board composed of specialists of the medical, surgical, and ancillary services convened each week to assess each new patient's status and to reach consensus on treatment recommendations. All other breast patients who presented with an undiagnosed breast lump or mass were treated in the General Surgery Clinic.

Utilizing ten examination rooms, patients were seen first by a resident/intern/medical student, and then by a staff surgeon.

While a February 1996 customer opinion analysis relating to the performance of the BTC revealed an overall high satisfaction level, patients revealed one area of concern. Namely, the lack of a caring environment due to a shared reception desk, waiting room area, and exam rooms with an extremely busy General Surgery clinic. In addition, the BTC was not designed as a full service center to meet all of the medical needs of breast cancer patients, and there was no mechanism to reach all of Region Nine beneficiaries. As a result, the BTC was unable to achieve an impact on the quality of breast cancer treatment for those beneficiaries outside of NMCSD's catchment area.

New Breast Health Center (BHC) Proposal

The proposal sent to ASD(HA) encompassed both the means to bring breast health care services to all Region Nine beneficiaries, through the use of satellite military treatment facilities, and the depth of a full-service medical center. The satellite military treatment facilities (MTFs) would be augmented with a breast care facilitator, an educational resource center, and a video teleconferencing link with the central MTF for consultation and conferences. In addition, under RNT's Managed Care Support Contract, limited care MTFs would be supplemented with a network of providers within their local community that would be responsible for minimum standards and reporting requirements. NMCSD would become a referral, full-service breast care center offering surgical, medical and radiological oncology, radiation therapy, chemotherapy, psychology, social work, physical therapy, and dietetic services. In addition, NMCSD would continue to function as the primary MTF for 40% of the region's population that lives within a 40-mile radius of the Medical Center.

At NMCSD's Breast Health Center, five treatment rooms would be available and surgery rotations would be conducted four days a week for a two-hour block each day, with the exception of Wednesday (see Figure 1 below). Providers would be broken down into two teams – Blue and Gold – with each team covering the clinic two days a week. The patient population treated by these surgery teams would be the sum of those patients originally treated in the Breast Tumor Clinic plus those patients seen in the General Surgery Clinic for breast health issues.

Figure 1 – BHC Surgical Team Rotations

	MON	*TUE*	*THU*	*FRI*
BLUE	---	*1230-1430*	---	*1100-1300*
GOLD	*1100-1300*	---	*1230-1430*	---

In the interest of medical education, this entire patient population would be seen by a non-staff member as well as by a staff physician whenever possible.

Implementing the Proposal

Funded with money from fiscal year 1996, RNT celebrated the opening of NMCSD's new BHC in April 1997. Satellite MTFs opened throughout Region Nine during the months that followed. The BHC is under the guidance of a part-time physician director and a full-time clinical nurse specialist. In cooperation with the Breast Care Project Advisory Board which is comprised of BHC providers, a breast cancer survivor, representatives from NMCSD, and RNT, the

physician and nurse are responsible for the daily operation of the clinic, as well as for generating future breast health care initiatives.

Monthly workload figures for the BHC Medical Expense Performance Reporting System (MEPRS) code revealed a dramatic increase since the opening date of the clinic in April 1997 (see Figure 2 below).

Figure 2 - *Naval Medical Center San Diego Workload and Man Hours Report FY 97 Visit Statistics*

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
83	73	76	102	81	127	99	185	273	348	377

Source: NMCSD Workload and Man Hours Fact Book (Resource Analysis Dept)

The increase in workload is primarily attributed to a shift from other areas such as the patient population originally treated under the General Surgery Clinic MEPR code and a new source of workload from the contracted social worker, psychologist, dietitian, and physical therapist. However, a report from the Composite Healthcare System (CHCS) also earmarks a small increase in the number of General Surgery patients treated at the BHC. As future marketing efforts are generated to promote NMCSD as the Breast Health Referral Center for all satellite MTFs within Region Nine, this number is expected to grow.

The increase in patient workload is significant because although the BHC is a new clinic, it immediately experienced facility design problems once operational. Specifically, the limited number of treatment rooms became problematic for both patients and staff for several reasons:

1) Patient treatment time increases significantly when medical education is being conducted.
2) Education efforts were expanded to include all patients previously treated at the BTC.
3) The number of available examination rooms is half the number that was previously being utilized in the General Surgery Clinic (5 compared to 10).

Statement of the Problem

Carlson, Hershey, and Kropp (1979) found that an important problem often faced by the manager of an outpatient health care clinic is how to determine the best combination of services, personnel, and facility space in order to maximize profits and achieve acceptable levels of day-to-day performance. While the BHC, in theory, offered full-service breast care for all local and remote beneficiaries, the reduction in treatment rooms made it difficult for clinic staff to: 1) deliver high quality and efficient health care to Region Nine beneficiaries and 2) maximize teaching opportunities. Because examinations could be conducted in only one of five rooms and treatment time increases significantly when medical education is being conducted, both providers and patients experienced opportunity costs. Staff providers stood idle while waiting for a medical student to finish an assessment, and excessive delays kept patients from returning to work or family, thereby increasing the cost of the visit. As a result, the trend since August 1997 has been a reduction in the amount of medical teaching (Appendix A). Because NMCSD is a teaching facility, the clinic manager and advisory board required immediate information on how the problem could be solved.

Literature Review

As far back as the 1960's, research documents managerial problems in predicting examining room requirements. Because health facilities construction is expensive as well as time-consuming, newly constructed space is expected to satisfy requirements several years into the future. While expert judgment and historical square-foot-per-bed ratios are most often used to determine long-term space requirements; this method tends to standardize requirements rather than consider the particular facilities needs. Consequently, managers need to conduct appropriate internal assessments to determine appropriate space requirements.

In 1992, Harvard Community Health Plan's (HCHP) Peabody Health Center experienced a typical facility design problem. Receiving an increasing number of member complaints at the Pediatric Department regarding extremely long waiting room delays, the Director of the Peabody Health Center requested the assistance of the Quality Consulting and Training Group of HCHP to research the issue. This group identified several factors that impacted on member waits, one of which was the number of examination rooms available per provider (Benneyan, Horowitz, & Terceiro, 1994).

According to Williams, Covert, and Steele (1967) most hospital administrators agree that waiting lines suggest a lack of concern for the patients by both administrators and medical staff (a perception that the MHS must struggle to change as TRICARE Prime is implemented nationwide). At the Peabody Health Center several surveys and focus groups identified member waits as one of the top drivers of member dissatisfaction and voluntary disenrollment. According to Swan, Trawick, and Carroll (1991), member satisfaction is dependent upon expectations and performance, and it can be classified into three categories:

1) High Customer Satisfaction - Performance is greater than or equal to the customer's expectation.

2) Customer Satisfaction - Performance is less than the customer's desired expectation but better than or equal to the predictive expectation.

3) Customer Dissatisfaction - Performance is less than the desired and the predictive expectation of the customer.

The resulting profit loss from patient dissatisfaction can be extremely high. For example, Maggard (as cited in Davis, 1991) developed a model that takes into consideration the loss of future profits resulting from dissatisfied customers (dissatisfaction being attributed to waiting time). "This loss of future profits can occur for several reasons, including: (1) failure of the customer to return (either permanently or for a finite period of time); (2) reduction in the frequency of visits; and (3) discussion of his/her dissatisfaction with friends and relatives, who then decide not to frequent the firm" (Davis, 1991, p 422). In addition, excessive and avoidable delays due to inefficiency in the health care system unnecessarily increase the cost to the patient in the form of an opportunity cost. Feldstein explains that the loss of pay for the several hours required to receive medical care dramatically increases the total cost of care (Feldstein , 1994).

"Member waits also impact the satisfaction of clinicians and other staff, who are doubly forced first to absorb the discontent of delayed patients and then to work additional hours! From a human resource point of view, therefore, the issue of member waits is linked to staff turnover, especially the ability to attract and retain qualified clinicians" (Benneyan, Horowitz, & Terceiro, 1994, p 325-326). In addition, excessive waiting periods often compromise the teaching mission of a facility. For example, academic health centers have a dual responsibility of providing an

environment conducive for teaching and research that also maximizes efficiency and effectiveness (Krall & Steffen, 1994).

To solve the waiting time problem within the Peabody Health Center, a cross-functional team was formed consisting of providers and administrators to generate process improvement ideas. Although many ideas were generated through this process, some uncertainty and disagreement naturally existed within the group as to "root causes" and which of those ideas might impact member waiting the most. Consequently, providers at the Peabody Health Center utilized computer simulation analysis to base decisions more on scientific analysis and less on intuition.

Benneyan et al, state that examining room requirements can be viewed as one of the resources consumed by patients as they move throughout the clinic. Logic dictates that a small number of rooms would result in low construction costs and high room utilization, while a large number of rooms would probably result in low patient and physician waiting time, but higher cost. However, the cross-functional team at the Peabody Health Center and researchers Sumner and Hsieh (1972) at the Medical College of Georgia Hospital and Clinics, found that in order to determine the appropriate number of examination rooms, a balance needed to be achieved between waiting times and resource utilization. O'Keefe (as cited in Kalton, Singh, August, Parin, & Othman, 1997) has conducted similar research to ensure that physicians are kept busy while patients encounter only reasonable delays. While it is imperative that patient waiting times be reduced due to the impact on both employee and patient satisfaction, tradeoffs must be examined between patient waits and resource utilization to ensure efficiency. The problem at Georgia's clinic was further complicated by the internal teaching mission. After a patient was admitted to the orthopedic clinic and a nurse had recorded the vital signs, the patient entered an

examining room to wait for examination first by a resident and then by a staff doctor. The resulting variability in treatment times as well as the long encounter time between a patient and the two physicians often created a domino effect. The University of Michigan's Multi-Disciplinary Breast Care Center faced a remarkably similar dilemma in accomplishing their teaching mission (Kalton, et al, 1997).

As a result, at the Medical College of Georgia Clinics, Sumner and Hsieh choose four measures of effectiveness to quantify the clinic's performance; i.e., clinic duration, examining room utilization, average patient waiting time, and average physician waiting time. Using a simulation model of the clinic, an analysis of the sensitivity of these four performance measures to changes in clinic components was used as a quantitative methodology for predicting long-range examining room requirements.

Similarly, Intermountain Health Care (IHC) planned on expanding the number of Family Practice Clinics through building and acquisition programs. However, an area of great concern for management centered on determining the optimum number of exam rooms for each primary care physician (PCP). To arrive at an optimum number when 1) exam rooms were assigned to individual PCPs, and 2) when any exam room could be used by any PCP, researchers Allen, Ballash, and Kimball (1997) utilized simulation techniques to measure several variables. Among these variables include the variation in personnel utilization, exam room utilization, waiting times during the clinic visit, and the average clinic length of stay.

"As health care continues to become more competitive, the ability to assess trade-offs between resource utilization, service, and operating costs grows in importance" (Benneyan, 1997, p. 1). Although computer simulation has been around for three decades, during the past ten years, this tool has established an amazing reputation. In fact, researchers in each of the clinics

discussed previously chose to use simulation as the means for identifying the best possible solutions for their specific problem. "Simulation allows the organization to test different process scenarios and vary model parameters in terms of the use of staff, scheduling, and space allocation prior to any formal or actual change. In addition, it highlights process implications derived from the implementation that may not have been anticipated" (Cirillo & Wise, 1996, p 53). Simulation provided each of the researchers with a dynamic and objective method for identifying bottlenecks in patient flow, adequacy of clinic spaces, resource utilization, and forecasts of how long patients would be in the clinic. Providing both pros and cons of each alternative, the models enabled decision-makers to understand the potential consequences of each selection. As a result, tradeoffs between resource utilization and operating characteristics such as waiting times could be considered when making the decision. By affording managers the opportunity to examine their individual system at such a detailed level, the simulation tool proved to be extremely valuable in formulating a facility construction. As future managers search over a range of "what if" type questions, simulation software can help them arrive at "optimal" decisions (Allen et al, 1997).

Purpose

The purpose of this study is to determine the appropriate number of examination rooms for NMCSD's Breast Health Center required to maintain clinic efficiency as defined by minimal patient waiting time, high utilization of examination rooms, and high utilization of providers, while supporting the teaching mission of the clinic. Staff general surgeons and the advisory board will be presented with scenarios that depict the impact varying numbers of examination rooms have on patient waiting time, examination room utilization, and provider utilization. Presented with this data, the staff general surgeons and advisory board will be able to evaluate tradeoffs between the

three variables in an effort to select the appropriate number of rooms. This determination will be based upon patient flows and processes specific to the BHC. Waiting times for patients and utilization figures for providers and exam rooms, based upon the current configuration of five examination rooms, will be used as a benchmark on which to measure alternative room configurations.

H1: The number of examination rooms will need to be increased at NMCSD's BHC to maintain clinic efficiency and accomplish the teaching mission of the clinic.

METHODS AND PROCEDURES

The scope and complexity of this study necessitates the use of a tool that takes into account all of the variables required to create an accurate depiction of the patient flow and work flow. Earlier this year, Baystate Health Systems, a multi-facility health system that provides a full continuum of care in the Pioneer Valley area of Western Massachusetts, utilized the MedModel healthcare simulation software program. Baystate decided to construct a new facility dedicated to ambulatory surgery. Adding to the complexity of this task was some uncertainty with the realization that recent facility construction had resulted in fine physical facilities, but that these physical areas had been found less than optimum when placed into actual operation. As a result, MedModel software was used to develop an optimum design for this new facility (Schroyer, 1997). Because of such successes in other healthcare systems and facilities, the MedModel program will be used to accomplish the research objective of this study.

The general steps that will be followed to conduct the simulation study are as follows:

PHASE 1: Problem Definition and Project Objectives

PHASE 2: Model Development, Data Collection, and Verification/Validation

PHASE 3: Experiment(s) and Analysis

PHASE 4: Presentation and Additional Analysis

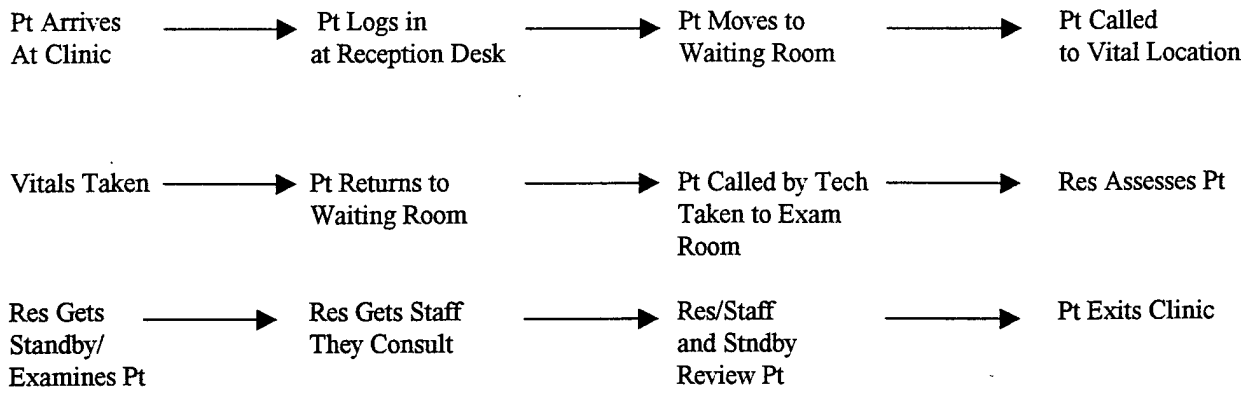
PHASE 5: Implementation **(this will be at the discretion of the BHC advisory committee)**

As stated previously, the purpose of this study is to determine the appropriate number of examination rooms for NMCSD's Breast Health Center required to maintain clinic efficiency as defined by minimal patient waiting time, high utilization of examination rooms, and high utilization of providers, while supporting the teaching mission of the clinic. To arrive at the appropriate number of examination rooms, each of these variables will be considered and evaluated as the number of rooms is varied. As a result, essential to phase 1 will be the definition of variables such as patient waiting time and utilization. Patient waiting time can be thought of as any subset of time between request for service and initiation of service. This time can be captured for each location that the patient encounters to help identify bottlenecks in the patient flow. The model will calculate daily utilization of each resource under study (staff providers and non-staff providers), as well as room utilization figures. Procedure room utilization includes room turn-around time. Provider utilization includes only time spent directly with the patient, reviewing information in CHCS and discussing a patient's condition with another provider.

Phase 2 data will be collected from department logbooks, hospital databases, physician and nurse interviews, and personnel observations. In particular, a patient flow chart will be established and approved by all providers and support staff so that consensus is reached on how

patients actually flow through the clinic. Ironically, this initial step is expected to be the cause of many debates. The tentative flow process for the patient is depicted below:

Figure 3 – Clinic Flow Chart



Note that no waiting times are actually depicted in this flow process. The model will identify waits and will record them accordingly. In addition to this type of data collection, a substantial amount of time will be spent at the clinic to collect a sample of examination times for each category of patient. To verify reliability, the model will be shown to individuals familiar with clinic operations and management to obtain acceptance of both the model and all underlying assumptions. Stability and validity will be accomplished by comparing the output results to actual systems in order to determine accuracy and to ensure that there are no obvious reality-based flaws. In addition to face validity which will be achieved through active participation of clinic staff members on a relatively frequent basis, examination of output statistics over multiple replications will be used to confirm model stability. Because the initial state value for the clinic is zero patients at the beginning of every day, no waiting period will be needed to run the model before achieving a steady state. Patient treatment profiles will be created by visit type (new or

follow-up) through real-time data collection and statistics generated from CHCS reports. The study will follow appropriate guidelines as dictated in the Ethical Principles in the Conduct of Research with Human Participants.

Phase 3 of the methods section involves experimentation. This phase of the project will be ongoing and will consist of one or more variables within the base model being changed and then studying the effect that this change has on the model results. For example, once the base model has been created, the model will be run with different numbers of examination rooms to study the effect on patient waiting time as well as on exam room and provider utilization rates.

Phase 4 and Phase 5 will involve a presentation of findings to the Breast Health Center staff and discussion on what the results mean. Specifically, discussion will focus on how all other variables were impacted by each examining room variation. This information will provide the clinic manager with the necessary quantitative data to propose an appropriate facility expansion.

RESULTS

As defined in the methods and procedures section, there are five phases that need to be followed when conducting the simulation study. Phase one of the simulation study was accomplished by defining the project objective, i.e., determine the appropriate number of examination rooms required to maintain clinic efficiency as defined by minimal patient waiting, high utilization of examination rooms, and high utilization of providers, while supporting the teaching mission of the clinic. However, because the number of staff and resident providers working in the clinic changed each day, the original project objective was expanded from simply determining the appropriate number of rooms, to determining the appropriate number of rooms,

staff providers, and residents. Different provider mixes clearly impact utilization figures and it therefore became obvious that in order to recommend a viable solution for improving efficiency, all three variables (number of rooms, number of staff, and number of residents) needed to be considered.

Phase two was accomplished by collecting hard data through personal observation of clinic activities, such as treatment times and patient flow. Several weeks were spent timing clinical processes, at random, of both new and follow-up patients so that the data could then be placed into Stat-fit, a statistics program within MedModel, and an appropriate distribution reflected in the processing logic. The specific information collected for both new and follow-up patients includes: time spent collecting vital signs information, time spent by the resident reviewing the chart, time spent by the resident assessing the patient, time spent conducting an initial examination (the model reflects that 80% of the time a female standby will be captured in order to conduct this procedure), time spent by the staff provider and by the resident during the second examination review (the model reflects that 57% of the time a female standby will be captured in order to conduct this procedure), and time spent by the female standby assisting the resident. In addition, information was collected from the Composite Healthcare Computer System (CHCS) as well as from discussions with staff providers, residents, and the administrative personnel assigned to the clinic. From the information obtained, the clinic hours of operation were updated to reflect a recent policy change and the patient flow process was confirmed as a reflection of current operations. (Because the clinic is still very new, numerous policy changes have occurred in the clinic since the submission of the Graduate Management Project Proposal). With the new clinic hours, the resources were assigned to the following shifts in the base model:

Administrative Clerk and Female-Standbys - (Listed as shift BHCloc.sft in the model)	1030-1330 Monday and Friday 1200-1500 Tuesday and Thursday
Staff Providers and Residents - (Listed as shift 3.sft in the model)	1100-1300 Monday and Friday 1230-1430 Tuesday and Thursday

The extra hour worked by the administrative clerk and the female standbys reflects the fact that these resources are at the clinic to receive patients and prepare them for the provider's examination, even before the providers have arrived in the clinic. This is important because patients are told to arrive 20 minutes prior to their actual appointment time and follow a normal distribution of N(0,3). Likewise, these same resources remain in the clinic after the surgeons have seen all scheduled patients in order to take care of administrative functions, including requesting records for patients who are scheduled the next day.

Once enough time-series data was collected, the model was built with the assistance of the Pro-Model staff in San Antonio, Texas. Because the model needed to reflect operations unique to a teaching facility, this expertise was essential for building an accurate model. While the mix of providers working in the clinic varied each day, a specific number of staff providers and residents was set in order to create the base model. Consequently, the initial model was built with two staff providers, five residents, three female standbys, one administrative clerk, and five examination rooms. This model is listed as Model 525 (5 residents/2 staff/5 rooms). Because the logic followed by the patients and the providers is the same for each examination room, macros were used throughout the processing logic. In addition, pre-off shift logic of census = zero was implemented for one staff provider and two residents to ensure that those providers not being utilized toward the end of the clinic shift were released, while still providing coverage for the patients remaining in the clinic (this was designed to help reflect more accurate utilization figures).

After the base model had been created, the model was replicated 30 times and the results reviewed. The Med Model Software program generates a detailed summary analysis on all aspects of the model, including utilization figures, waiting times, and non-use dollar costs. All of the data generated by the base model, as well as a graphical depiction of the utilization figures for resources, entities, and locations are cited in Appendix 2. As mentioned earlier, the objective statement had been expanded from determining the appropriate number of examination rooms to determining the appropriate number of rooms, staff providers, and residents. Consequently, as part of phase 3 in the simulation study, a total of 26 additional models were created and the results of each model, after being replicated 30 times, are cited in Appendixes 3-28.

Unfortunately, the original plan was to utilize an optimization software within MedModel called Simrunner. This tool would automatically reflect the appropriate number of examination rooms and providers based upon the decision variables of patient waiting time, examination room utilization, and provider utilization. However, each examination room was created as a separate location, due to the unique processing logic within the model. As a result, a macro could not be created and individual model variations had to be run.

The 27 variations (which include the original base line model) are listed below: (the model parameters range from 2-4 staff providers, 5-7 residents, and 5-7 examination rooms).

Table 1 - 27 Model Variations

5 Res / 2 Staff / 5 Rooms	5 Res / 2 Staff / 6 Rooms	5 Res / 2 Staff / 7 Rooms
5 Res / 3 Staff / 5 Rooms	5 Res / 3 Staff / 6 Rooms	5 Res / 3 Staff / 7 Rooms
5 Res / 4 Staff / 5 Rooms	5 Res / 4 Staff / 6 Rooms	5 Res / 4 Staff / 7 Rooms
6 Res / 2 Staff / 5 Rooms	6 Res / 2 Staff / 6 Rooms	6 Res / 2 Staff / 7 Rooms
6 Res / 3 Staff / 5 Rooms	6 Res / 3 Staff / 6 Rooms	6 Res / 3 Staff / 7 Rooms
6 Res / 4 Staff / 5 Rooms	6 Res / 4 Staff / 6 Rooms	6 Res / 4 Staff / 7 Rooms
7 Res / 2 Staff / 5 Rooms	7 Res / 2 Staff / 6 Rooms	7 Res / 2 Staff / 7 Rooms
7 Res / 3 Staff / 5 Rooms	7 Res / 3 Staff / 6 Rooms	7 Res / 3 Staff / 7 Rooms
7 Res / 4 Staff / 5 Rooms	7 Res / 4 Staff / 6 Rooms	7 Res / 4 Staff / 7 Rooms

The impact of each model variation on patient waiting time (listed as a percentage of time spent waiting for a resource and actual waiting time in the waiting room), staff utilization, resident utilization, examination room utilization, and non-use dollar cost are listed below:

Table 2 – 27 Model Variation Results

	Wait Times NP	Wait Times FP	Waiting Room Times	Staff (U)	Res (U)	Room (U)	Non- Use $ Cost
MODEL #							
525	52.11%	42.42%	11.55 – SD (1.13)	79.95 - 82.29%	77.67 - 91.43%	67.18 - 76.16%	$221/$429
535	51.82%	38.47%	9.57 – SD (.87)	50.79 - 69.37%	77.04 - 88.54%	65.09 - 73.56%	$616/$476
545	51.91%	38.78%	8.50 – SD (1.00)	27.14 - 62.38%	74.05 - 83.87%	63.00 - 74.46%	$1106/$522
625	52.11%	42.43%	11.55 – SD (1.31)	79.95 - 87.27%	30.12 - 88.46%	67.18 - 76.07%	$221/$906
635	51.82%	38.46%	9.57 - SD (.87)	50.79 - 69.40%	24.87 - 86.07%	65.12 - 73.55%	$616/$956
645	51.91%	38.77%	8.50 - SD (1.00)	27.14 - 62.43%	19.07 - 82.56%	62.98 - 74.50%	$1105/$1003
725	52.11%	42.43%	11.55 - SD (1.31)	79.95 - 82.27%	25.21 - 82.51%	67.18 - 76.07%	$221/$1392
735	51.82%	38.46%	9.57 - SD (.87)	50.79 - 69.40%	17.80 - 80.30%	65.12 - 73.55%	$616/$1441
745	51.91%	38.77%	8.50 - SD (1.00)	27.14 - 62.43%	17.19 - 78.70%	62.98 - 74.50%	$1105/$1486
526	57.02%	53.59%	8.14 - SD (1.43)	82.45 - 83.95%	82.15 - 95.59%	63.79 - 73.30%	$195/$303
536	56.30%	47.42%	6.36 - SD (.56)	52.91 - 68.38%	80.43 - 89.76%	57.01 - 68.74%	$590/$383
546	56.12%	46.90%	5.96 - SD (.68)	28.24 - 62.25%	79.89 - 87.72%	55.17 - 70.00%	$1062/$411
626	56.97%	51.87%	7.60 - SD (.86)	85.17 - 86.53%	72.91 - 88.96%	62.20 - 74.30%	$159/$580
636	56.22%	45.81%	5.90 - SD (.77)	54.90 - 68.92%	69.76 - 80.54%	53.19 - 68.58%	$554/$747
646	55.73%	43.68%	5.50 - SD (.63)	32.72 - 62.07%	67.00 - 78.40%	50.65 - 66.97%	$1020/$798
726	56.97%	51.87%	7.60 - SD (.86)	85.17 - 86.53%	27.09 - 86.66%	62.20 - 74.30%	$159/$1062
736	56.22%	45.81%	5.90 - SD (.77)	54.90 - 68.92%	10.30 - 78.96%	53.19 - 68.58%	$554/$1229
746	55.73%	43.68%	5.50 - SD (.63)	32.72 - 62.07%	7.85 - 75.86%	50.65 - 66.97%	$1020/$1282
527	60.66%	60.11%	5.59 - SD (1.00)	82.61 - 84.62%	83.05 - 96.31%	61.54 - 68.70%	$186/$273
537	60.30%	54.72%	4.37 - SD (.54)	54.92 - 69.65%	81.60 - 89.65%	49.23 - 65.98%	$564/$360
547	60.47%	53.01%	4.06 - SD (.45)	30.34 - 61.89%	79.41 - 88.50%	45.56 - 64.87%	$1052/$404
627	61.34%	59.63%	5.26 - SD (.84)	86.12 - 86.51%	75.94 - 92.34%	59.21 - 68.21%	$152/$459
637	58.71%	51.29%	4.26 - SD (.52)	59.57 - 71.46%	73.31 - 81.81%	41.04 - 63.78%	$514/$695
647	57.98%	49.22%	3.90 - SD (.41)	30.40 - 62.46%	65.40 - 78.51%	36.42 - 63.13%	$1025/$820
727	61.52%	59.65%	5.56 - SD (1.69)	86.61 - 87.40%	71.56 - 85.35%	58.86 - 68.80%	$147/$794
737	58.92%	50.34%	4.08 - SD (.30)	57.81 - 71.05%	48.11 - 74.73%	37.69 - 64.03%	$521/$1137
747	58.25%	47.26%	3.84 - SD (.43)	31.03 - 61.68%	40.72 - 73.16%	34.47 - 61.50%	$1013/$1275

Lowest % waiting for Res (NP and FP)

Highest Resident Utilization

Highest Staff Utilization

Lowest Waiting Room Times

Recommended Choice is model 626 or model 636 for overall clinic efficiency

The Med Model Healthcare Simulation Software User's Guide - Version 3.01, defines each of the variables cited in the above spreadsheet as follows:.

Entity % Wait for Resource, etc. (NP - New Patient and FP - Follow-up Patient) - The percentage of time the entity spent waiting for a resource, a WAIT UNTIL condition, another entity to join or combine, or waiting behind other entities, etc. (Med Model Users Guide, p. 519).

Waiting Room Times - The amount of time, in minutes, that entities spent in the waiting room before being called back to a treatment room

Utilization % - The percentage of time the resource spent traveling to be used, transporting or processing an entity, or servicing a location or other resource (Med Model Users Guide, p. 516)

Non-Use Dollar Cost Average ($ staff value / $ resident value) - The average dollar cost for non-utilization of staff providers and residents based on an estimated salary of $60 per hour for each provider.

While overall run times are not depicted in the spreadsheet, it is worthy to note that model 525 (the base model) does run an average of fifteen to thirty minutes longer, per day, than model 747. However, a huge difference in overall run length is not reflected because every model has scheduled appointments. Therefore, even though more providers and rooms may be available in which to treat patients, the patients are still arriving on a set schedule during the clinics hours of operation. However, because the total run length times do vary (even if it is only a small degree), this factor must be considered when comparing percentages of time spent waiting for resources (data in columns one and two of the spreadsheet).

DISCUSSION

To verify reliability, the model was shown to individuals familiar with clinic operations and management, to obtain acceptance of both the model and all underlying assumptions. Reliability was accomplished by looking at the animation portion of the model and confirming that the patient flow presented was in fact representative of the patient flow in the clinic. To verify and validate the model, a comparison of means was made between two sets of observed data and two sets of computer generated data (from 30 replications) using a T-Test. The first set of data consisted of time spent collecting a patient's vital signs. Here the value for T was .111. Because this value did not exceed the critical value, the difference between the two data sets was not significant. However, the second set of data that was compared was actual time spent in the waiting room prior to being called back to the exam room. When the collected data and the computer generated data were compared there was a significant difference. To arrive at a value of T that fell below the critical value for the specific degrees of freedom, a 21 minute wait function needed to be added in the processing logic.

Further investigation revealed that this significant difference in sample means does not mean that the model is invalid, but rather that the model is a reflection of clinical processes only, rather than a depiction of clinic reality. For example, the average for observed waiting room times was 30.95 minutes, while the computer generated average for waiting room times was 12 minutes. This difference can be explained by various factors that the computer generated sample did not consider, such as: 1) staff providers and residents arriving late to the clinic (sometimes as much as 60 minutes), 2) doctors leaving the clinic because they have other scheduled or last minute commitments, 3) inefficiencies in filling an empty room, which the model does not capture,

4) paperwork completed by the provider, after the patient has left the clinic, which prevents the provider from taking on a new patient, but which the model does not capture, and finally 5) telephone calls and bathroom breaks. Taking all of these factors into consideration and confirming that the difference in sample means could realistically be explained by the variances, the model was reviewed by clinic personnel and validated as representing actual clinical processes. Model stability was verified by running 30 replications for each of the 27 variations and confirming that no outliers existed in the results.

Although the models reflect clinical processes only and not reality, they are still valuable decision making tools because all the models are based on the same starting point. Thus, as one or more variables are changed, any differences generated in the results can be directly attributed to the variables changed.

The spreadsheet presented earlier synthesizes the key variables that needed to be considered in choosing which model would promote overall clinic efficiency. If lowest waiting room time was the number one priority for the decision-makers, model 747 (7 residents/4 staff/ 7 rooms) would be chosen, as patients only wait an average of 3.84 minutes in the waiting room. However, if the percentage of time an entity spent waiting for a resource was the main decision factor, model 635 (6 residents/3 staff/ 5 rooms) or model 735 (7 residents/3 staff/ 5 rooms) would be chosen as these two models result in the lowest percentage values. Of great significance is that as the time spent in the waiting room decreases, the percentage of time an entity is waiting for a resident or other provider appears to increase (% wait for res, etc.) and vice versa. This can be seen graphically on the entity states graph enclosed in each Appendix. This occurs, in part, because patients are now waiting in an examination room vice the general waiting room and this time is then captured as time waiting for providers rather than time during

which the entity is blocked from moving to the next location. It is imperative that decision-makers recognize this correlation when assigning weights to each variable. If the number one concern for decision makers was to ensure the highest utilization of staff providers, model 727 (7 residents/2 staff/ 7 rooms) would be selected as that results in a utilization range of 86.61% - 87.40% for staff providers. If however, resident utilization was the number one concern, model 527 (5 residents/2 staff/ 7 rooms) would be selected, as this results in a utilization range of 83.05%-96.31% for resident providers. If room utilization was the number one variable to consider, model 625 (6 residents/2 staff/ 5 rooms) or model 725 (7 residents/2 staff/ 5 rooms) would be selected for each model results in a room utilization range of 67.18%-76.07%. Finally, in addition to utilization ranges and entity wait times, the non-use dollar cost averages listed in the far right column of the spreadsheet, could also be used to determine which model represents optimum efficiency. Based on this variable alone, model 527 (5 residents /2 staff/7 rooms) would be selected as it results in the smallest amount of non-use dollar cost.

The information presented in the spreadsheet is also presented graphically in Appendices 2-28. For each model, four graphs are provided: 1) Resource States, 2) Resource Utilization, and 3) Entity States, and 4) Location Utilization. The Resource States Graph shows the relative amount of time each resource spent in a particular state, including 'in use' data, which differs from utilization data, since it does not include time spent by a resource traveling to be used. The resource utilization graph depicts the utilization of all resources including staff and residents, as well as female standbys and administrative personnel. The entity states graph shows: 1) the percentage of time an entity spent traveling between locations; 2) the percentage of time the entity waited for a resident or other resource; 3) the percentage of time the entity spent processing at a location or on a queue; and 4) finally the percentage of time the entity spent waiting for the next

location to become available. Finally, the Location Utilization graph depicts the utilization of all locations used in the model.

CONCLUSIONS AND RECOMMENDATIONS

The expected finding of this study was that NMCSD's Breast Health Center would require additional examination rooms to improve efficiency. As workload increased and the space in which to work decreased, the teaching mission was sacrificed in order to treat patients in a timely manner. Thus, the teaching mission could be re-established with additional examination rooms. The question, however, was how many more rooms were needed?

This question could not be considered without also recognizing the daily shift in the mix of providers working at the clinic. Because the number of providers directly impacts utilization figures, an investigation into what mix of providers would work well in a variety of examination room scenarios was essential for determining an optimum clinic solution. By presenting the clinic staff with 27 scenarios of staff providers, residents, and room variations (phase 4 of the simulation study), hard data was available on which to determine an optimal clinic choice. Based upon the data listed in the spreadsheet and on the graphs in Appendices 2-28, the Head, Breast Health Center and the Head, General Surgery Clinic choose model 626 and model 636 for optimal clinic efficiency. The best alternative will always be determined by the decision-maker, rather than the author.

At the beginning of this project, clinic efficiency was defined as minimal patient waiting time, high utilization of examination rooms, and high utilization of providers, while still supporting the teaching mission of the clinic. The variables that received the greatest weight from

the decision-makers were minimal patient waiting time and provider utilization. Once these priorities had been established, the decision-makers conceded that they would not be able to expand the clinic to seven exam rooms, and therefore only 18 of the 27 models created would be considered. Of these 18 models, models 626 and 636 were selected for several reasons:

First, the clinic has the capacity to expand to six examination rooms. Second, the percentage of time spent waiting for a resource and the number of minutes spent in the waiting room, reflect a 'conservative, middle of the road choice' (percentage wait times increase slightly compared to the base model, but the waiting room times decrease significantly). Third, provider utilization figures also represent a 'conservative, middle of the road choice'. More importantly however, the Head, General Surgery Clinic agrees that a mix of two staff providers and six residents or three staff providers and six residents represents a realistic option that could be implemented and followed. Further, under this new provider mix rotation, residents could be assigned their own examination room. The Head, Breast Health Center believes that if each resident is assigned their own room, the current appointment schedule could be tailored to meet the expanded room capacity and resource mix, thereby increasing the utilization numbers that are currently predicted for both staff and residents in these two models. Either more patients could be seen during the same block of time, or the same number of patients could be seen in less time. For example, maybe the current patient load could be examined in 1 hour and 30 minutes vice the 2 full hours the clinic is currently operating. To confirm this provider's expectations, additional models could be run in the future, with altered patient arrival cycles.

The results of this study will be useful for the surgeons rotating through the clinic because their teaching mission will be accomplished with greater ease. They will no longer have to sacrifice provider teaching to achieve appropriate patient waiting times. However, the results will

also be useful for patients and the entire Naval Medical Center. First, the patients will benefit, as they will no longer suffer the long delays encountered when teaching is conducted. Second, the Naval Medical Center will benefit because an improvement in efficiency will result in happier patients, who will spread this news to friends and family. This improved efficiency will assist NMCSD as it markets to bring beneficiaries into TRICARE Prime at the MTF. Finally, the project's results will be available during the upcoming Joint Commission on the Accreditation of Healthcare Organizations inspection, to serve as evidence of NMCSD's commitment to continuous efficiency improvement.

LIMITATIONS OF THE STUDY

This analysis was undertaken with the purpose of providing as much valid information as possible to determine the most efficient option for running the Breast Health Referral Center; however, this study is not without limitations. First, a limited amount of data was collected due to time constraints and also the lengthy duration of some clinical processes. The limited data collection could affect the selected distributions and descriptive statistics. However, the modeler evaluated each reported variable in the output and made an evaluation of the validity of the result.

Second, as mentioned earlier, the models reflect clinical processes vice reality since several factors, such as the late arrival of providers and delays in filling examination rooms, were not incorporated into the model. While this does not limit the value of the models, in functioning as decision-making tools, it does limit the scope of what the models depicts.

APPENDICES

A: Letter Referencing a Decrease in the Teaching Mission
B: Model 525 Graphs
C: Model 535 Graphs
D: Model 545 Graphs
E: Model 625 Graphs
F: Model 635 Graphs
G: Model 645 Graphs
H: Model 725 Graphs
I: Model 735 Graphs
J: Model 745 Graphs
K: Model 526 Graphs
L: Model 536 Graphs
M: Model 546 Graphs
N: Model 626 Graphs
O: Model 636 Graphs
P: Model 646 Graphs
Q: Model 726 Graphs
R: Model 736 Graphs
S: Model 746 Graphs
T: Model 527 Graphs
U: Model 537 Graphs
V: Model 547 Graphs
W: Model 627 Graphs
X: Model 637 Graphs
Y: Model 647 Graphs
Z: Model 727 Graphs
AA: Model 737 Graphs
BB: Model 747 Graphs

APPENDIX - A

6-Aug-97

From: Head, Gold Team
To: Gold Team Staff and Chief Resident

Subj: **BREAST HEALTH CENTER CLINIC COVERAGE**

1. It is obvious that we have way too many physicians present for the Breast Health Center (BHC), given the number of exam rooms available to us. My solution would be to increase the number of exam rooms available, but this will obviously take time. In addition, CDR Johnstone has asked us to "go along" with the growing pains of the BHC for the first month or two. He admits that it is likely that he will need to increase the number of rooms available, but not right away.

2. Until we get more rooms, I would like to set up the following schedule for the staff for BHC clinic:

1030 – 1300 Monday	1100 – 1330 Thursday
CDR Gubler	CDR Magrino
CDR Roberts	CDR Liberman
LCDR Steele	CDR Findley

This is not meant to restrict anyone from showing up on the other days! As a matter of fact, those assigned to the BHC should feel free to call the others for help as needed, and those not assigned should stop by and check to make sure that the clinic is adequately covered.

3. The number of housestaff and students who show up is up to the Chief Resident, within some parameters:
   - -The Chief should be at every BHC clinic.
   - -At least one junior should be at every BHC clinic.
   - -At least four housestaff or students other than the Chief should be at every BHC clinic.

4. Let's give this a try and see how it flies. If we end up with not enough people at BHC for clinic, it will return to being an "All Hands" clinic.

T. Magrino

Copy: CDR Carrillo
CDR Johnstone
Colleen Murphy

(ENCL(1))

APPENDIX - B

General Report
Output from A:\final1.pkg.mod
Date: Mar/27/1998 Time: 03:04:44 PM

Scenario : Model Parameters
Replication : Average
Period : Final Report (0 sec to 99.91558333 hr Elapsed: 99.91558333 hr)
Simulation Time : 99.14795 hr (Std. Dev. 0.38805 hr)

LOCATIONS

Location Name	Scheduled Hours	Capacity	Total Entries	Average Minutes Per Entry	Average Contents	Maximum Contents	Cur Cont
Waiting Room	13.03538333	21	112	11.557063	1.65613	6.1	
Waiting Room	0.8389703736	0	0	1.131622	0.141609	0.305129	
Vitals	13.03538333	1	56	2.943707	0.211526	1	
Vitals	0.8389703736	0	0	0.133099	0.0154689	0	
Reception in	13.03538333	1	56	1.065373	0.0763732	1	
Reception in	0.8389703736	0	0	0.120465	0.00811597	0	
Reception Que	13.03538333	999999	56	0.389149	0.0278804	3	
Reception Que	0.8389703736	0	0	0.119063	0.0085096	0.742781	
reception out	13.03538333	1	56	0.000000	0	1	
reception out	0.8389703736	0	0	0.000000	0	0	
Entrance	15.42177444	20	56	0.000000	0	1	
Entrance	0.6271477787	0	0	0.000000	0	0	
Clinic Exit	15.42177444	10	56	0.000000	0	1	
Clinic Exit	0.6271477787	0	0	0.000000	0	0	
Laundry	13.03538333	20	0	0.000000	0	0	
Laundry	0.8389703736	0	0	0.000000	0	0	
Conference Room	13.03538333	15	56	12.597005	0.89826	3.5	
Conference Room	0.8389703736	0	0	2.111100	0.108482	0.629724	
Treatment room 1	13.03538333	1	11.4667	52.011284	0.761601	1	
Treatment room 1	0.8389703736	0	0.776079	3.788928	0.0445687	0	
Entity Location 1	13.03538333	1	22.9333	9.779105	0.286229	1	
Entity Location 1	0.8389703736	0	1.55216	1.378244	0.0372933	0	
Treatment room 2	13.03538333	1	11.1667	53.221029	0.747314	1	
Treatment room 2	0.8389703736	0	1.23409	10.137683	0.0464341	0	
Entity location 2	13.03538333	1	22.3333	10.521836	0.295586	1	
Entity location 2	0.8389703736	0	2.46819	2.278091	0.0418617	0	
Treatment room 3	13.03538333	1	11.5333	49.820735	0.732171	1	
Treatment room 3	0.8389703736	0	0.899553	4.822635	0.0484284	0	
Entity Location 3	13.03538333	1	23.0667	9.702195	0.285517	1	
Entity Location 3	0.8389703736	0	1.79911	1.495182	0.0420835	0	
Treatment room 4	13.03538333	1	11.2333	50.321200	0.718131	1	
Treatment room 4	0.8389703736	0	0.935261	6.343078	0.049137	0	
Entity location 4	13.03538333	1	22.4667	10.284886	0.29237	1	
Entity location 4	0.8389703736	0	1.87052	2.279991	0.0438785	0	
Treatment room 5	13.03538333	1	10.6	50.010830	0.671813	1	
Treatment room 5	0.8389703736	0	1.22051	6.309884	0.0551256	0	
Entity location 5	13.03538333	1	21.2	10.297023	0.276315	1	
Entity location 5	0.8389703736	0	2.44103	1.813474	0.038231	0	
standby location	13.03538333	3	112	0.186702	0.02685	2.03333	

standby location	0.8389703736	0	0	0.065711	0.00962717	0.413841

LOCATION STATES BY PERCENTAGE (Multiple Capacity)

Location Name	Scheduled Hours	% Empty	% Partially Occupied	% Full	% Down	
Waiting Room	13.03538333	38.95	61.05	0.00	0.00	(Average)
Waiting Room	0.8389703736	3.43	3.43	0.00	0.00	(Std. Dev.)
Reception Que	13.03538333	97.87	2.13	0.00	0.00	(Average)
Reception Que	0.8389703736	0.52	0.52	0.00	0.00	(Std. Dev.)
Entrance	15.42177444	100.00	0.00	0.00	0.00	(Average)
Entrance	0.6271477787	0.00	0.00	0.00	0.00	(Std. Dev.)
Clinic Exit	15.42177444	100.00	0.00	0.00	0.00	(Average)
Clinic Exit	0.6271477787	0.00	0.00	0.00	0.00	(Std. Dev.)
Laundry	13.03538333	100.00	0.00	0.00	0.00	(Average)
Laundry	0.8389703736	0.00	0.00	0.00	0.00	(Std. Dev.)
Conference Room	13.03538333	42.34	57.66	0.00	0.00	(Average)
Conference Room	0.8389703736	5.09	5.09	0.00	0.00	(Std. Dev.)
standby location	13.03538333	97.58	2.41	0.01	0.00	(Average)
standby location	0.8389703736	0.83	0.83	0.05	0.00	(Std. Dev.)

LOCATION STATES BY PERCENTAGE (Single Capacity)

Location Name	Scheduled Hours	% Operation	% Setup	% Idle	% Waiting	% Blocked	% Down	
Vitals	13.03538333	21.15	0.00	78.85	0.00	0.00	0.00	(Averag
Vitals	0.8389703736	1.55	0.00	1.55	0.00	0.00	0.00	(Std. D
Reception in	13.03538333	7.64	0.00	92.36	0.00	0.00	0.00	(Averag
Reception in	0.8389703736	0.81	0.00	0.81	0.00	0.00	0.00	(Std. D
reception out	13.03538333	0.00	0.00	100.00	0.00	0.00	0.00	(Averag
reception out	0.8389703736	0.00	0.00	0.00	0.00	0.00	0.00	(Std. D
Treatment room 1	13.03538333	19.29	0.00	23.84	56.87	0.00	0.00	(Averag
Treatment room 1	0.8389703736	2.80	0.00	4.46	4.02	0.00	0.00	(Std. D
Entity Location 1	13.03538333	28.62	0.00	71.38	0.00	0.00	0.00	(Averag
Entity Location 1	0.8389703736	3.73	0.00	3.73	0.00	0.00	0.00	(Std. D
Treatment room 2	13.03538333	19.76	0.00	25.27	54.97	0.00	0.00	(Averag
Treatment room 2	0.8389703736	3.40	0.00	4.64	4.12	0.00	0.00	(Std. D
Entity location 2	13.03538333	29.56	0.00	70.44	0.00	0.00	0.00	(Averag
Entity location 2	0.8389703736	4.19	0.00	4.19	0.00	0.00	0.00	(Std. D
Treatment room 3	13.03538333	19.20	0.00	26.78	54.02	0.00	0.00	(Averag
Treatment room 3	0.8389703736	3.03	0.00	4.84	4.51	0.00	0.00	(Std. D
Entity Location 3	13.03538333	28.55	0.00	71.45	0.00	0.00	0.00	(Averag
Entity Location 3	0.8389703736	4.21	0.00	4.21	0.00	0.00	0.00	(Std. D
Treatment room 4	13.03538333	18.69	0.00	28.19	53.13	0.00	0.00	(Averag
Treatment room 4	0.8389703736	3.55	0.00	4.91	5.41	0.00	0.00	(Std. D
Entity location 4	13.03538333	29.24	0.00	70.76	0.00	0.00	0.00	(Averag
Entity location 4	0.8389703736	4.39	0.00	4.39	0.00	0.00	0.00	(Std. D
Treatment room 5	13.03538333	16.56	0.00	32.82	50.62	0.00	0.00	(Averag
Treatment room 5	0.8389703736	2.51	0.00	5.51	4.93	0.00	0.00	(Std. D
Entity location 5	13.03538333	27.63	0.00	72.37	0.00	0.00	0.00	(Averag
Entity location 5	0.8389703736	3.82	0.00	3.82	0.00	0.00	0.00	(Std. D

RESOURCES

Resource Name	Units	Scheduled Hours	Number Of Times Used	Average Minutes Per Usage	Average Minutes Travel To Use	Average Minutes Travel To Park	% Blocked In Travel
doctor staff.1	1	11.20730667	32.6333	16.604680	0.405928	0.721311	0.00
doctor staff.1	0	0.8781482762	2.04237	1.838178	0.058565	0.032411	0.00
doctor staff.2	1	8.629746111	23.3667	17.491355	0.378033	0.721438	0.00
doctor staff.2	0	0.3463159239	2.04237	2.163429	0.063768	0.046342	0.00
doctor staff	2	19.83705278	56	16.900876	0.394940	0.721144	0.00
doctor staff	0	0.9622979541	0	1.288884	0.045652	0.022064	0.00
Resident.1	1	11.20617333	11.7667	45.794423	0.493313	0.579301	0.00
Resident.1	0	0.8781482762	1.04	5.659701	0.068375	0.042285	0.00
Resident.2	1	11.20617333	11.3	46.092200	0.590891	0.711482	0.00
Resident.2	0	0.8781482762	1.05536	7.211624	0.057641	0.034292	0.00
Resident.3	1	9.228405556	11.1667	44.992120	0.557978	0.662993	0.00
Resident.3	0	0.6106588288	0.874281	4.503713	0.052496	0.061590	0.00
Resident.4	1	9.169597778	10.9667	45.561466	0.513426	0.635342	0.00
Resident.4	0	0.6920530289	0.999425	3.942731	0.055130	0.056995	0.00
Resident.5	1	9.152183333	10.8	45.395483	0.579783	0.686129	0.00
Resident.5	0	0.6300429819	1.0635	4.840162	0.049352	0.064120	0.00
Resident	5	49.96253333	56	45.323169	0.546998	0.655414	0.00
Resident	0	2.770734469	0	3.184651	0.013107	0.016122	0.00
standby vitals.1	1	13.05083333	87.5667	4.024471	0.301384	0.354509	0.00
standby vitals.1	0	0.8389703736	5.46262	0.311206	0.016975	0.013991	0.00
standby vitals.2	1	13.05083333	65.8	3.840594	0.322902	0.354002	0.00
standby vitals.2	0	0.8389703736	3.57578	0.309985	0.024155	0.016508	0.00
standby vitals.3	1	13.05083333	52.5667	3.327415	0.373502	0.349862	0.00
standby vitals.3	0	0.8389703736	3.82084	0.490900	0.031184	0.010759	0.00
standby vitals	3	39.1525	205.933	3.776352	0.326811	0.353044	0.00
standby vitals	0	2.516911121	2.62525	0.180288	0.007439	0.006920	0.00
Rachael	1	13.03538333	56	1.065373	0.000000	0.000000	0.00
Rachael	0	0.8389703736	0	0.120465	0.000000	0.000000	0.00

RESOURCE STATES BY PERCENTAGE

Resource Name	Scheduled Hours	% In Use	% Travel To Use	% Travel To Park	% Idle	% Down	
doctor staff.1	11.20730667	80.32	1.98	2.19	15.52	0.00	(Average)
doctor staff.1	0.8781482762	4.36	0.32	0.31	4.27	0.00	(Std. Dev.)
doctor staff.2	8.629746111	78.24	1.71	2.09	17.96	0.00	(Average)
doctor staff.2	0.3463159239	3.78	0.33	0.43	3.57	0.00	(Std. Dev.)
doctor staff	19.83705278	79.45	1.86	2.14	16.54	0.00	(Average)
doctor staff	0.9622979541	3.36	0.20	0.32	3.22	0.00	(Std. Dev.)
Resident.1	11.20617333	79.73	0.86	1.56	17.85	0.00	(Average)
Resident.1	0.8781482762	6.07	0.14	0.24	6.12	0.00	(Std. Dev.)
Resident.2	11.20617333	76.67	1.00	2.02	20.30	0.00	(Average)
Resident.2	0.8781482762	4.79	0.16	0.24	4.69	0.00	(Std. Dev.)
Resident.3	9.228405556	90.24	1.13	1.67	6.96	0.00	(Average)
Resident.3	0.6106588288	2.21	0.15	0.31	1.92	0.00	(Std. Dev.)
Resident.4	9.169597778	90.40	1.03	1.63	6.94	0.00	(Average)

Resident.4	0.6920530289	2.33	0.14	0.28	2.14	0.00	(Std. Dev.)
Resident.5	9.152183333	88.60	1.14	1.76	8.50	0.00	(Average)
Resident.5	0.6300429819	2.41	0.15	0.31	2.19	0.00	(Std. Dev.)
Resident	49.96253333	84.62	1.02	1.73	12.63	0.00	(Average)
Resident	2.770734469	1.94	0.06	0.15	1.84	0.00	(Std. Dev.)
standby vitals.1	13.05083333	44.98	3.38	3.84	47.80	0.00	(Average)
standby vitals.1	0.8389703736	3.12	0.29	0.26	3.29	0.00	(Std. Dev.)
standby vitals.2	13.05083333	32.31	2.73	2.92	62.04	0.00	(Average)
standby vitals.2	0.8389703736	2.85	0.36	0.28	3.18	0.00	(Std. Dev.)
standby vitals.3	13.05083333	22.38	2.52	2.34	72.76	0.00	(Average)
standby vitals.3	0.8389703736	3.52	0.33	0.25	3.69	0.00	(Std. Dev.)
standby vitals	39.1525	33.22	2.88	3.03	60.87	0.00	(Average)
standby vitals	2.516911121	2.50	0.18	0.19	2.77	0.00	(Std. Dev.)
Rachael	13.03538333	7.64	0.00	0.00	92.36	0.00	(Average)
Rachael	0.8389703736	0.81	0.00	0.00	0.81	0.00	(Std. Dev.)

FAILED ARRIVALS

Entity Name	Location Name	Total Failed	
New Patient	Entrance	0	(Average)
New Patient	Entrance	0	(Std. Dev.)
Fol Patient	Entrance	0	(Average)
Fol Patient	Entrance	0	(Std. Dev.)

ENTITY ACTIVITY

Entity Name	Total Exits	Current Quantity In System	Average Minutes In System	Average Minutes In Move Logic	Average Minutes Wait For Res, etc.	Average Minutes In Operation	Average Minutes Blocked	
New Patient	24	0	83.428708	3.608517	43.468981	15.361507	20.989704	(
New Patient	0	0	4.872595	0.163001	3.012275	1.674154	1.865596	(
Entity Consult	0	0	-	-	-	-	-	(
Entity Consult	0	0	-	-	-	-	-	(
Fol Patient	32	0	78.417091	3.694853	33.336110	18.337235	23.048892	(
Fol Patient	0	0	6.208423	0.129173	4.064020	1.324930	2.839530	(
standby consult	56	0	35.417812	2.414665	8.347782	24.655365	0.000000	(
standby consult	0	0	3.043474	0.014154	2.078131	1.289493	0.000000	(

ENTITY STATES BY PERCENTAGE

Entity Name	% In Move Logic	% Wait For Res, etc.	% In Operation	% Blocked	
New Patient	4.34	52.11	18.42	25.14	(Average)
New Patient	0.30	2.09	1.72	1.37	(Std. Dev.)
Fol Patient	4.74	42.42	23.49	29.35	(Average)
Fol Patient	0.43	2.55	2.18	2.30	(Std. Dev.)
standby consult	6.86	23.29	69.85	0.00	(Average)
standby consult	0.57	3.88	3.40	0.00	(Std. Dev.)

VARIABLES

Variable Name	Total Changes	Average Minutes Per Change	Minimum Value	Maximum Value	Current Value	Average Value	
vPT in Clinic	112	53.114973	0	11.2333	0	0.758349	(Average)
vPT in Clinic	0	0.207880	0	0.430183	0	0.0482001	(Std. Dev.)
vVital Number	56	104.428681	0	56	56	28.1313	(Average)
vVital Number	0	0.032327	0	0	0	0.109063	(Std. Dev.)
vtreat1	22.9333	259.288090	0	1	1	0.904373	(Average)
vtreat1	1.55216	17.054560	0	0	0	0.00739424	(Std. Dev.)
vtreat2	22.3333	268.657389	0	1	1	0.905374	(Average)
vtreat2	2.46819	35.040873	0	0	0	0.00959793	(Std. Dev.)
vtreat3	23.0667	258.206114	0	1	1	0.906924	(Average)
vtreat3	1.79911	20.785352	0	0	0	0.00801866	(Std. Dev.)
vtreat4	22.4667	265.352617	0	1	1	0.907816	(Average)
vtreat4	1.87052	23.334635	0	0	0	0.0101526	(Std. Dev.)
vtreat5	21.2	282.548388	0	1	1	0.913151	(Average)
vtreat5	2.44103	32.544456	0	0	0	0.00722853	(Std. Dev.)
vtreat6	0	0.000000	0	0	0	0	(Average)
vtreat6	0	0.000000	0	0	0	0	(Std. Dev.)

LOGS

Log Name	Number Of Observations	Minimum Value	Maximum Value	Average Value	
Total Vital Time	56	2.044867	6.349300	2.943707	(Average)
Total Vital Time	0	0.012966	1.159241	0.133099	(Std. Dev.)
Total Time	56	31.416133	142.316267	75.021221	(Average)
Total Time	0	5.562802	31.822020	4.905531	(Std. Dev.)

LOCATIONS COSTING

Location Name	$ Operation Cost	% Operation Cost	$ Resource Cost	% Resource Cost	$ Total Cost	% Total Cost	
Waiting Room	0.000000	-	0.000000	0.00	0.000000	0.00	(Aver
Waiting Room	0.000000	-	0.000000	0.00	0.000000	0.00	(Std.
Vitals	0.000000	-	0.000000	0.00	0.000000	0.00	(Aver
Vitals	0.000000	-	0.000000	0.00	0.000000	0.00	(Std.
Reception in	0.000000	-	0.000000	0.00	0.000000	0.00	(Aver
Reception in	0.000000	-	0.000000	0.00	0.000000	0.00	(Std.
Reception Que	0.000000	-	0.000000	0.00	0.000000	0.00	(Aver
Reception Que	0.000000	-	0.000000	0.00	0.000000	0.00	(Std.
reception out	0.000000	-	0.000000	0.00	0.000000	0.00	(Aver
reception out	0.000000	-	0.000000	0.00	0.000000	0.00	(Std.
Entrance	0.000000	-	0.000000	0.00	0.000000	0.00	(Aver
Entrance	0.000000	-	0.000000	0.00	0.000000	0.00	(Std.
Clinic Exit	0.000000	-	0.000000	0.00	0.000000	0.00	(Aver
Clinic Exit	0.000000	-	0.000000	0.00	0.000000	0.00	(Std.

Laundry	0.000000	-	0.000000	0.00	0.000000	0.00	(Aver.
Laundry	0.000000	-	0.000000	0.00	0.000000	0.00	(Std.
Conference Room	0.000000	-	1928.598800	29.25	1928.598800	29.25	(Aver.
Conference Room	0.000000	-	244.810354	2.06	244.810354	2.06	(Std.
Treatment room 1	0.000000	-	228.866667	3.50	228.866667	3.50	(Aver.
Treatment room 1	0.000000	-	38.221436	0.64	38.221436	0.64	(Std.
Entity Location 1	0.000000	-	689.866667	10.50	689.866667	10.50	(Aver.
Entity Location 1	0.000000	-	94.888586	1.33	94.888586	1.33	(Std.
Treatment room 2	0.000000	-	239.133333	3.63	239.133333	3.63	(Aver.
Treatment room 2	0.000000	-	63.623208	0.81	63.623208	0.81	(Std.
Entity location 2	0.000000	-	715.600000	10.88	715.600000	10.88	(Aver.
Entity location 2	0.000000	-	125.540377	1.71	125.540377	1.71	(Std.
Treatment room 3	0.000000	-	228.000000	3.48	228.000000	3.48	(Aver.
Treatment room 3	0.000000	-	45.923475	0.72	45.923475	0.72	(Std.
Entity Location 3	0.000000	-	684.666667	10.46	684.666667	10.46	(Aver.
Entity Location 3	0.000000	-	100.479311	1.66	100.479311	1.66	(Std.
Treatment room 4	0.000000	-	220.800000	3.39	220.800000	3.39	(Aver.
Treatment room 4	0.000000	-	48.024706	0.84	48.024706	0.84	(Std.
Entity location 4	0.000000	-	722.600000	10.93	722.600000	10.93	(Aver.
Entity location 4	0.000000	-	159.494157	1.87	159.494157	1.87	(Std.
Treatment room 5	0.000000	-	192.600000	2.94	192.600000	2.94	(Aver.
Treatment room 5	0.000000	-	33.031437	0.55	33.031437	0.55	(Std.
Entity location 5	0.000000	-	674.600000	10.27	674.600000	10.27	(Aver.
Entity location 5	0.000000	-	95.722516	1.38	95.722516	1.38	(Std.
standby location	0.000000	-	50.894533	0.78	50.894533	0.78	(Aver.
standby location	0.000000	-	18.443230	0.29	18.443230	0.29	(Std.
SUM	0.000000	0.00	6576.226667	100.00	6576.226667	100.00	(Aver.
SUM	0.000000	0.00	486.693059	0.00	486.693059	0.00	(Std.

RESOURCES COSTING

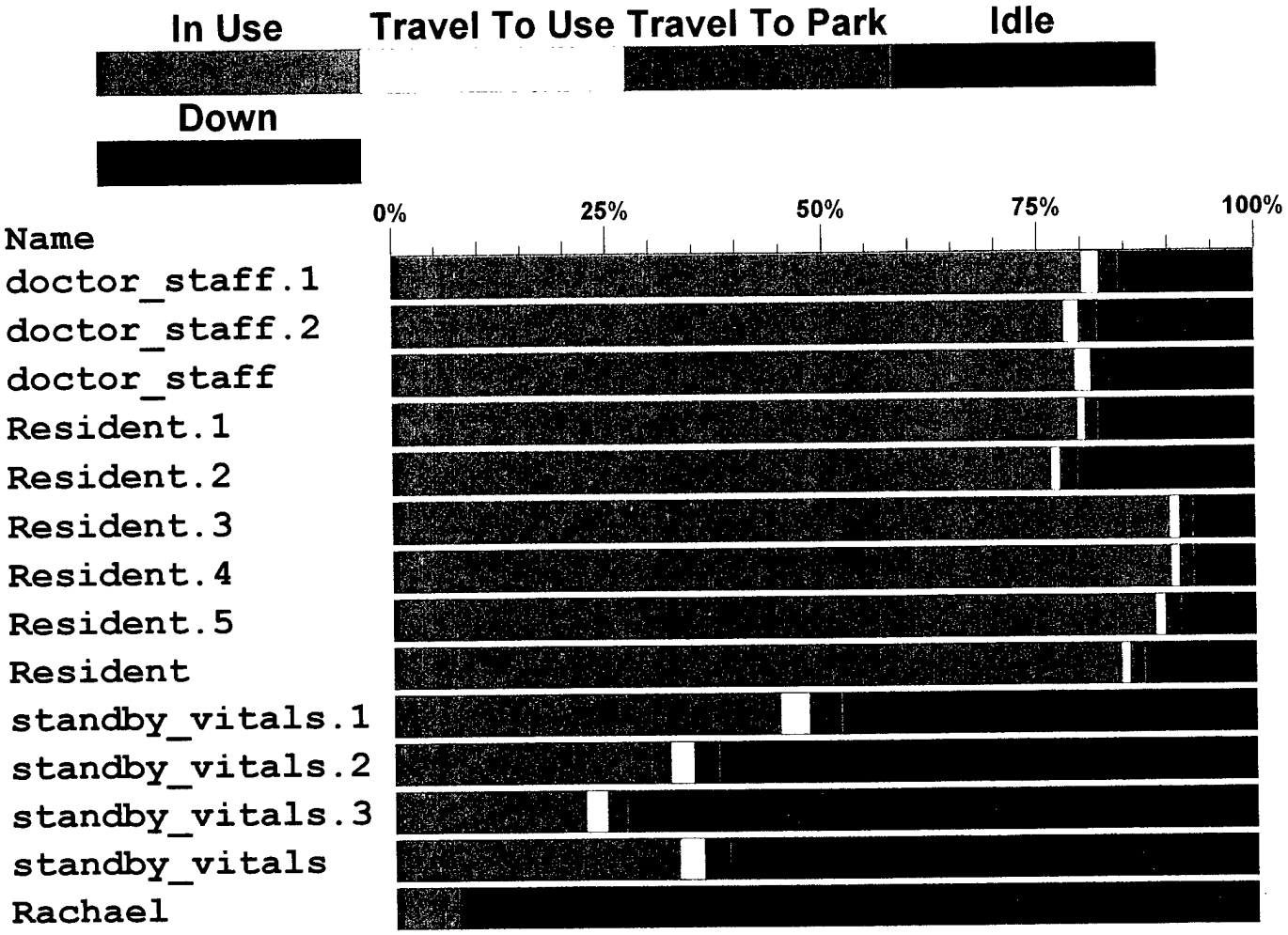
Resource Name	Units	$ NonUse Cost	% NonUse Cost	$ Usage Cost	% Usage Cost	$ Total Cost	% Total Cost	
doctor staff.1	1	236.249400	18.10	1082.082267	15.49	1318.331667	15.92	(A
doctor staff.1	0	54.455759	3.12	123.918338	0.80	103.883669	0.48	(S
doctor staff.2	1	207.065600	15.90	810.815800	11.67	1017.881400	12.33	(A
doctor staff.2	0	36.739041	2.10	59.707225	0.95	41.556436	0.71	(S
doctor staff	2	443.315000	34.00	1892.898067	27.16	2336.213067	28.26	(A
doctor staff	0	75.383581	3.64	144.355007	0.76	113.859594	0.51	(S
Resident.1	1	258.723600	19.72	1074.422667	15.38	1333.146267	16.10	(A
Resident.1	0	76.862837	4.72	140.405314	1.24	104.830976	0.48	(S
Resident.2	1	299.346200	23.11	1032.038000	14.79	1331.384200	16.08	(A
Resident.2	0	63.356729	4.60	115.902678	1.01	105.779617	0.49	(S
Resident.3	1	94.968667	7.31	999.969067	14.37	1094.937733	13.25	(A
Resident.3	0	22.293334	1.58	79.080970	1.02	73.258099	0.77	(S
Resident.4	1	93.397467	7.24	995.648133	14.30	1089.045600	13.17	(A
Resident.4	0	21.879157	1.78	90.138164	1.00	81.935564	0.70	(S
Resident.5	1	111.609400	8.62	974.117067	14.00	1085.726467	13.14	(A
Resident.5	0	21.329053	1.55	86.090439	1.12	75.112087	0.85	(S
Resident	5	858.045333	66.00	5076.194933	72.84	5934.240267	71.74	(A
Resident	0	102.944102	3.64	356.680922	0.76	332.490970	0.51	(S
standby vitals.1	1	0.000000	0.00	0.000000	0.00	0.000000	0.00	(A
standby vitals.1	0	0.000000	0.00	0.000000	0.00	0.000000	0.00	(S
standby vitals.2	1	0.000000	0.00	0.000000	0.00	0.000000	0.00	(A

standby vitals.2	0	0.000000	0.00	0.000000	0.00	0.000000	0.00	(S
standby vitals.3	1	0.000000	0.00	0.000000	0.00	0.000000	0.00	(A
standby vitals.3	0	0.000000	0.00	0.000000	0.00	0.000000	0.00	(S
standby vitals	3	0.000000	0.00	0.000000	0.00	0.000000	0.00	(A
standby vitals	0	0.000000	0.00	0.000000	0.00	0.000000	0.00	(S
Rachael	1	0.000000	0.00	0.000000	0.00	0.000000	0.00	(A
Rachael	0	0.000000	0.00	0.000000	0.00	0.000000	0.00	(S
SUM	-	1301.360333	100.00	6969.093000	100.00	8270.453333	100.00	(A
SUM	-	151.418795	0.00	486.996511	0.00	436.976547	0.00	(S

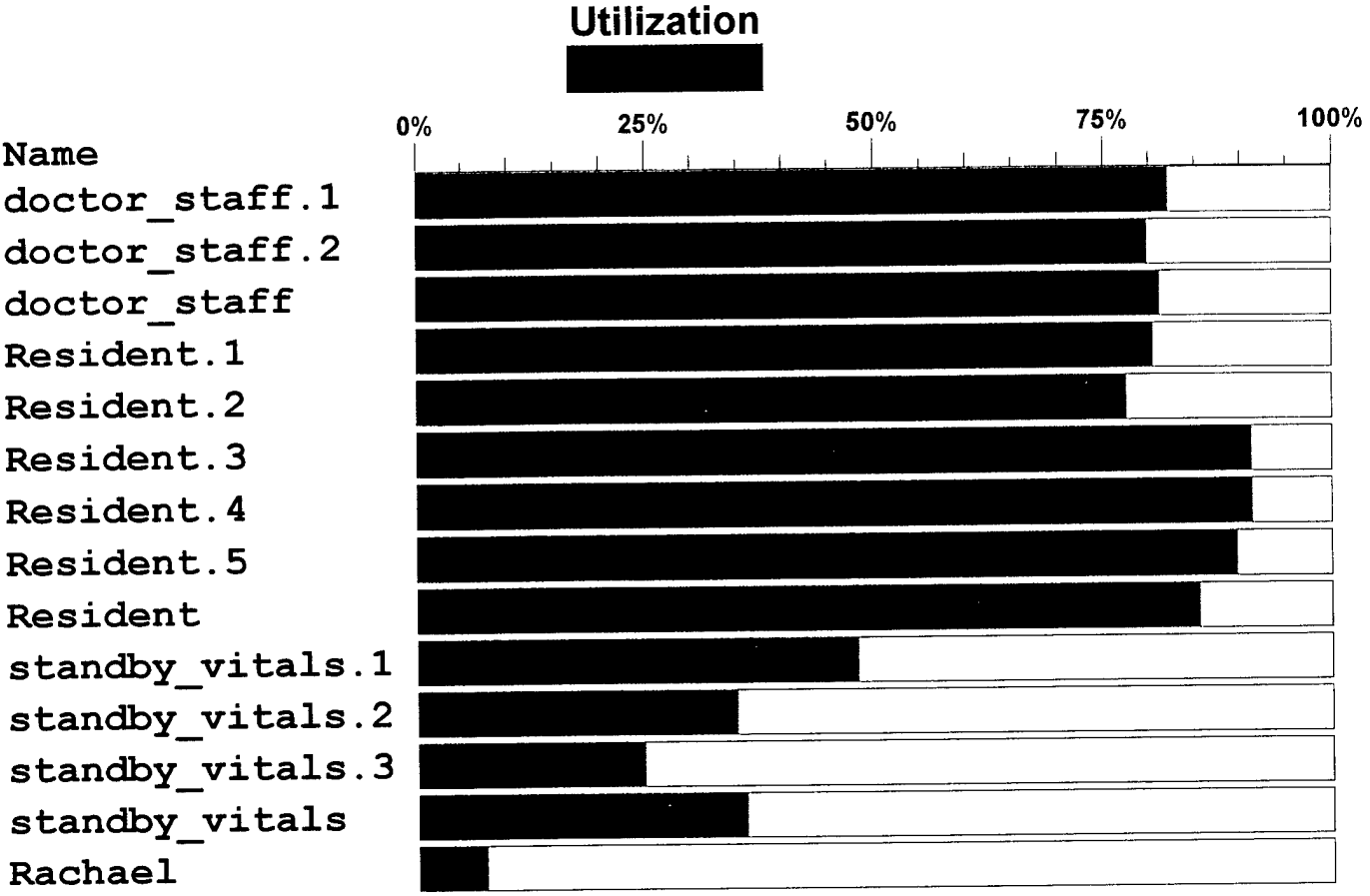
ENTITY ACTIVITY COSTING

Entity Name	Explicit Exits	$ Total Cost	% Total Cost	
New Patient	24	0.000000	0.00	(Average)
New Patient	0	0.000000	0.00	(Std. Dev.)
Entity Consult	0	-	-	(Average)
Entity Consult	0	-	-	(Std. Dev.)
Fol Patient	32	0.000000	0.00	(Average)
Fol Patient	0	0.000000	0.00	(Std. Dev.)
standby consult	56	6969.093000	100.00	(Average)
standby consult	0	486.996511	0.00	(Std. Dev.)
SUM	-	6969.093000	100.00	(Average)
SUM	-	486.996511	0.00	(Std. Dev.)

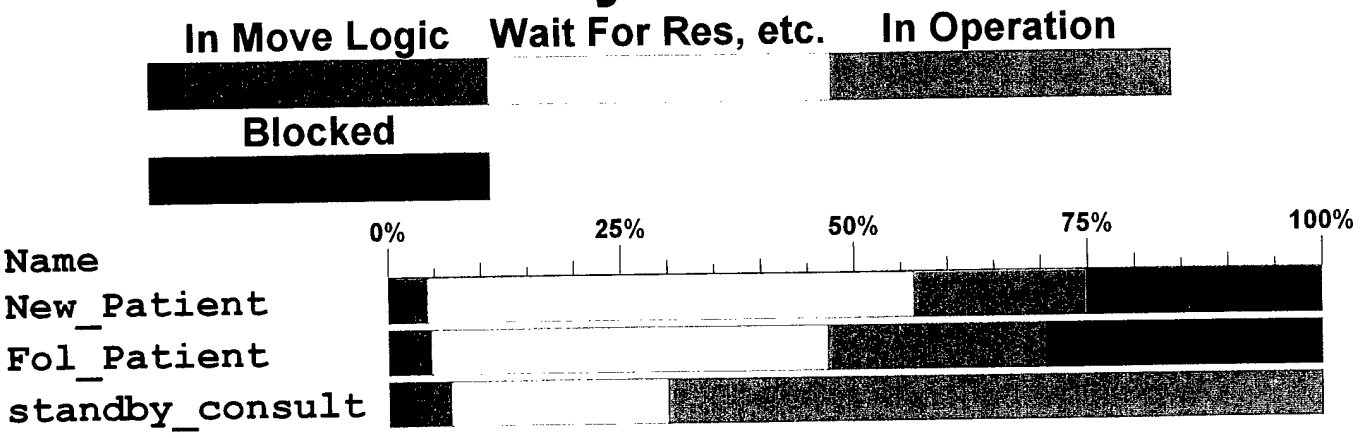
Resource States



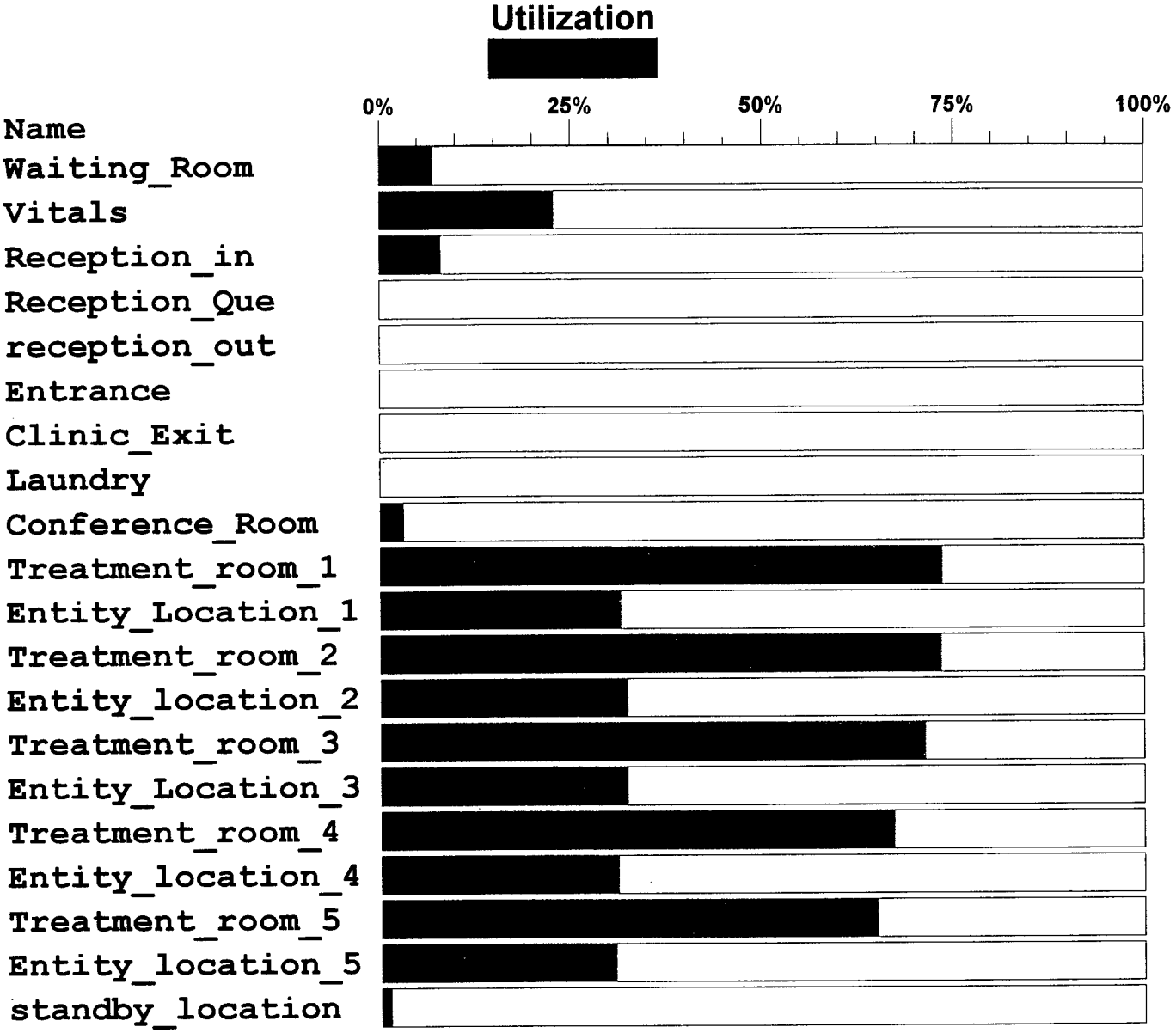
Resource Utilization



Entity States

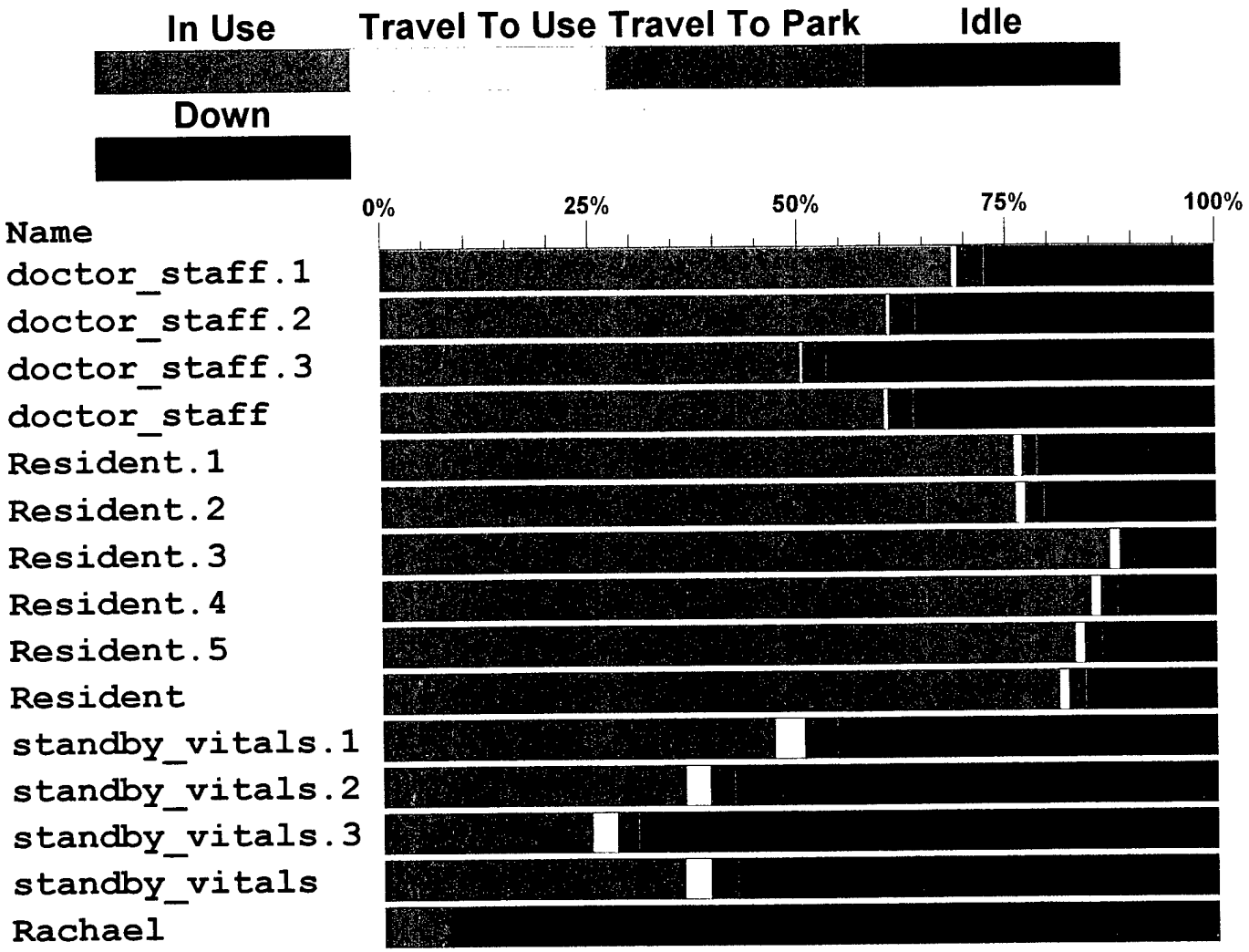


Location Utilization



APPENDIX - C

Resource States



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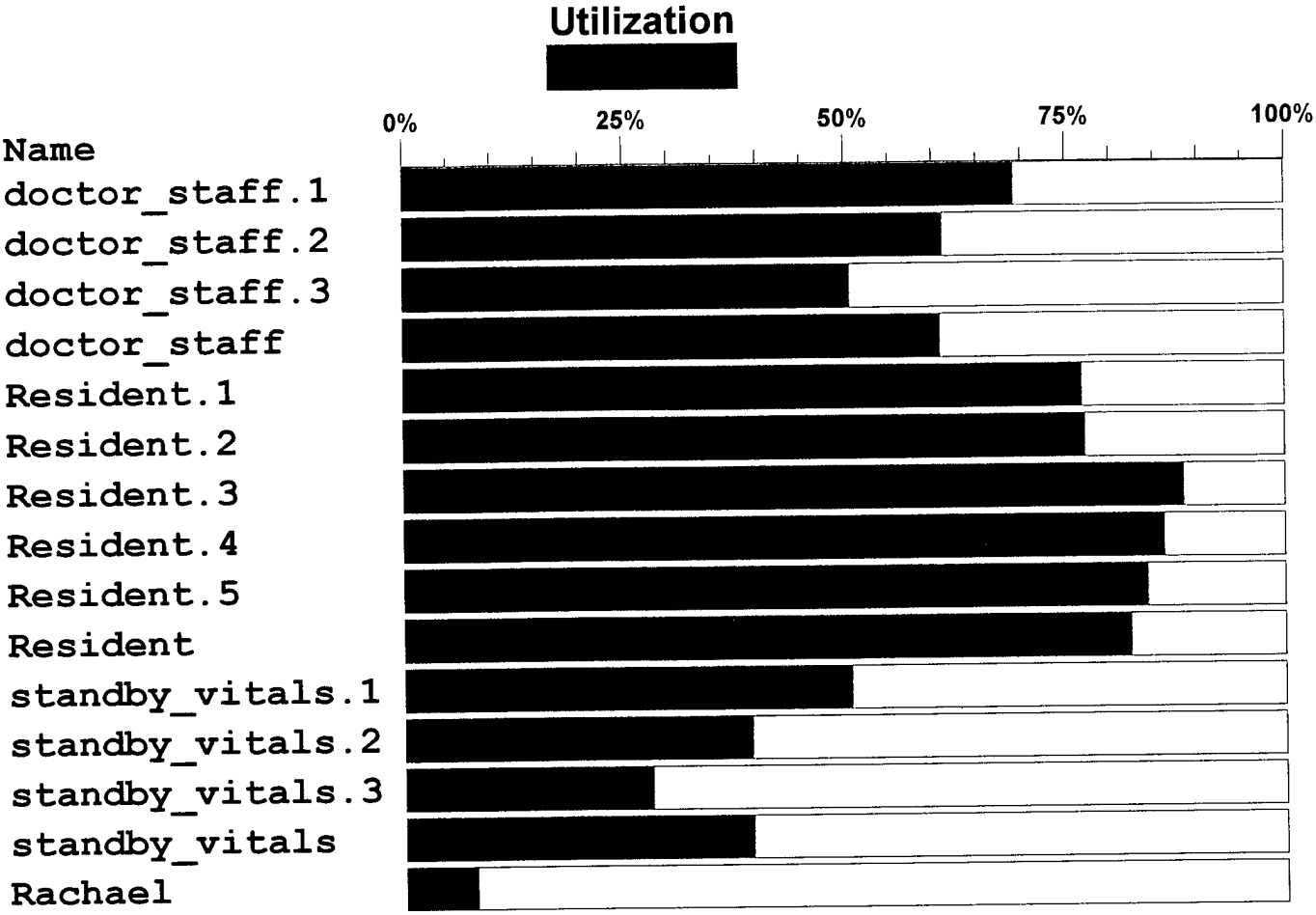
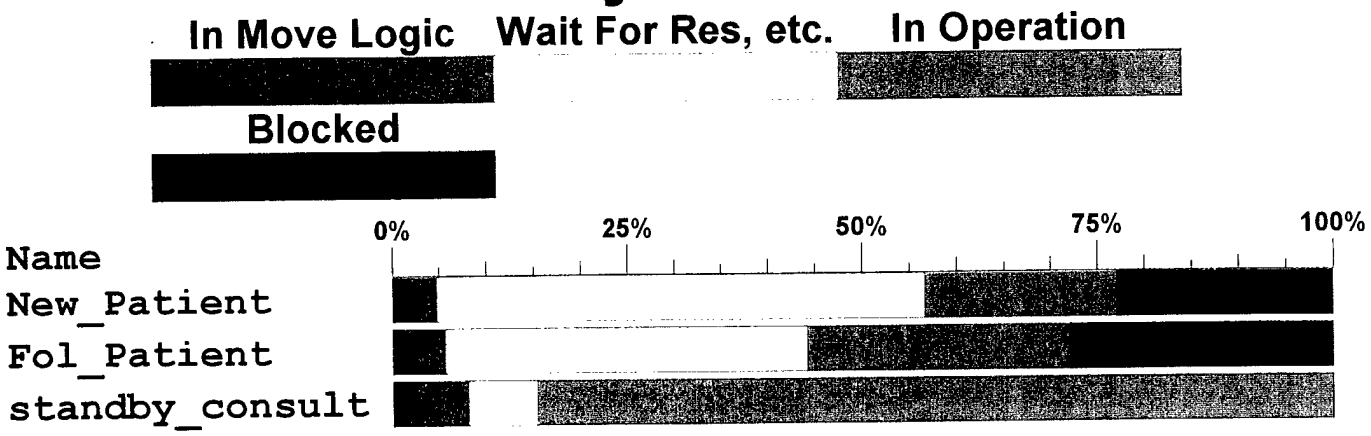
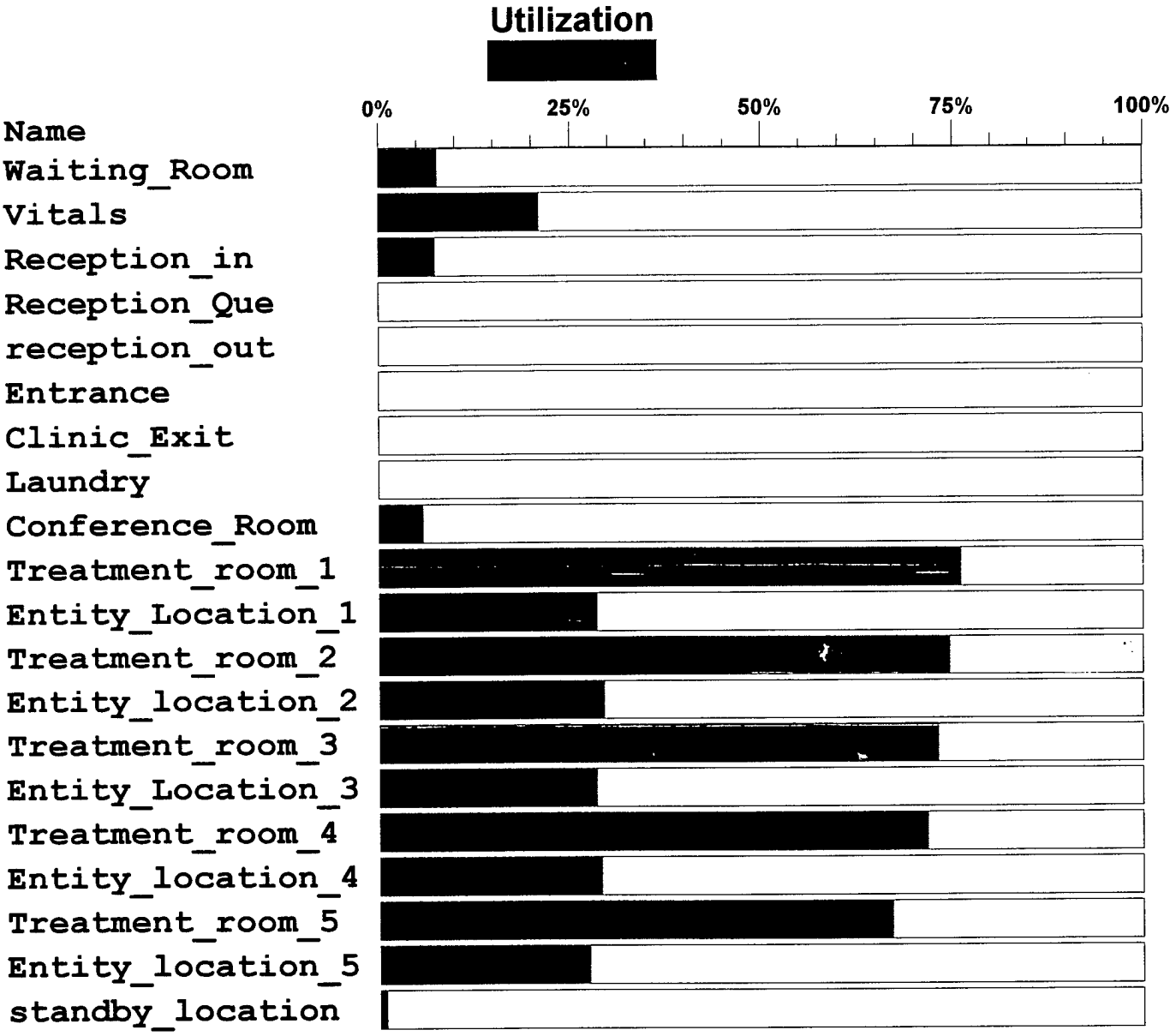


Entity States

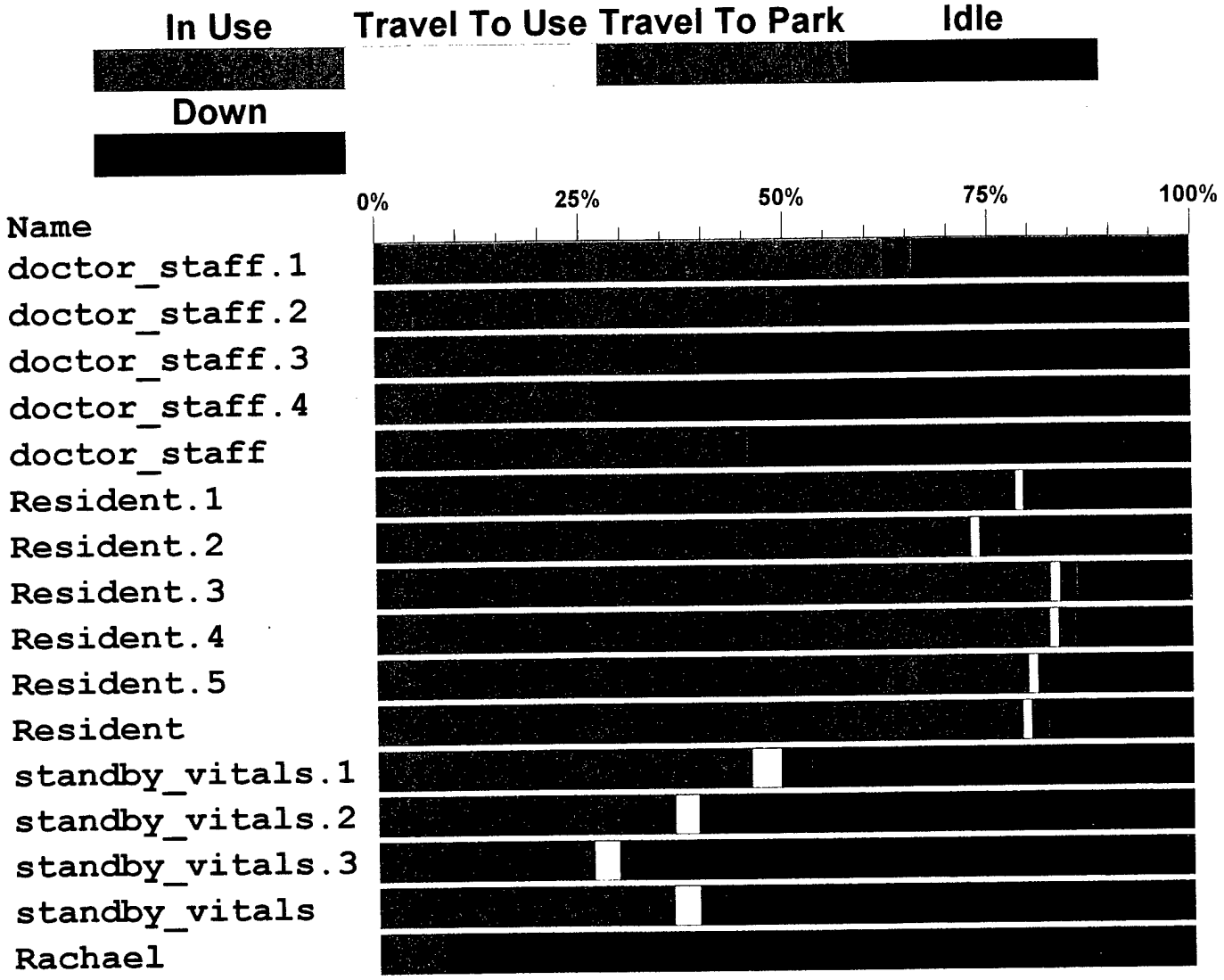


Location Utilization



APPENDIX - D

Resource States



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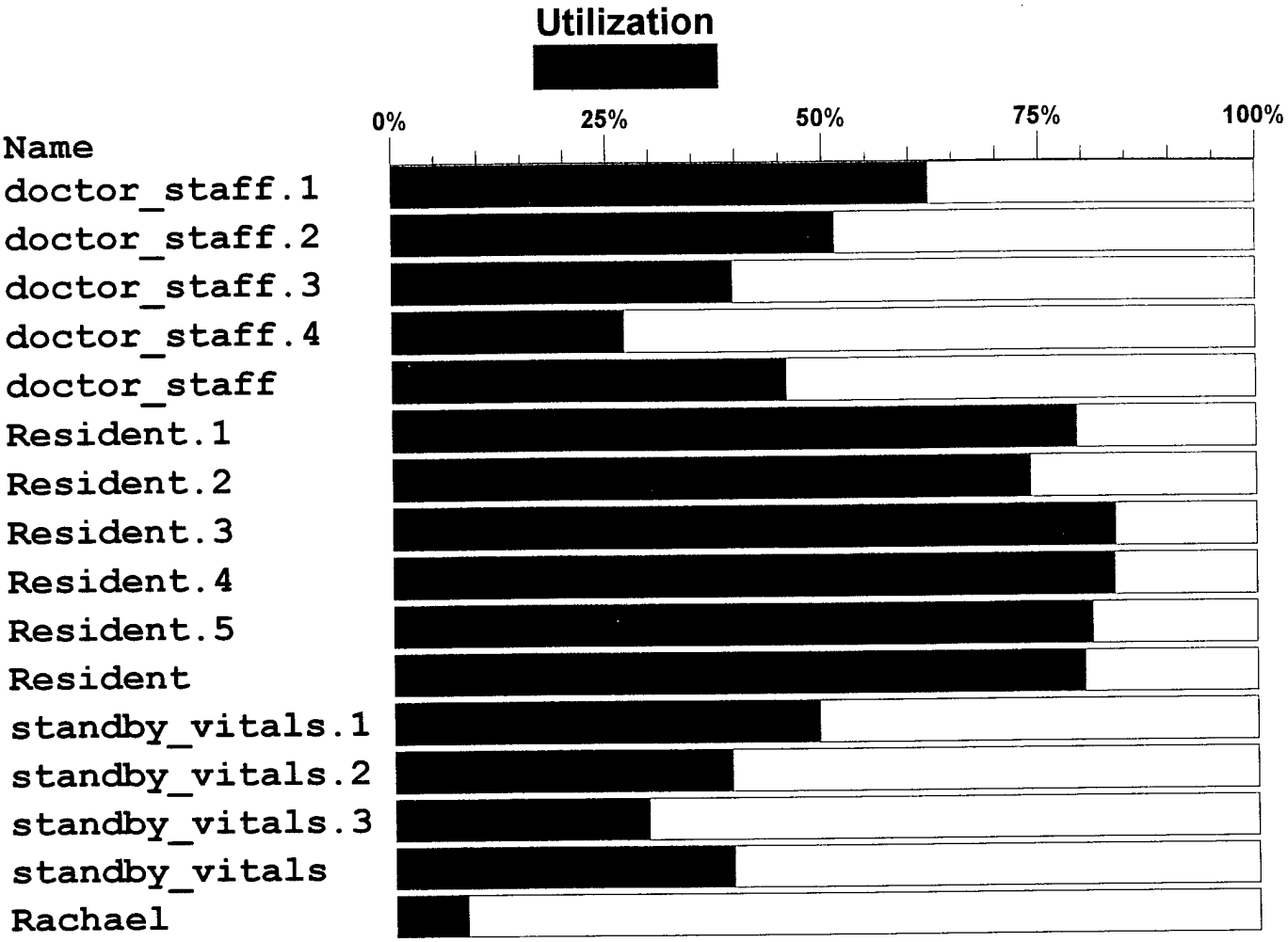

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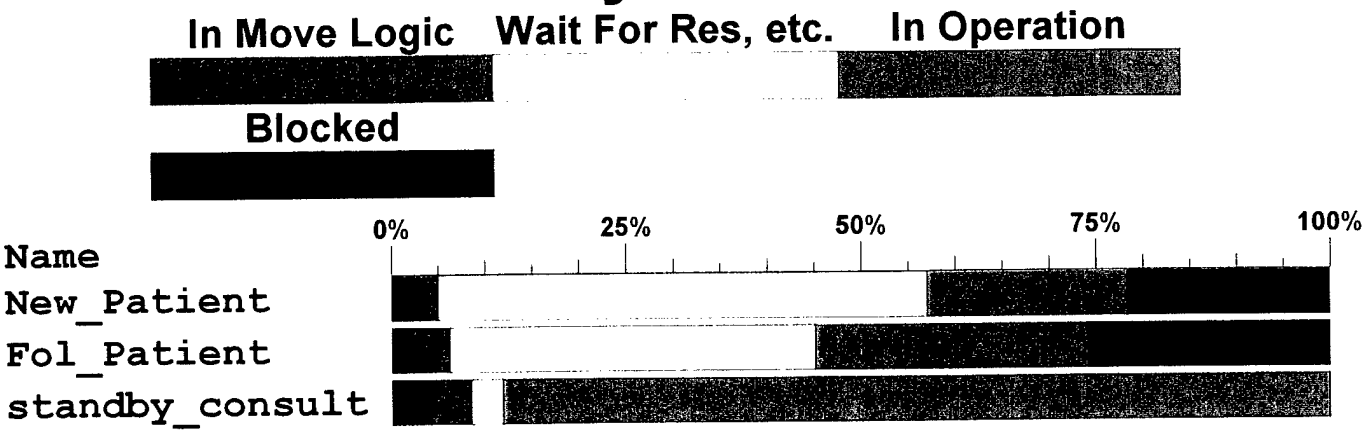

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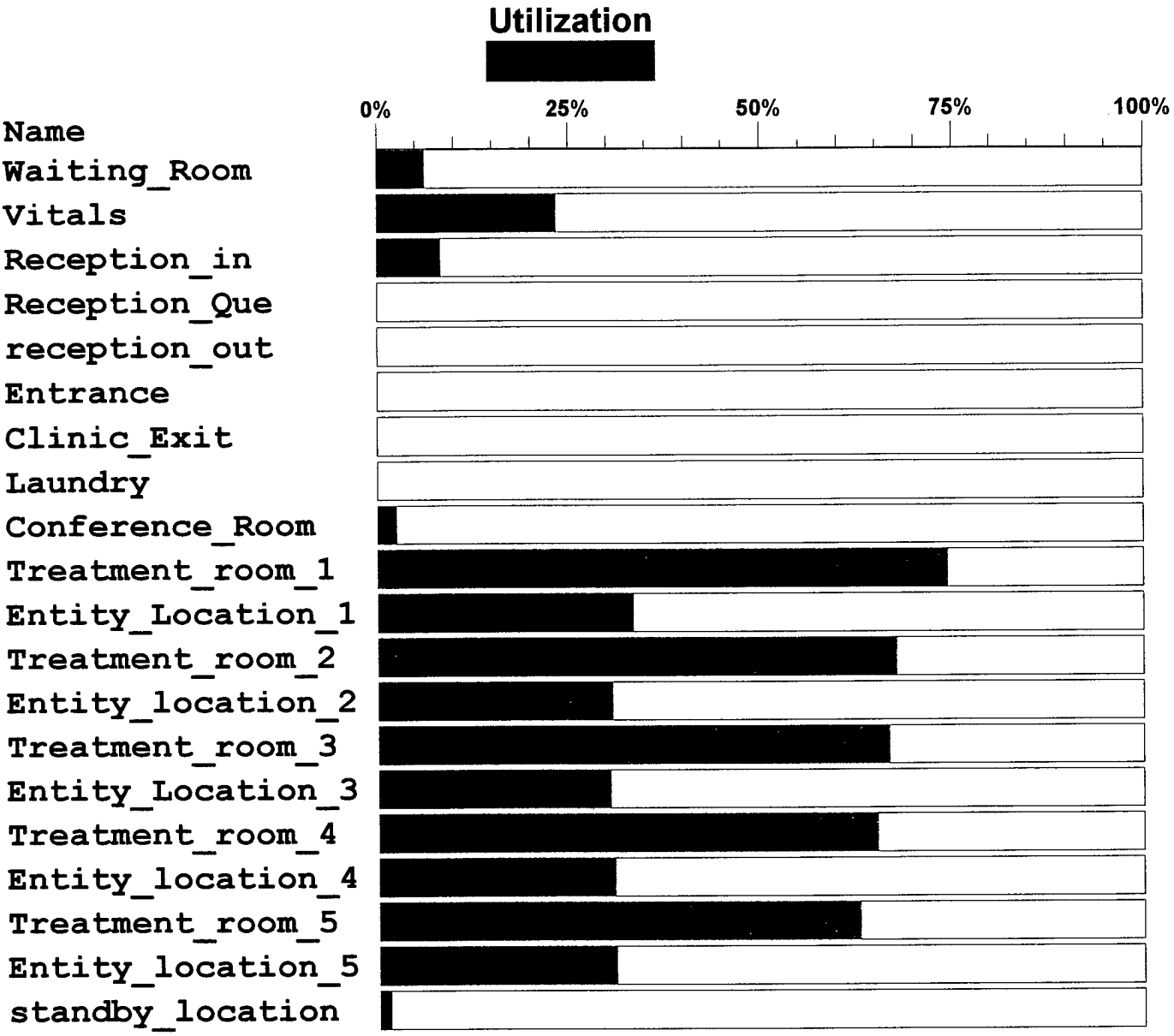
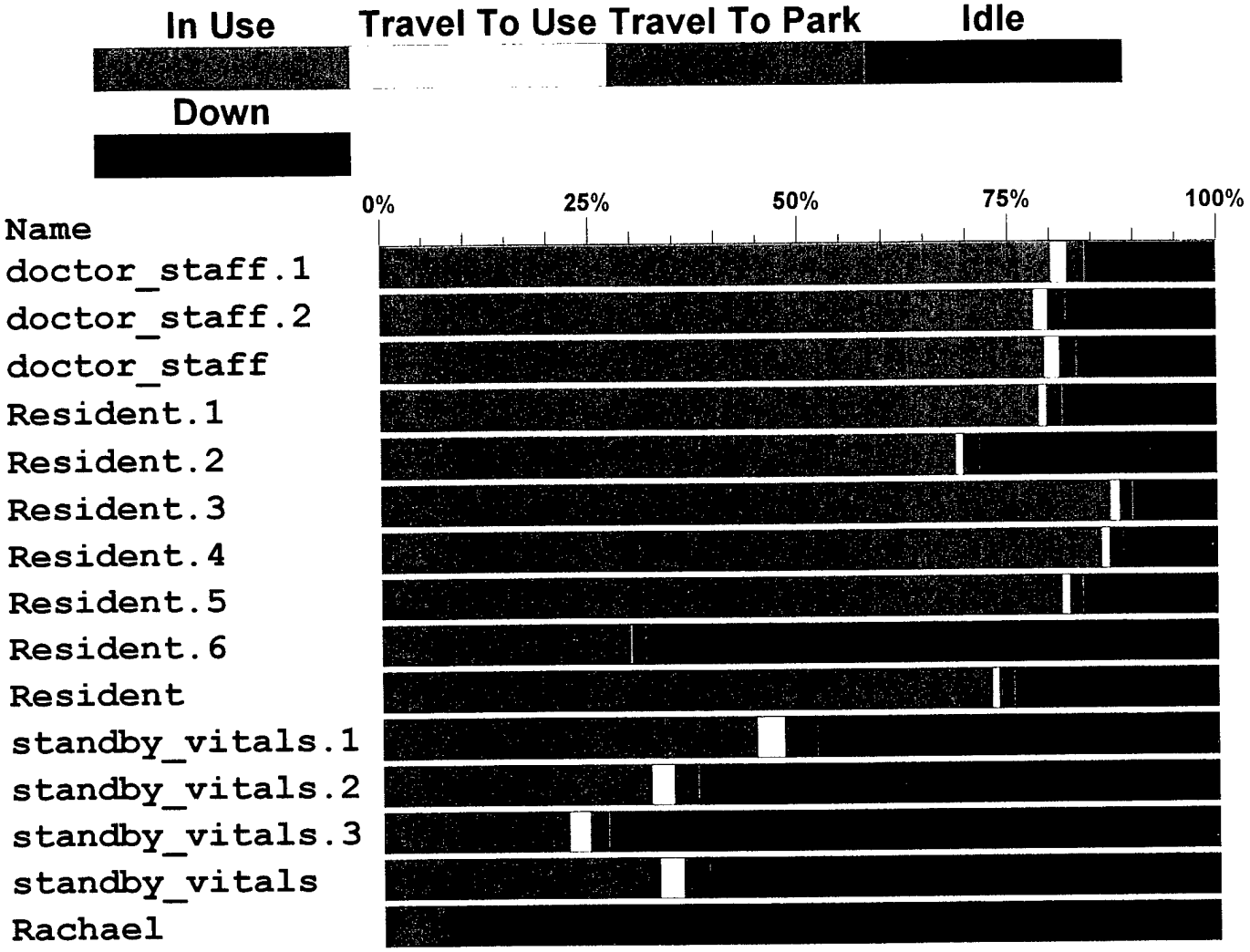


APPENDIX - E

Resource States



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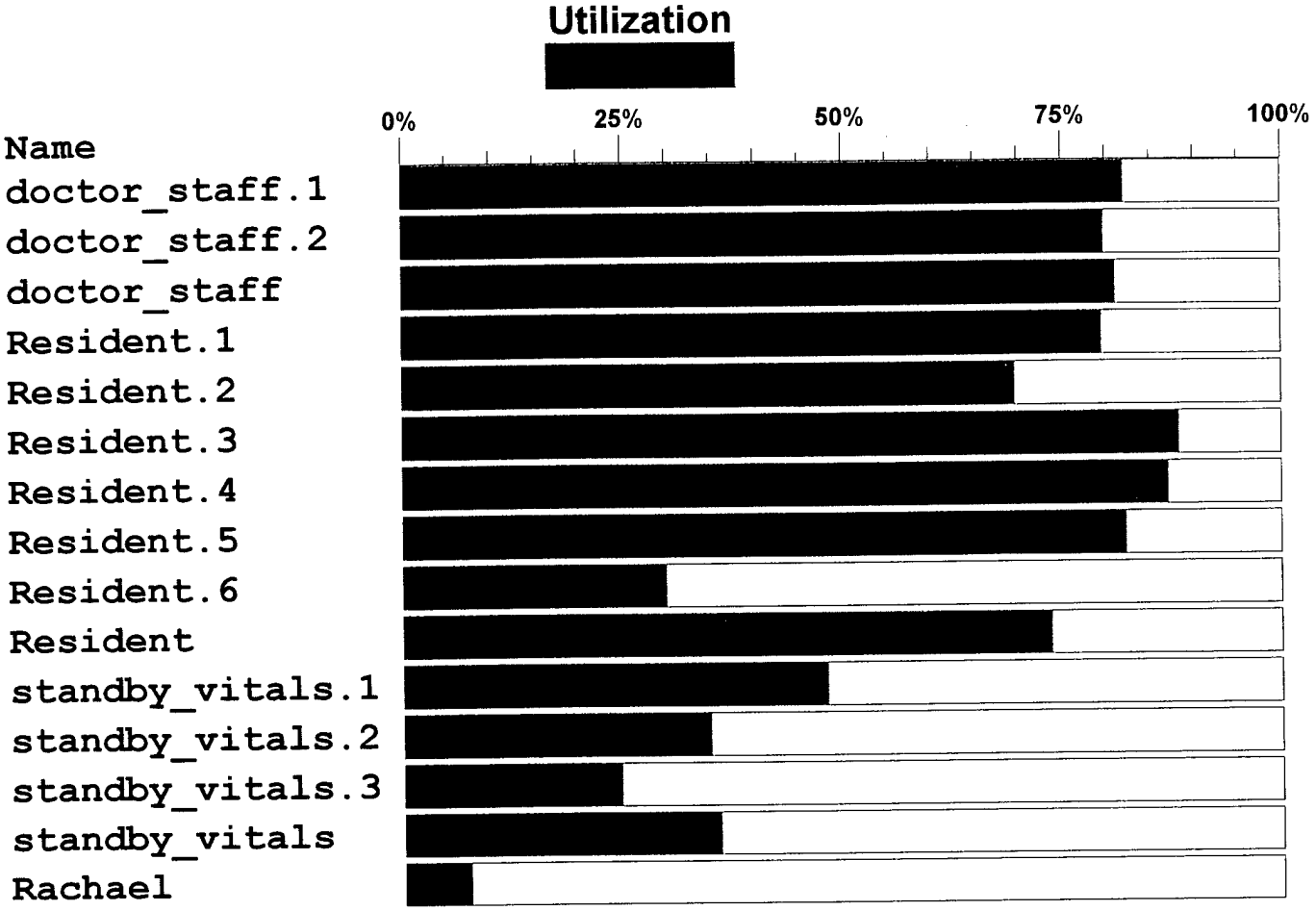

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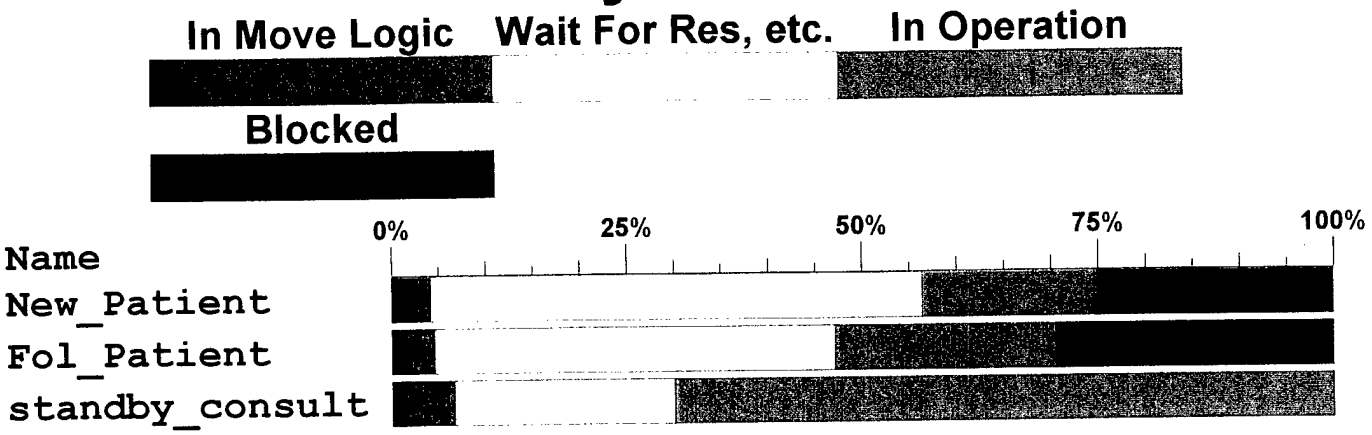

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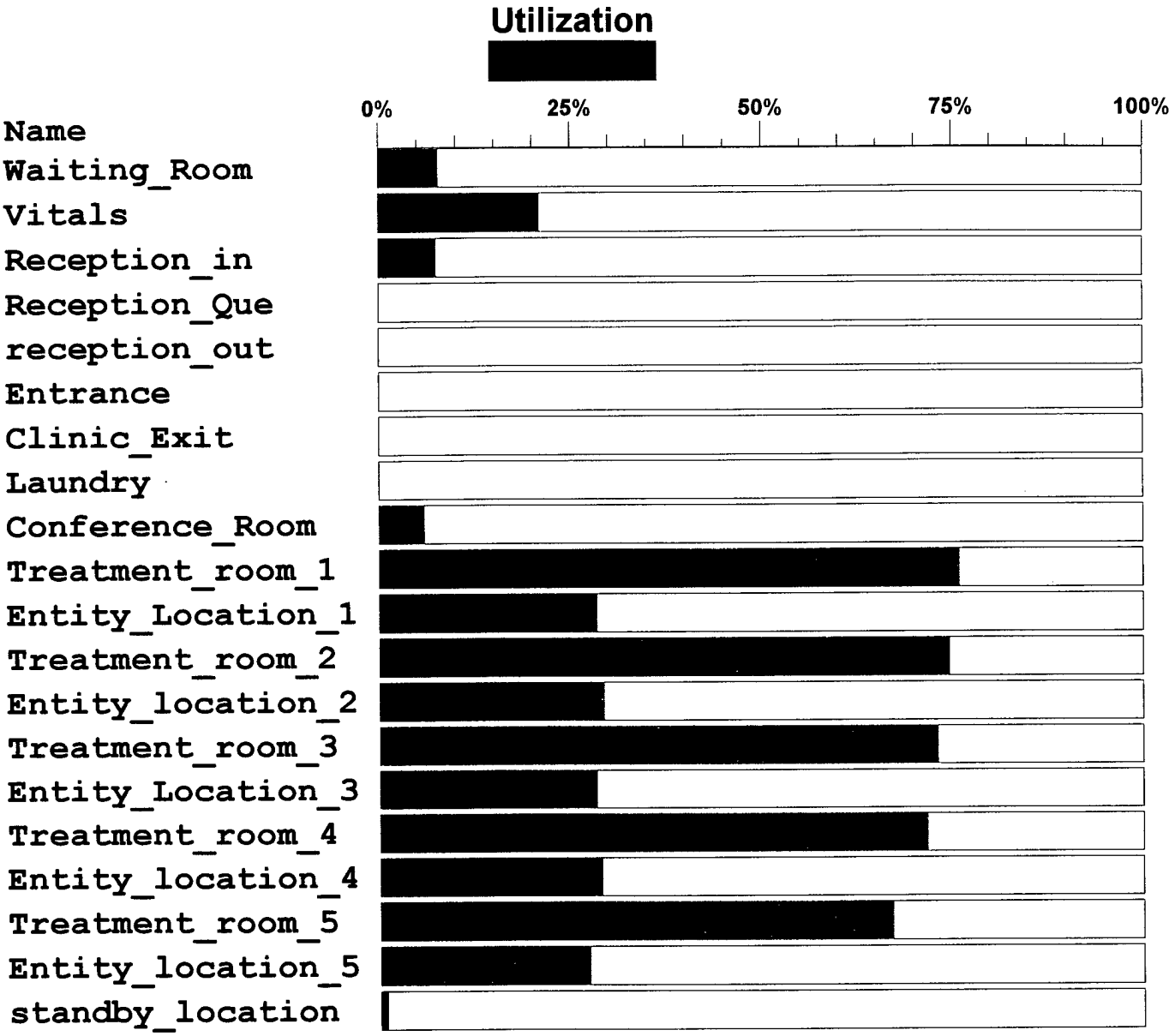
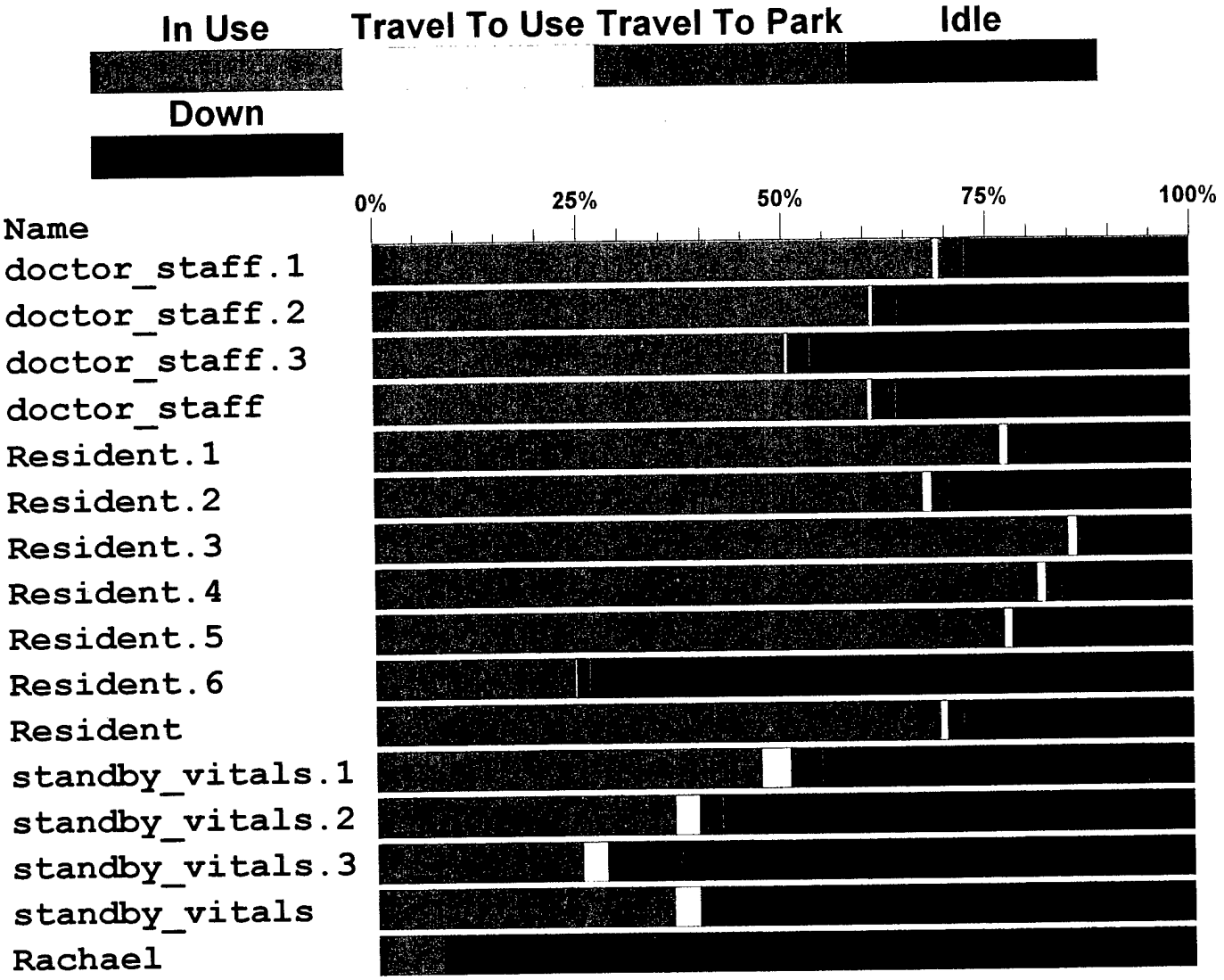


APPENDIX - F

Resource States



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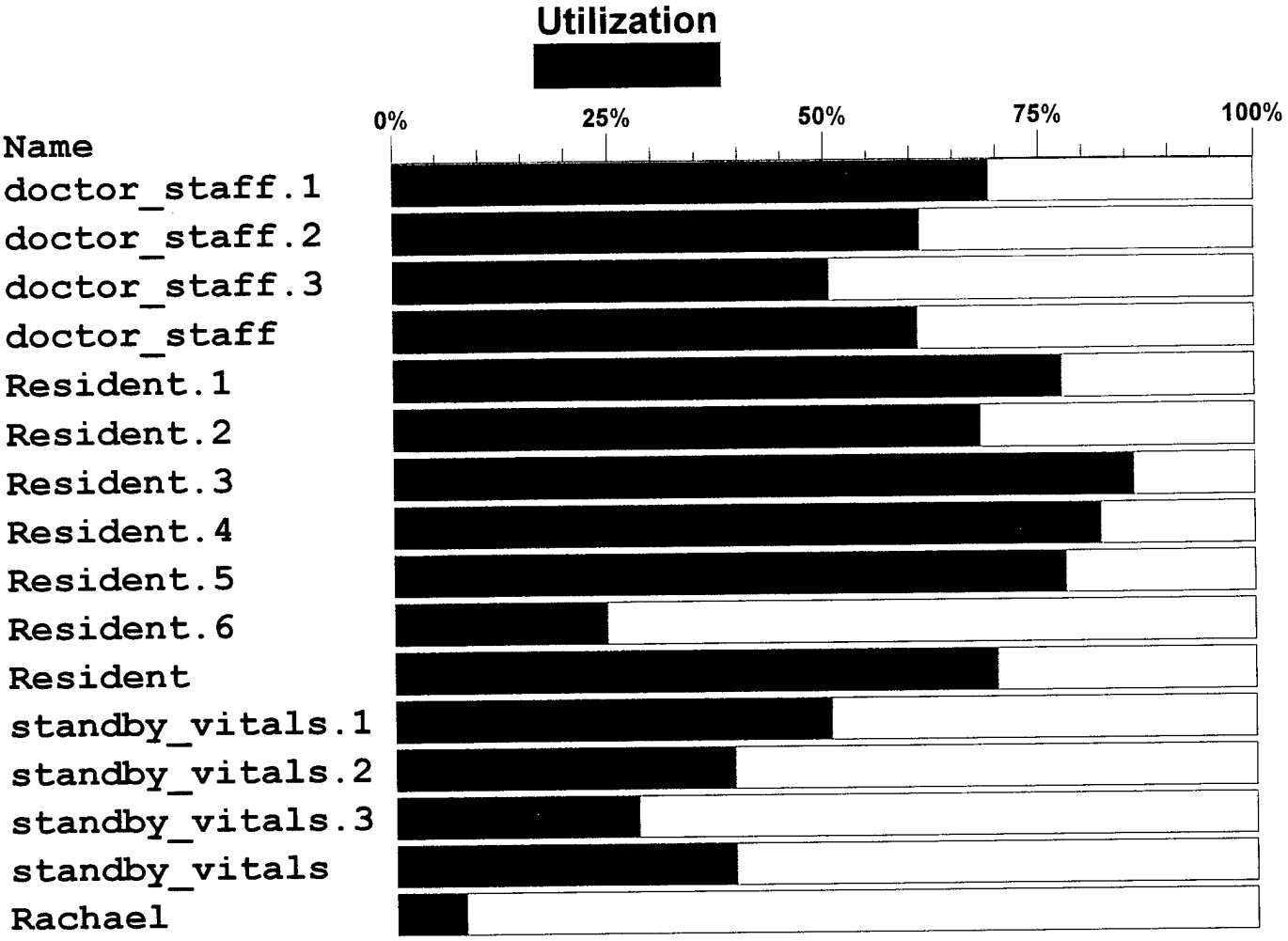

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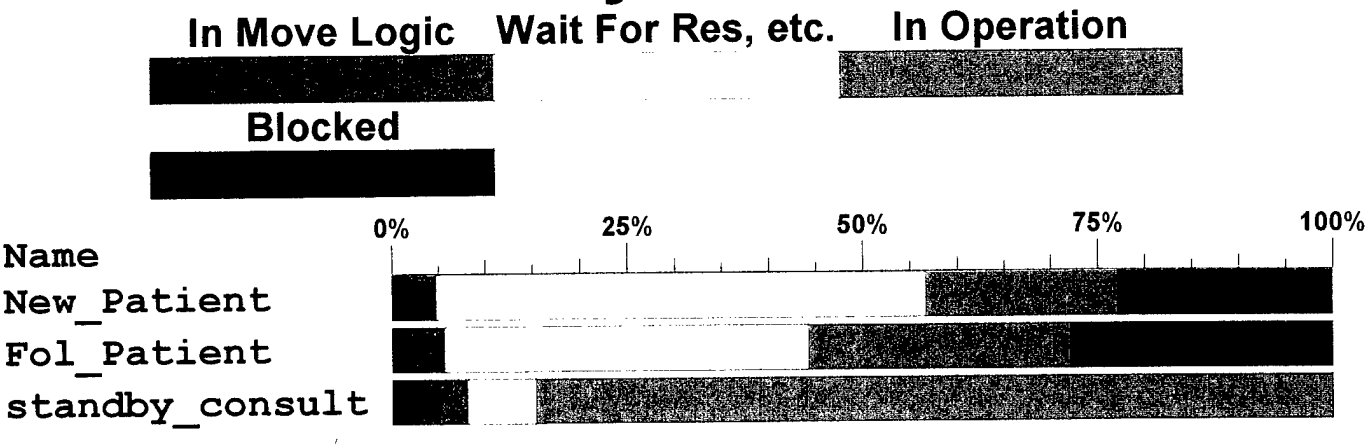

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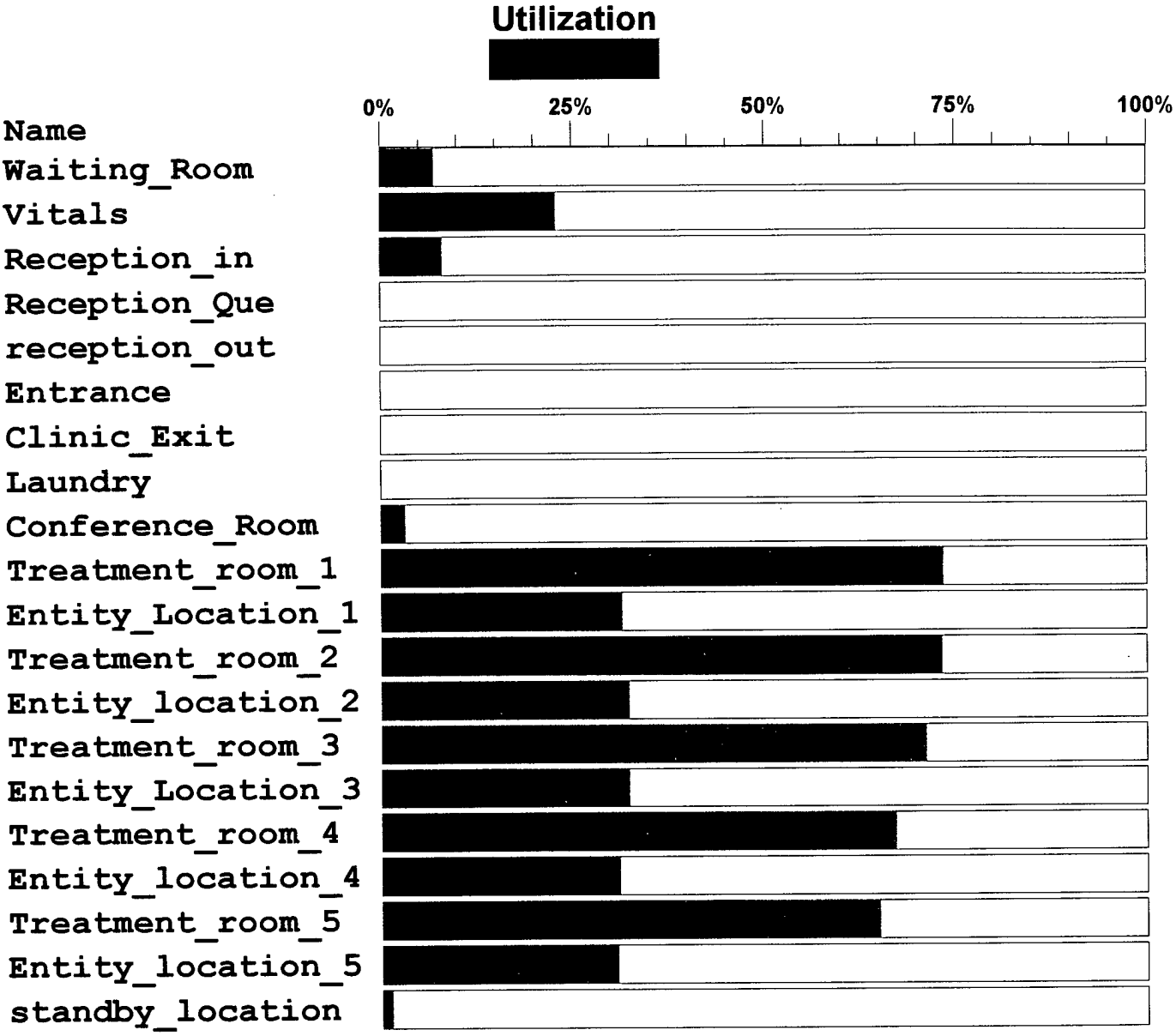
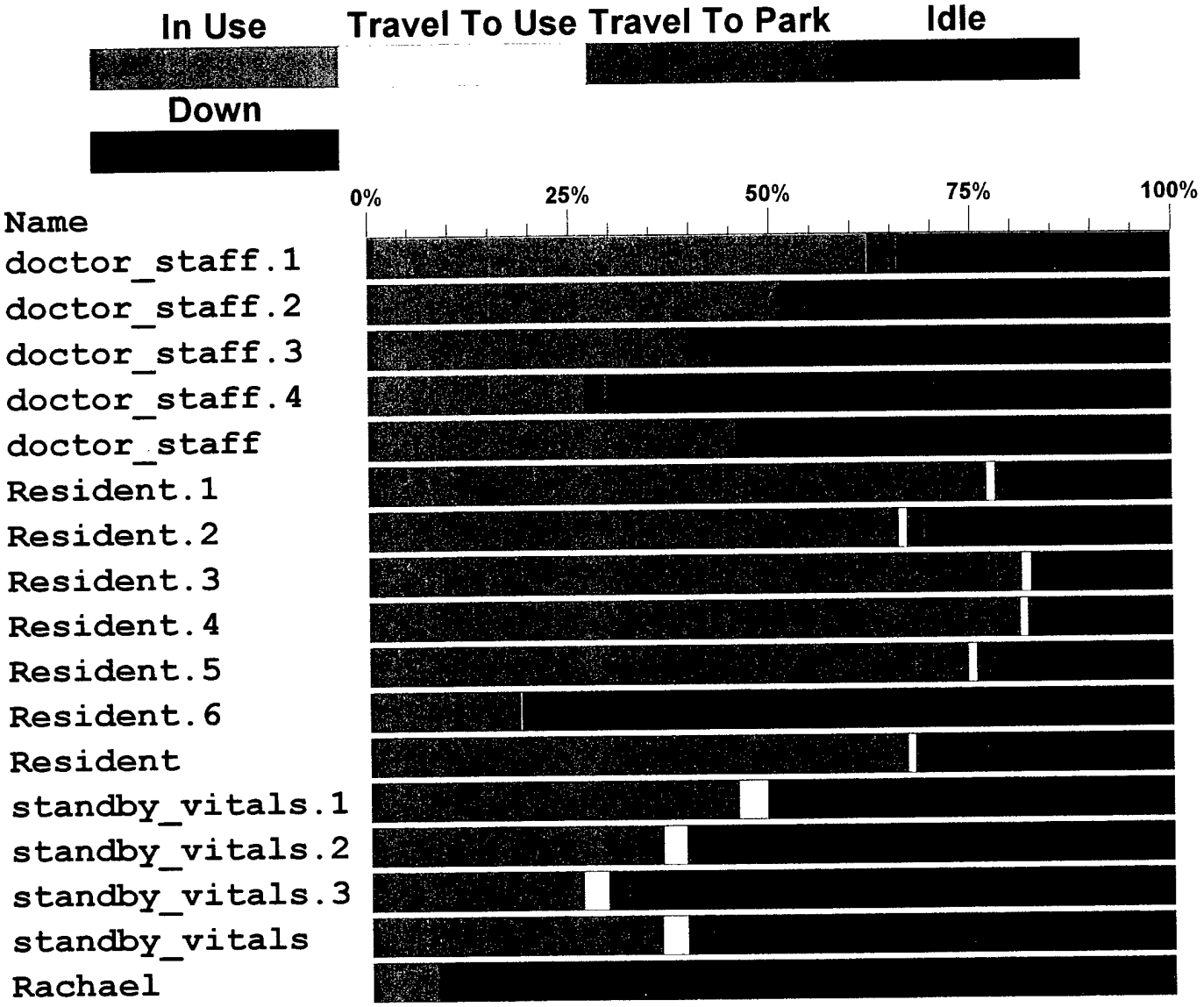


APPENDIX - G

Resource States



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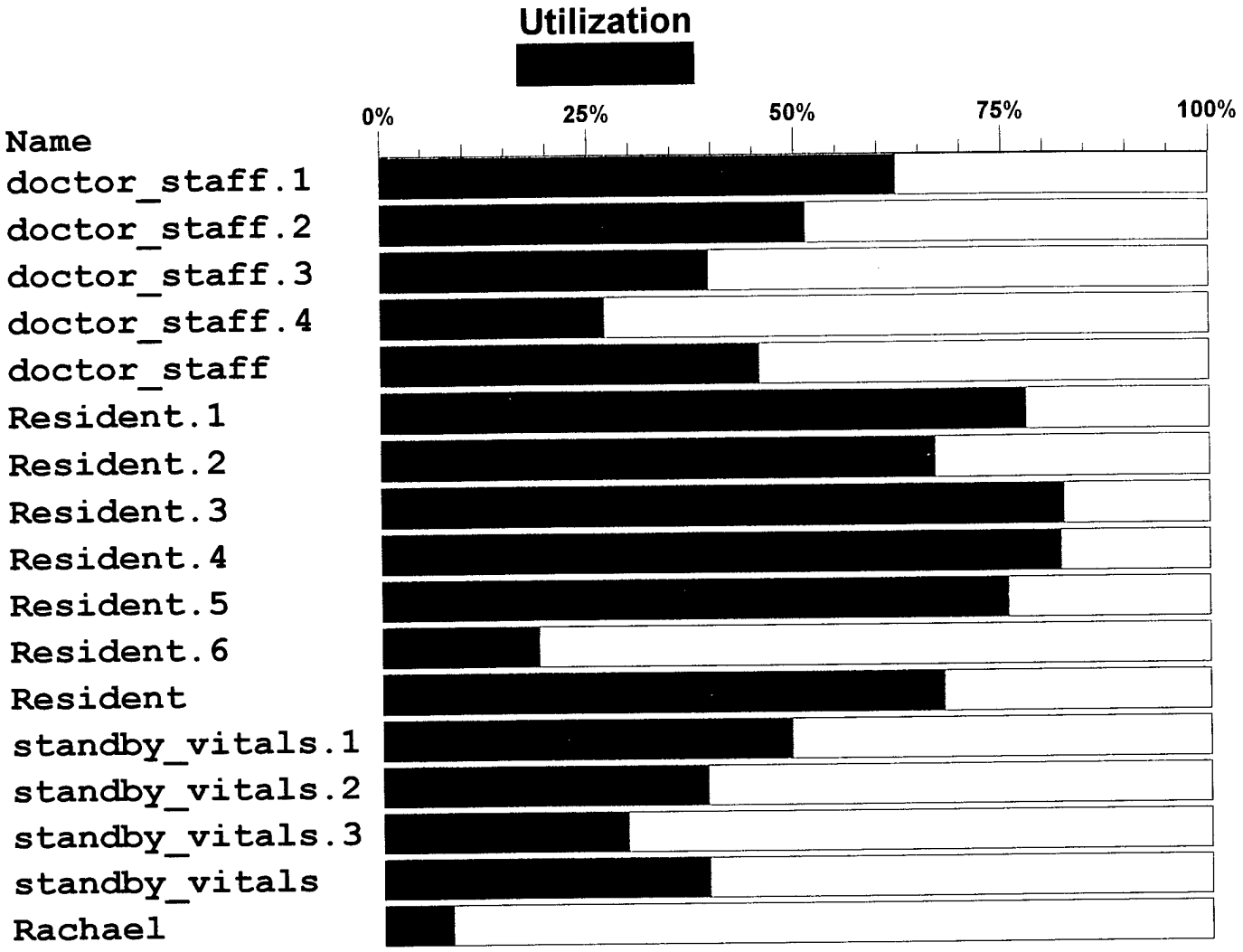

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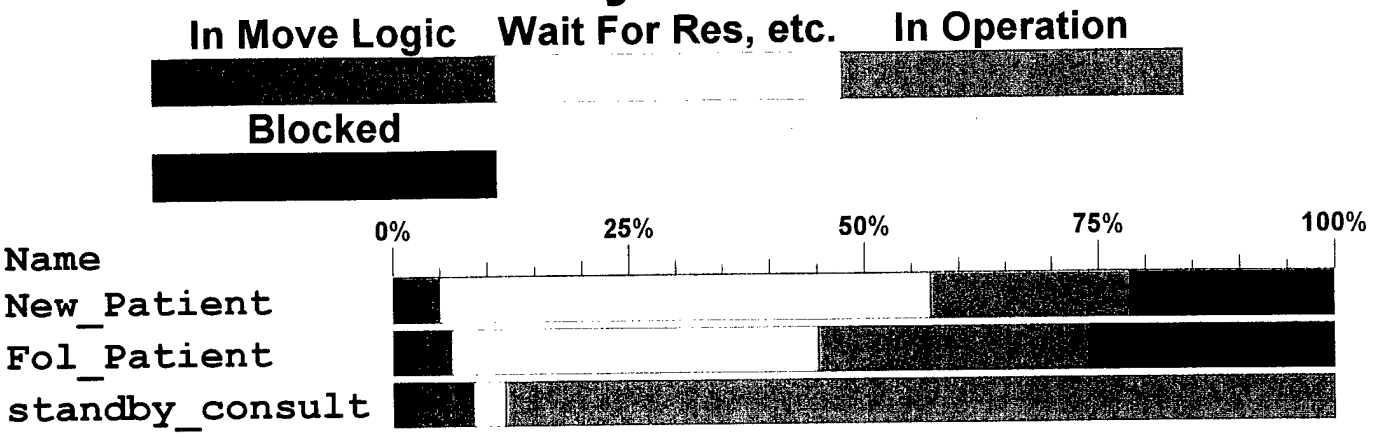

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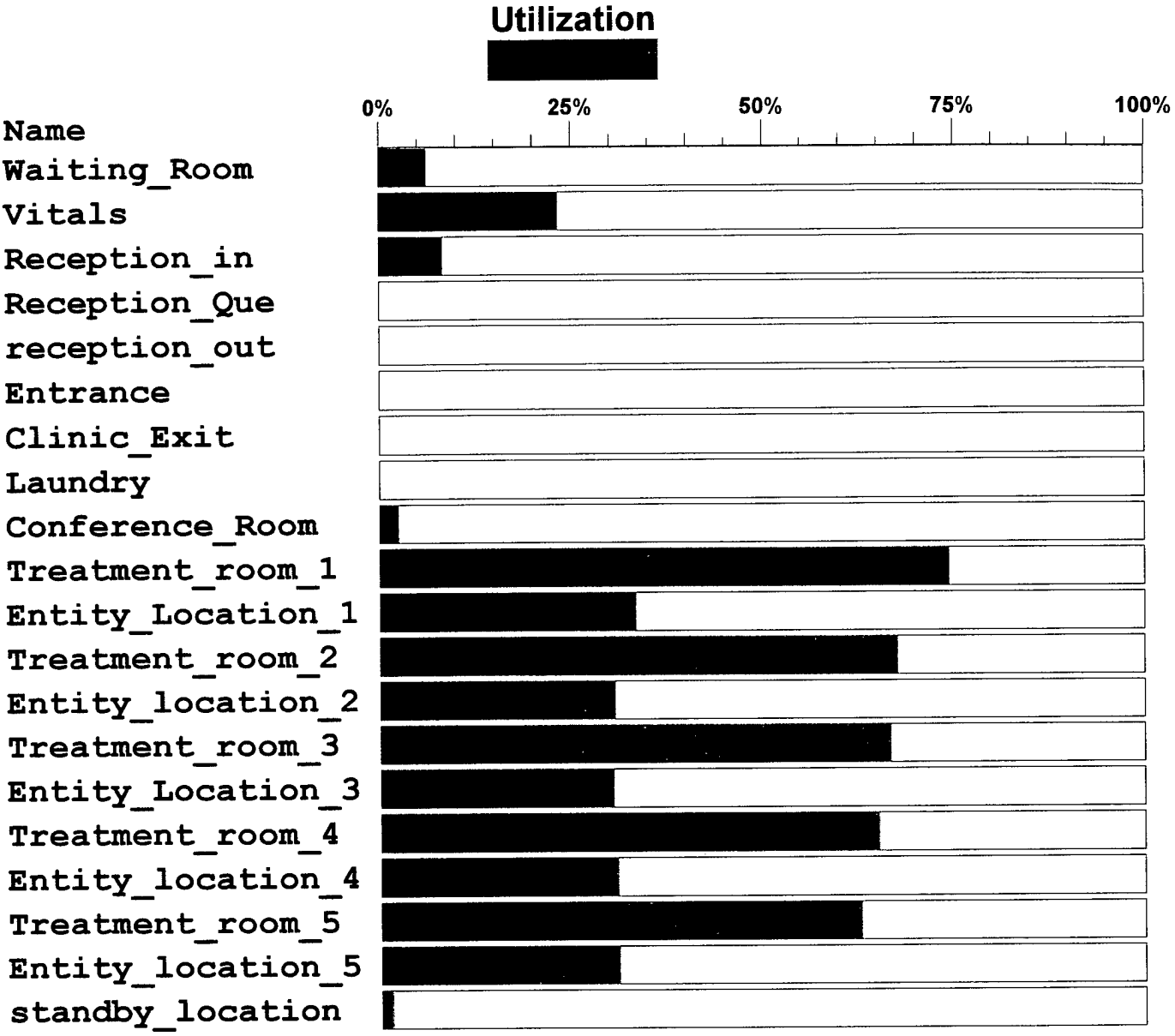
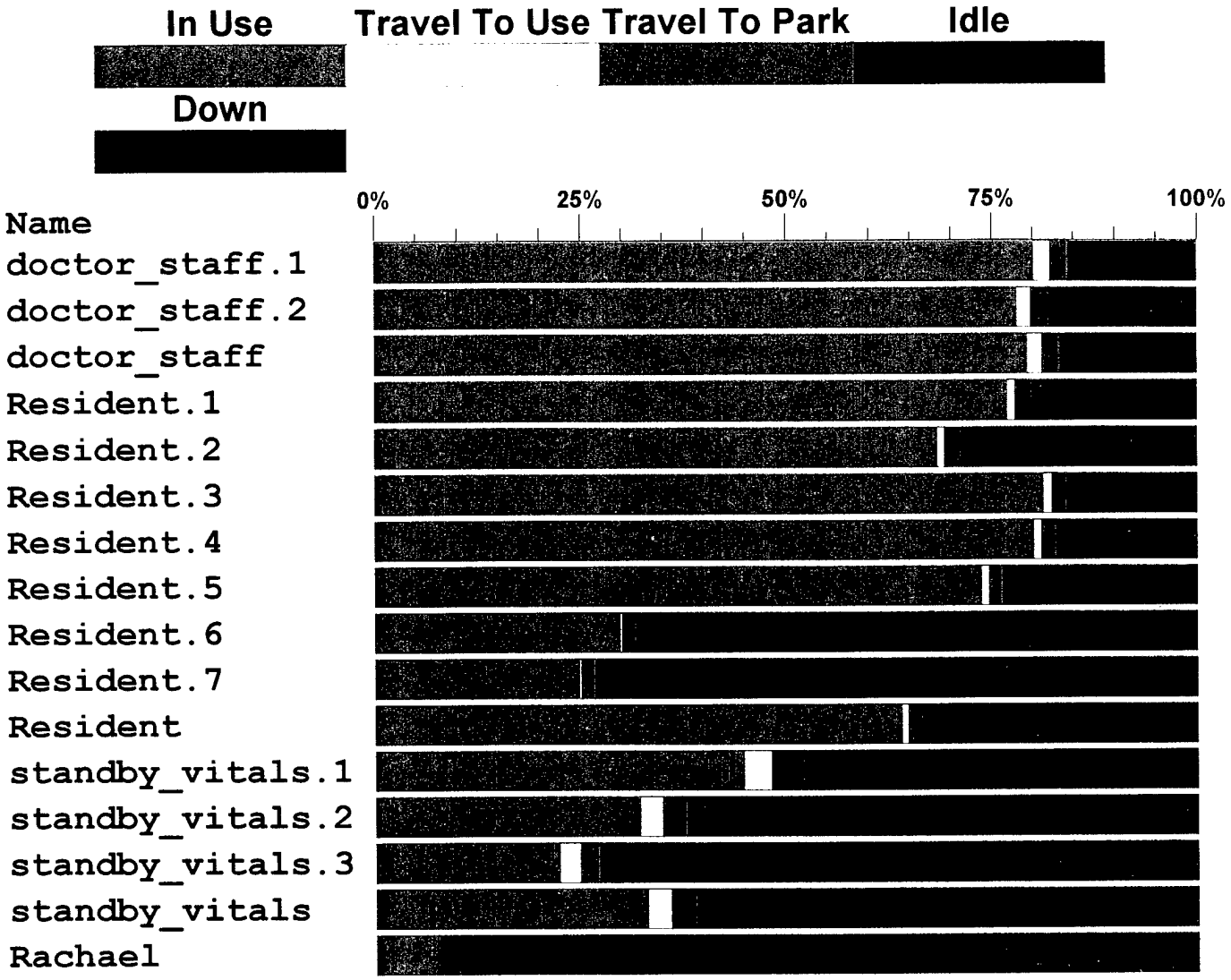


APPENDIX - H

Resource States



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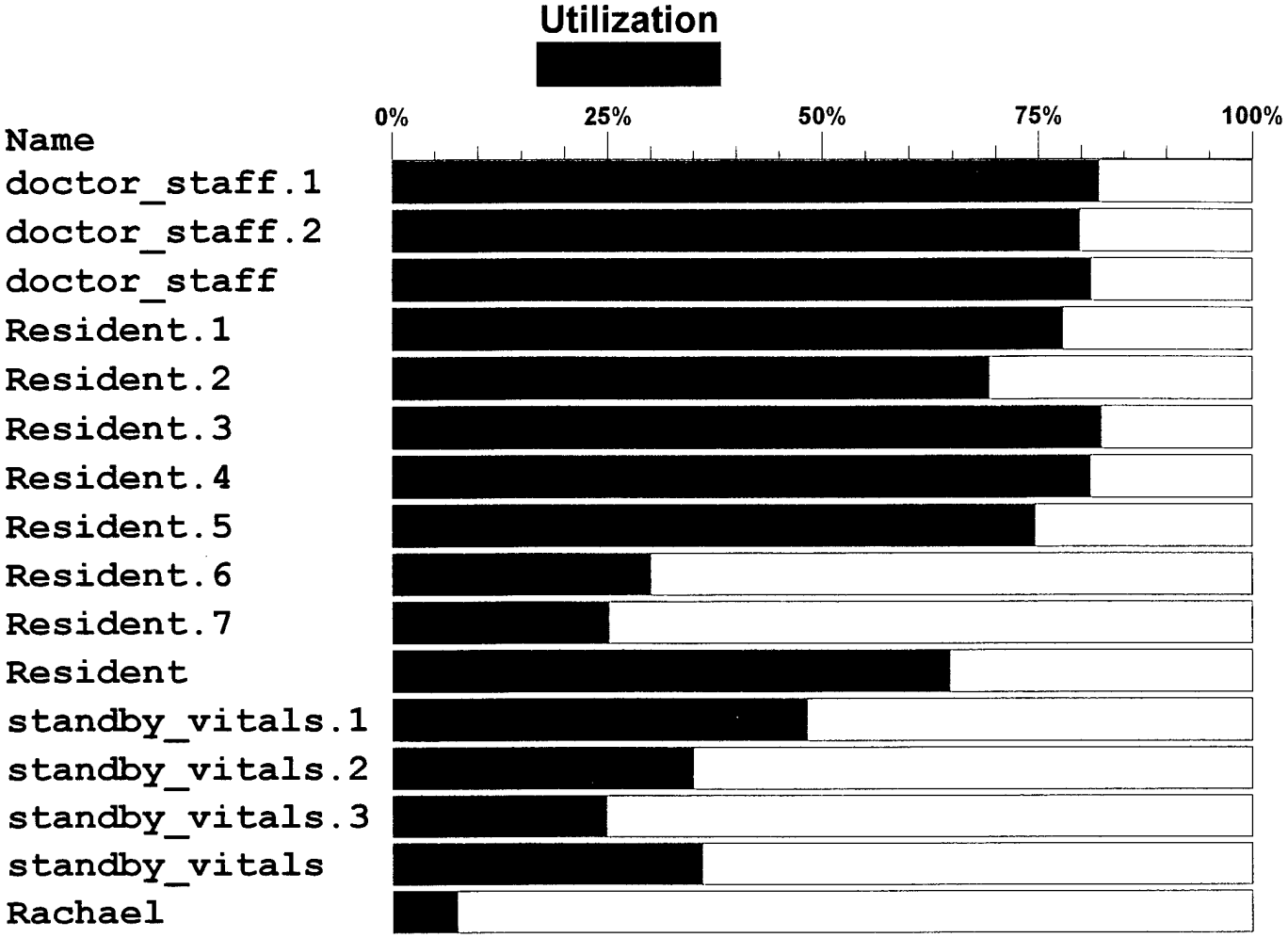

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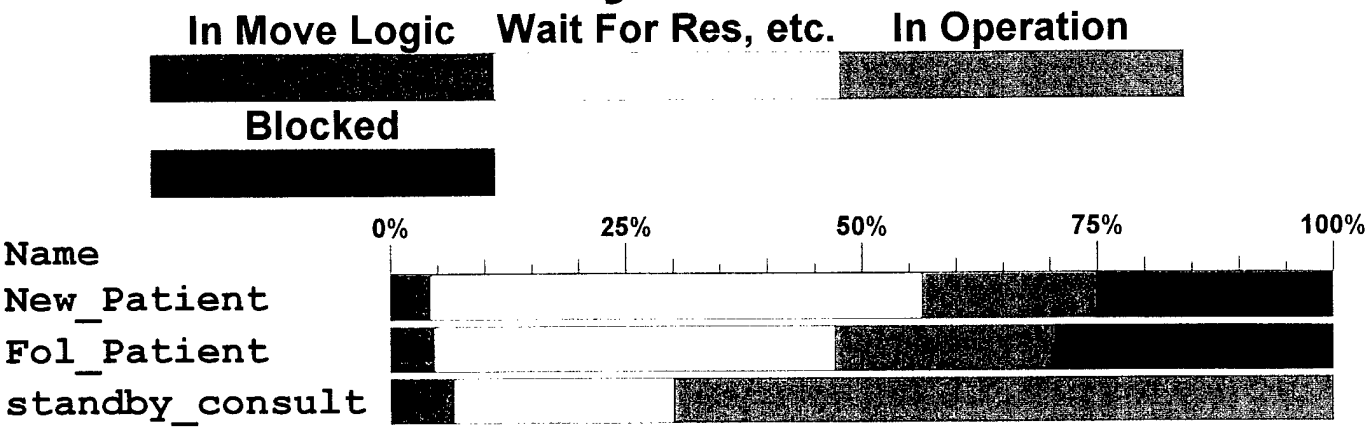

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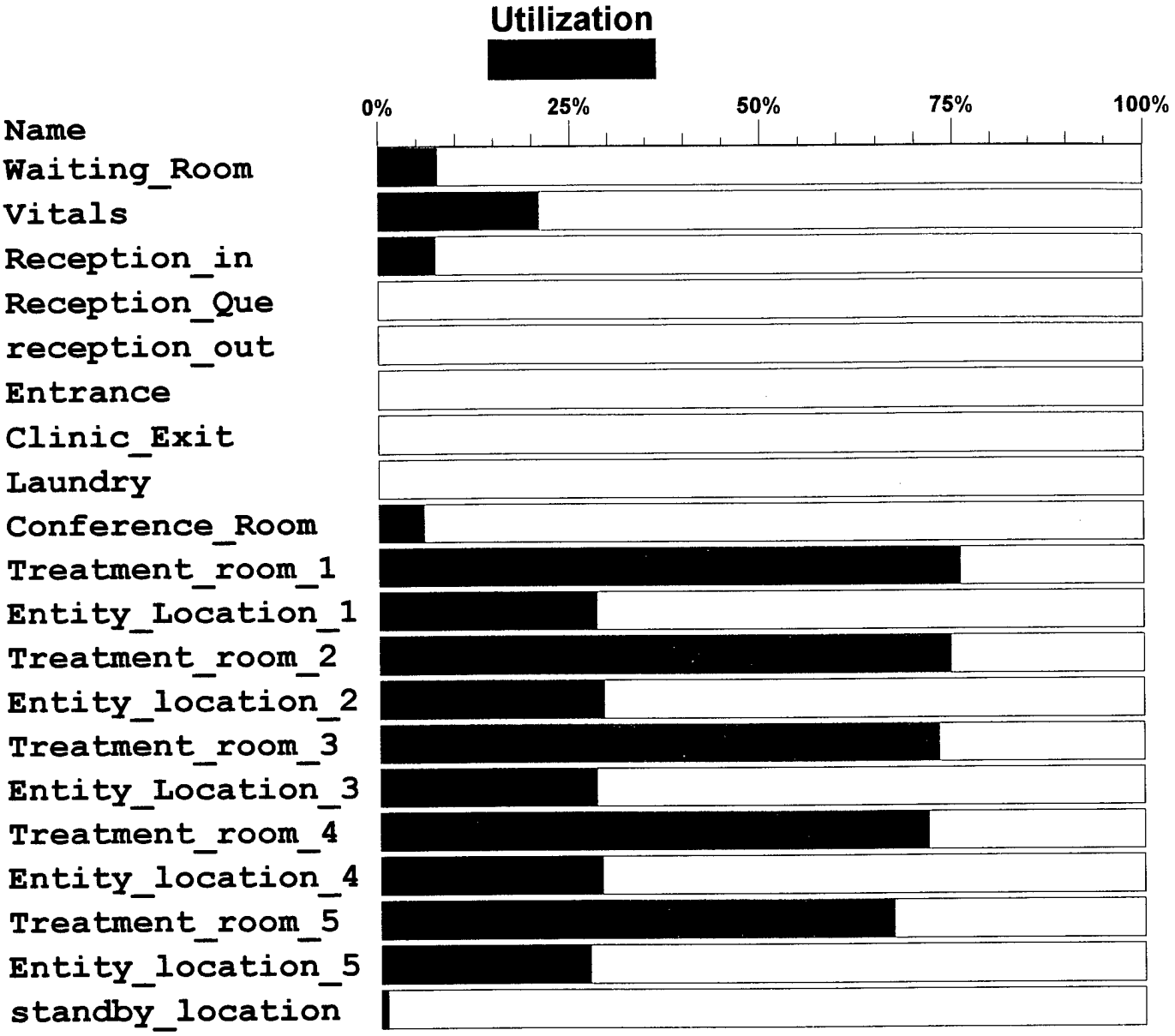
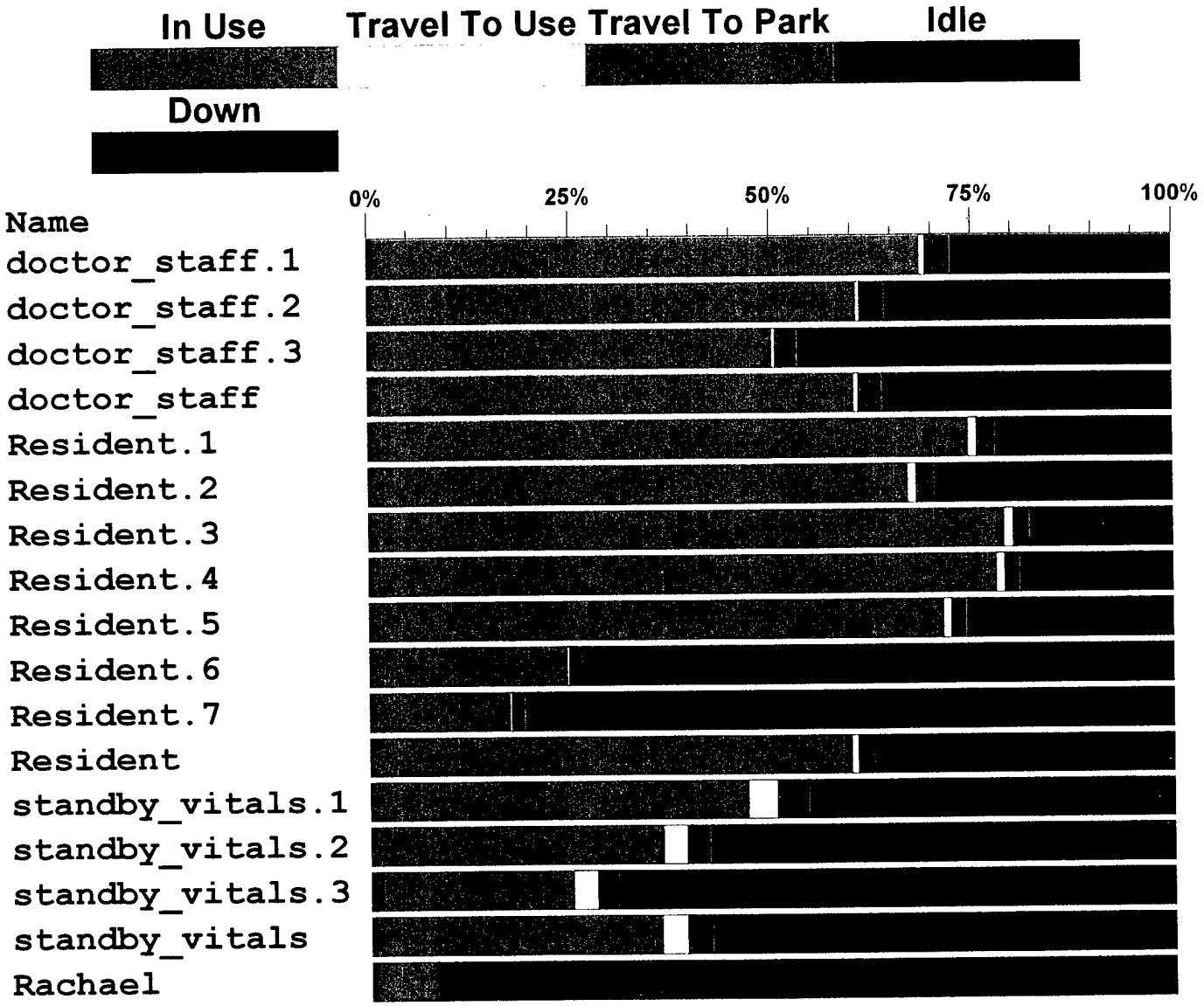


APPENDIX - I

Resource States



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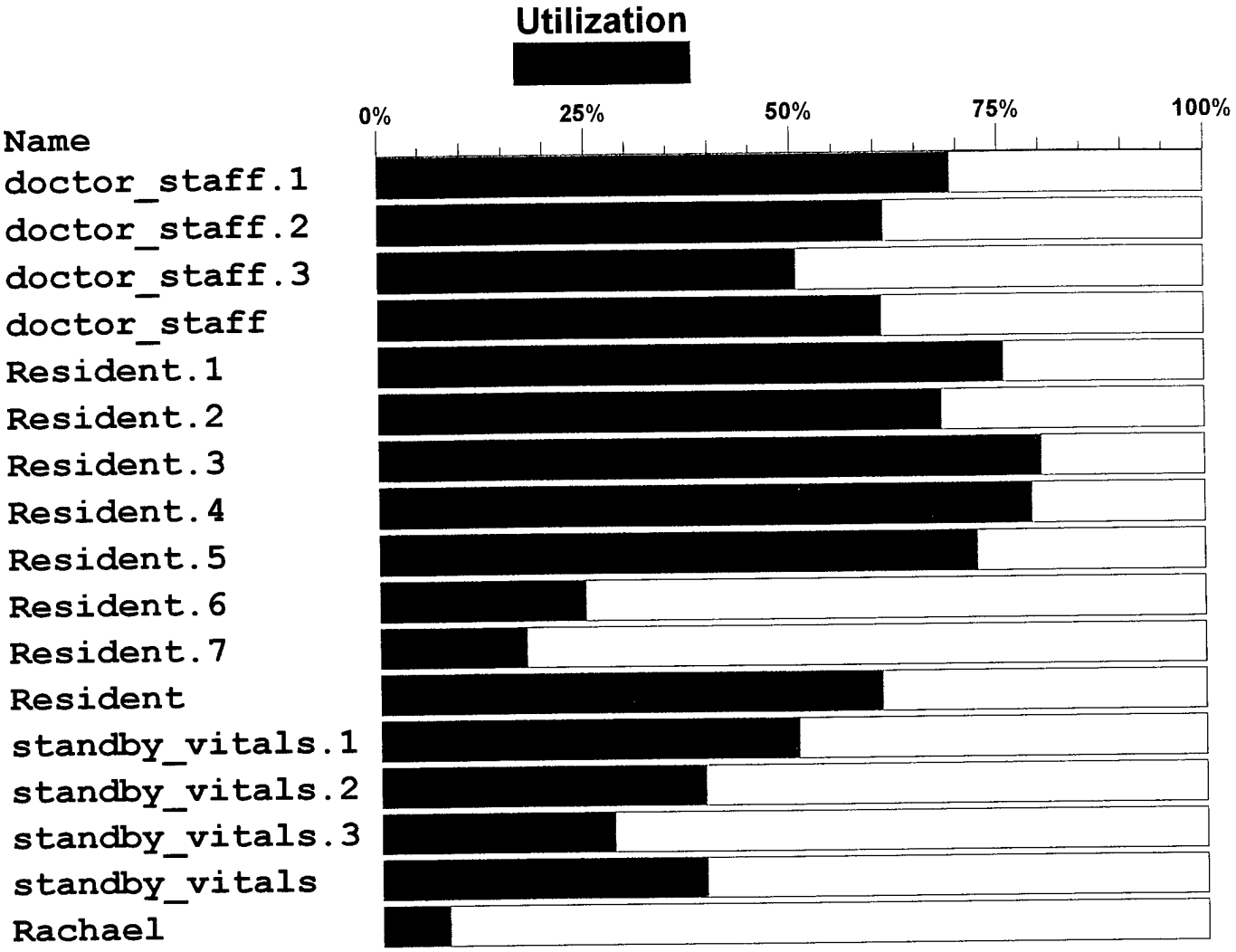

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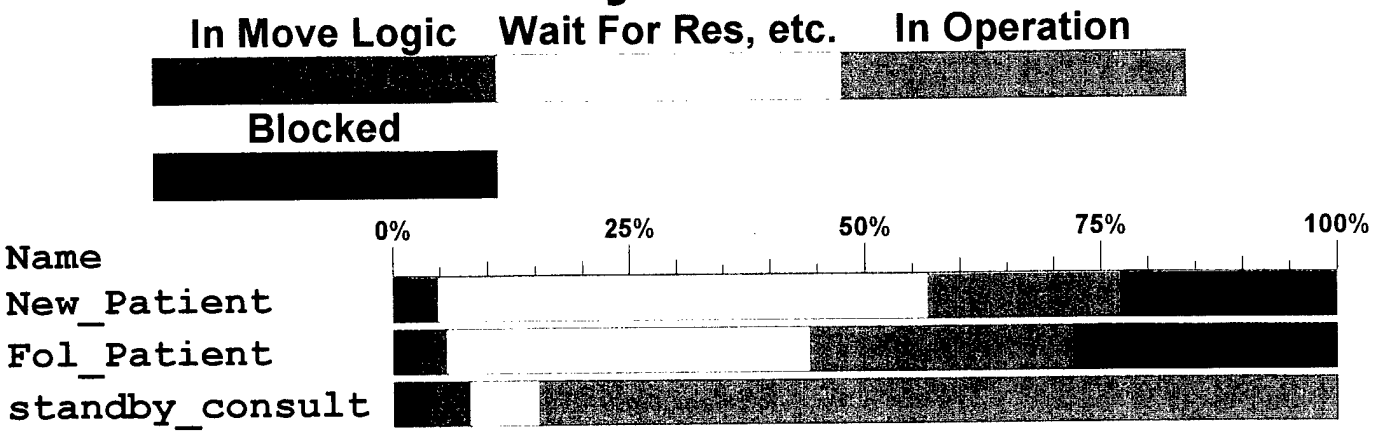

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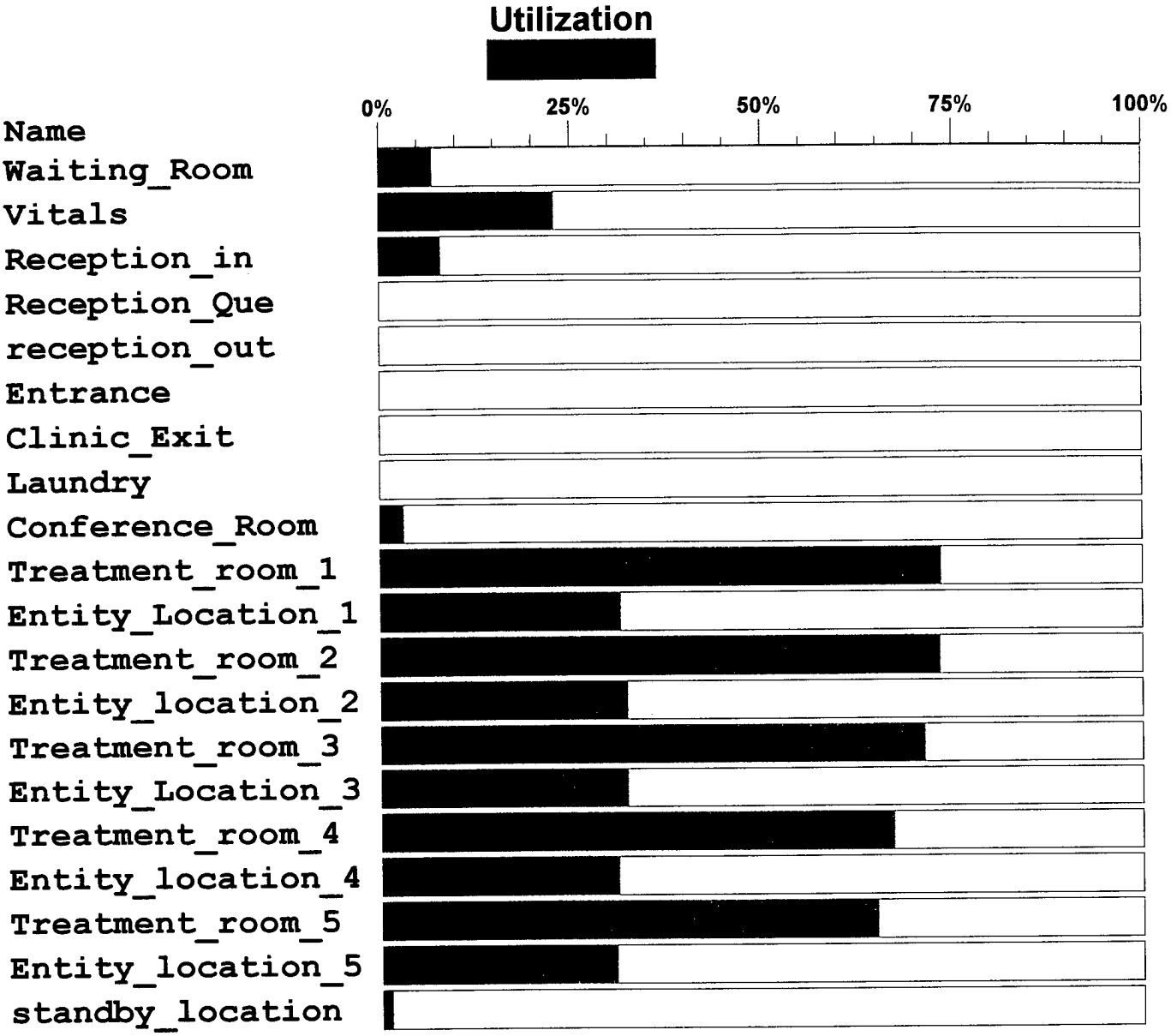
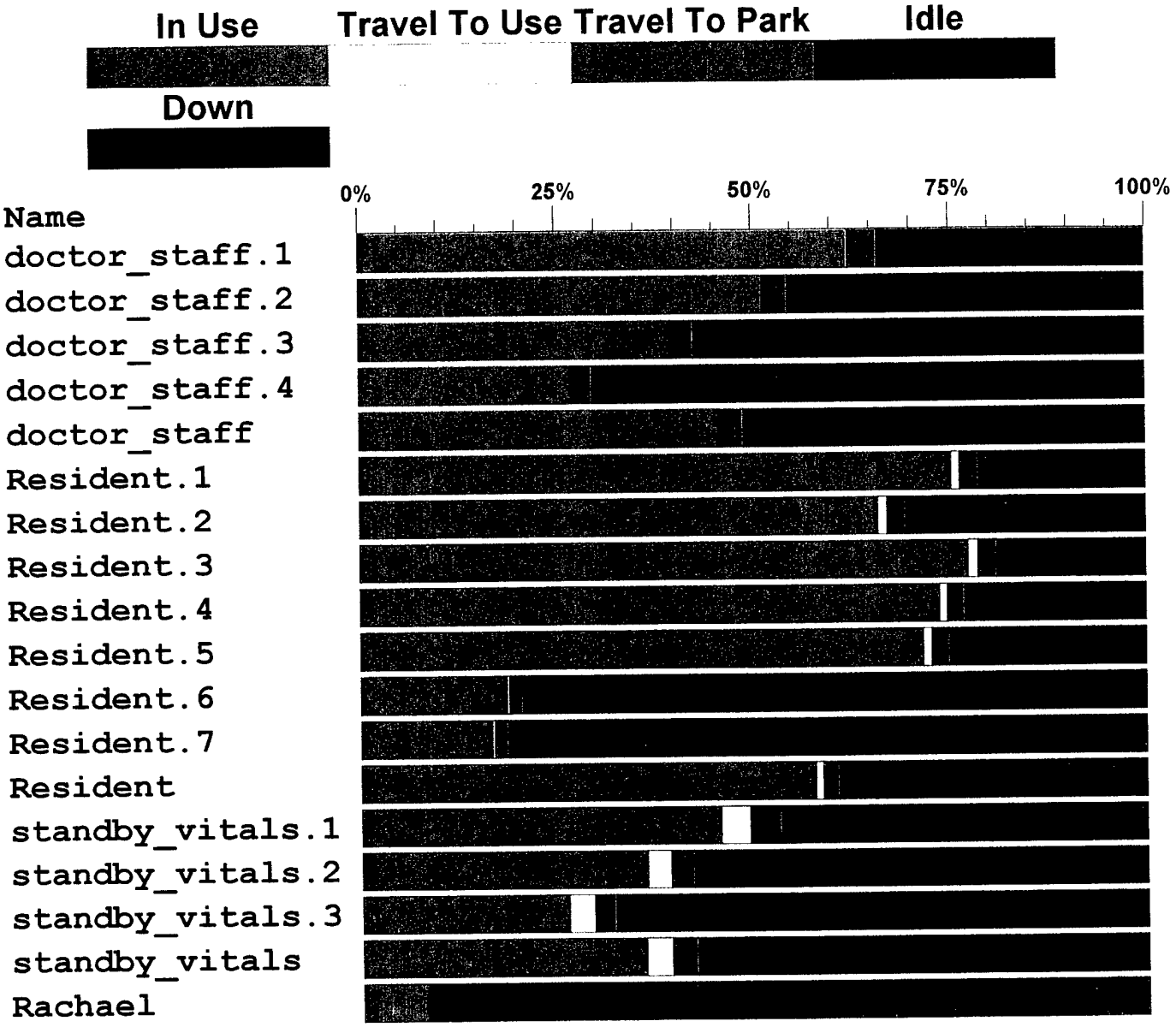


APPENDIX - J

Resource States



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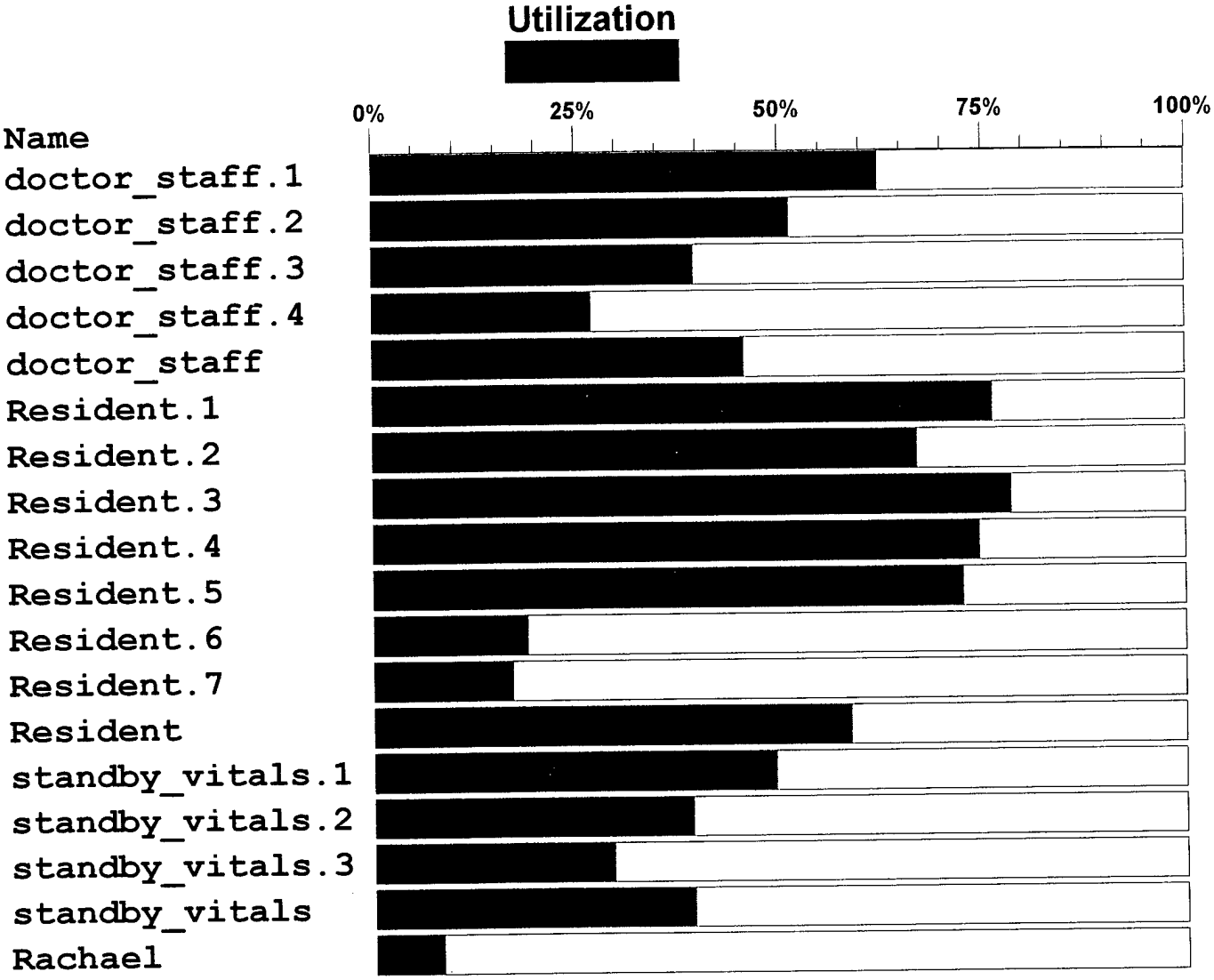

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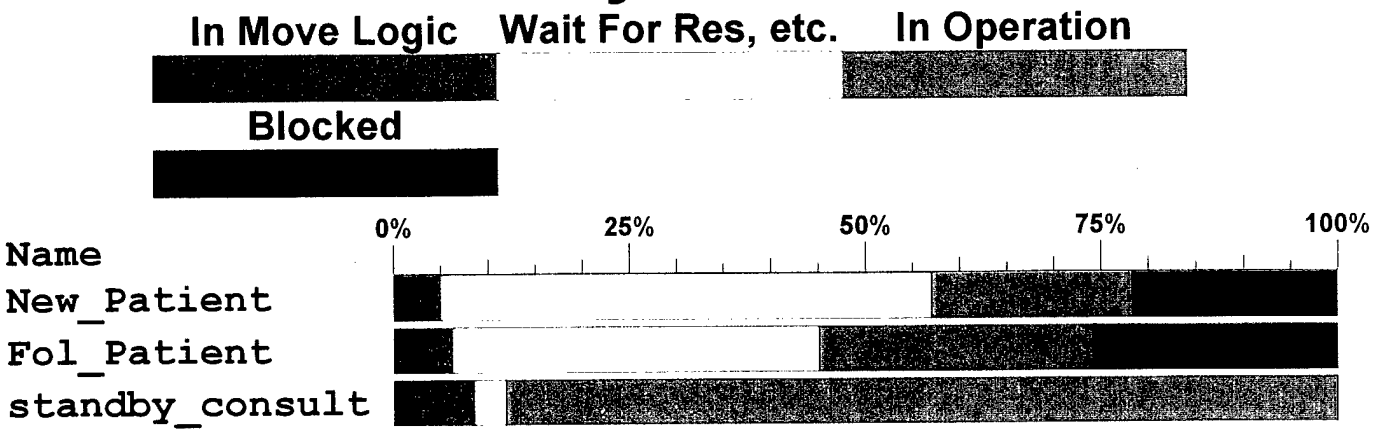

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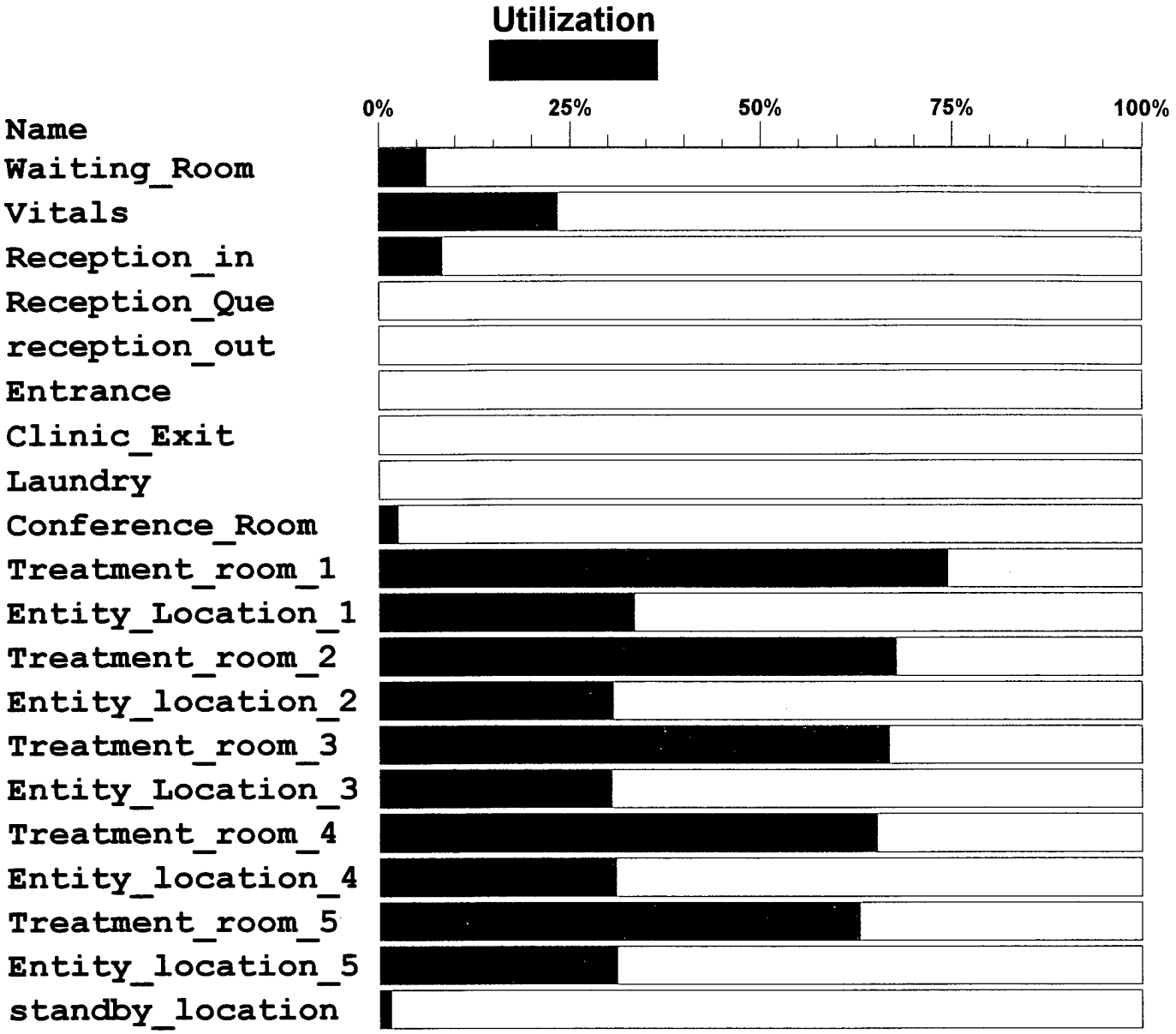
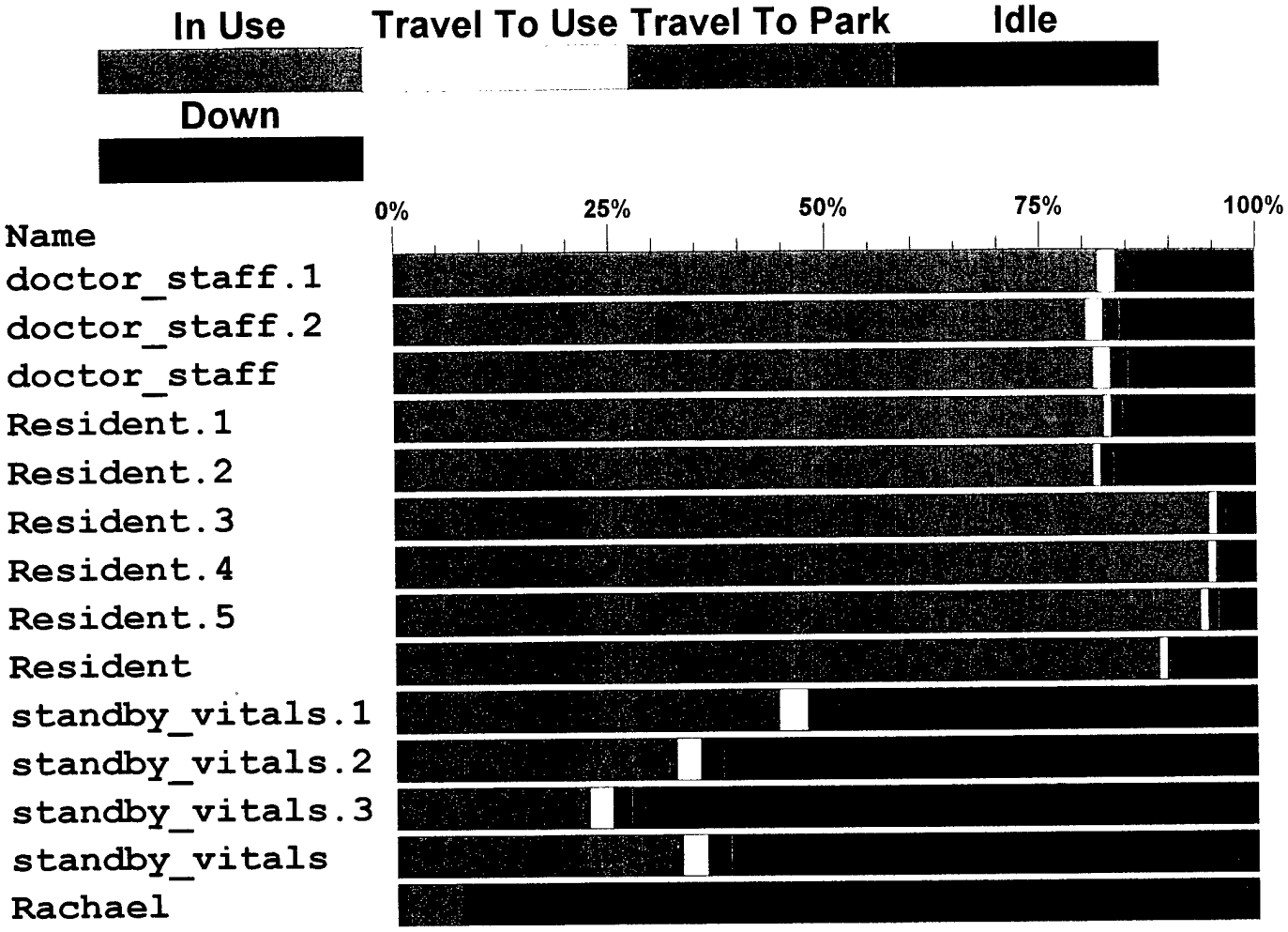


APPENDIX - K

Resource States



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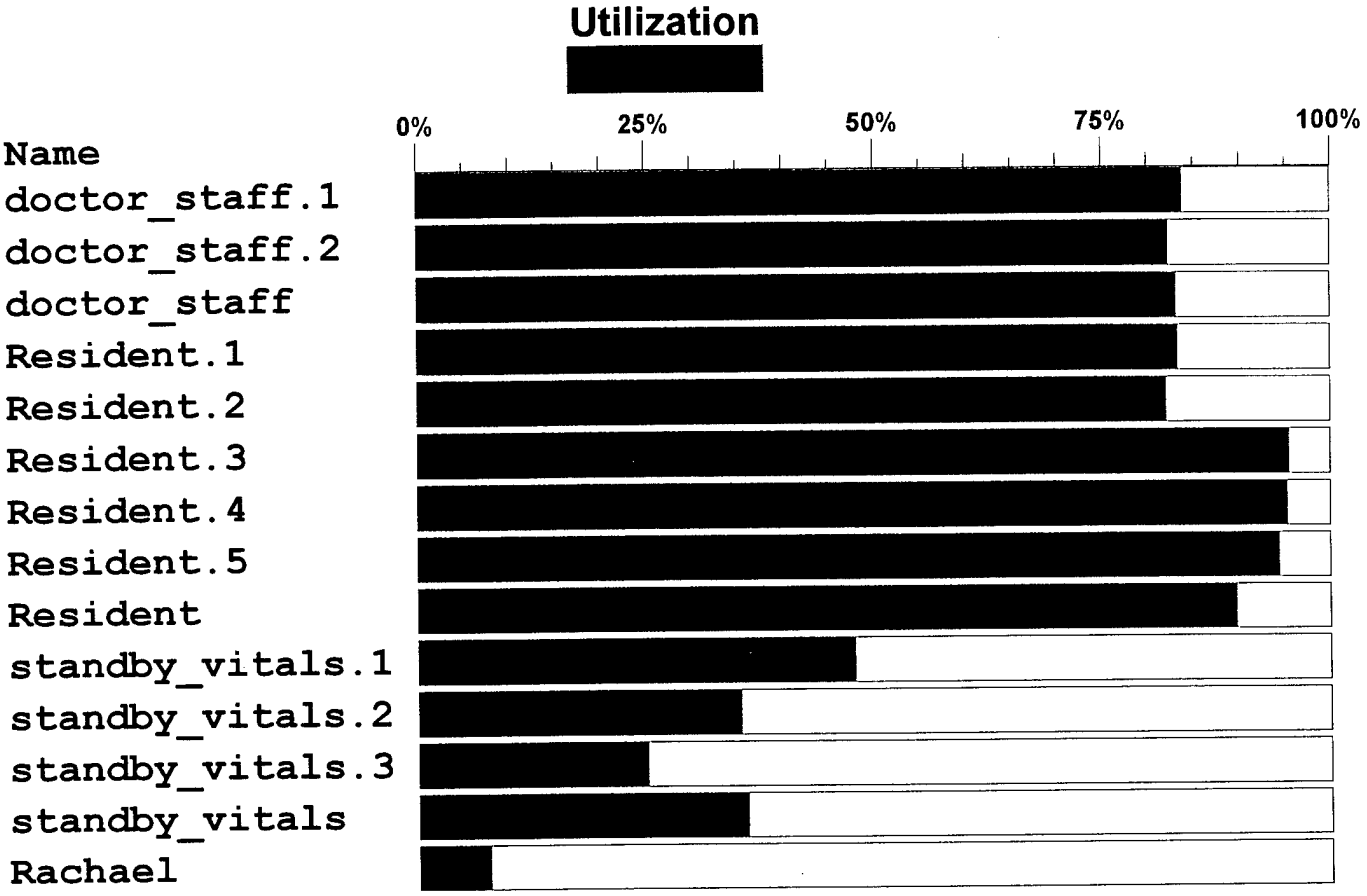

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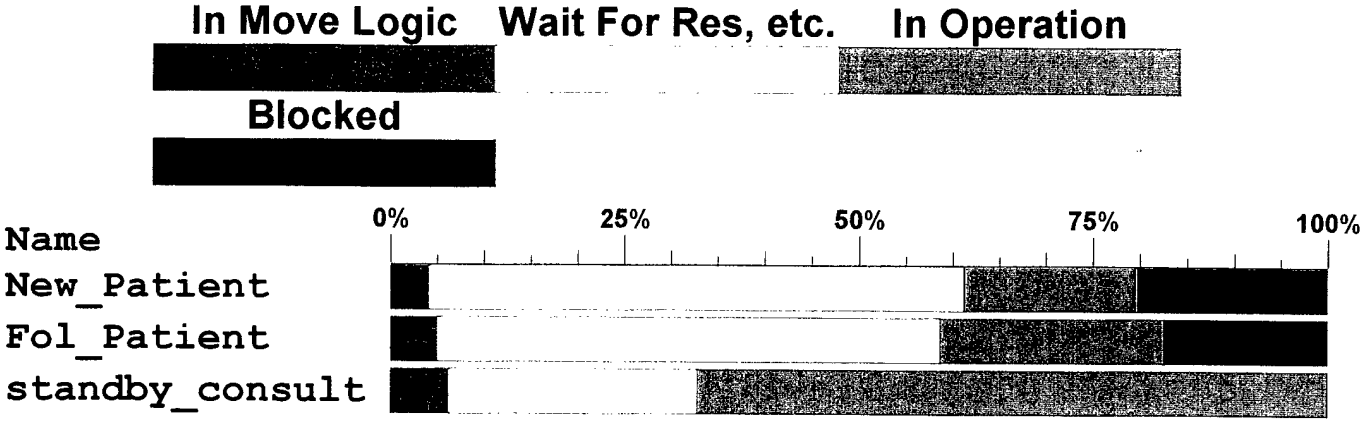

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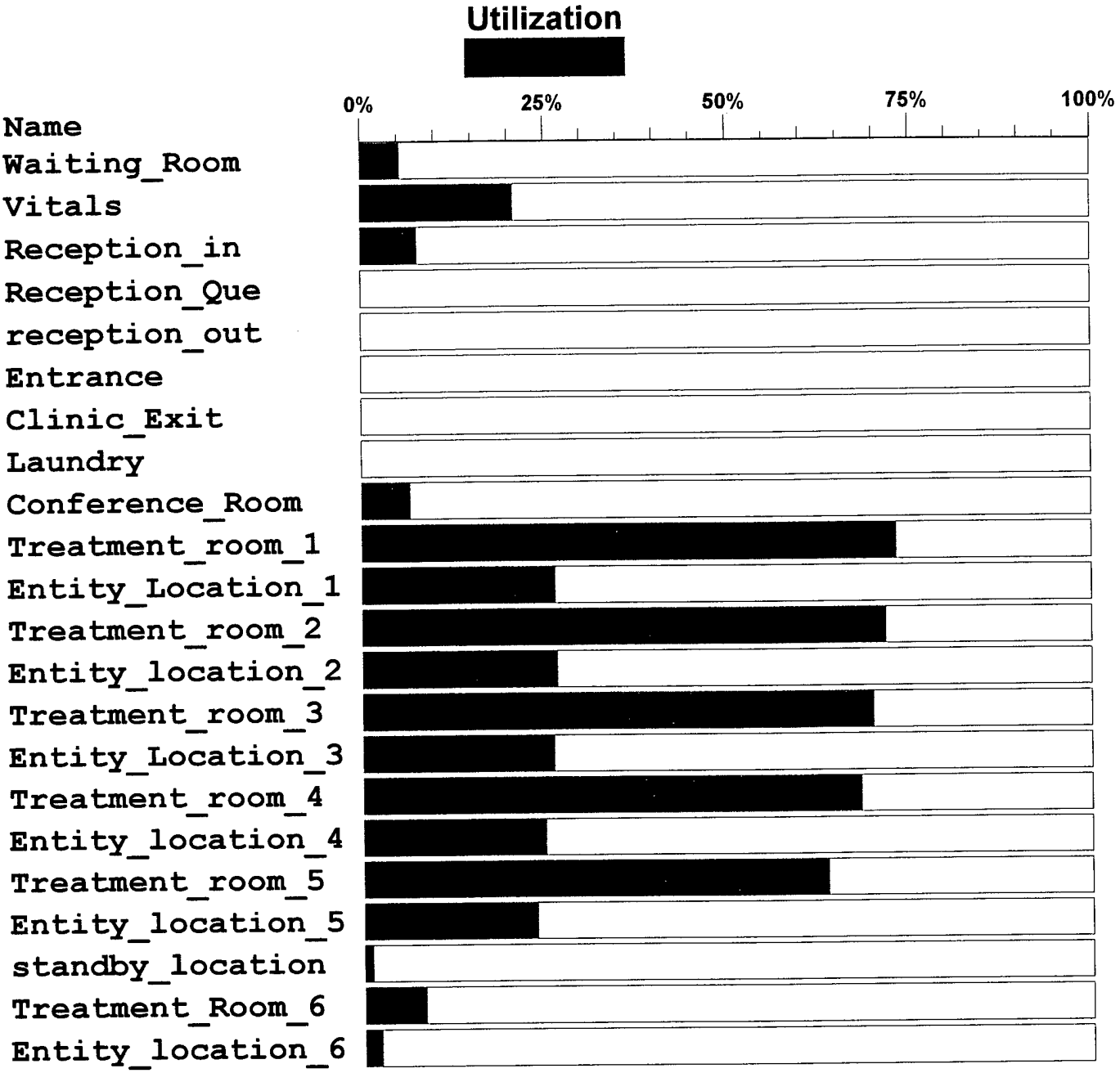
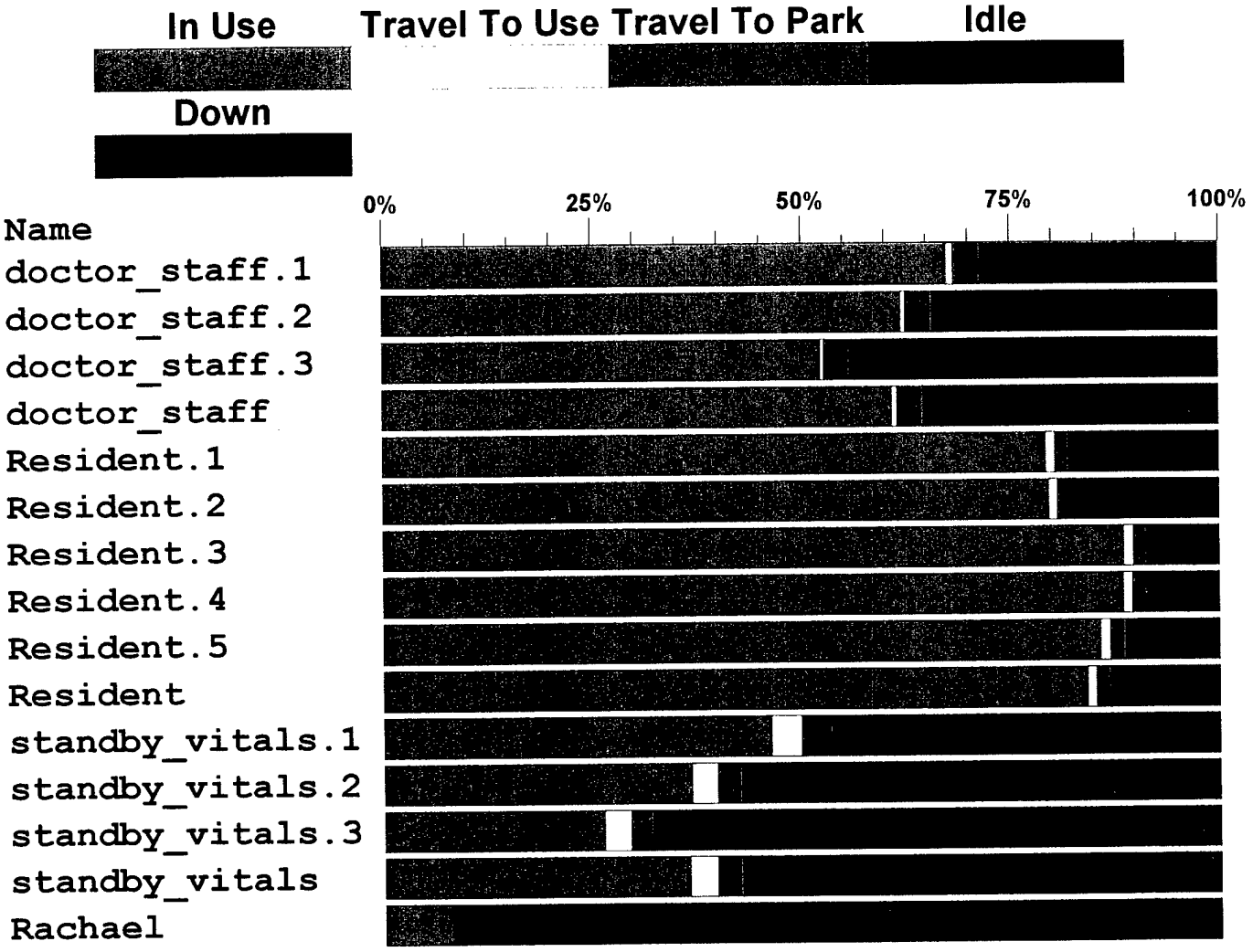


APPENDIX - L

Resource States



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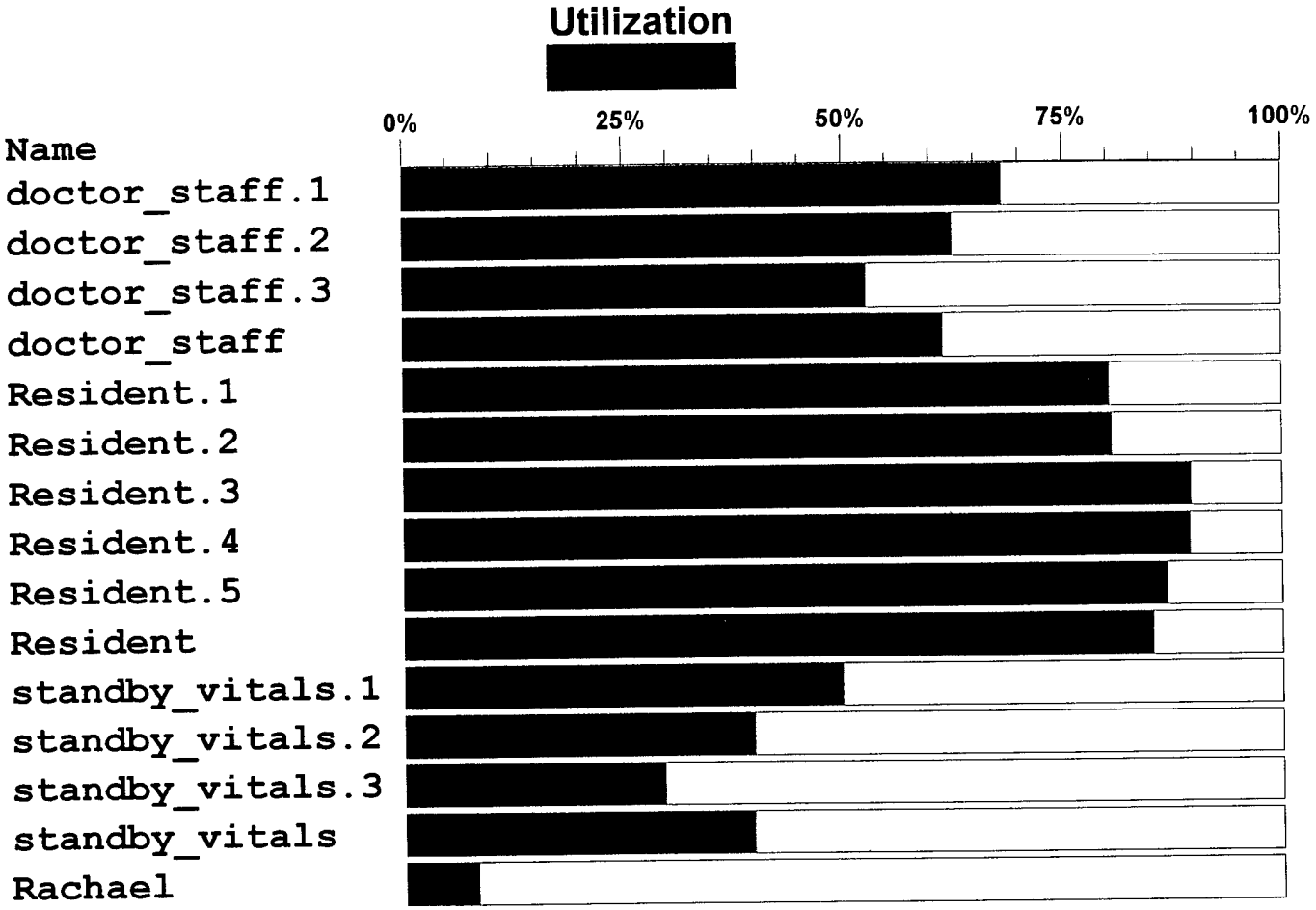

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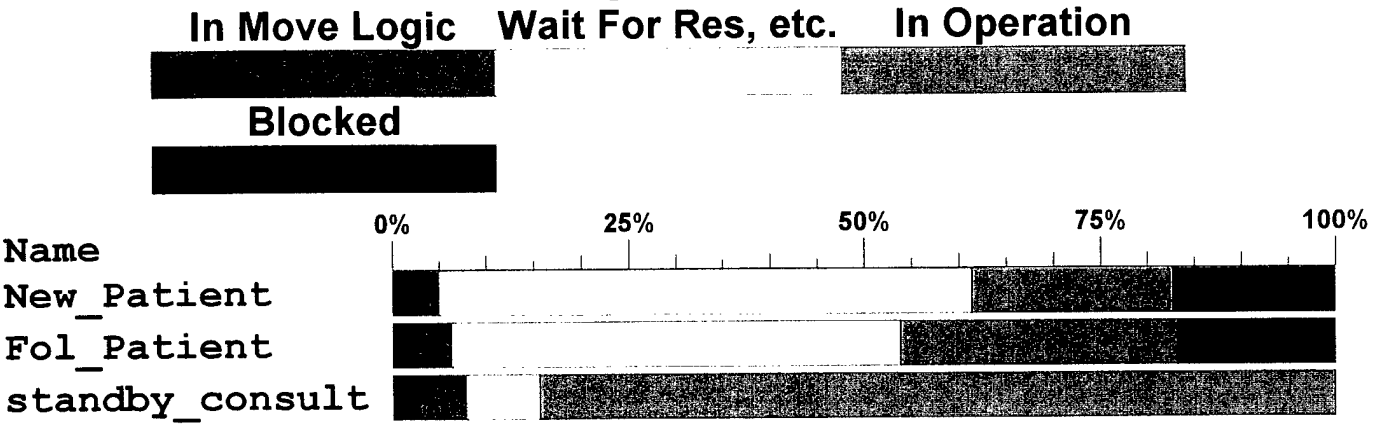

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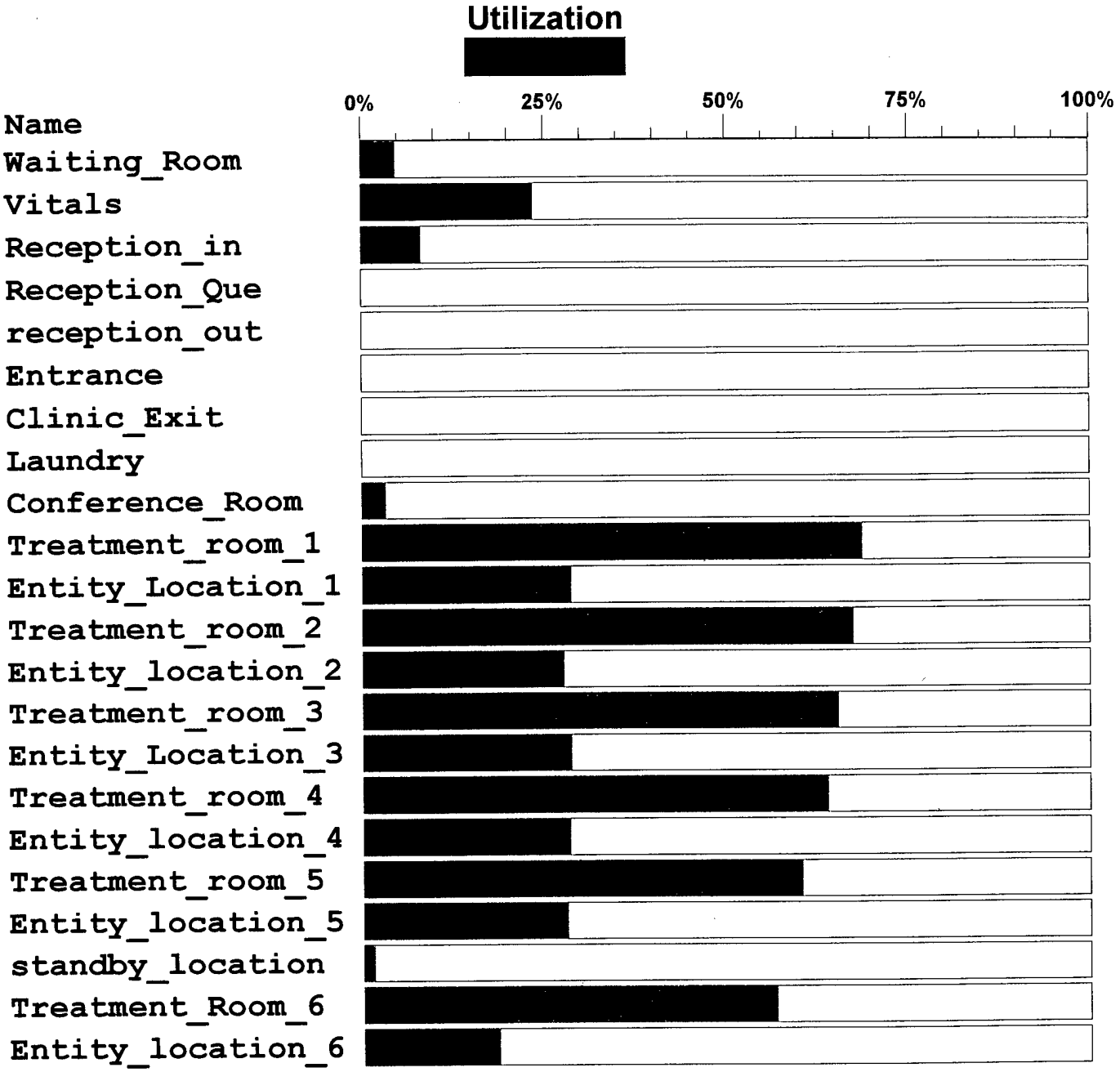
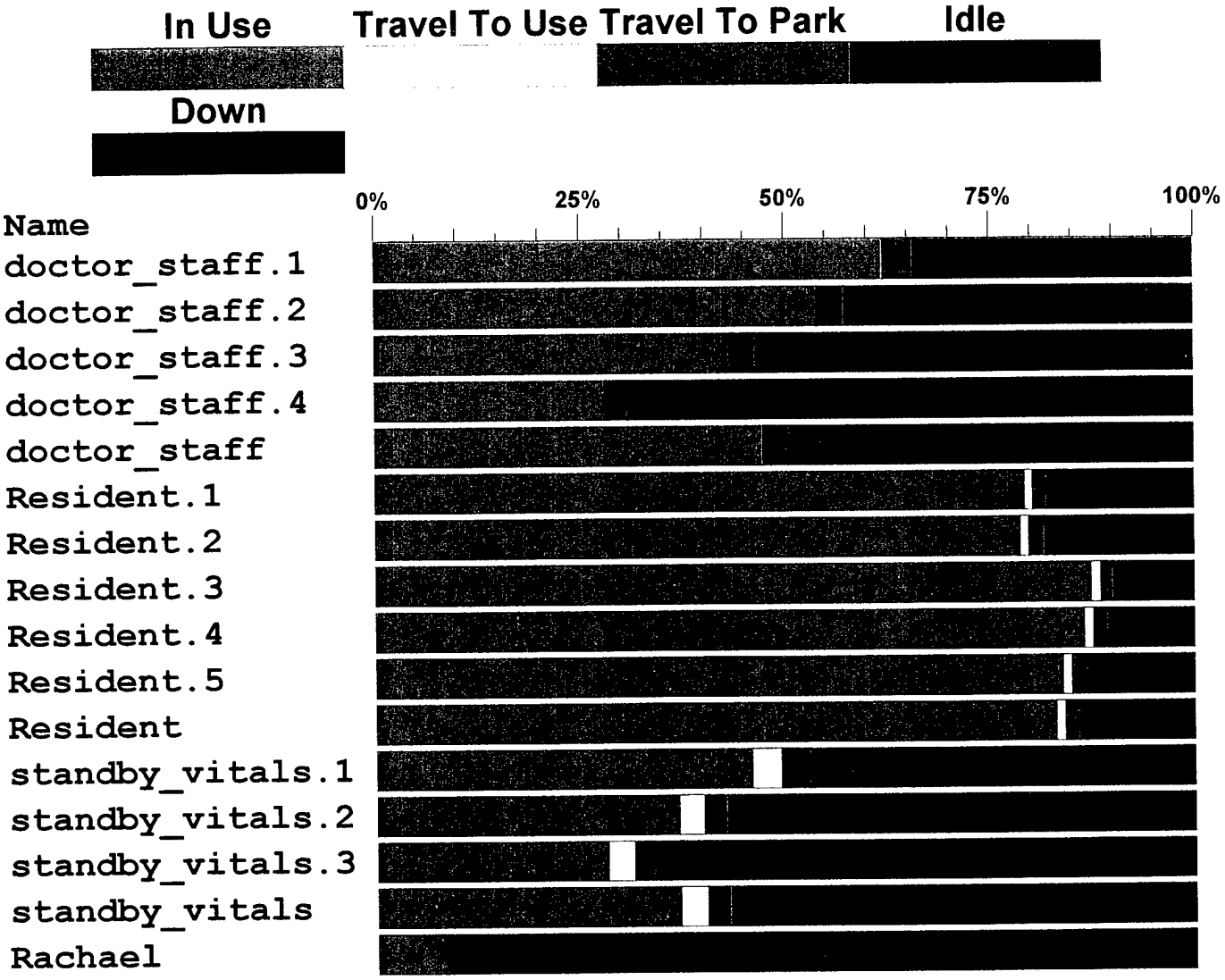


APPENDIX - M

Resource States



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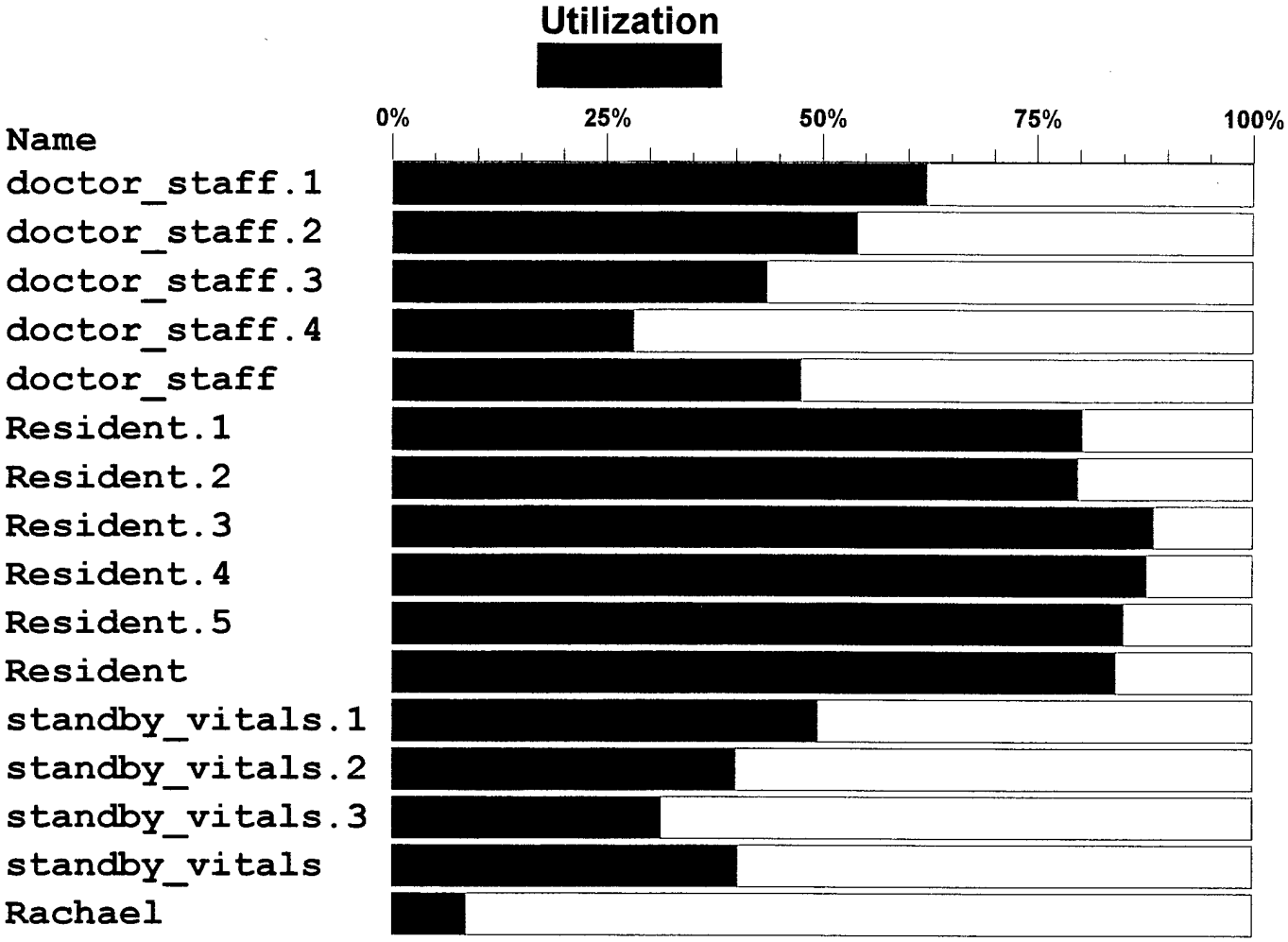

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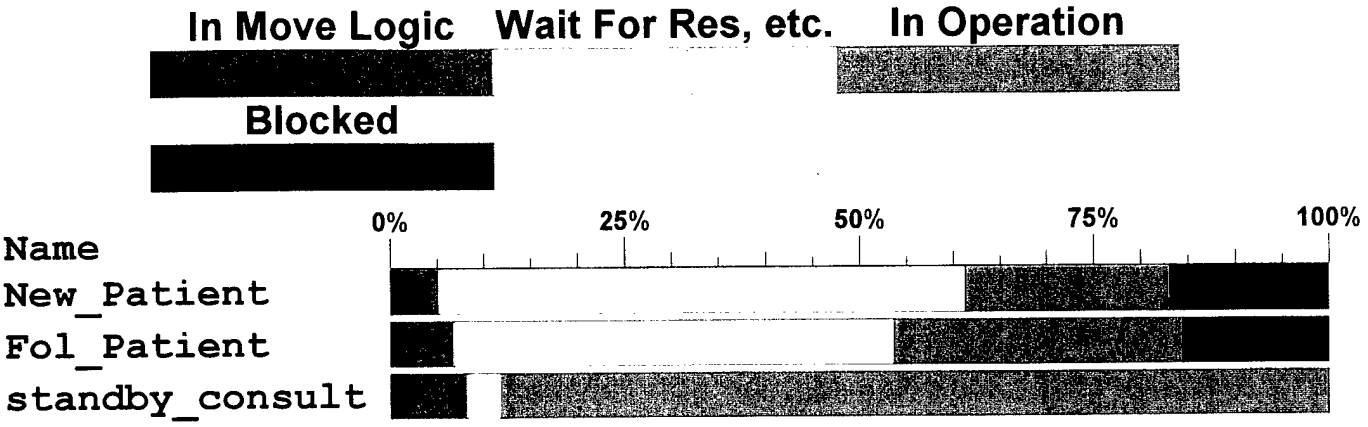

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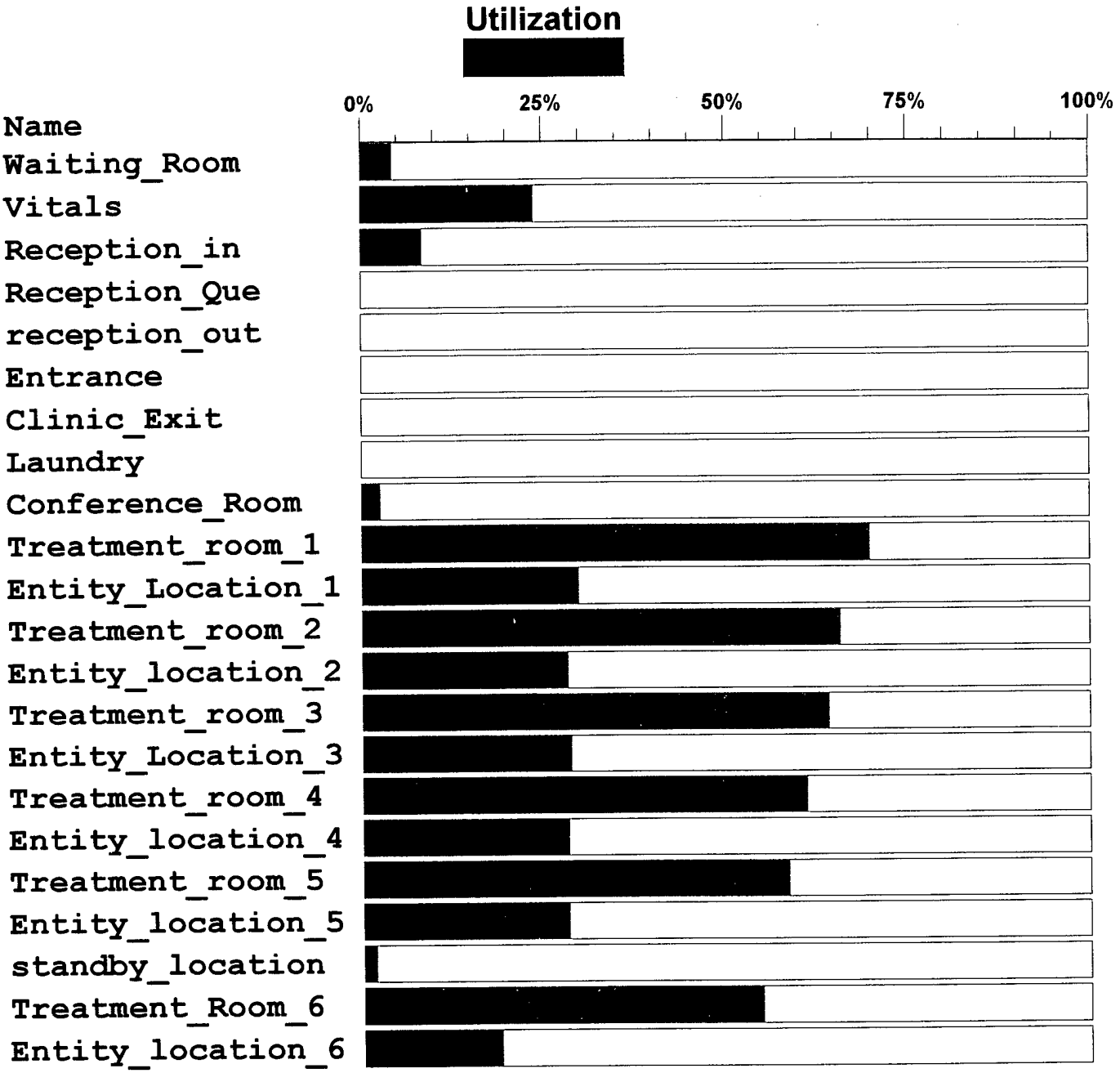
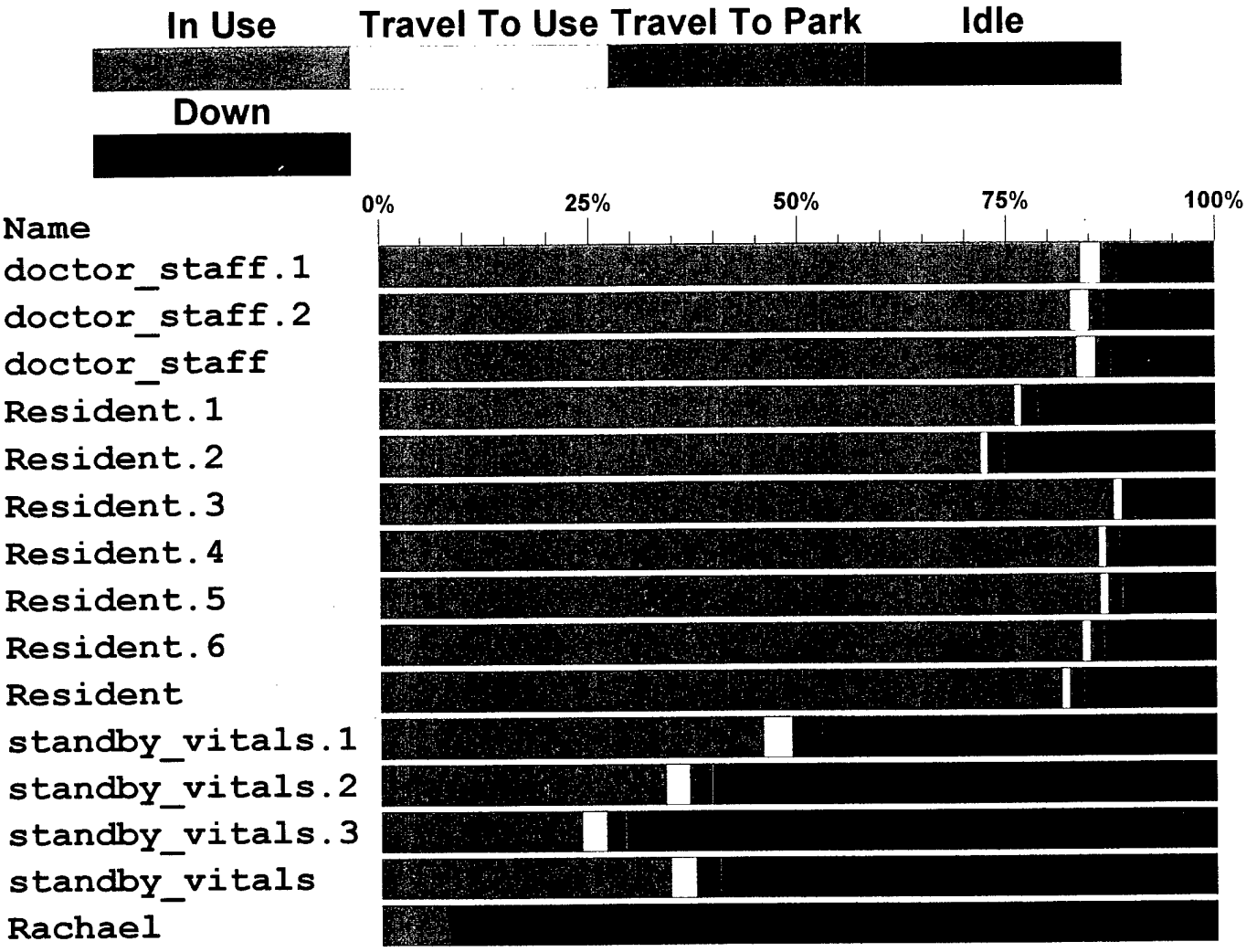


APPENDIX - N

Resource States



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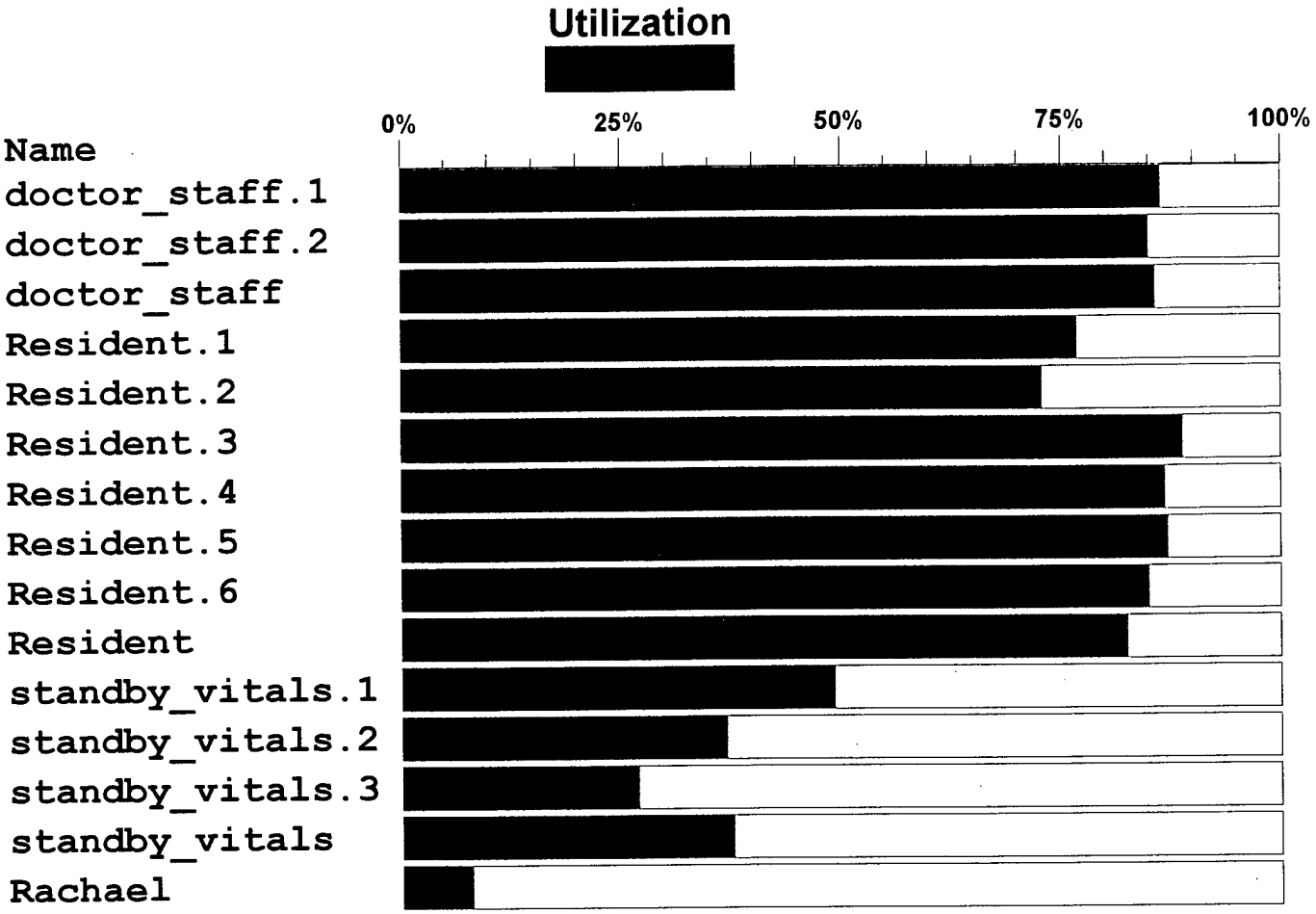

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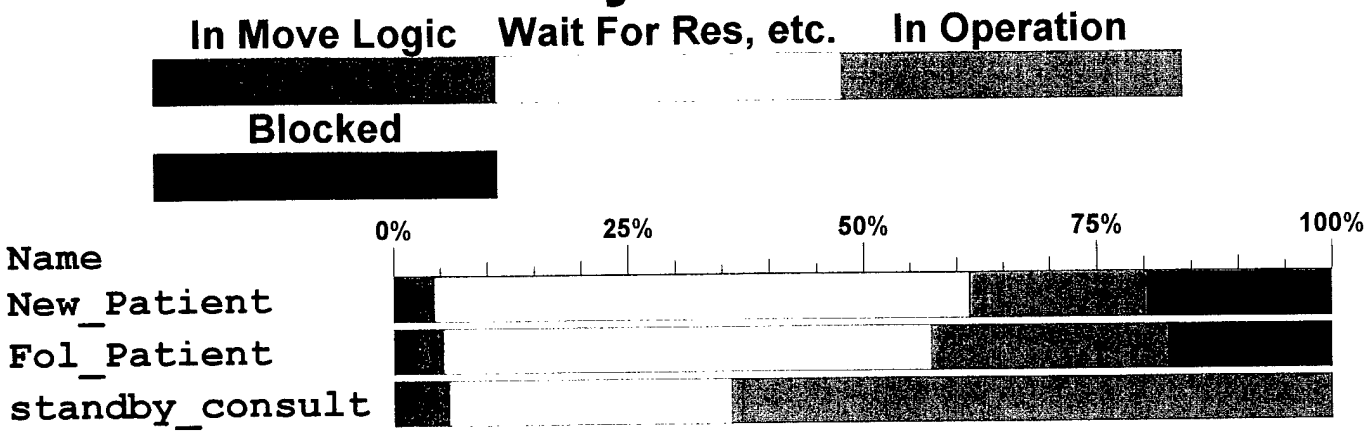

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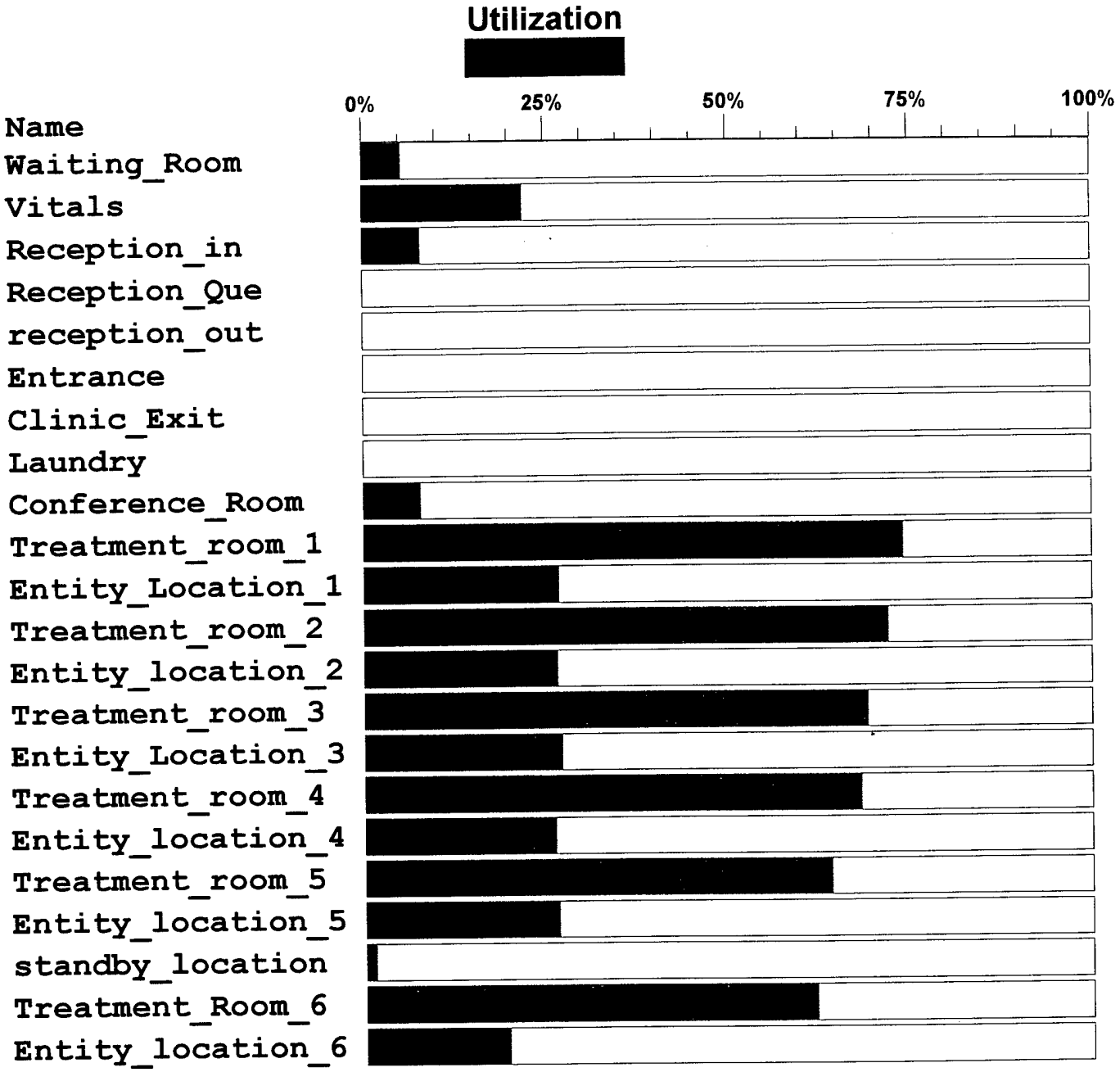
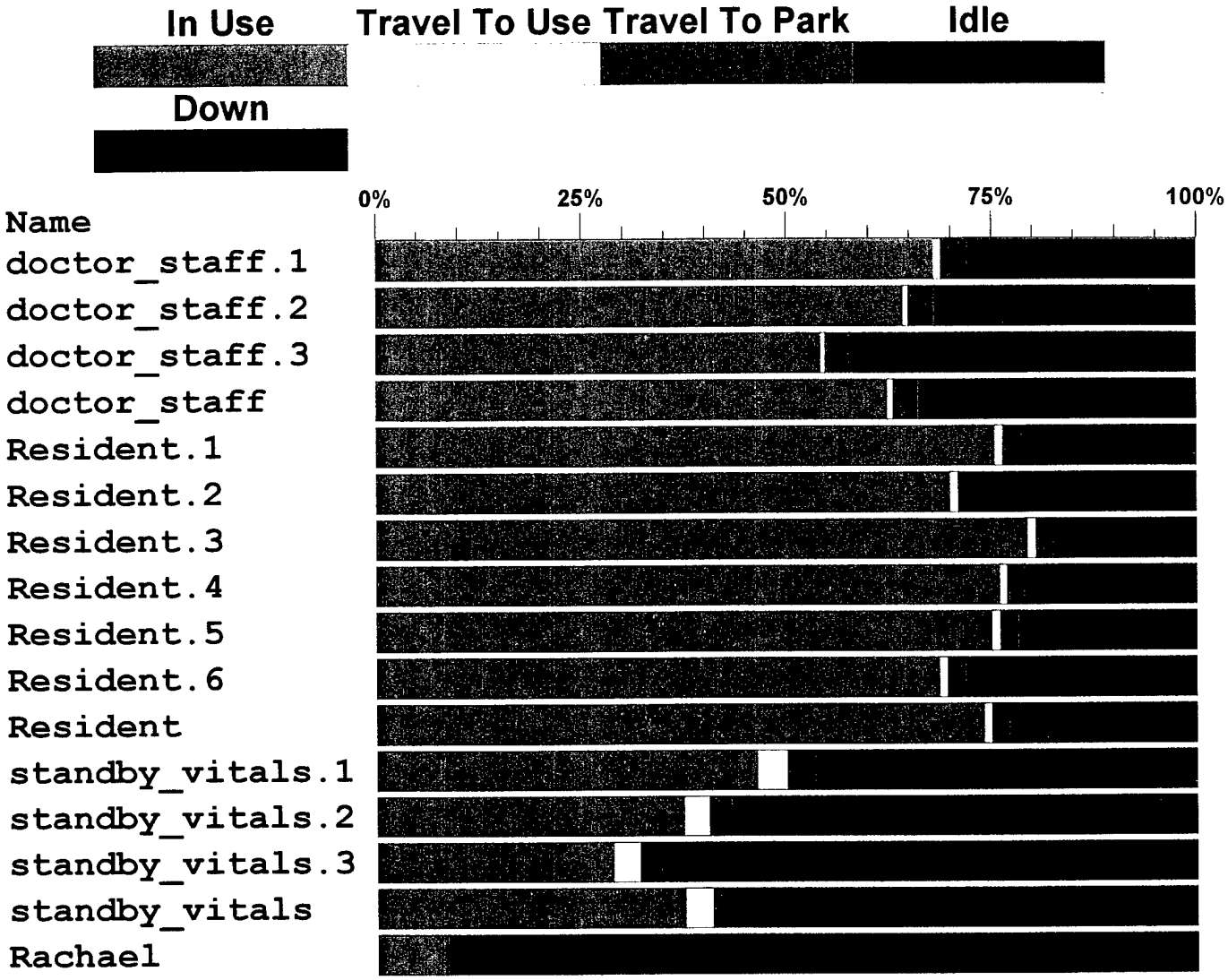


APPENDIX - O

Resource States



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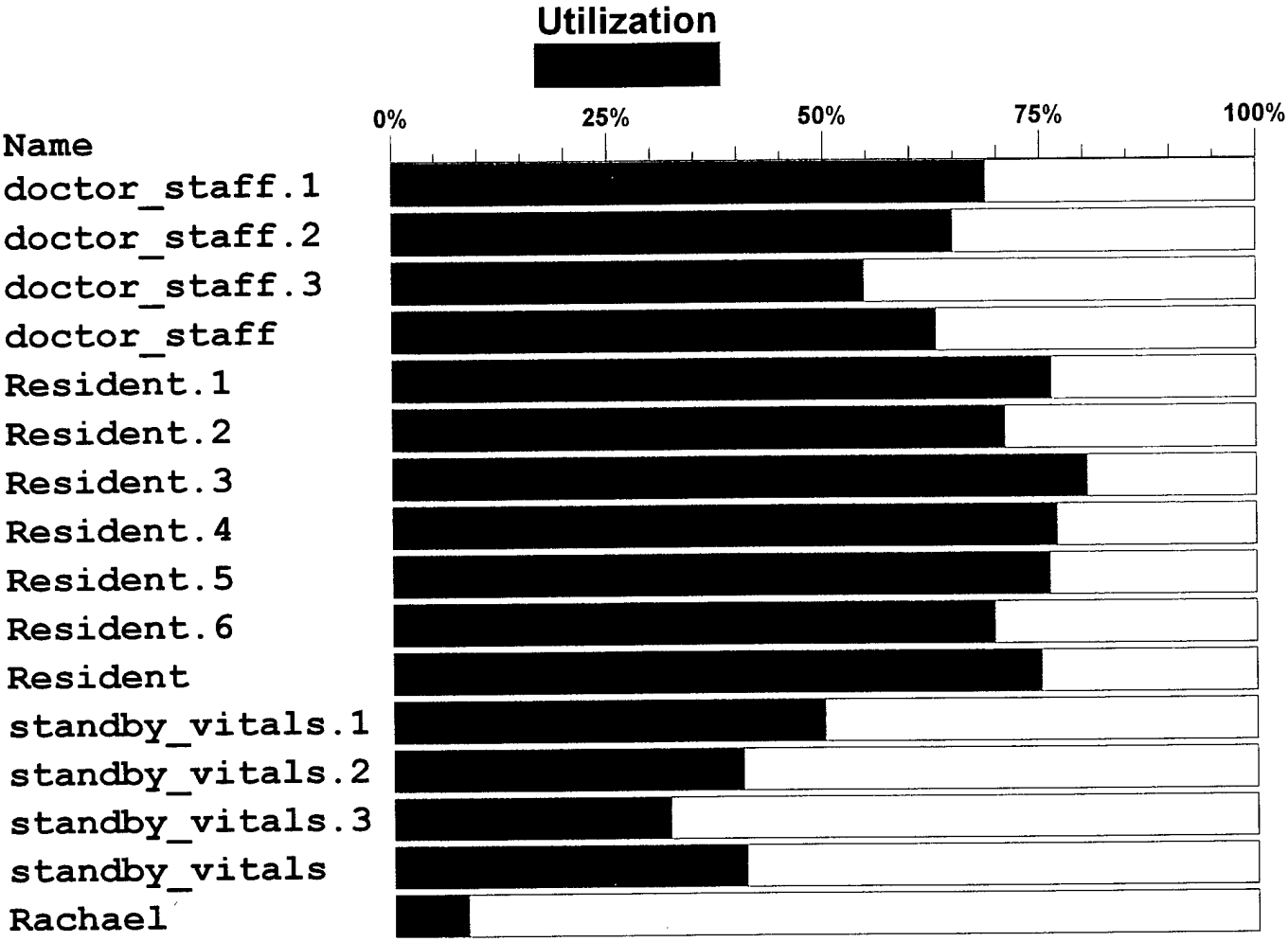

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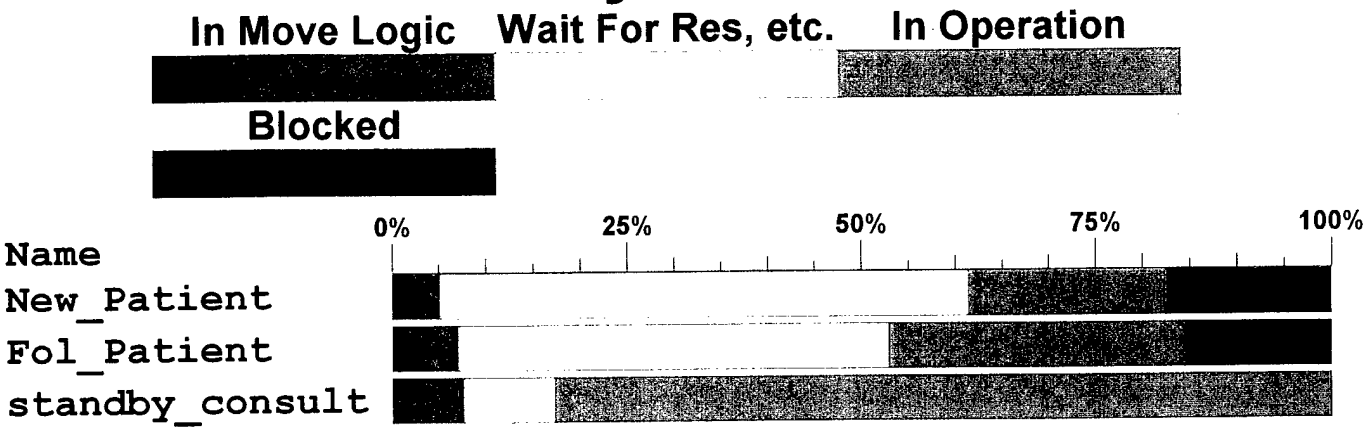

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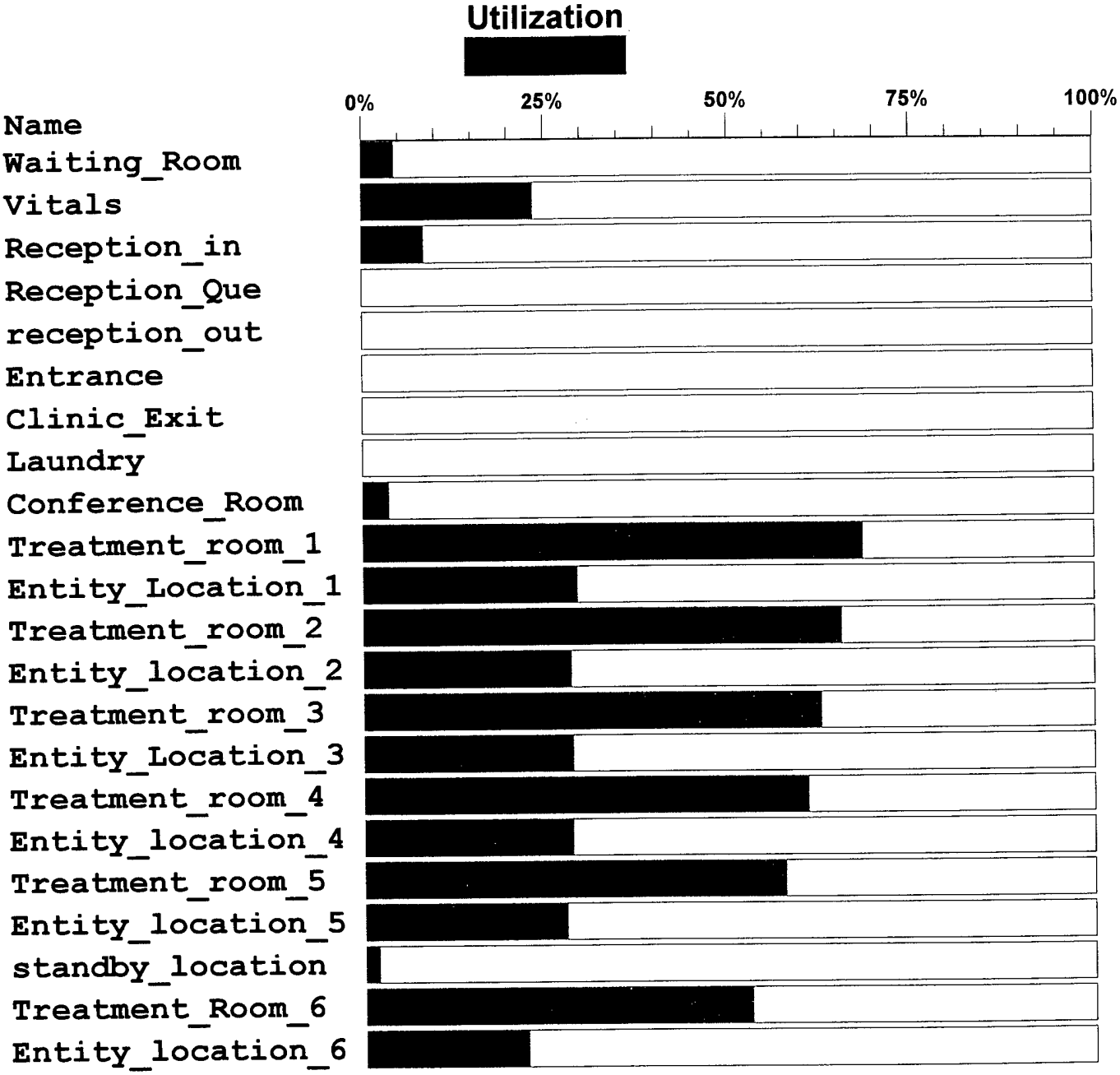
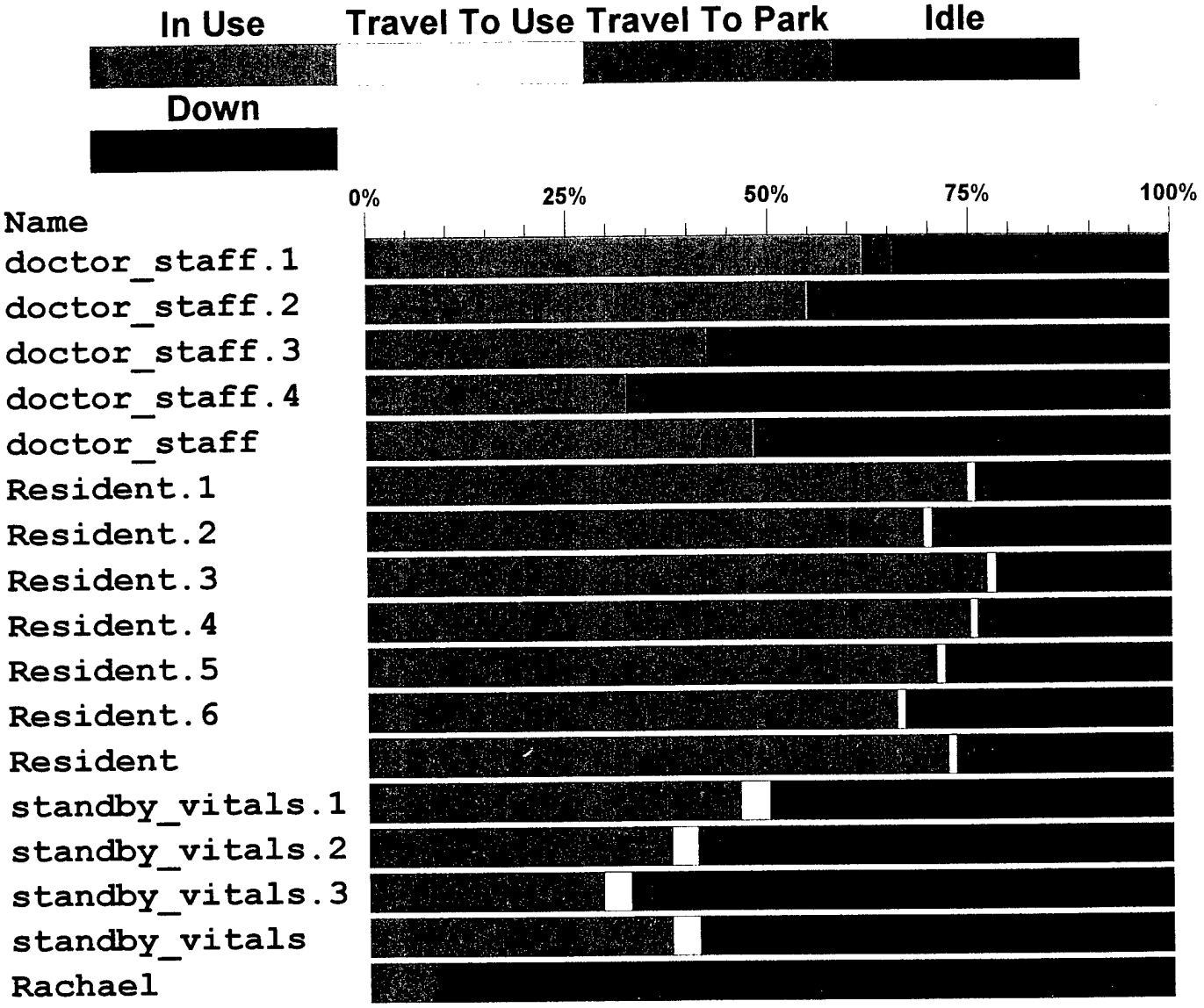
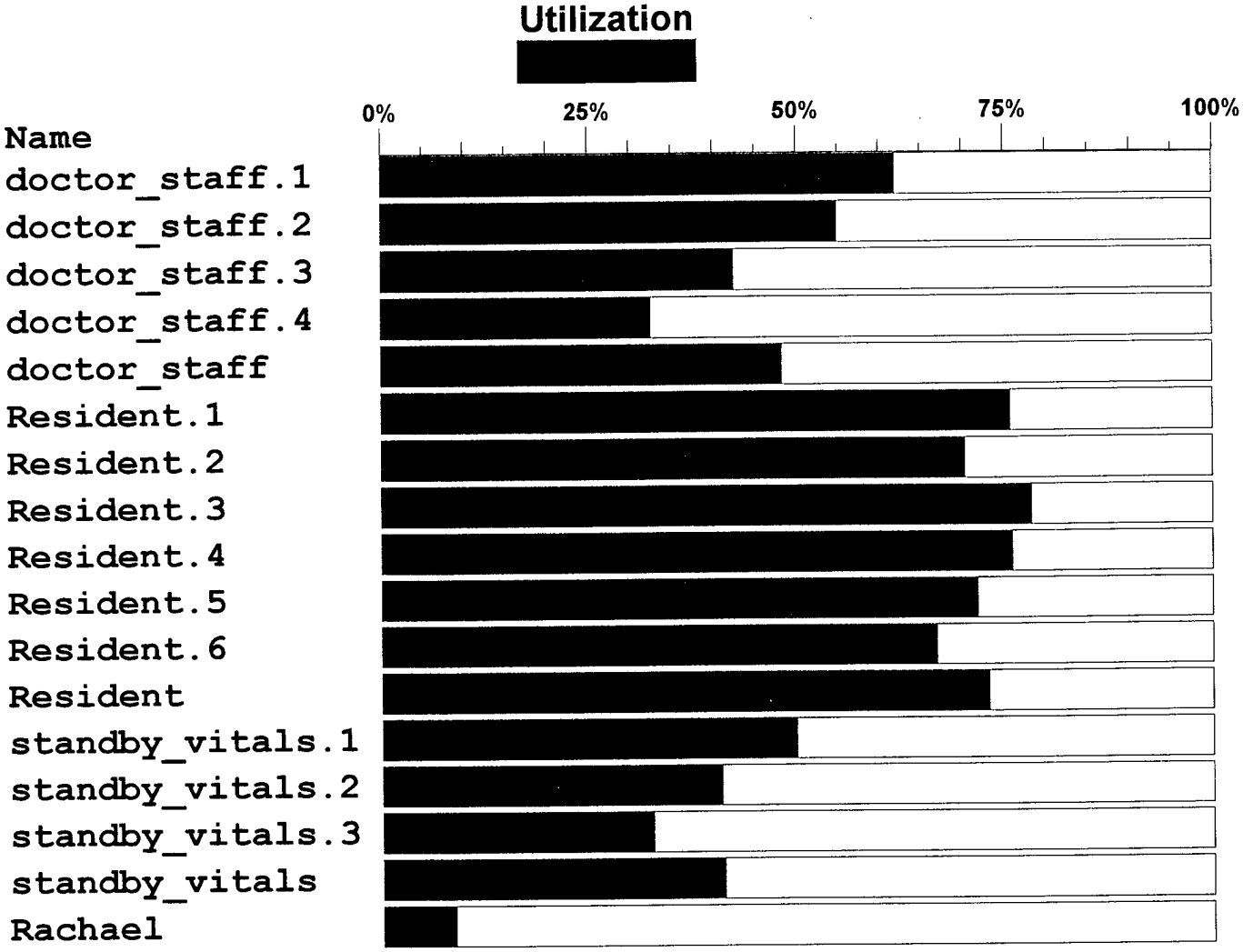


APPENDIX - P

Resource States



Resource Utilization



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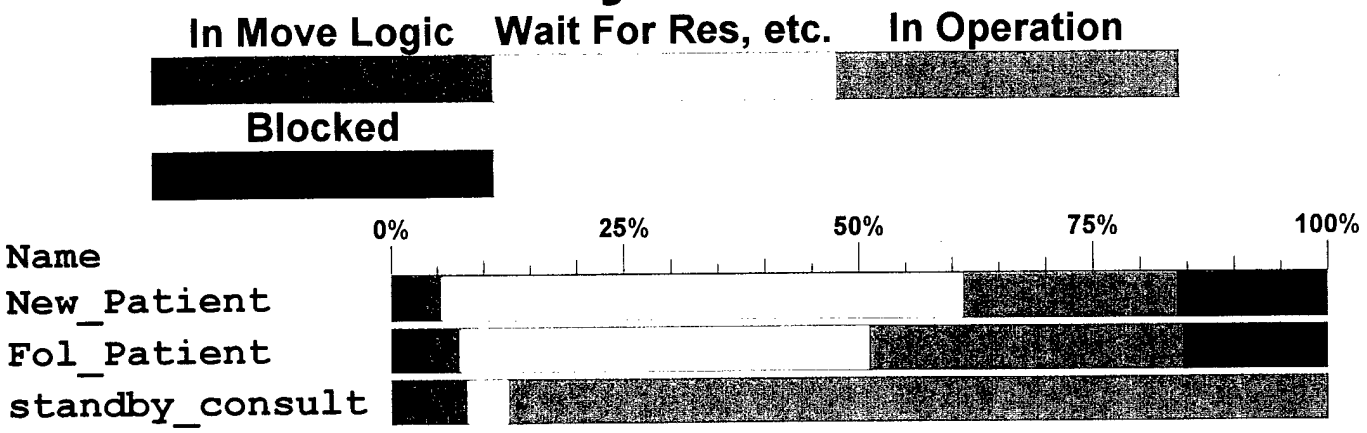

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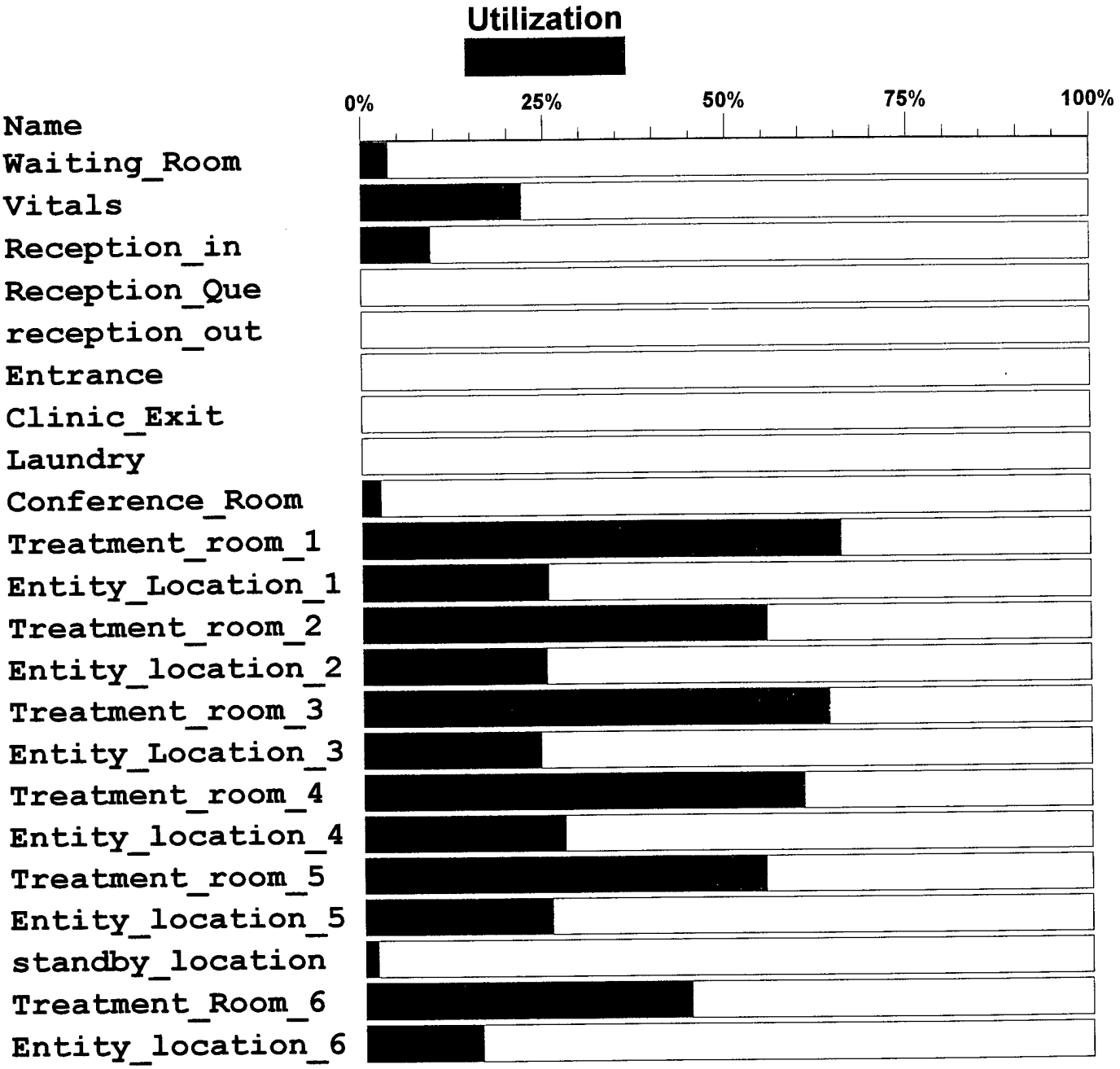
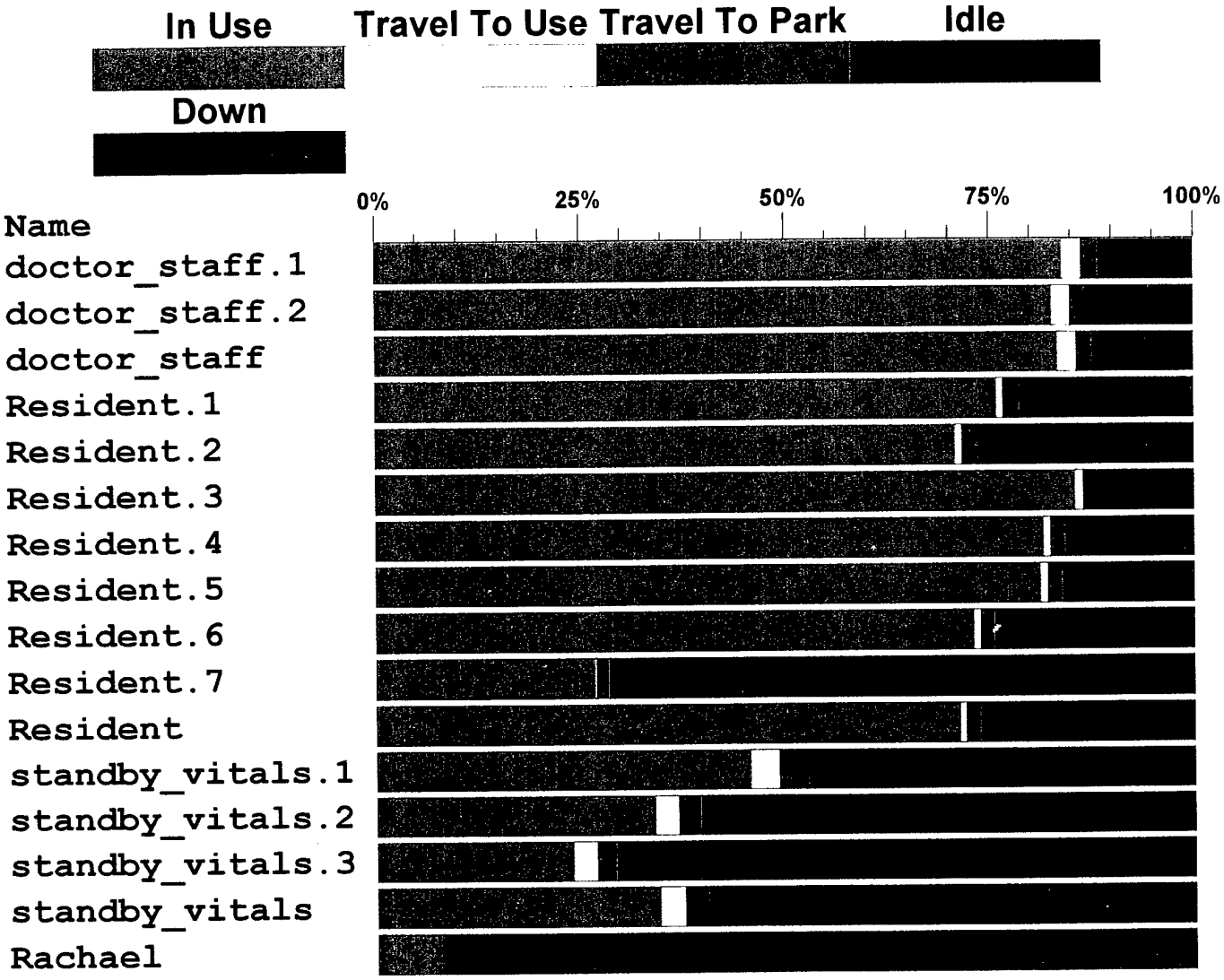


APPENDIX - Q

Resource States



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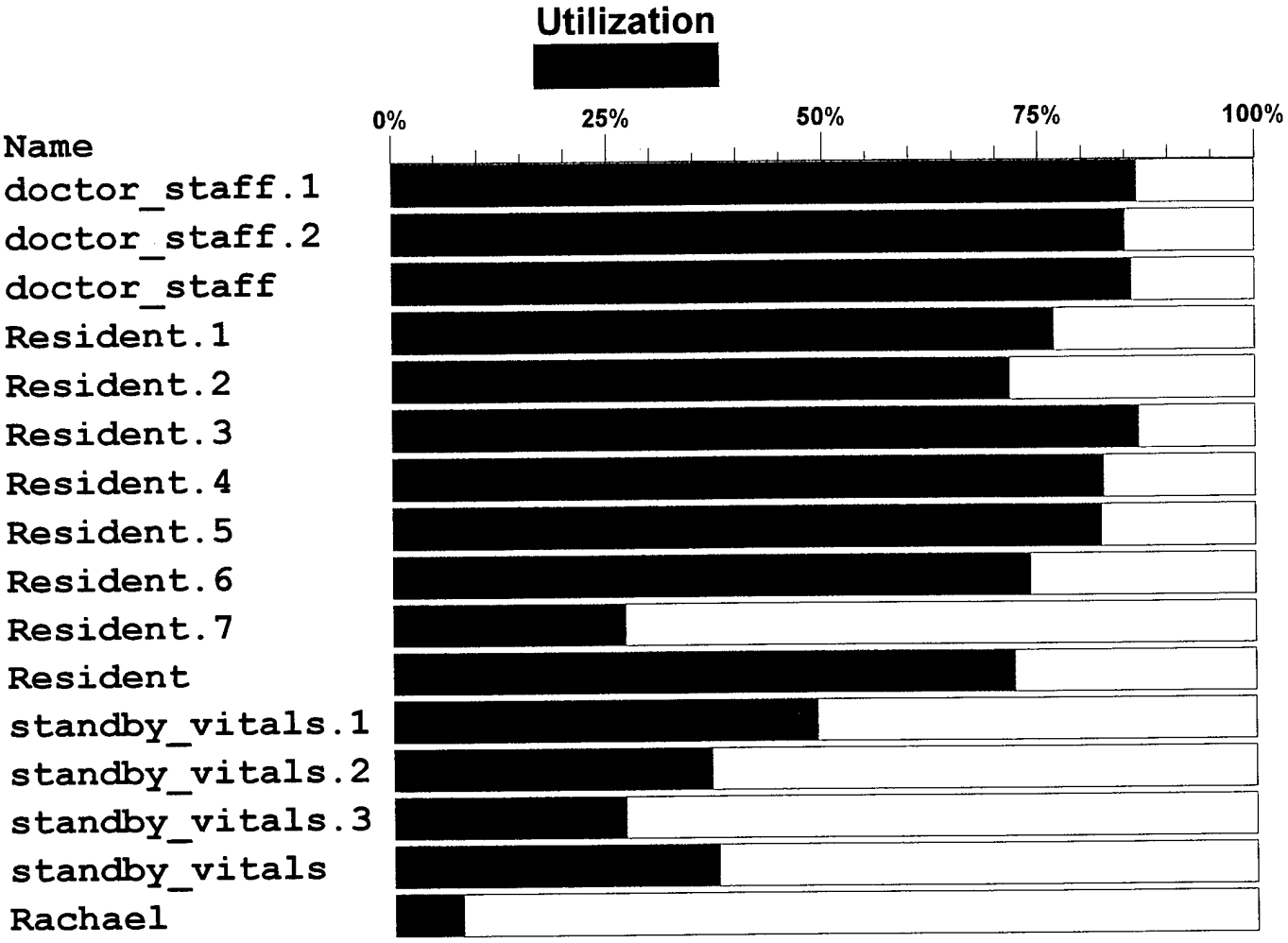

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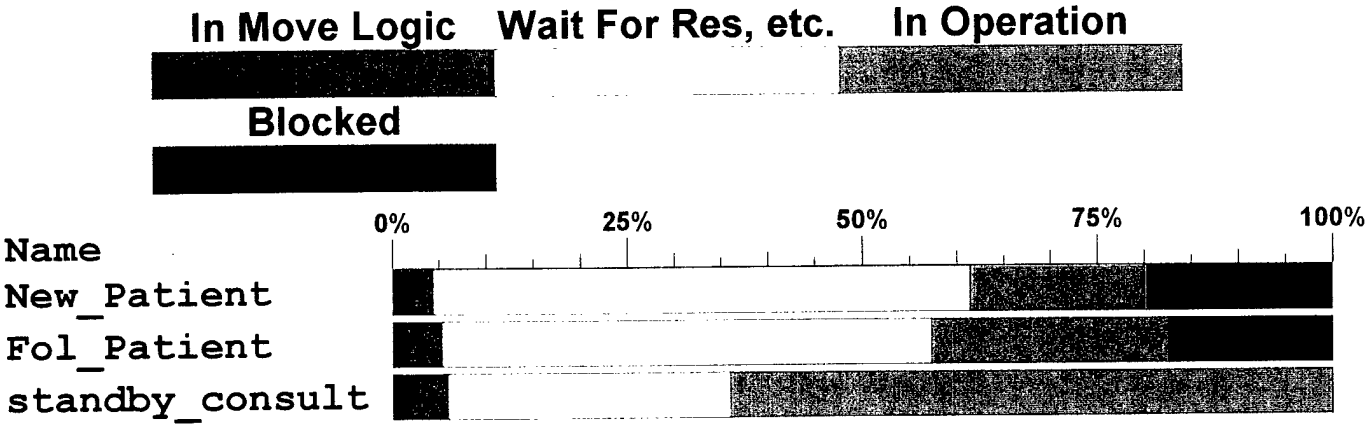

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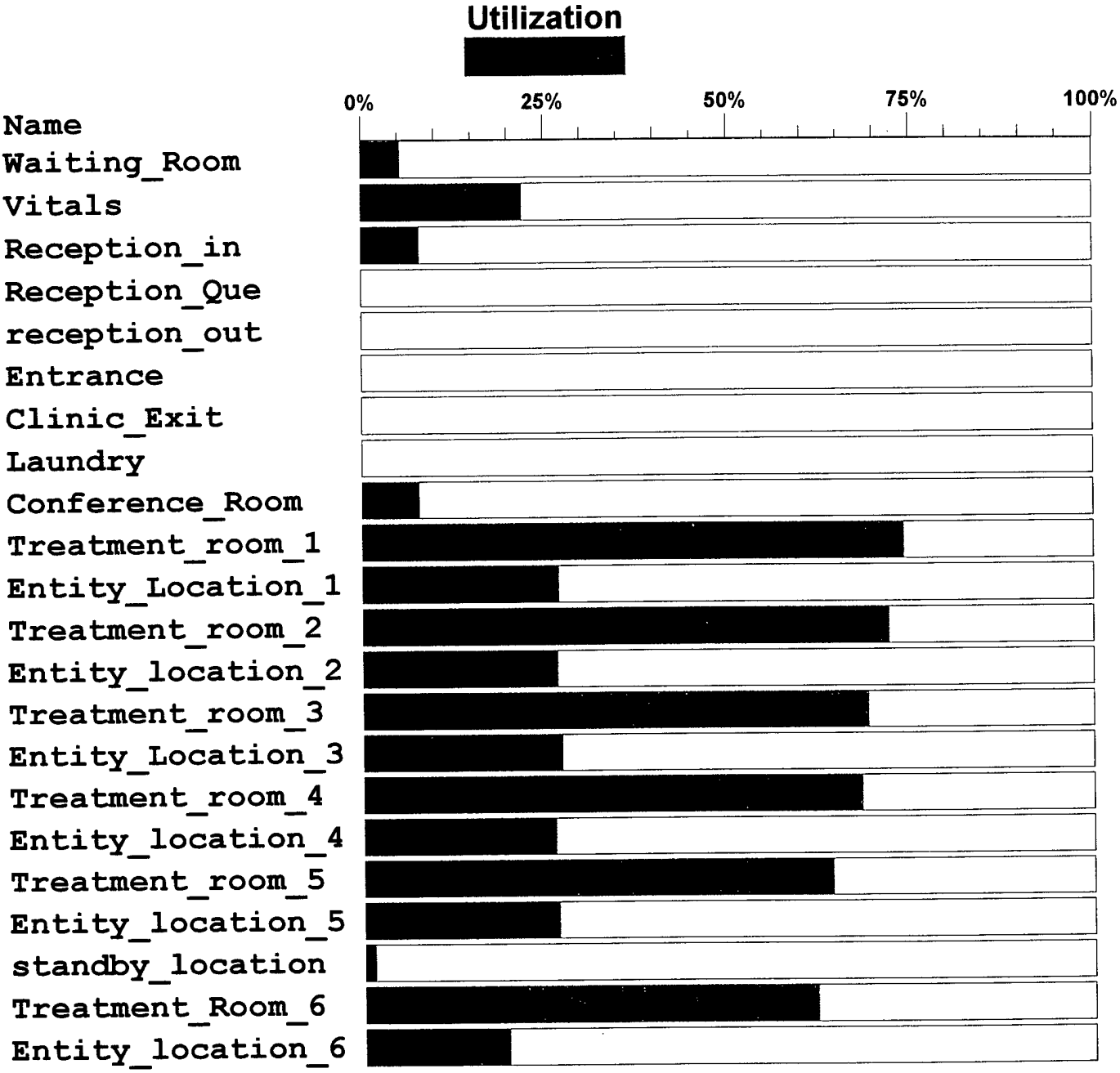
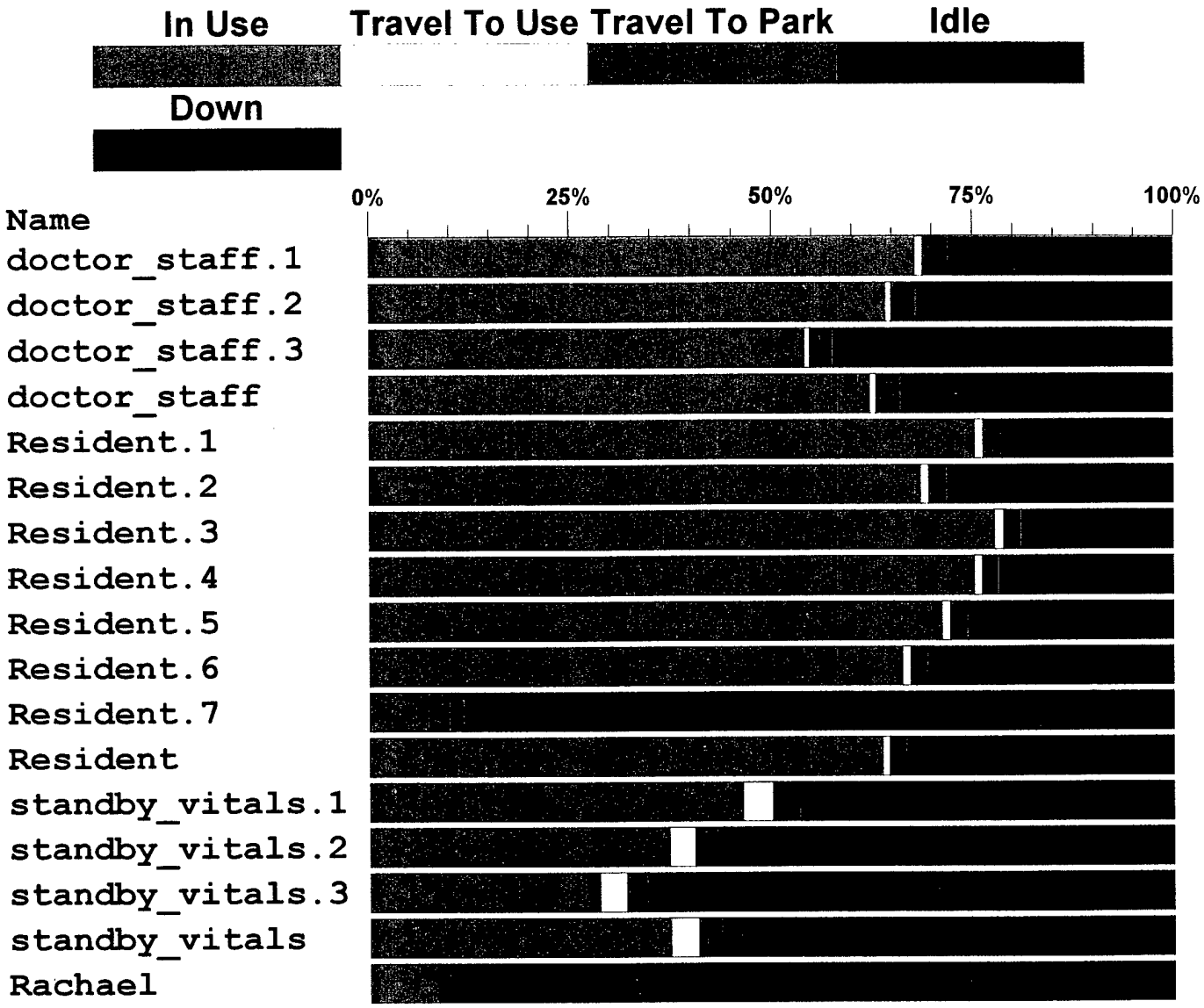


APPENDIX - R

Resource States



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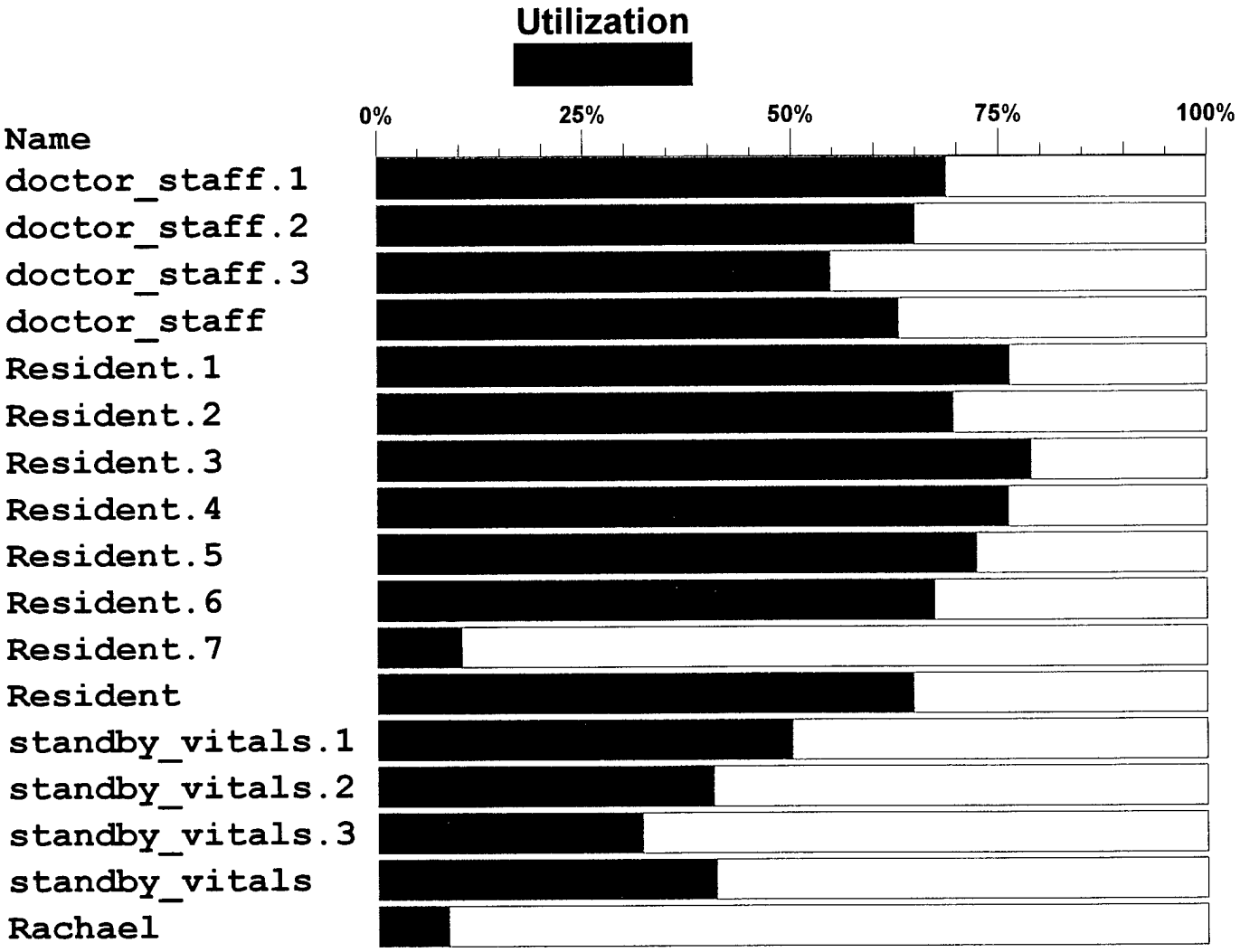

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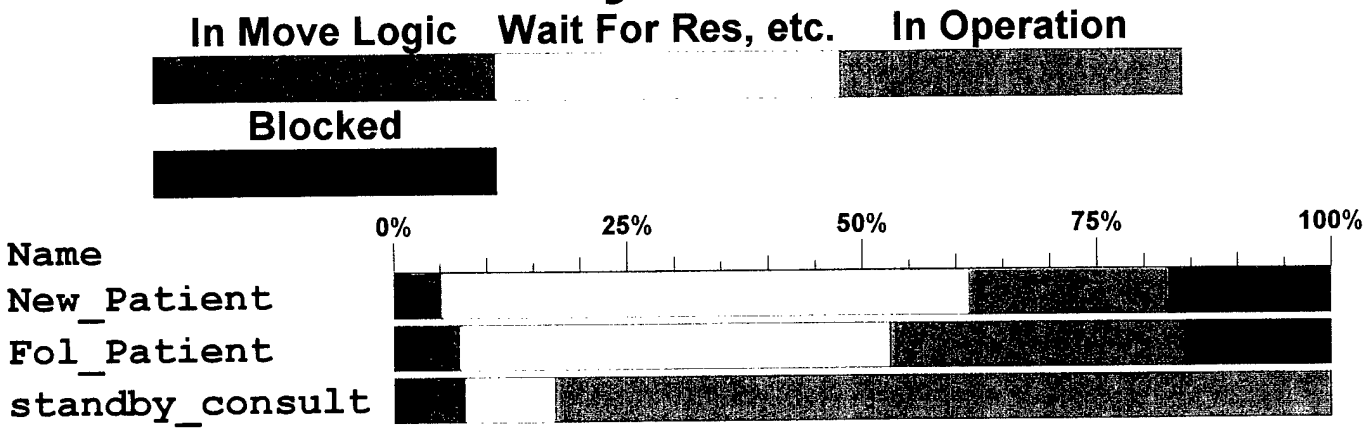

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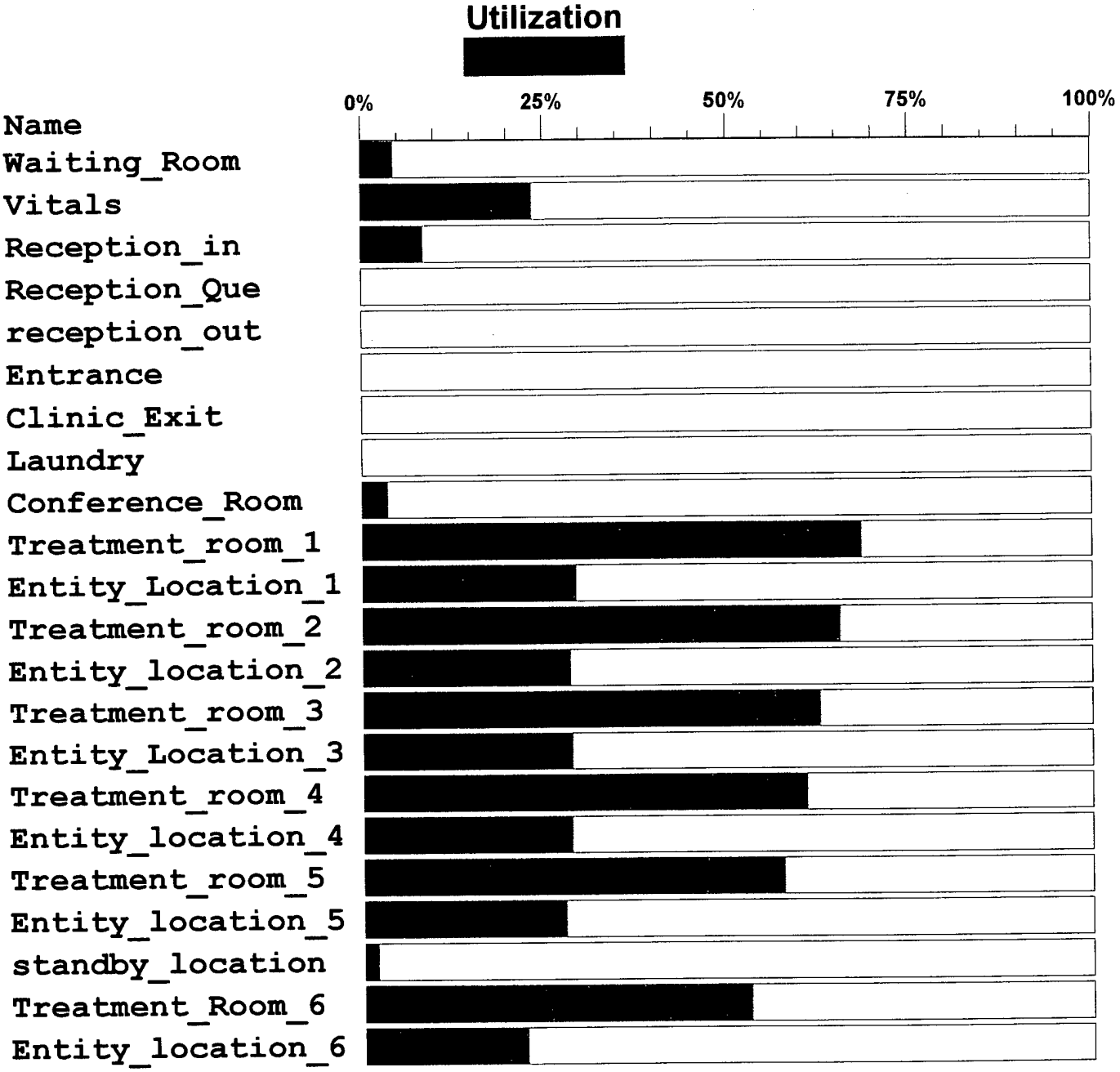
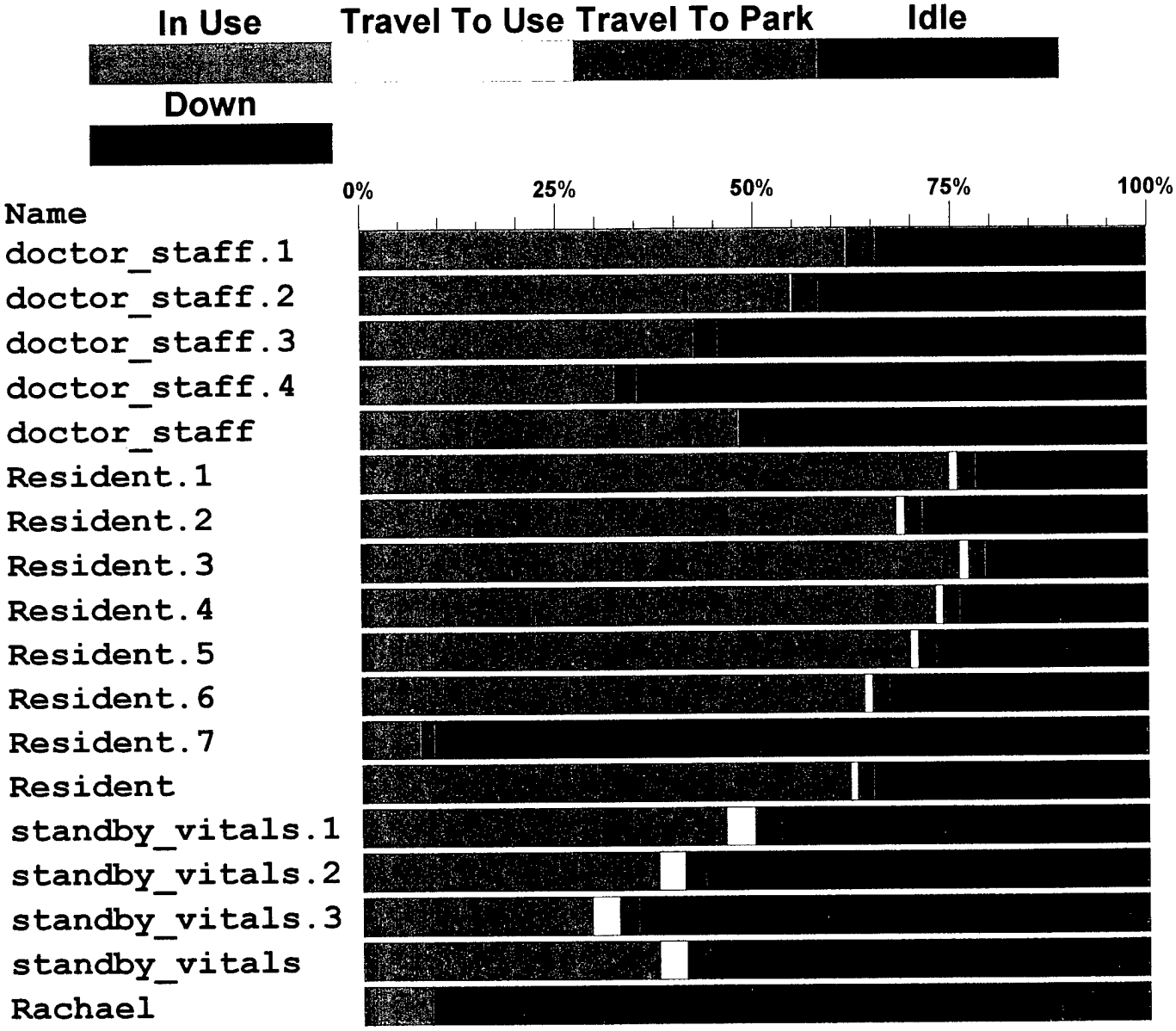


APPENDIX - S

Resource States



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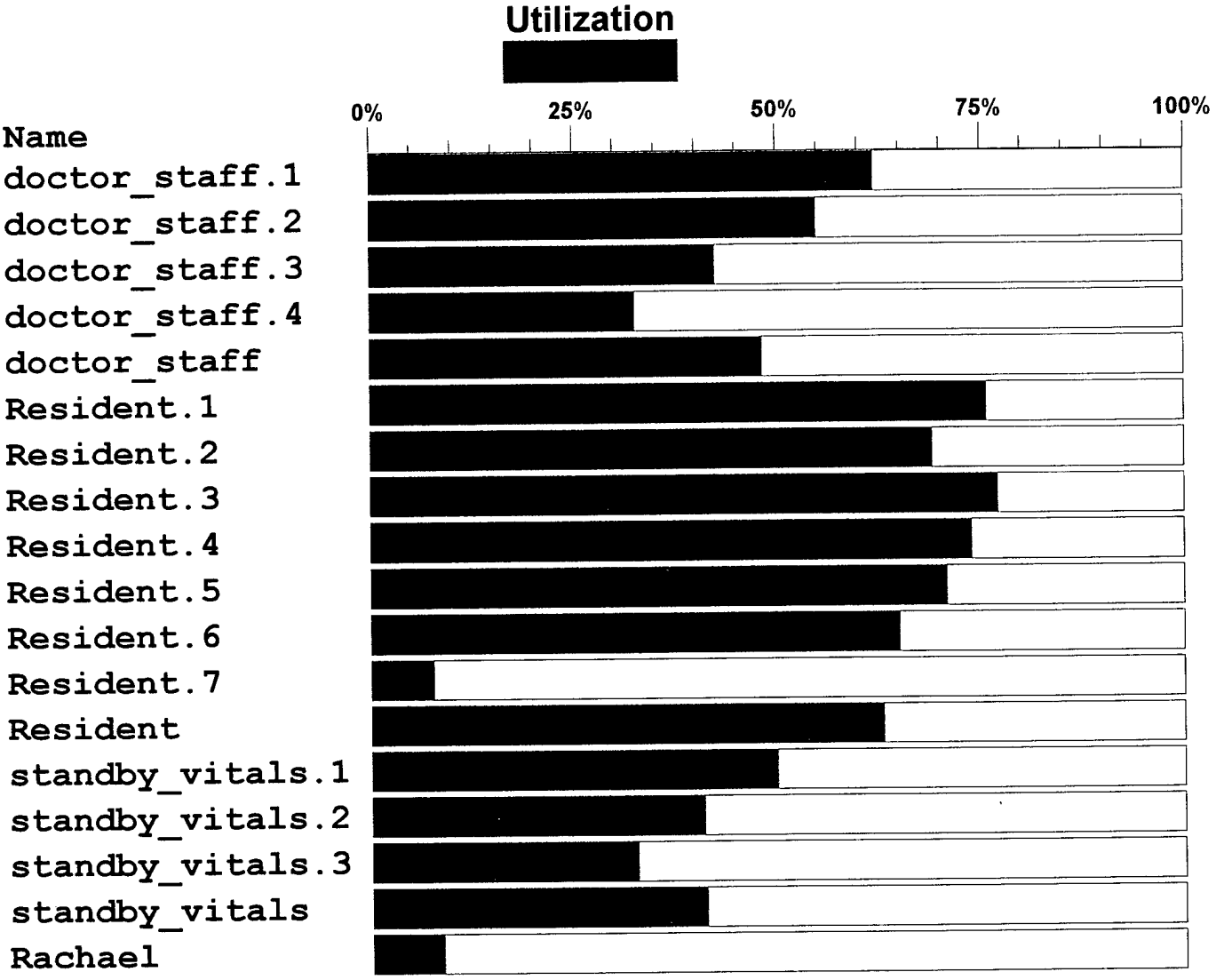

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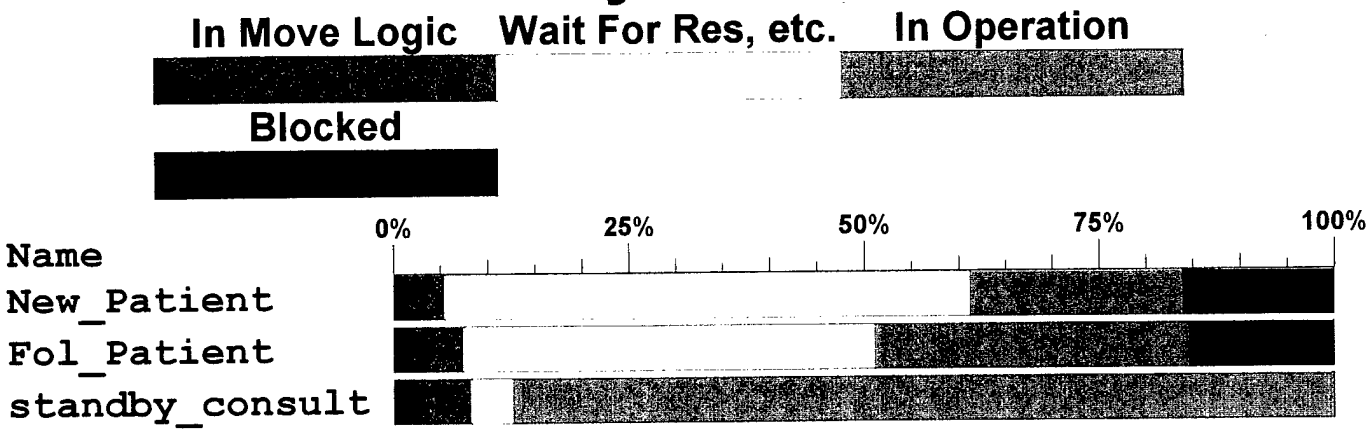

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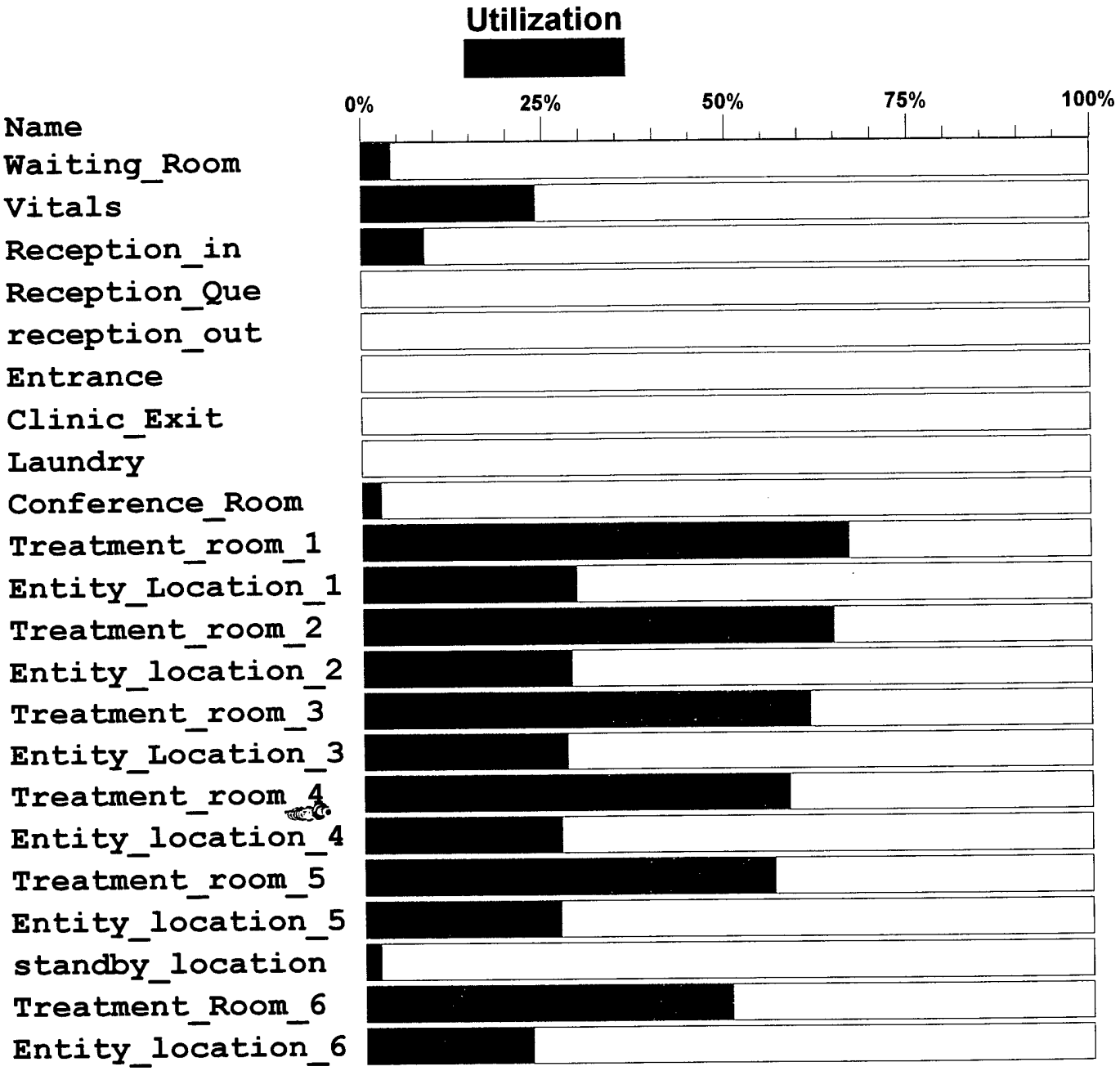

APPENDIX - T

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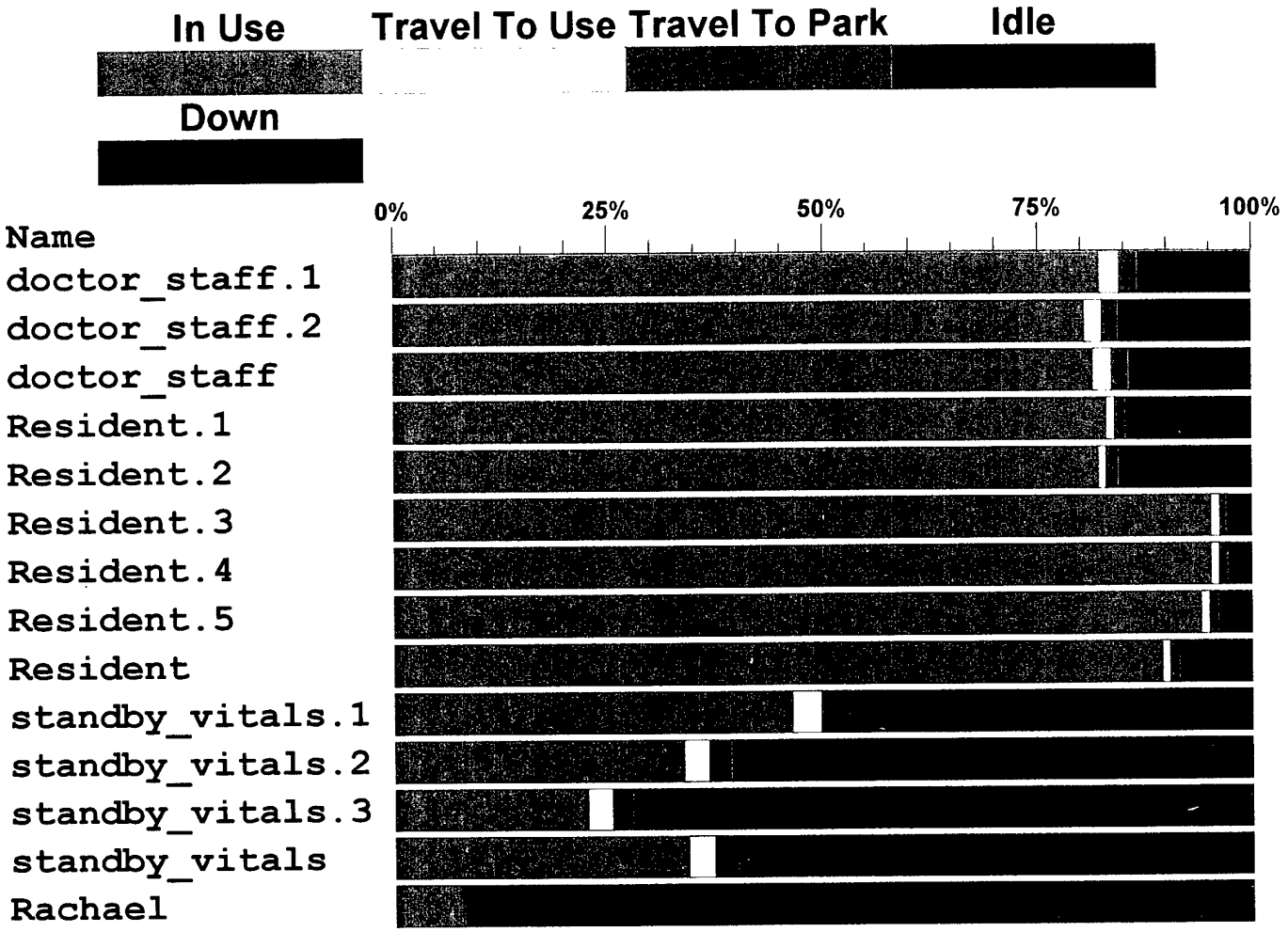

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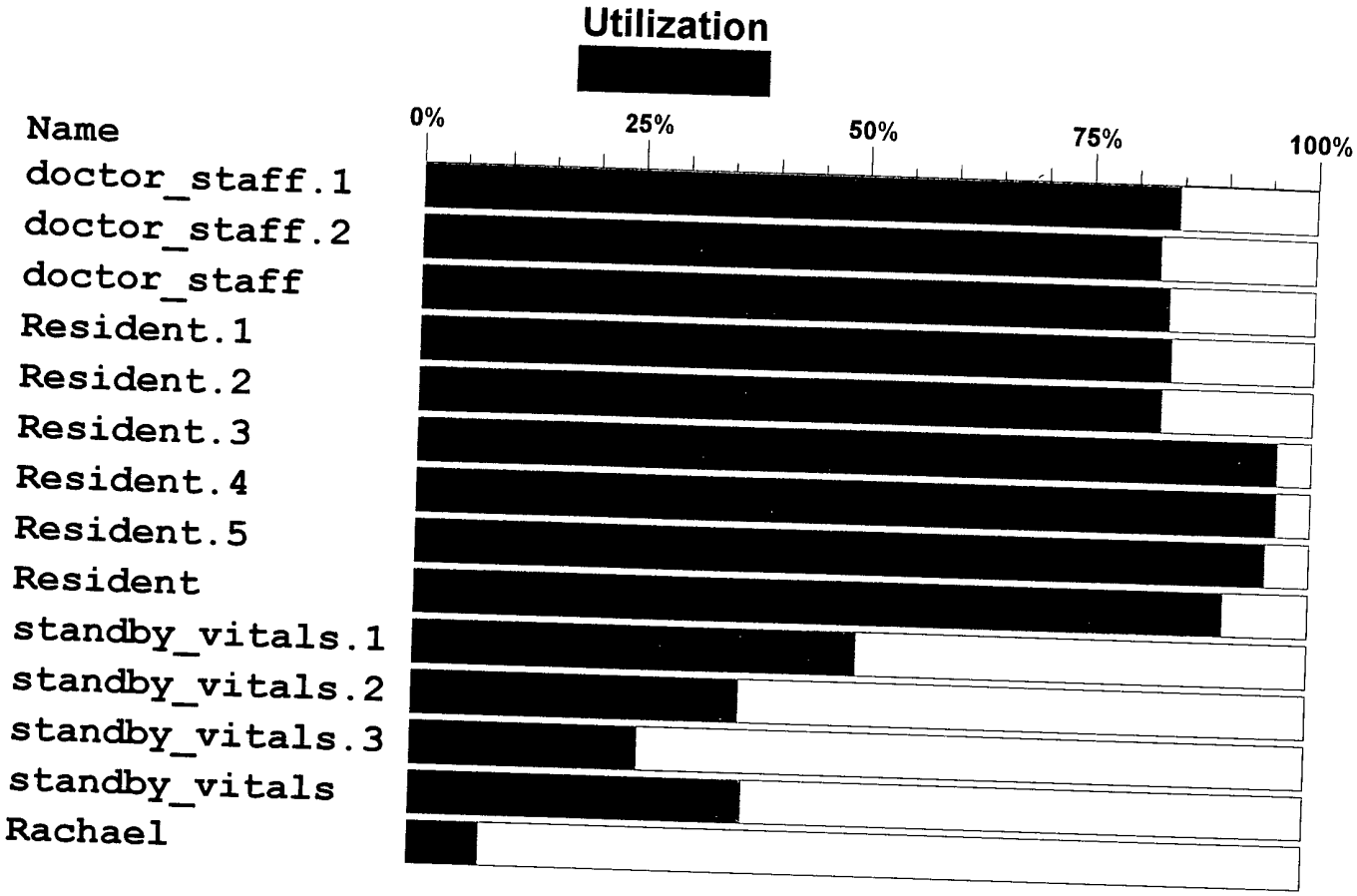

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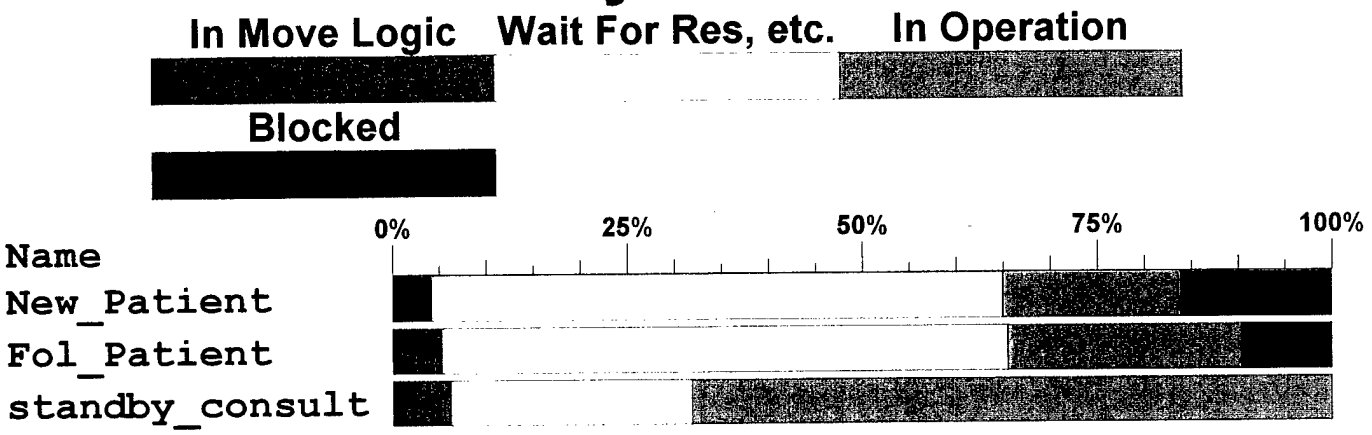

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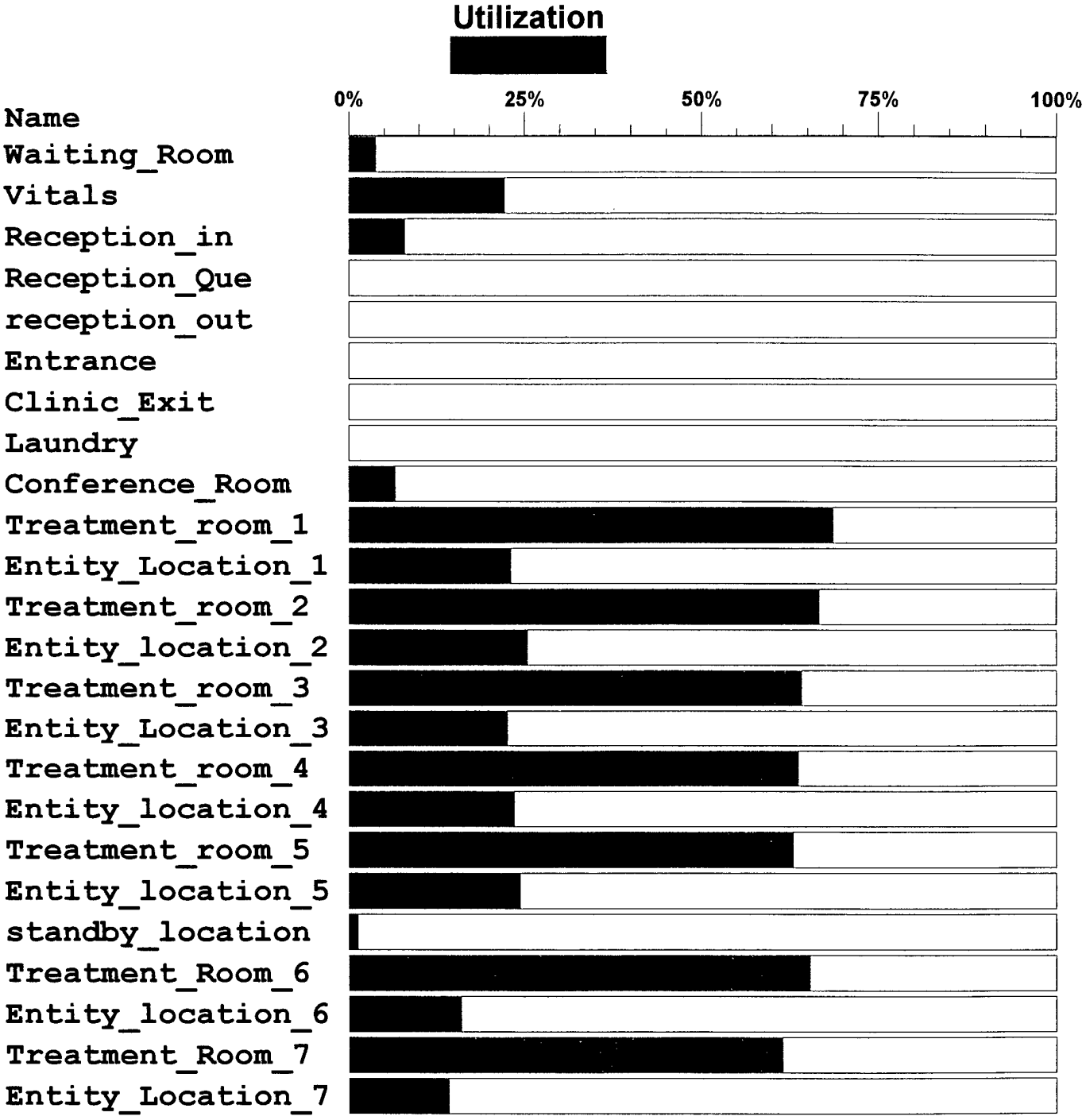
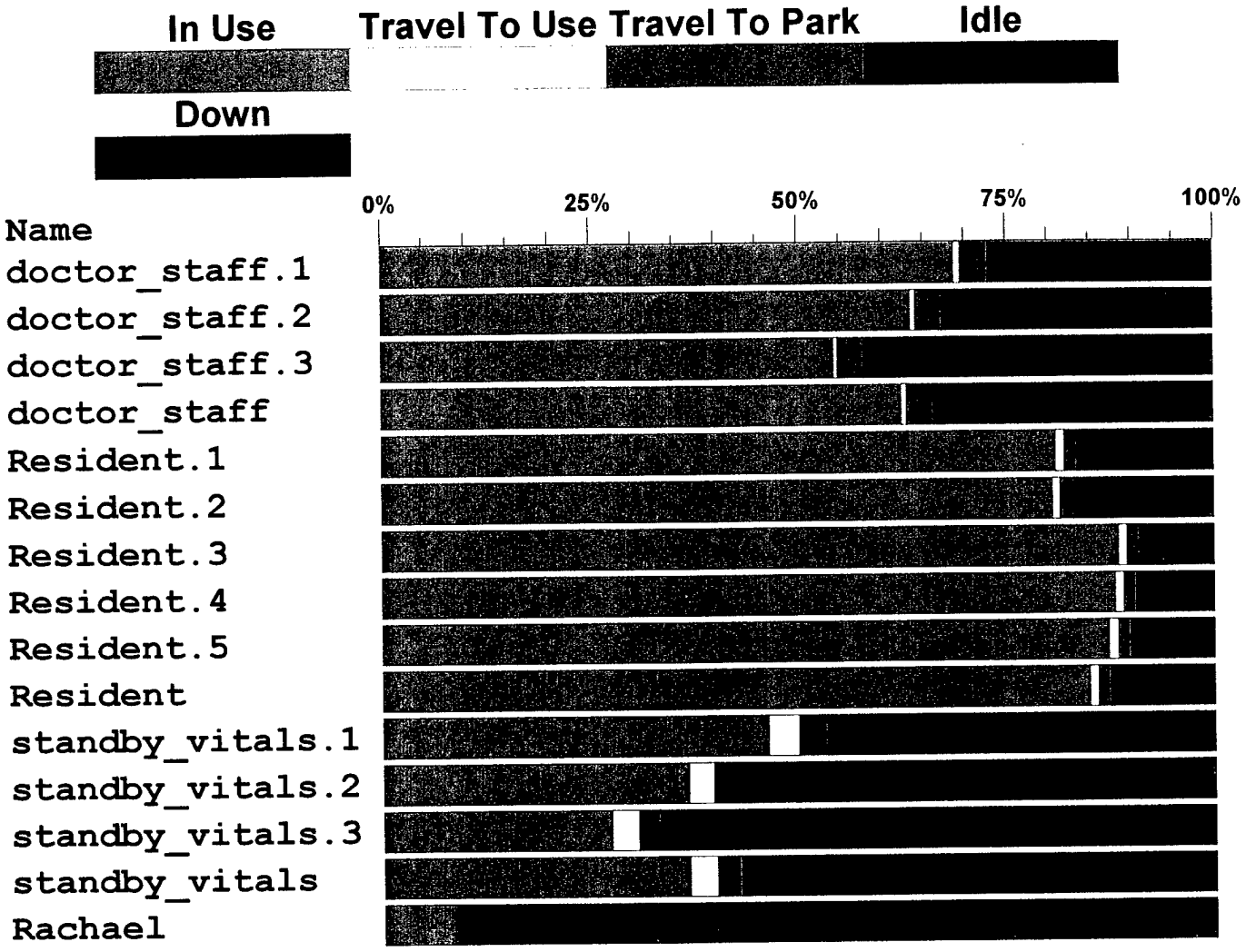


APPENDIX - U

Resource States



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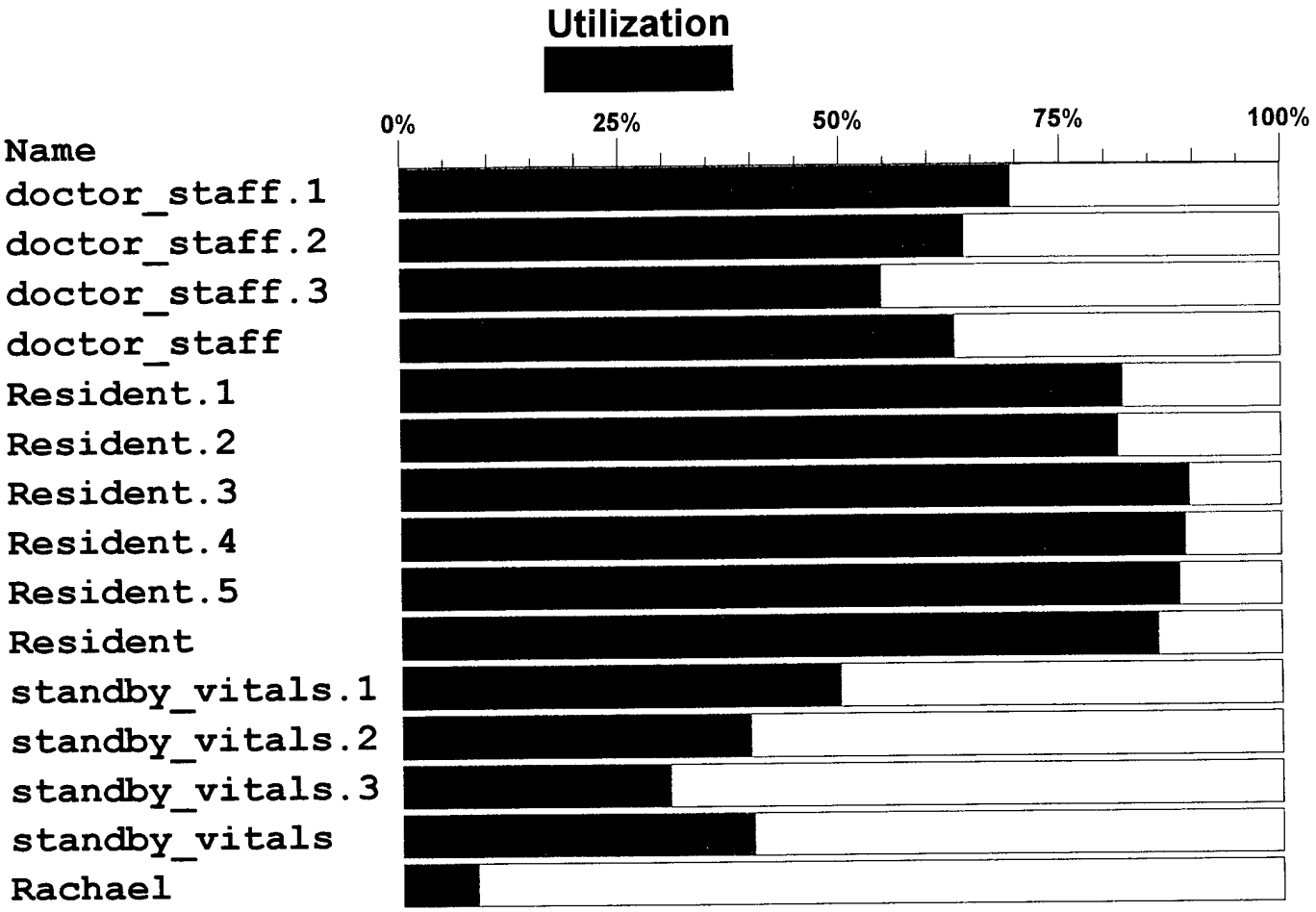

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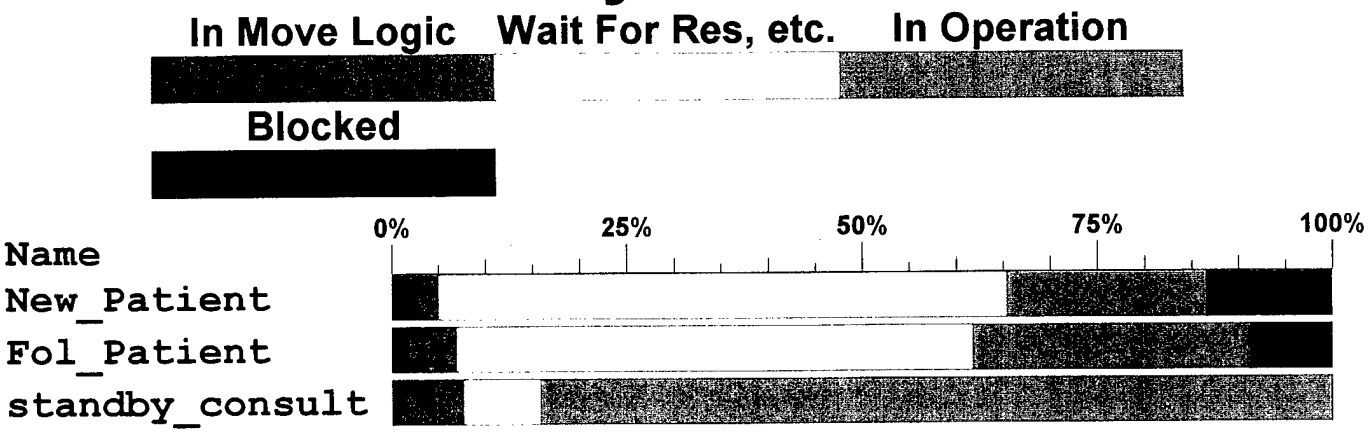

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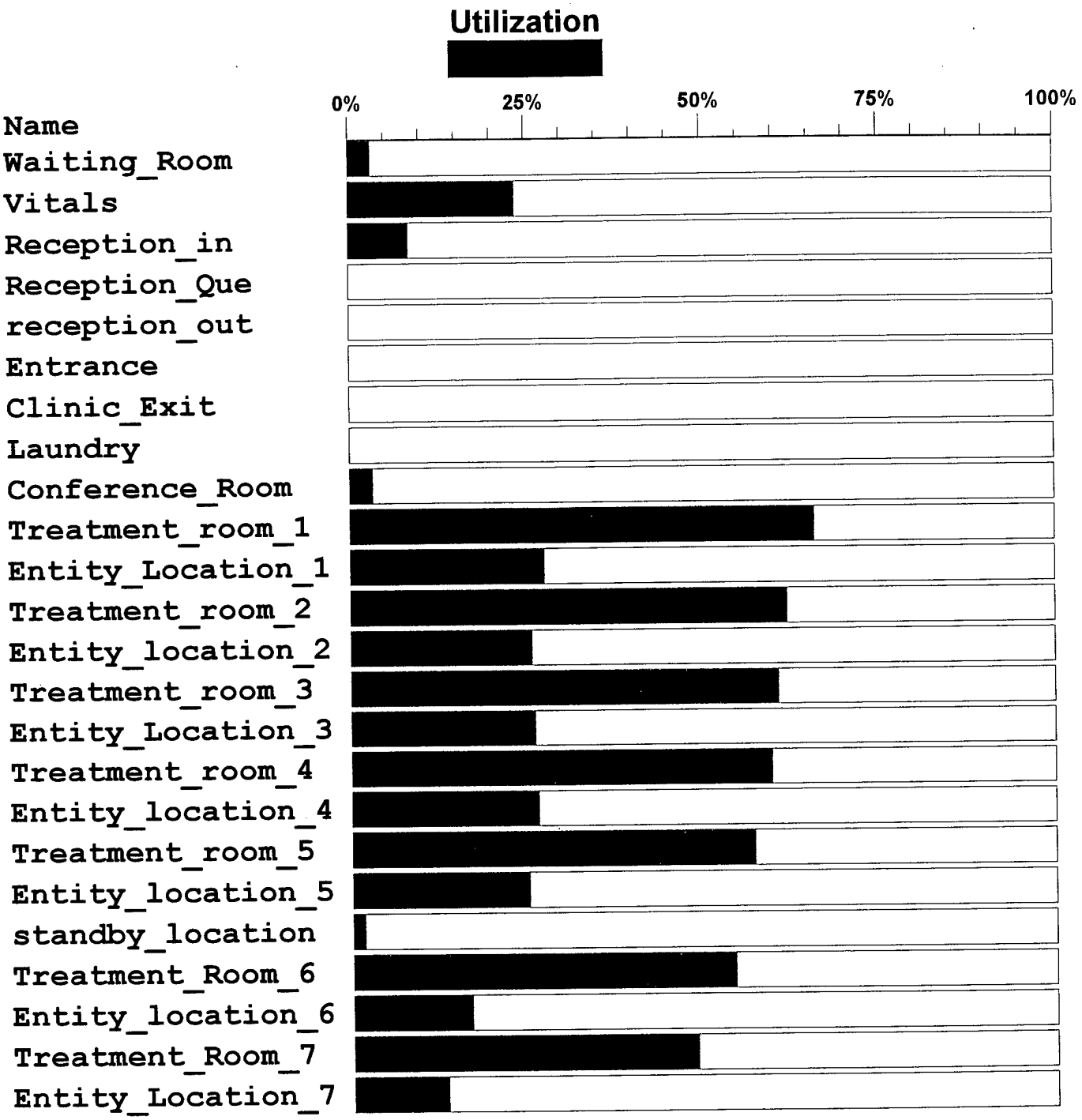
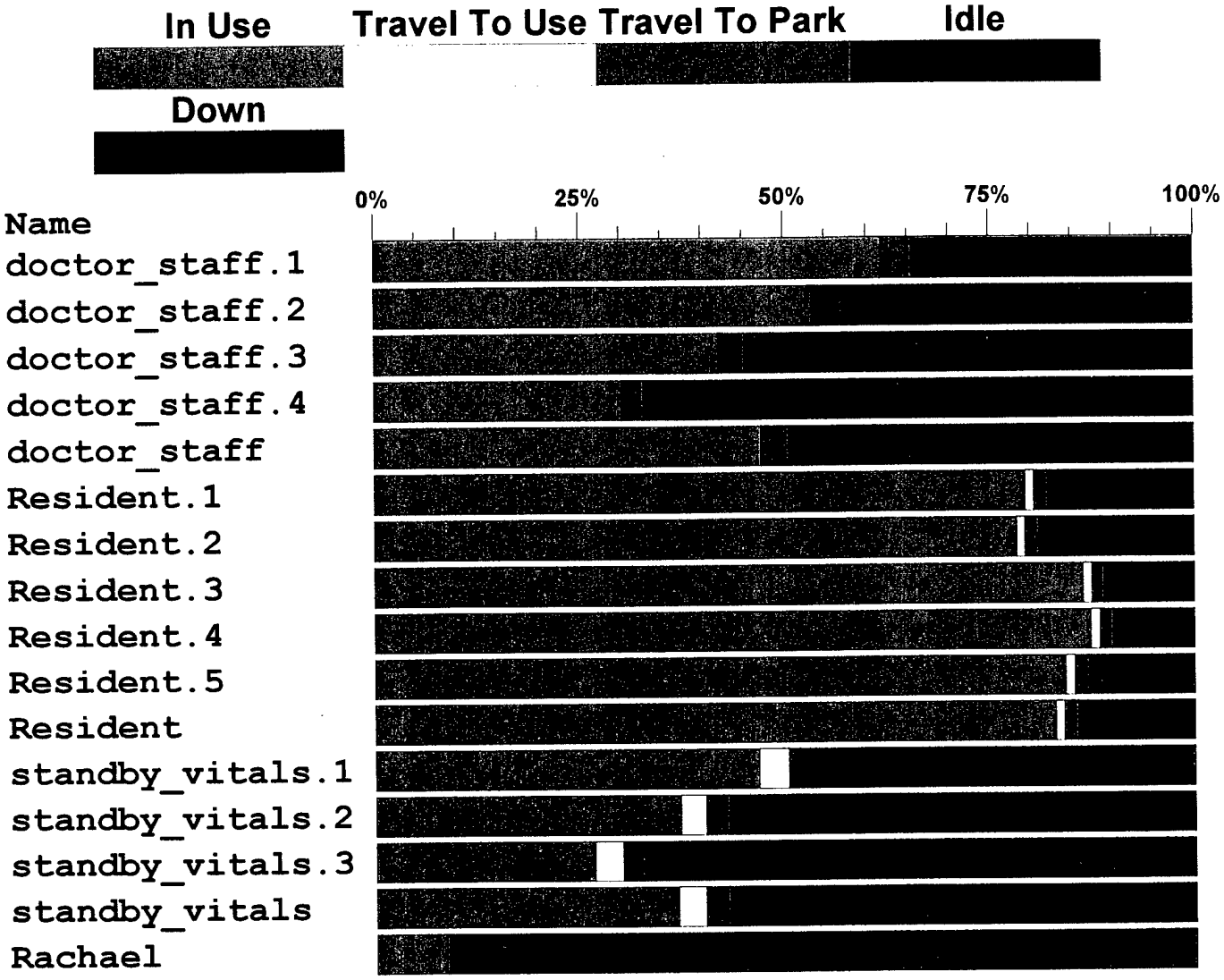


APPENDIX - V

Resource States



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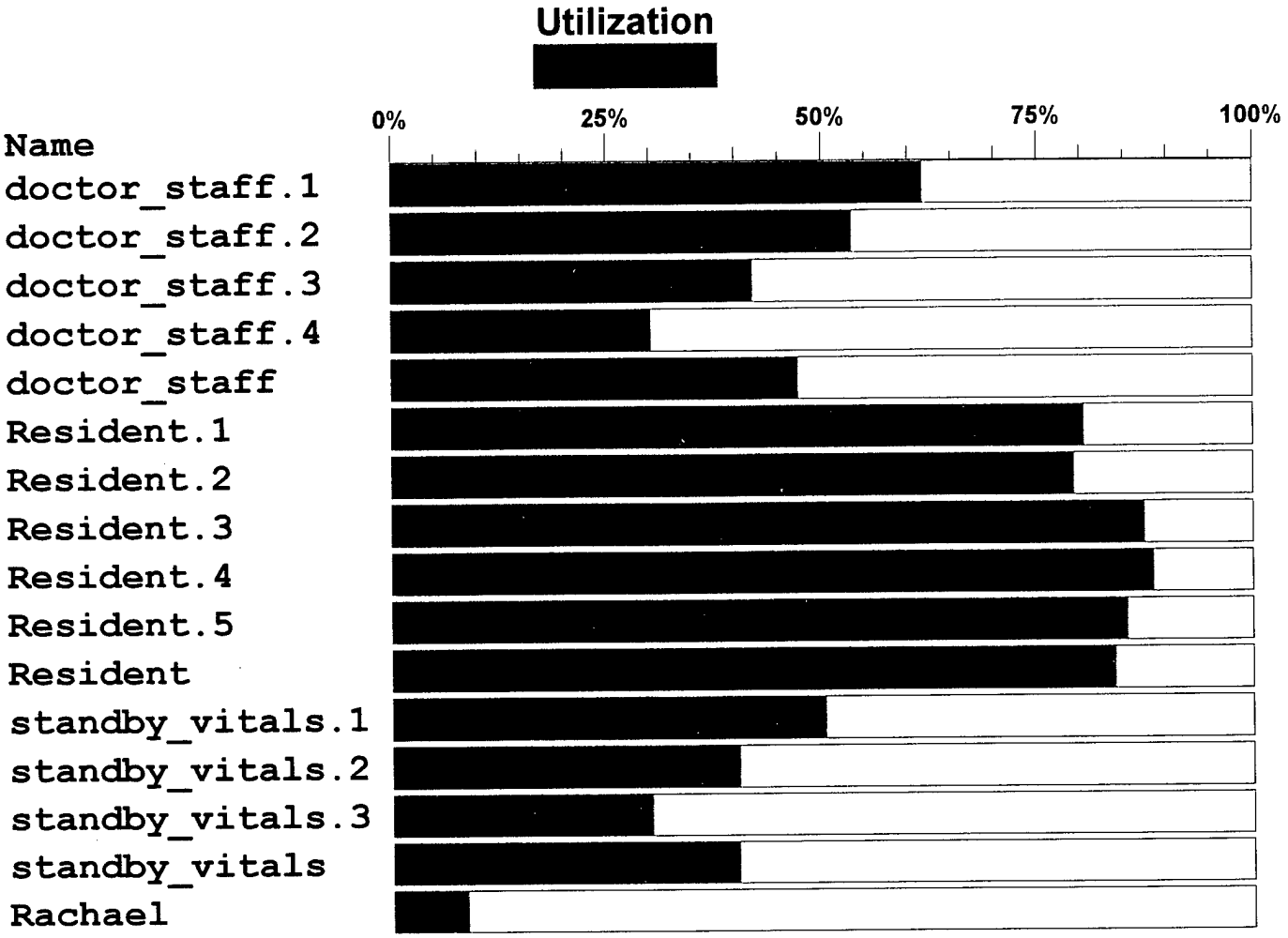

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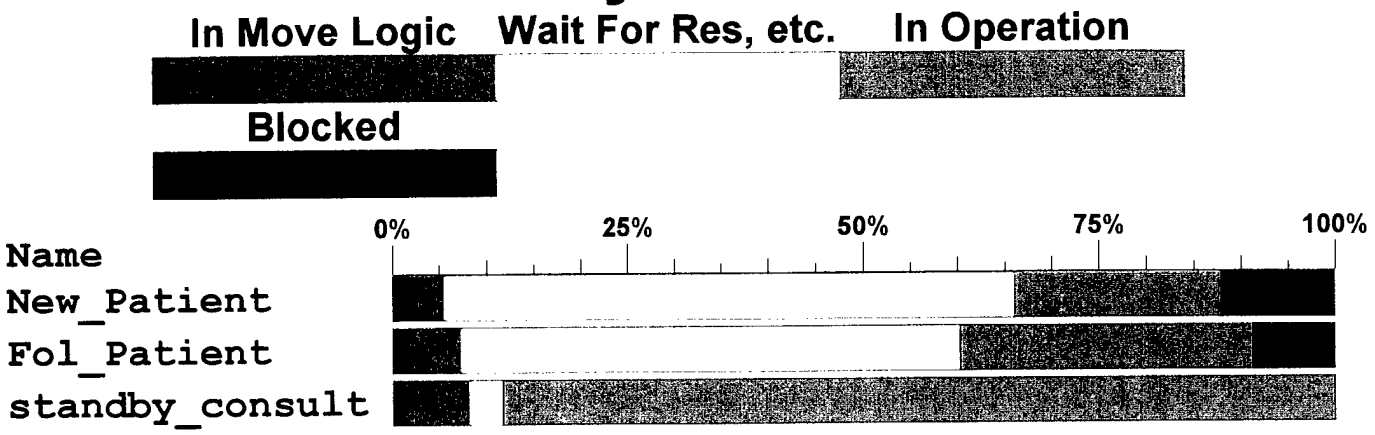

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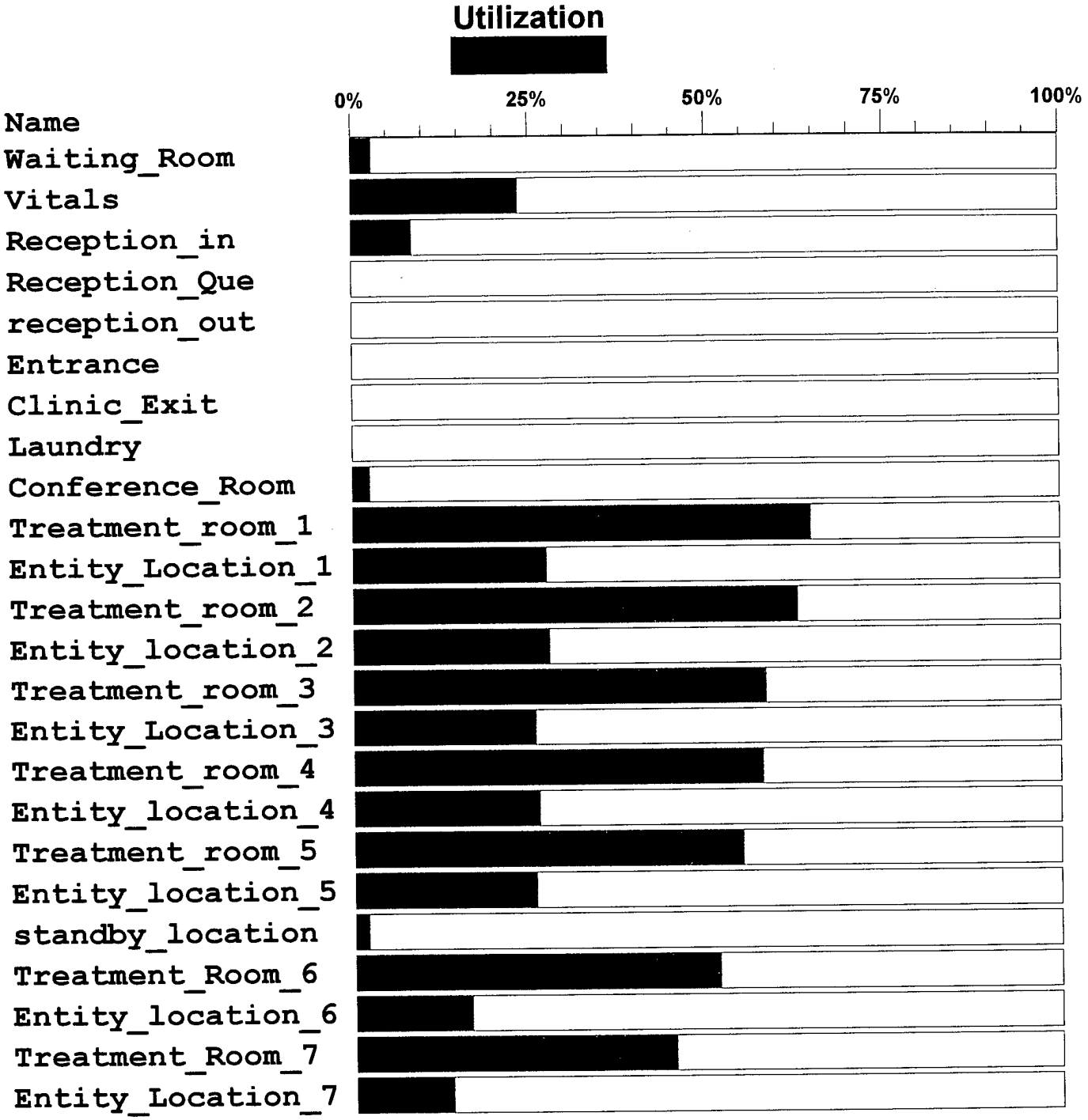
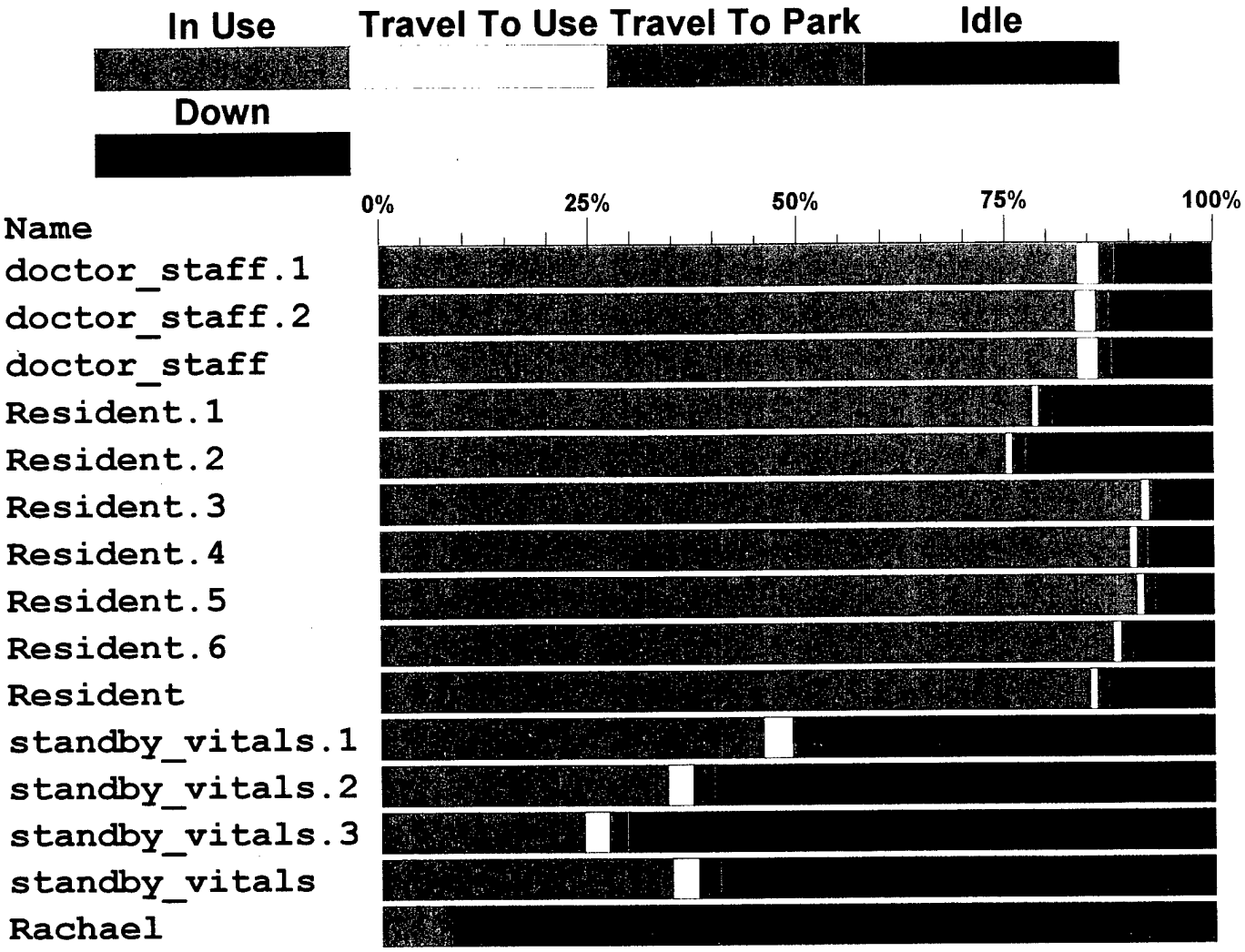


APPENDIX - W

Resource States



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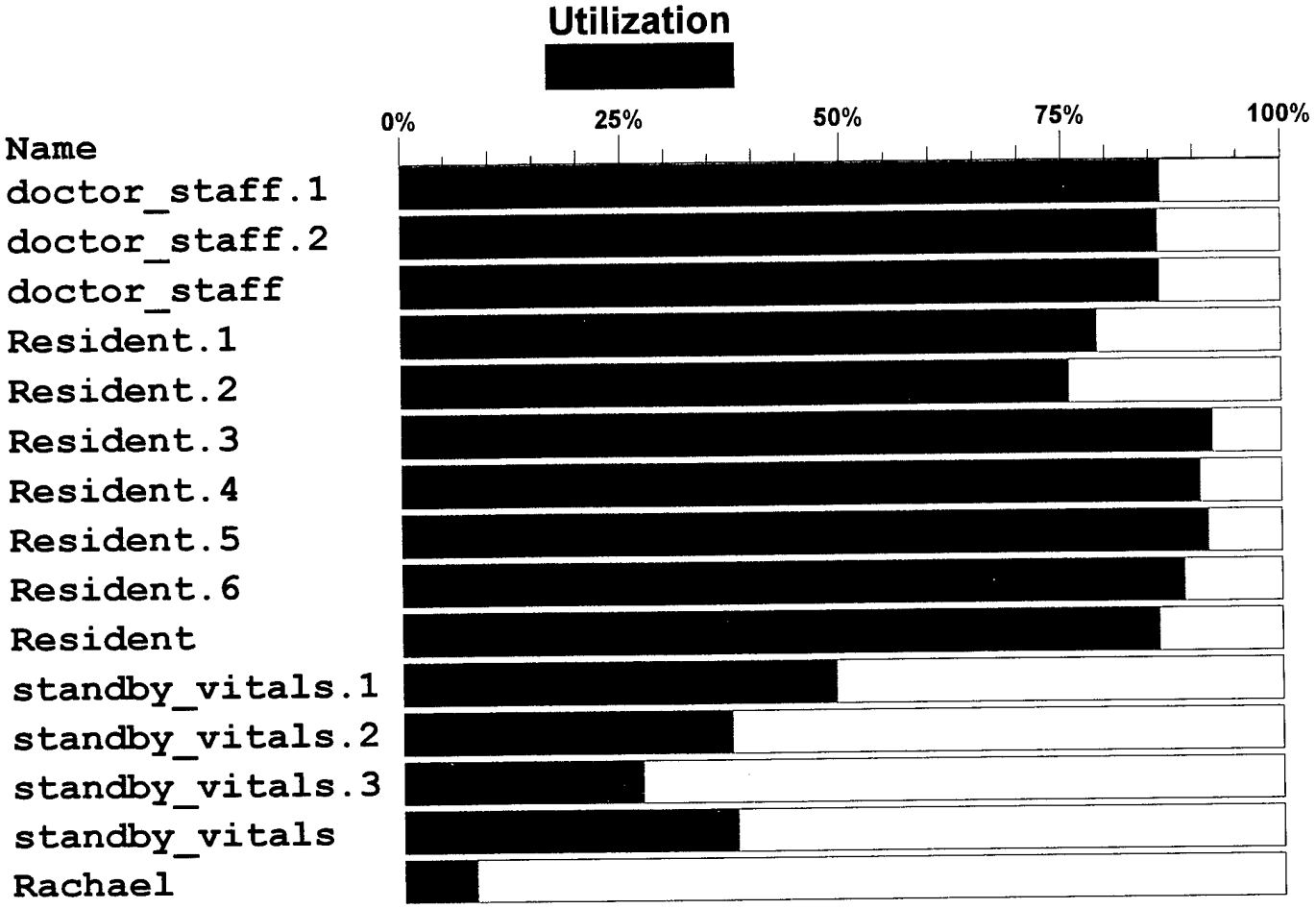

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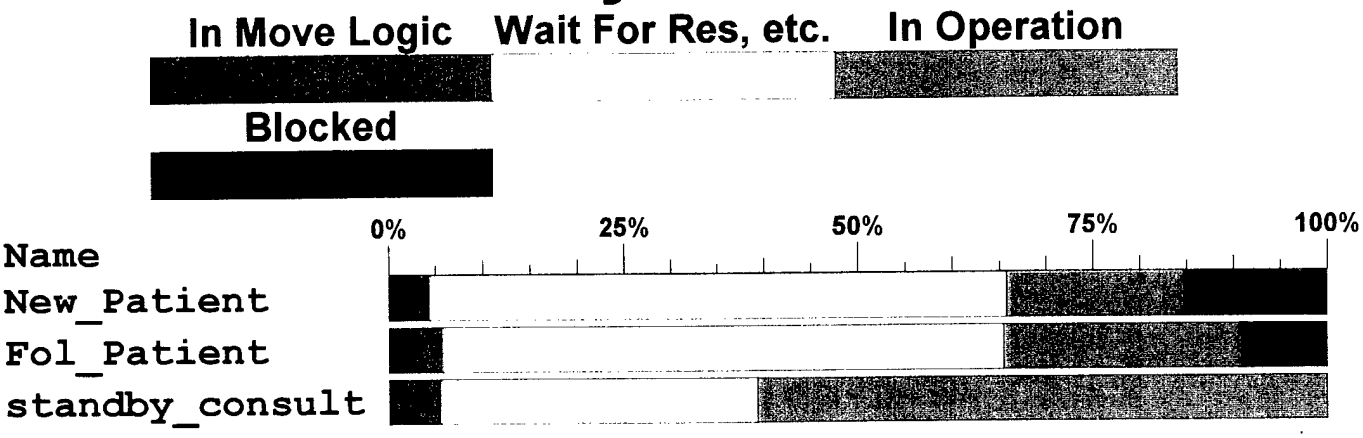

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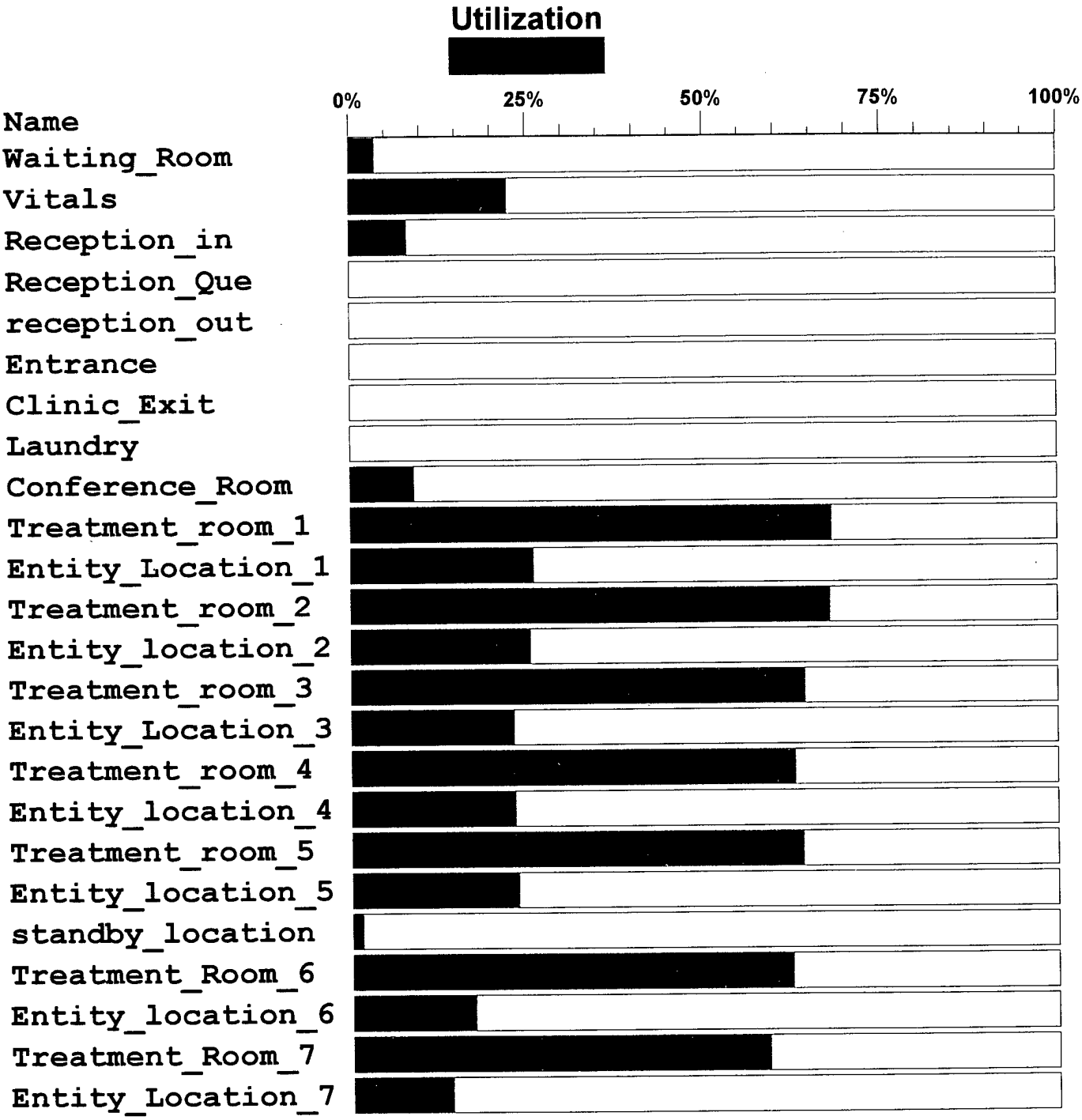
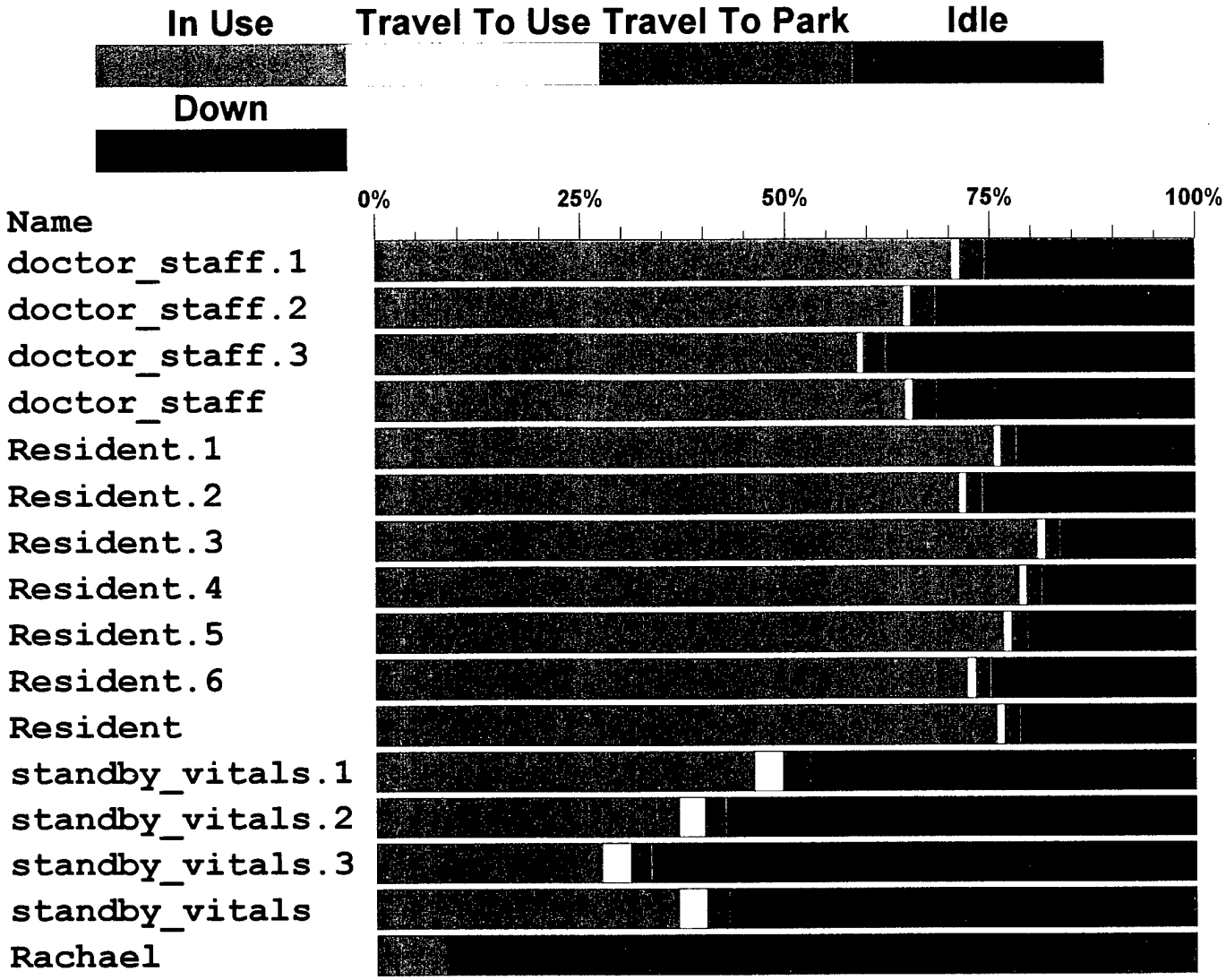


APPENDIX - X

Resource States



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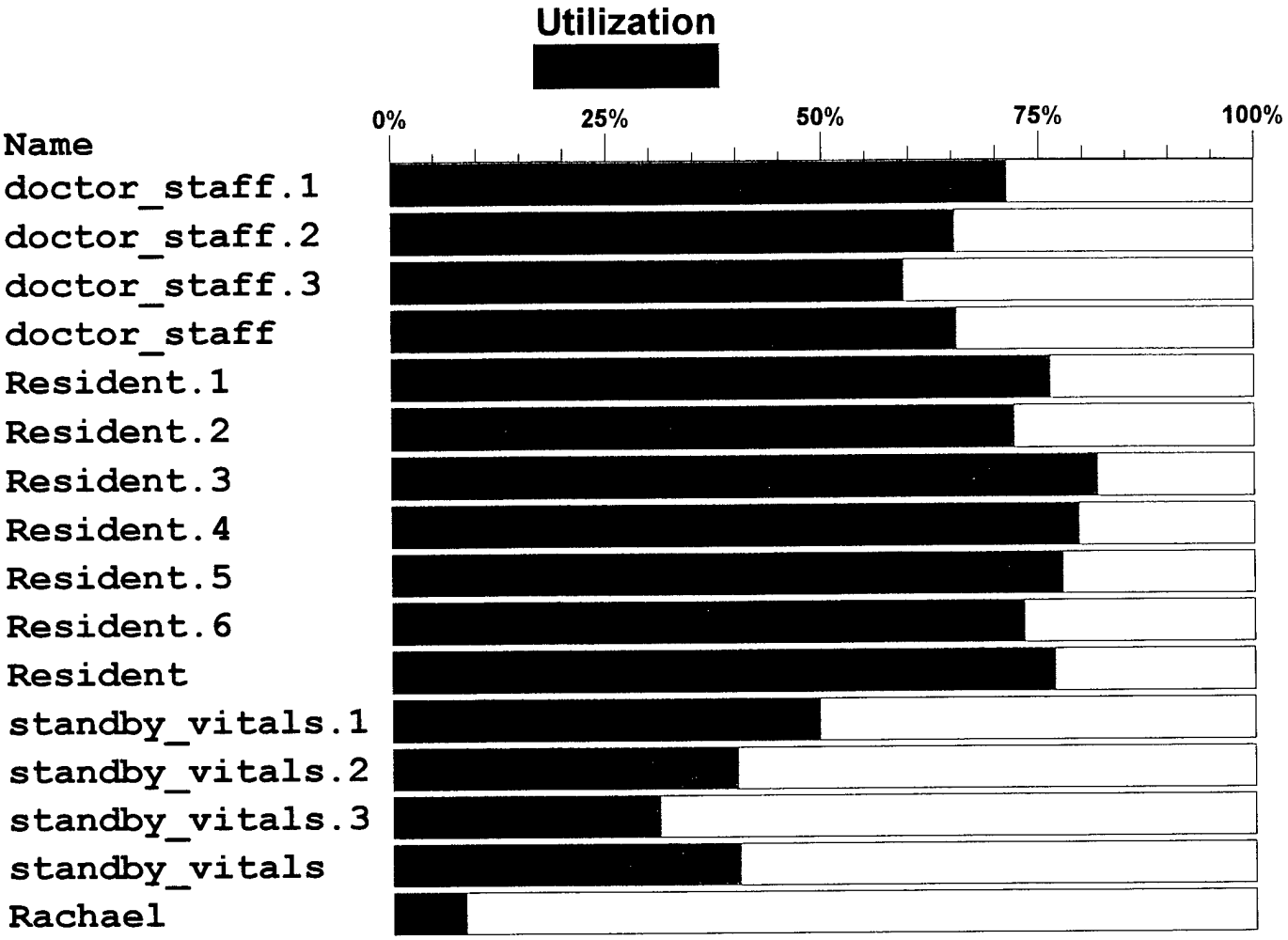

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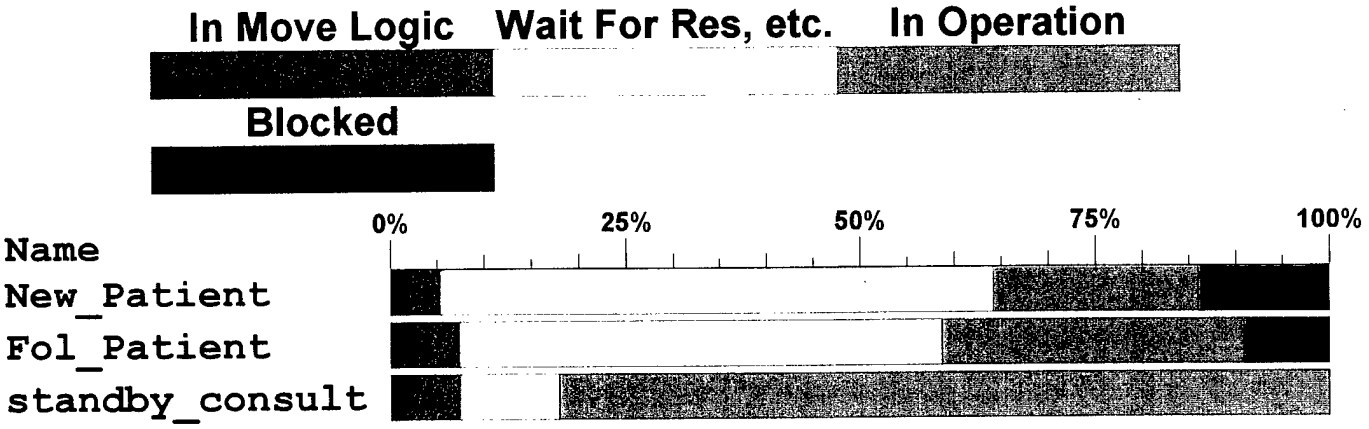

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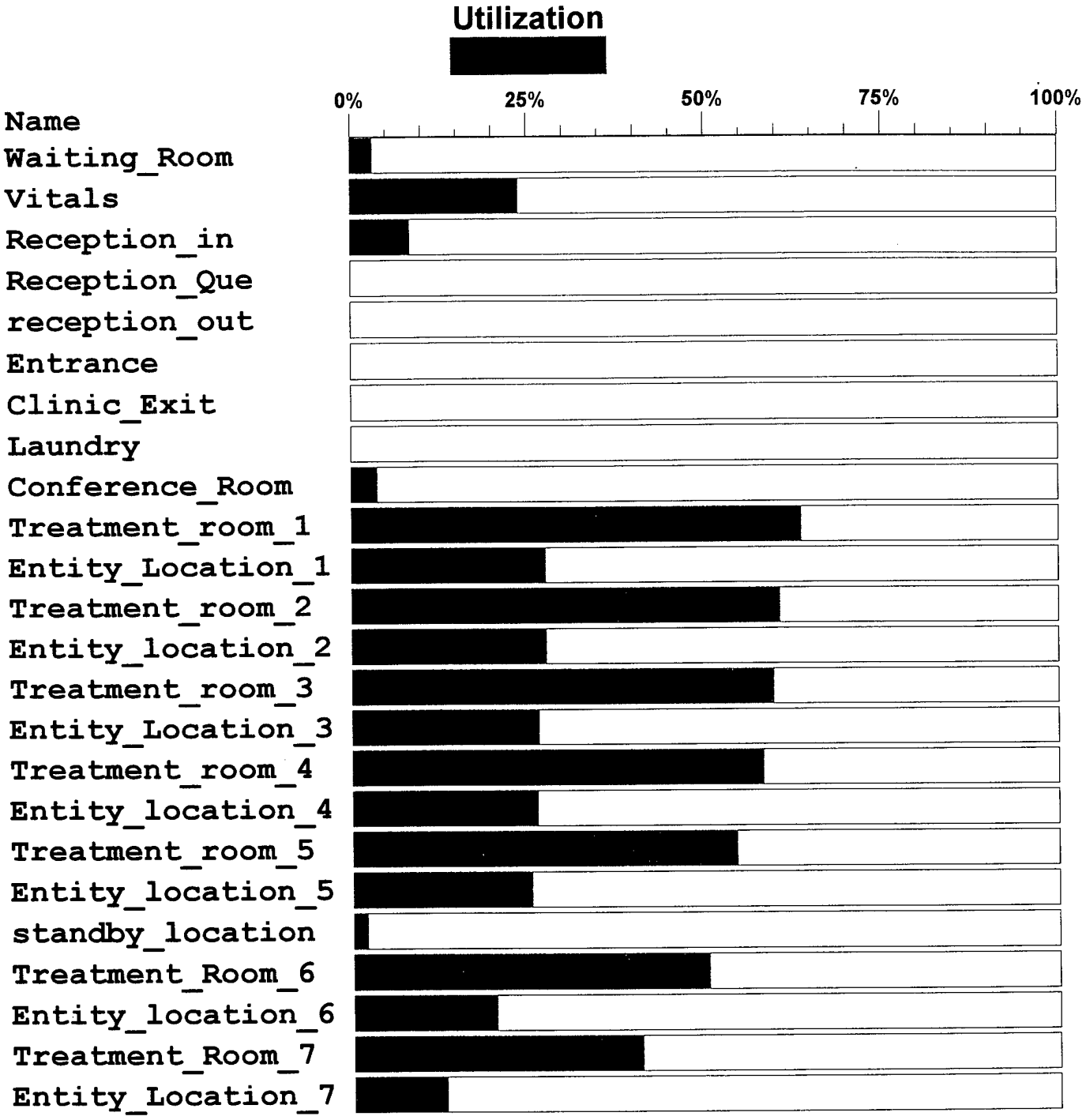

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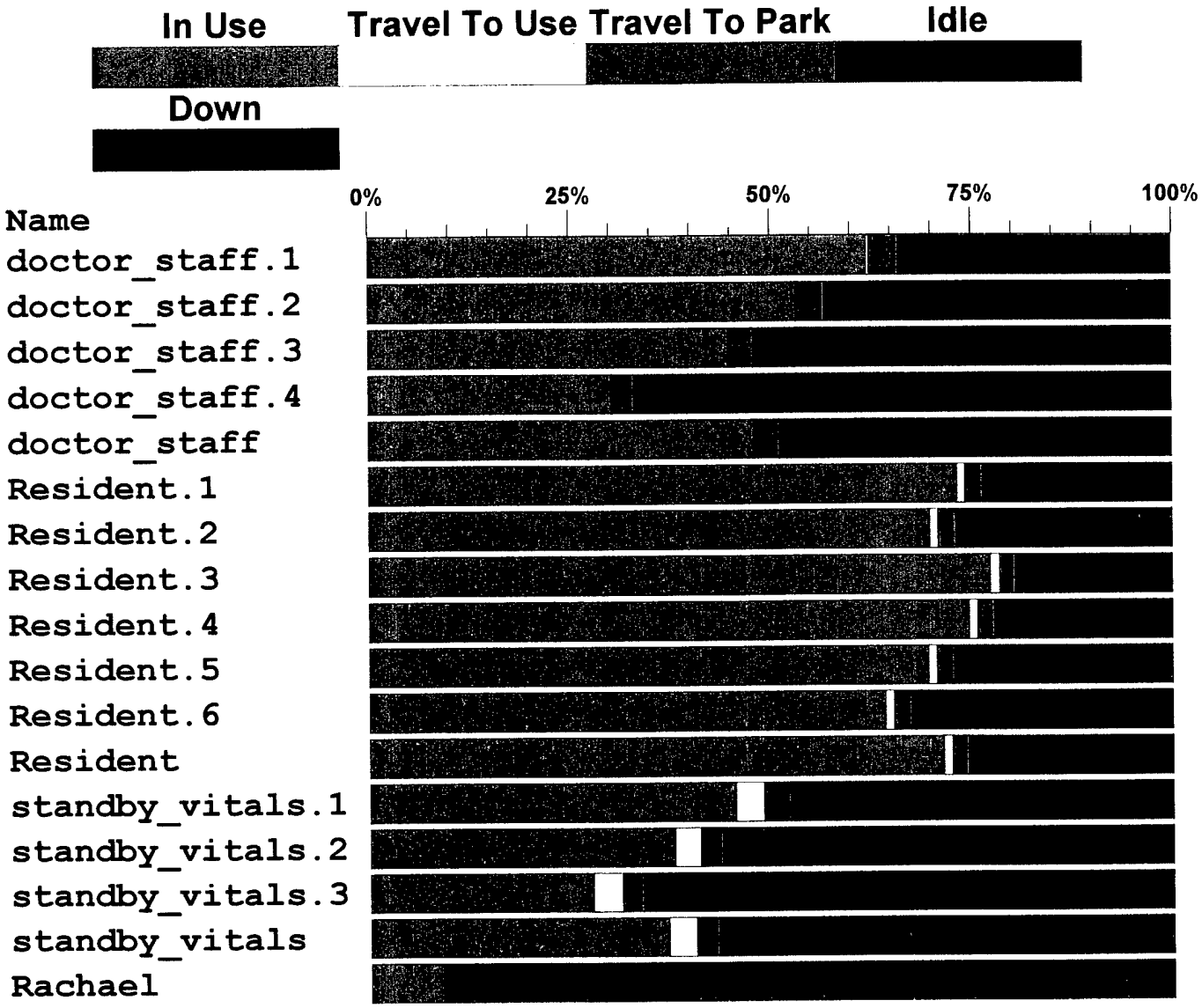

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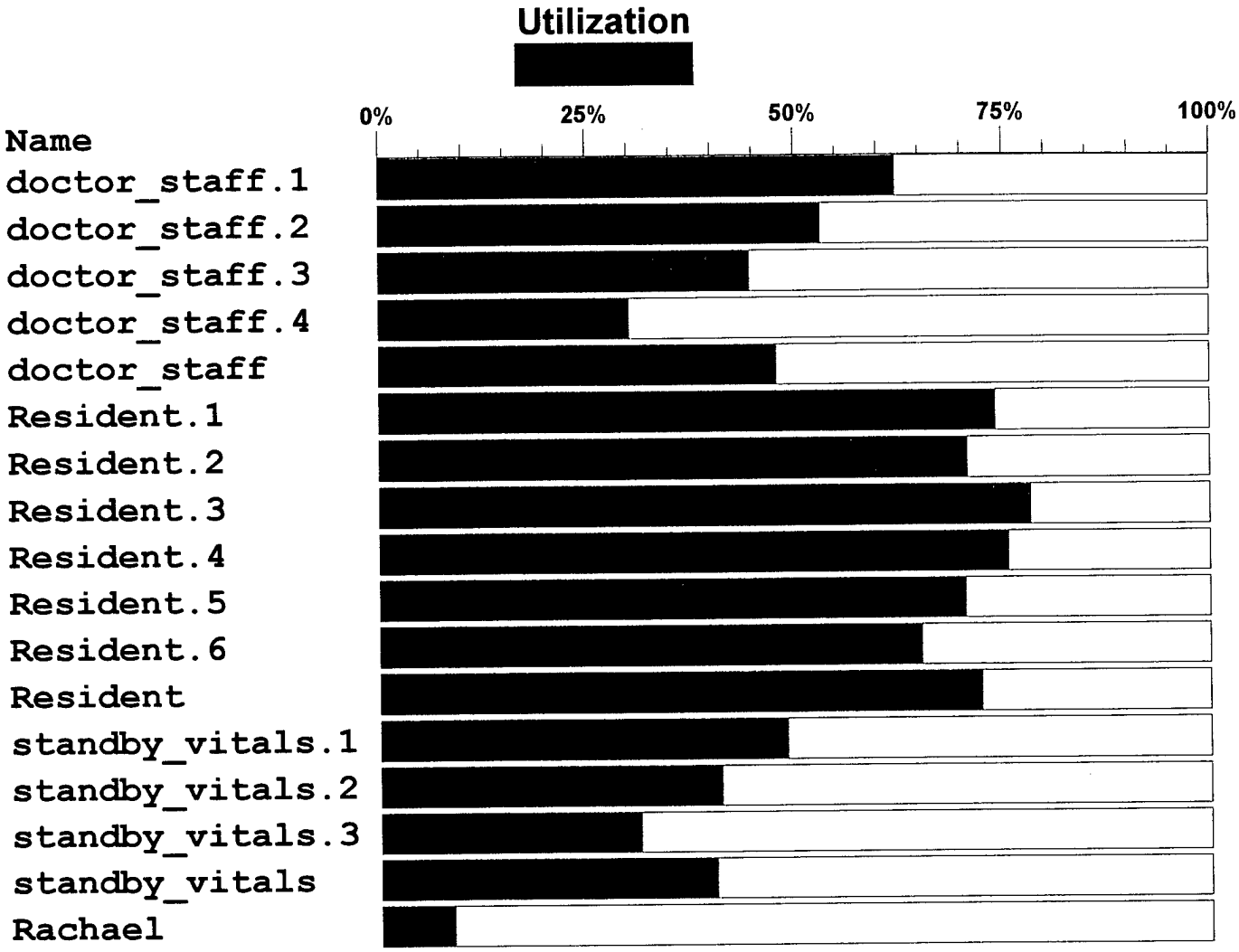

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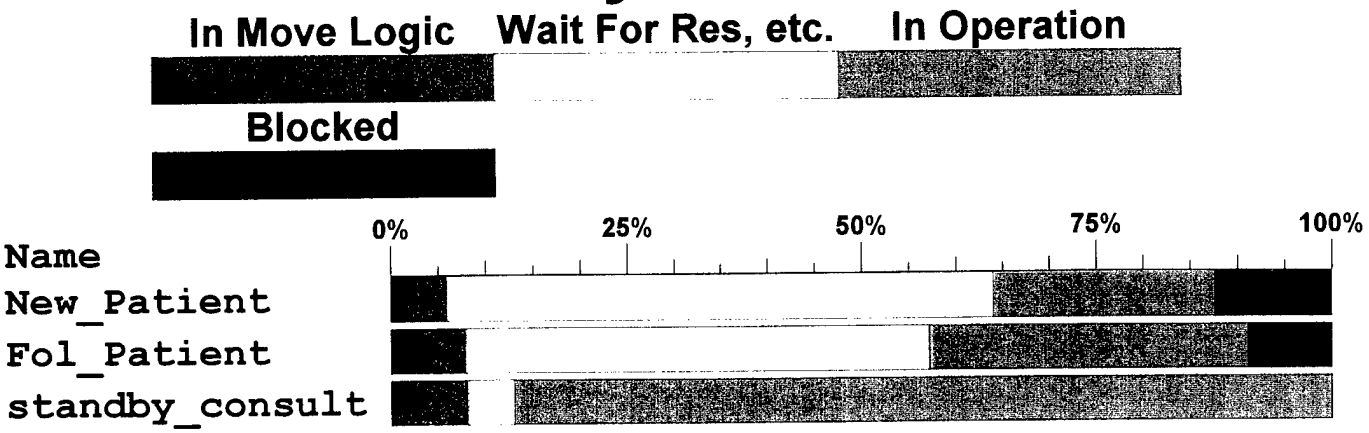

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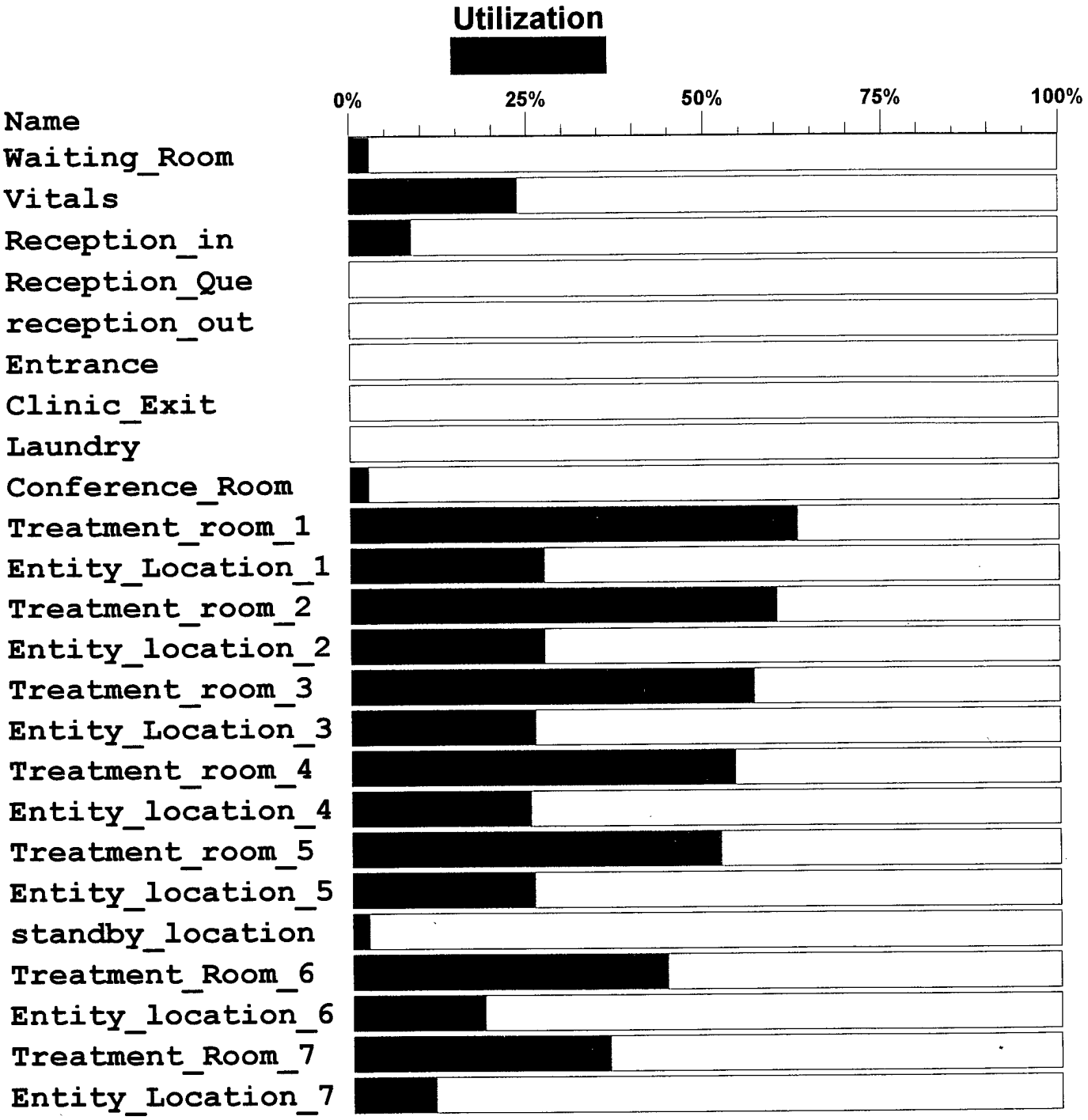

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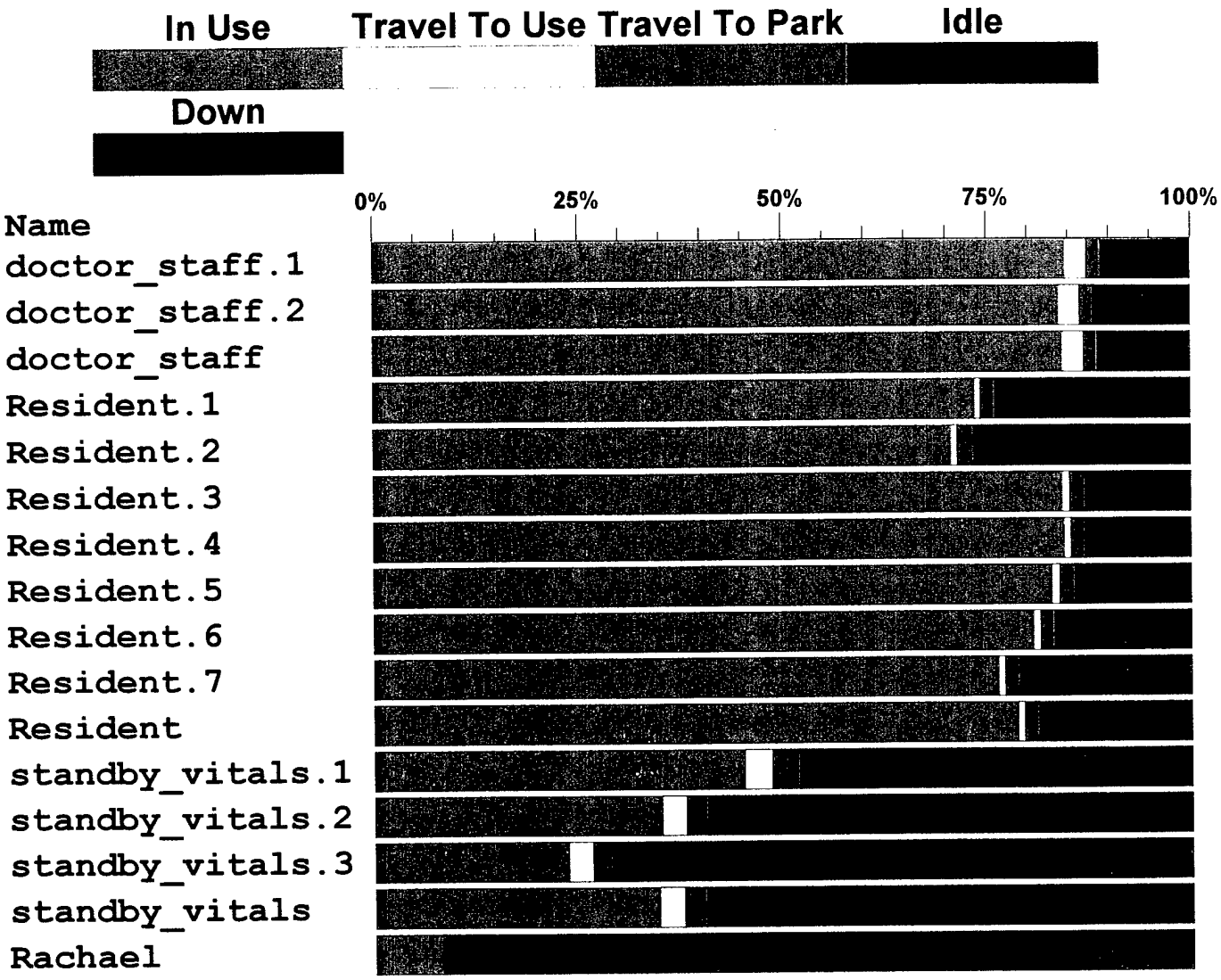

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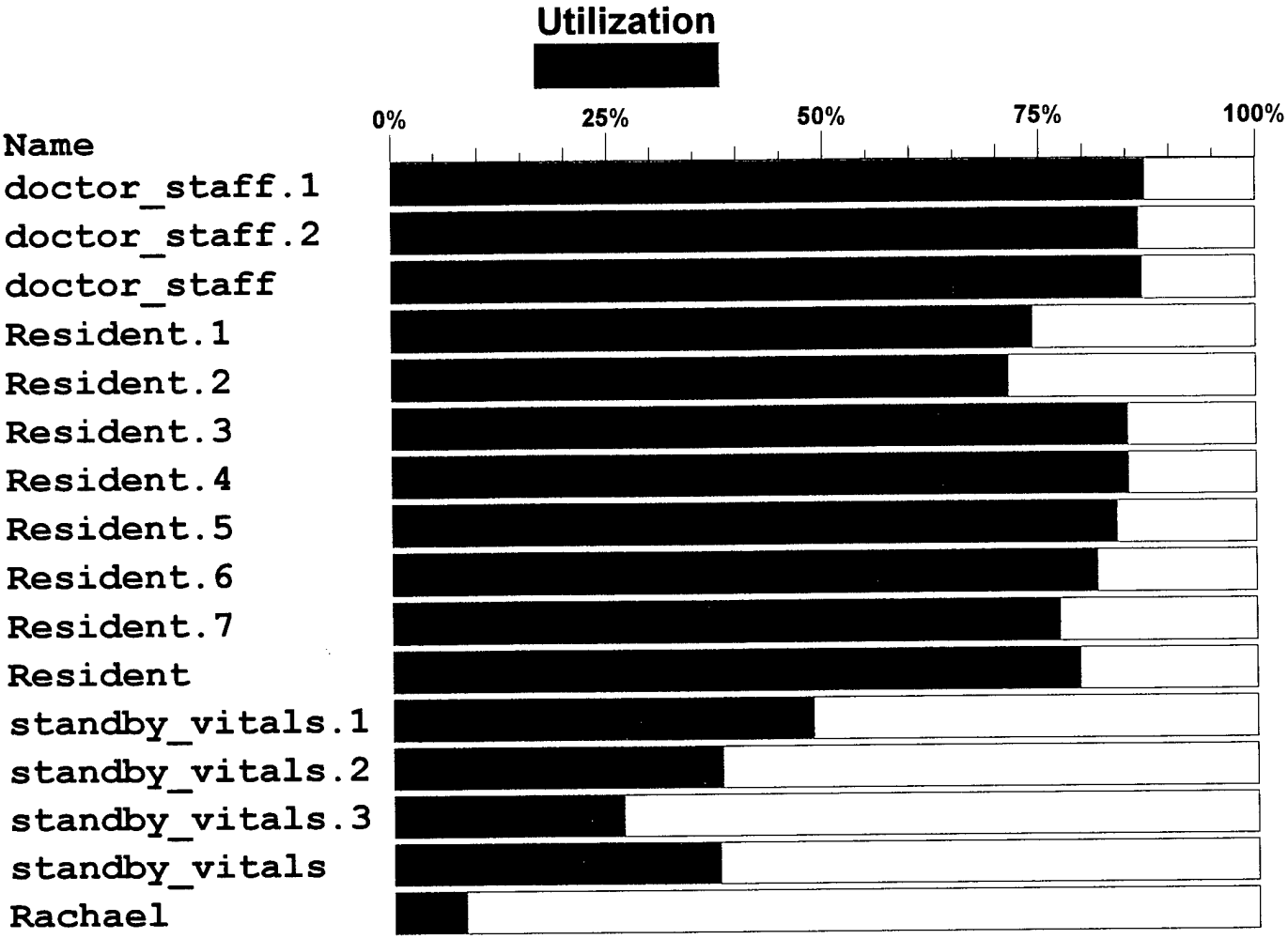

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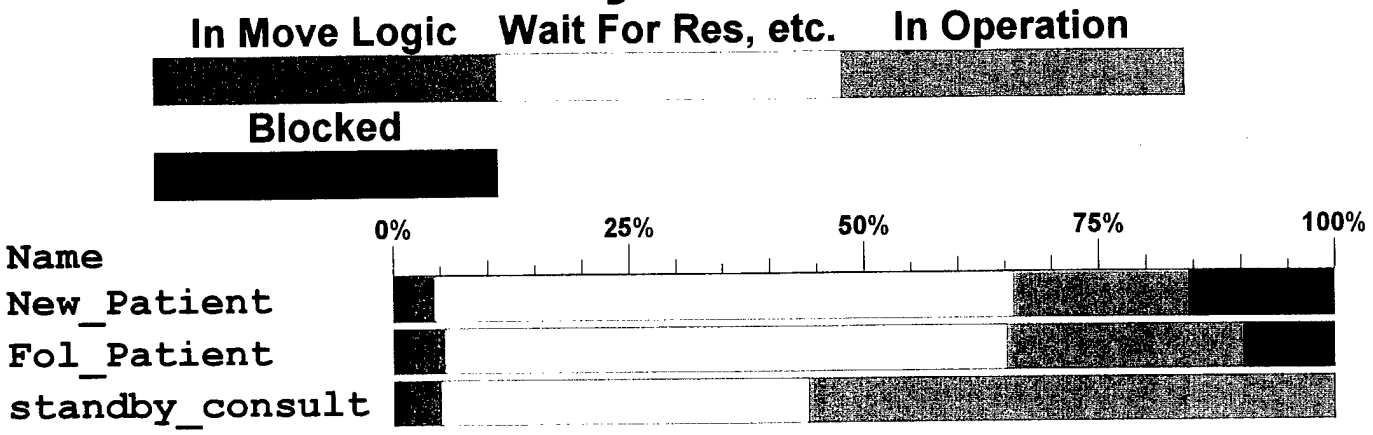

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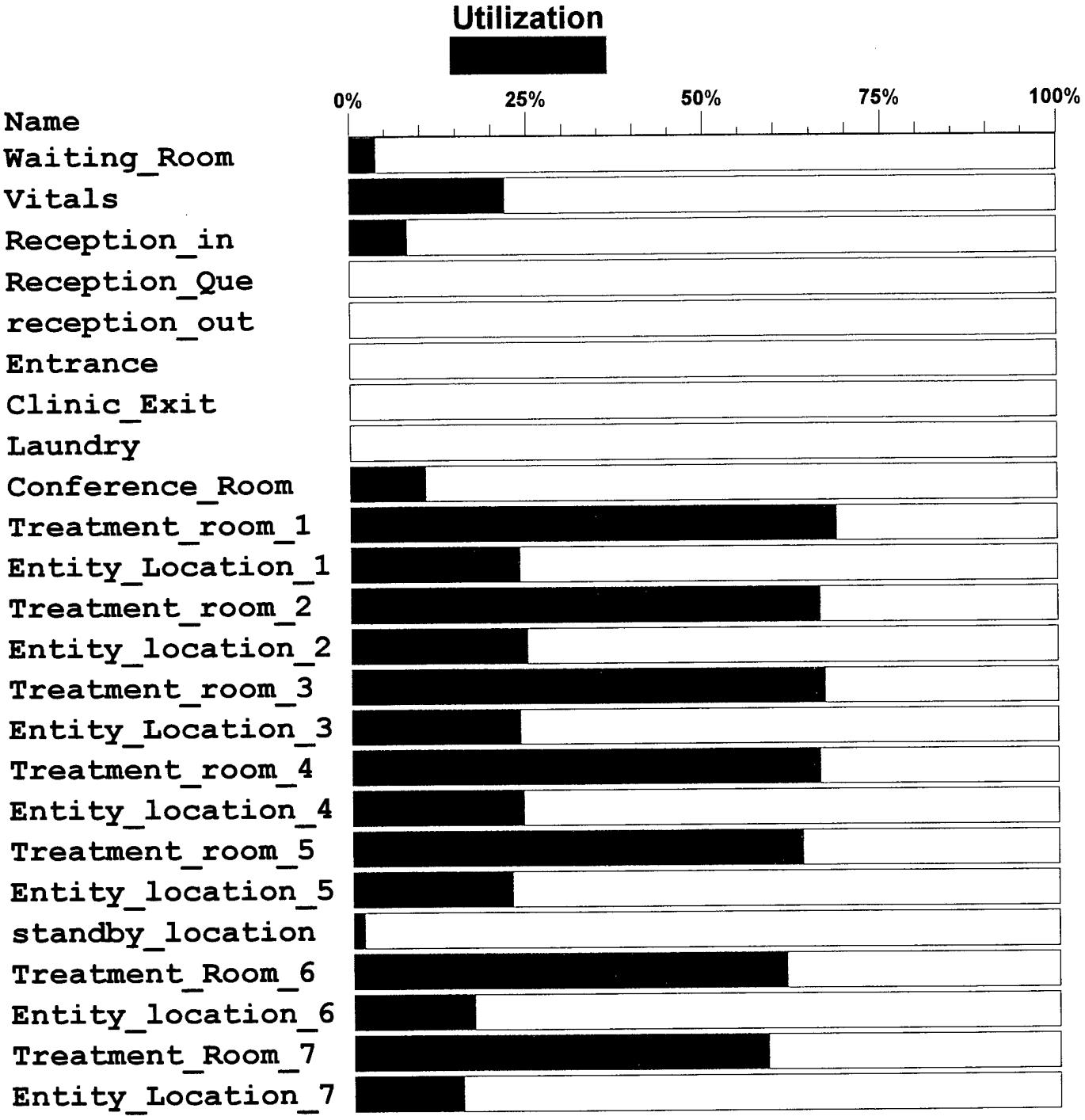
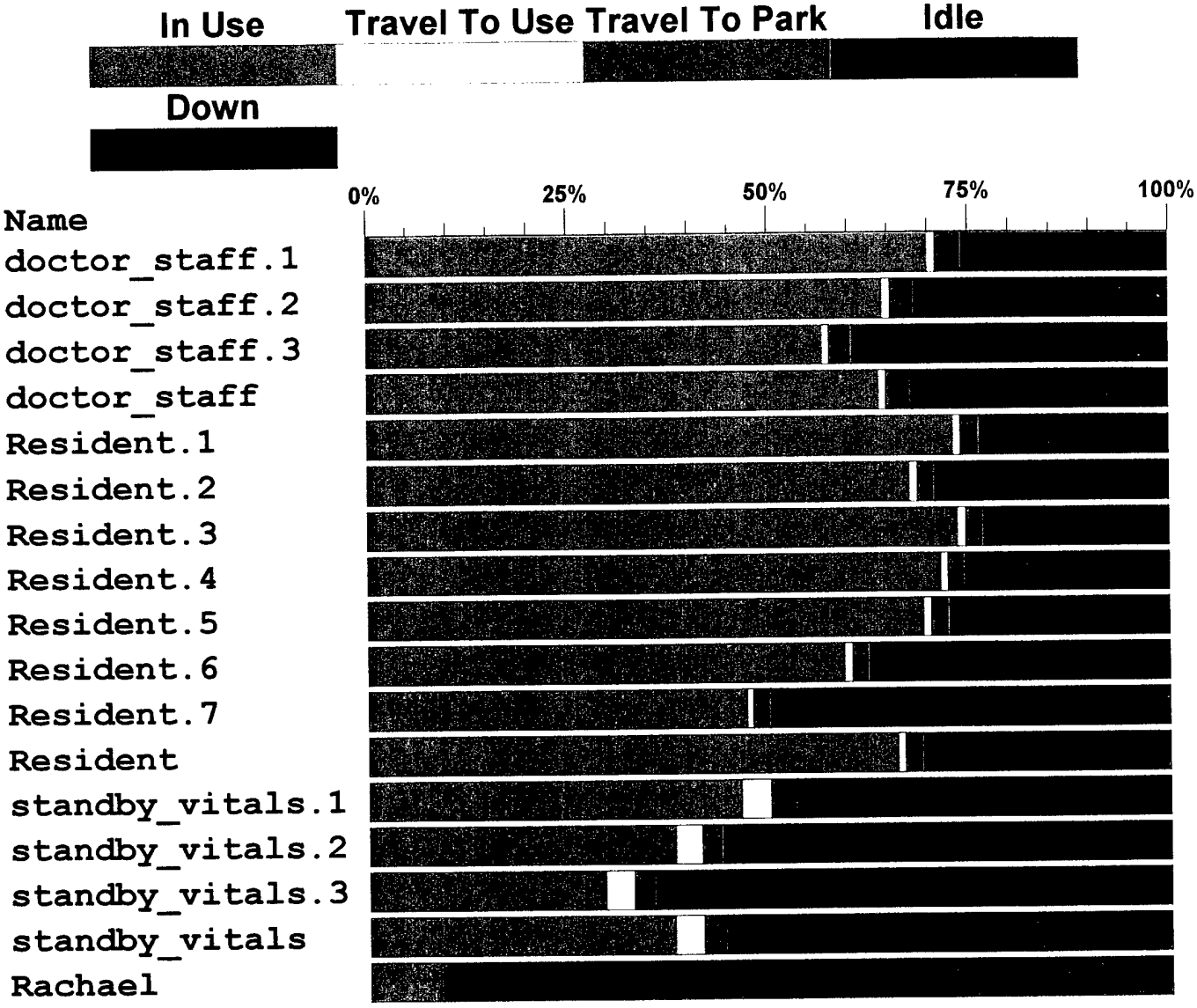


APPENDIX - AA

Resource States



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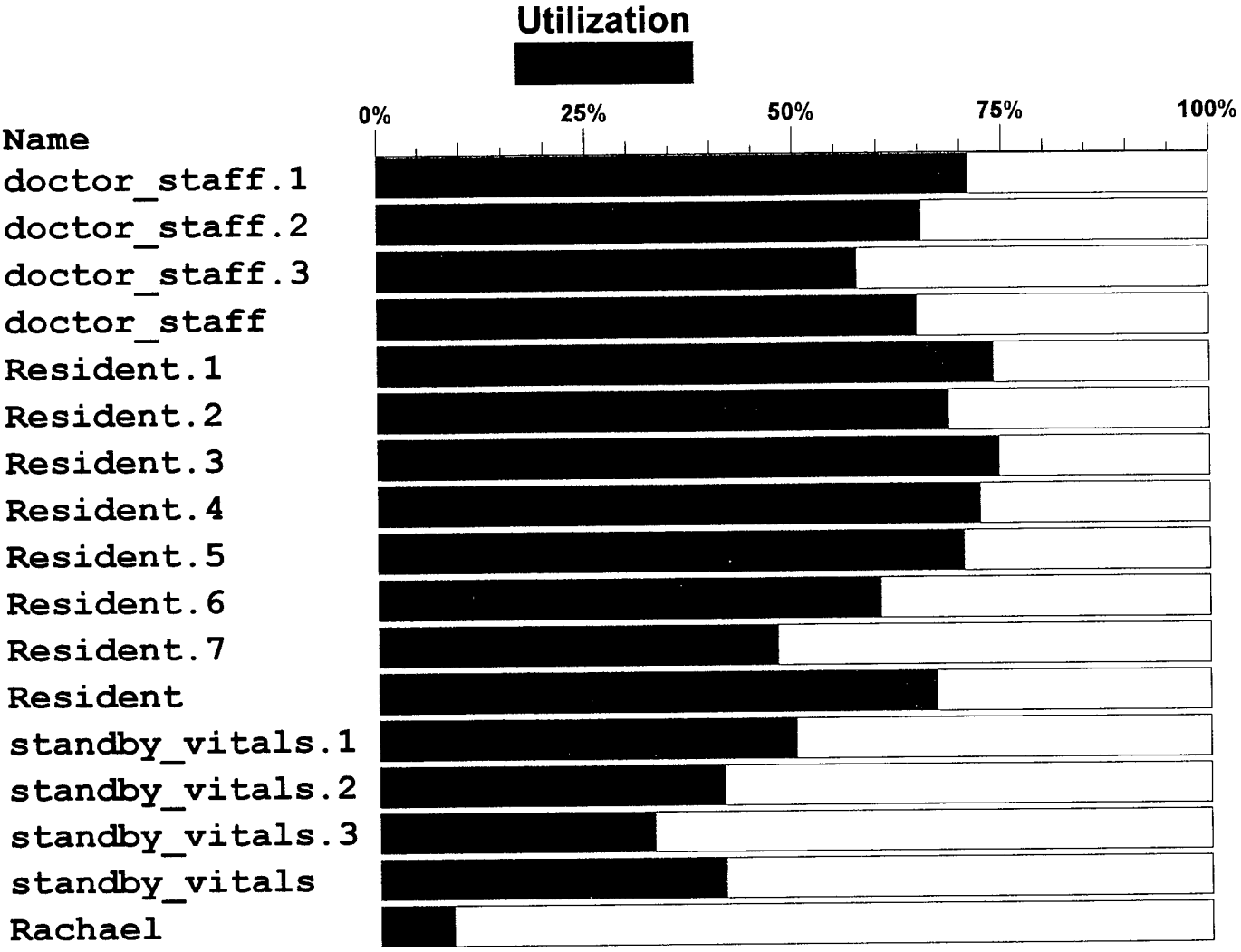
Resource Utilization



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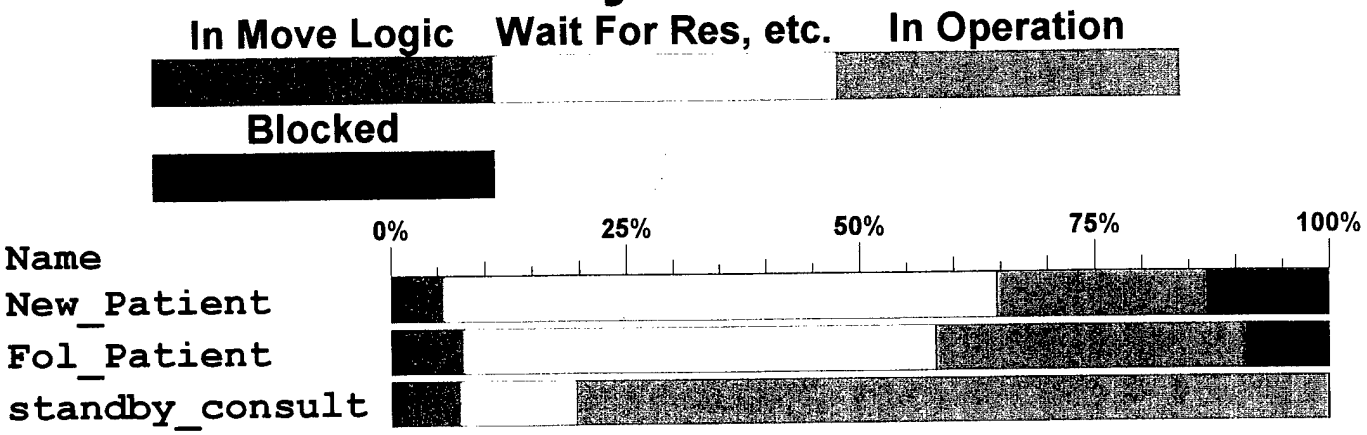

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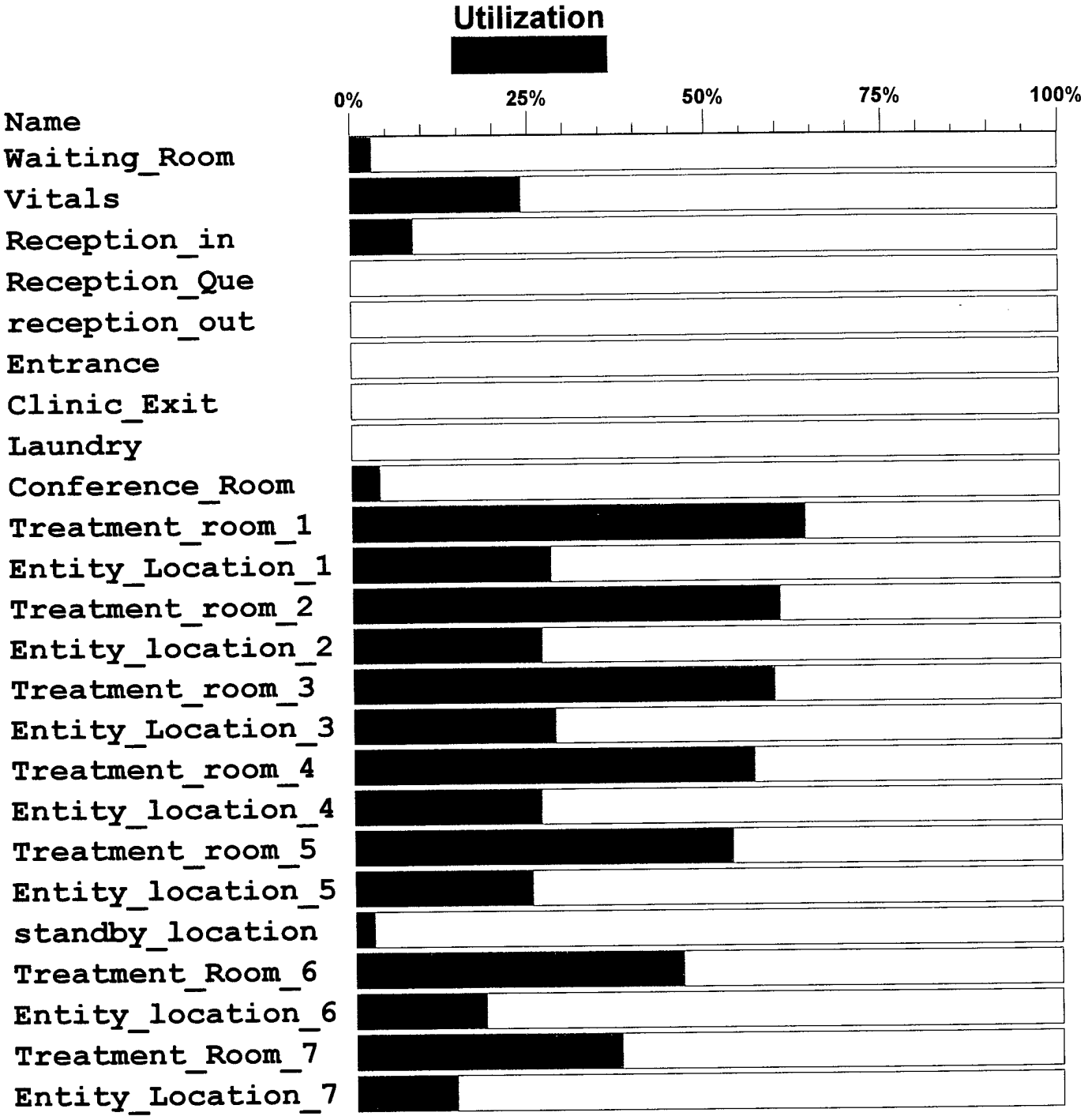

APPENDIX - BB

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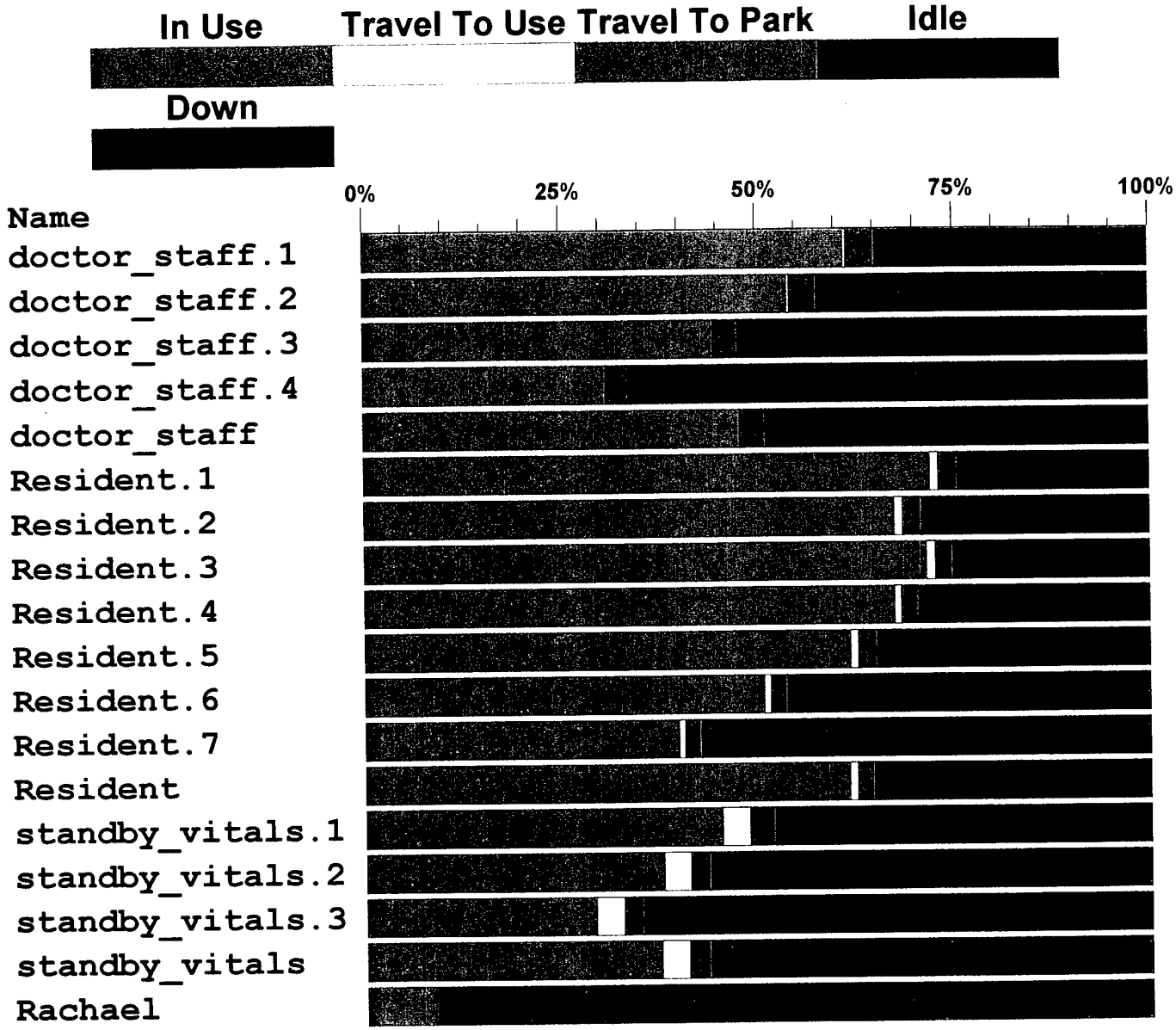

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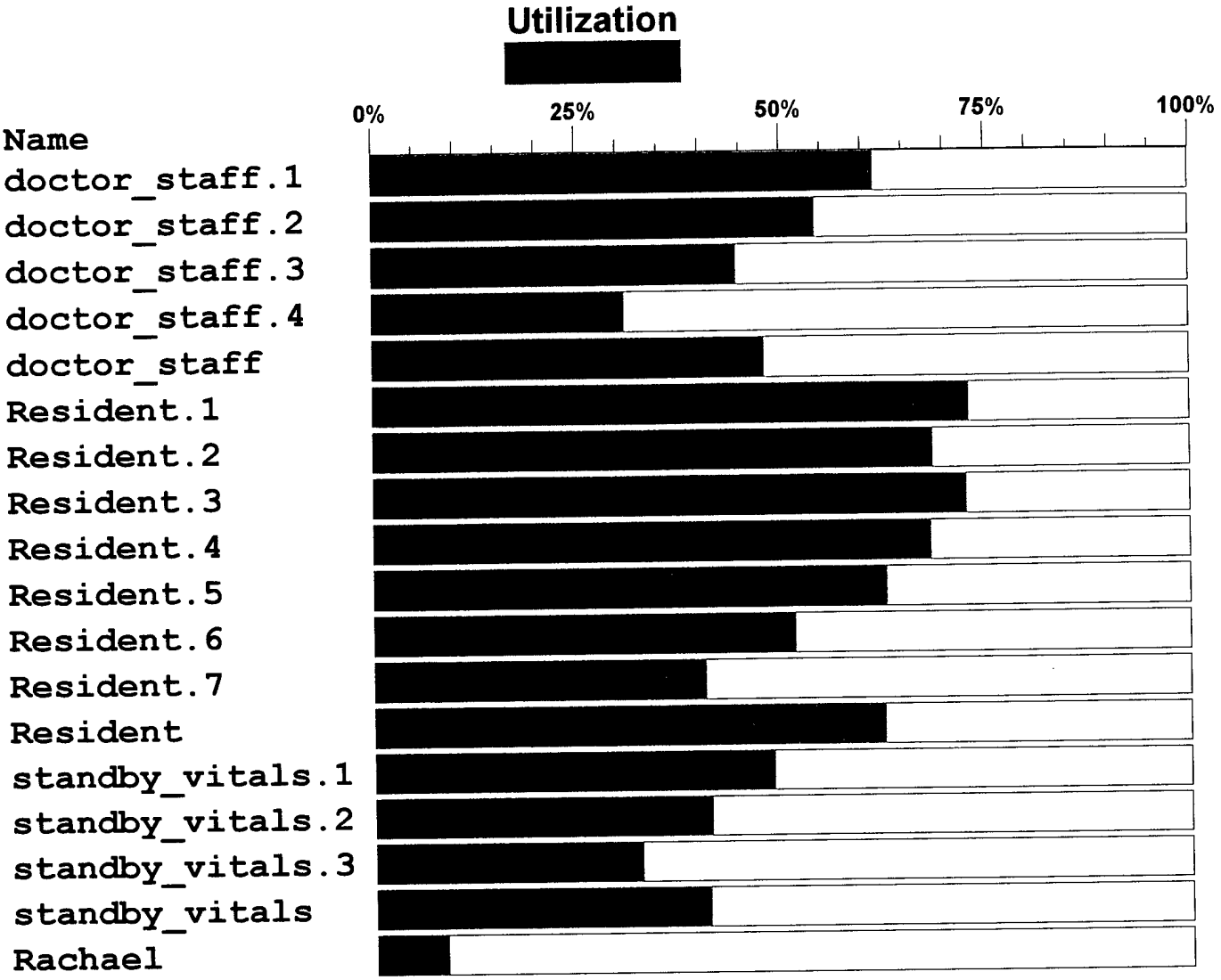

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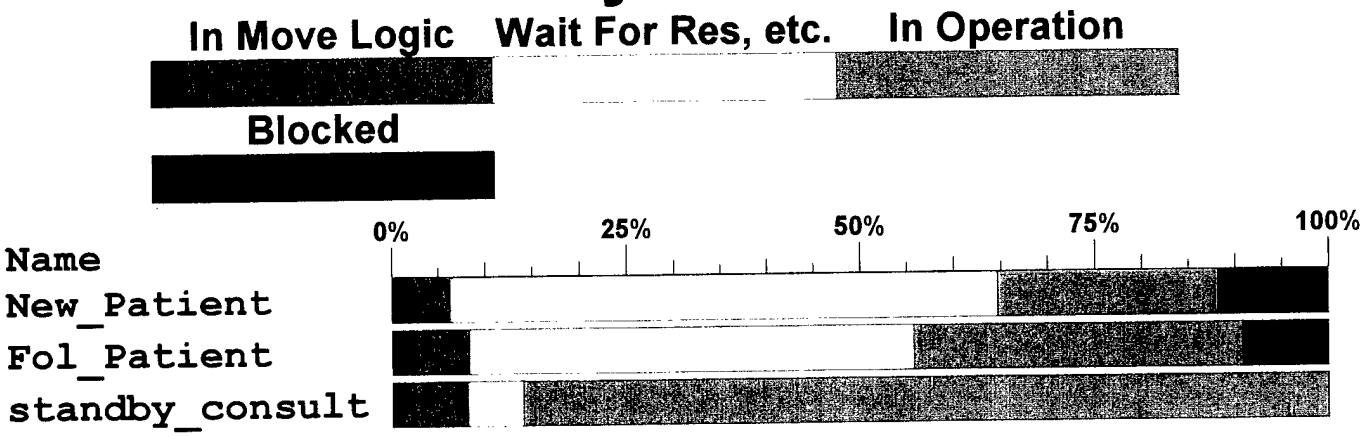

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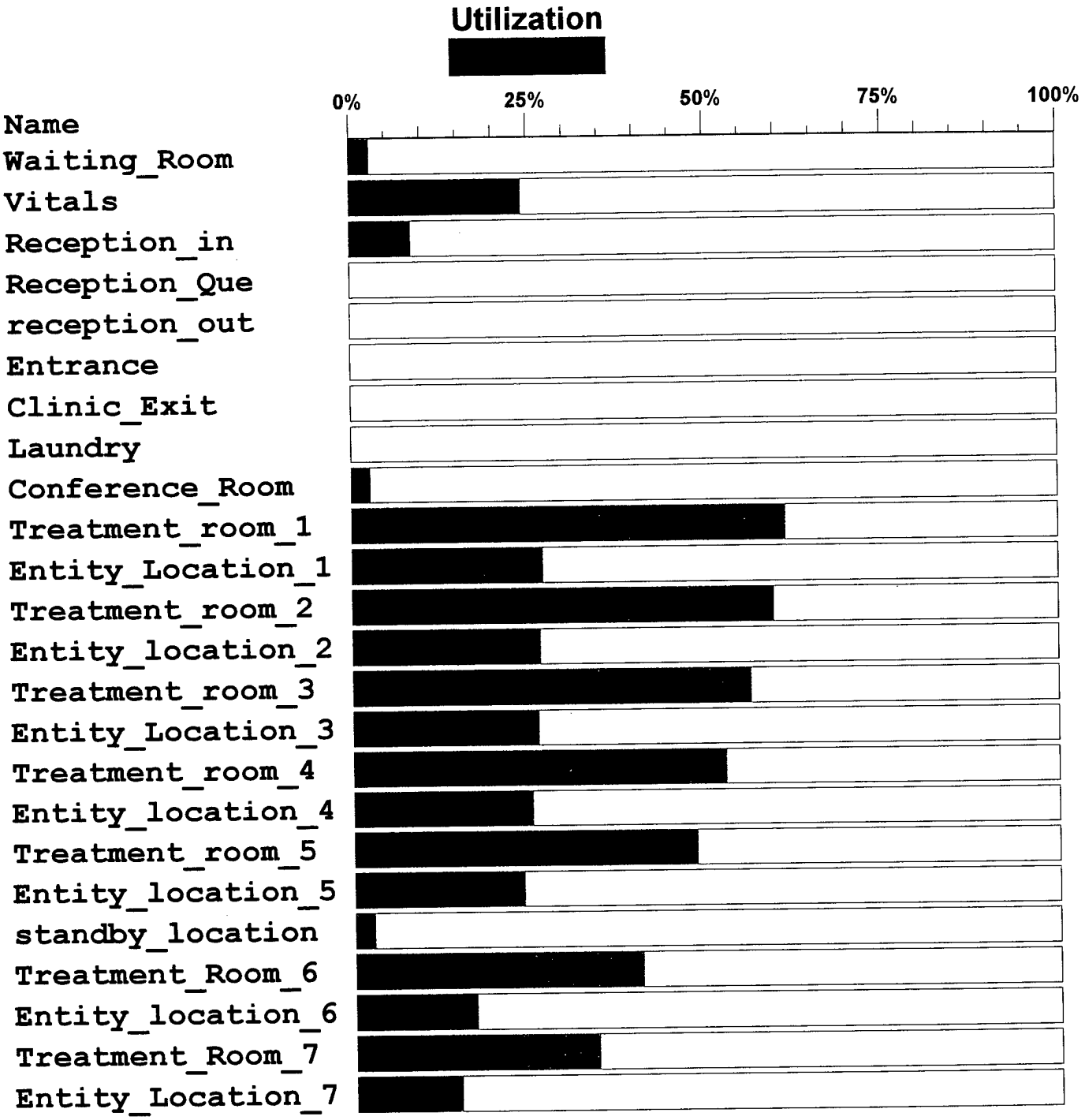

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