Fairness in Patient Routing: Maternity Wards in Rambam Hospital

Technion – Israel Institute of Technology

- Technical Report -

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Preface and Acknowledgments

This report is a detailed summary of a project prepared as part of the requirements for a Bachelor of Science degree in Industrial Engineering and Management from the Technion, Israel Institute of Technology by four team members: Noa David, Alon Dourban, Michal Gologorsky and Ori Plonsky.

The project was held in full cooperation with the Obstetrics and Gynecology division in Rambam hospital in Haifa, Israel. Ms. Michal Kranzler, head nurse of the division, and Ms. Sarah Zafrir, director of the Information, Computerization and Communications department were the team's advisors and contacts in the hospital.

Prof. Avishai Mandelbaum and Prof. Anat Rafaeli from the Technion were the head academic advisors of the team. Ms. Dorit Efrat and Mr. Itamar Zaied, both from the Technion, were also academic advisors.

The project was initiated on April 25th 2010 and submitted for review on February 13th 2011, although some parts of this report are related to work performed in later stages.
The full project report (in Hebrew) submitted can be retrieved from:
http://ie.technion.ac.il/serveng/References/Students'%20Seminar%20Spring%202010/Final%20Report.pdf

The team members acknowledge and greatly appreciate the help and assistance from their academic advisors. The team members also acknowledge the important contribution and help from Ms. Kranzler and Ms. Zafrir. Finally, the team members thank the entire nursing staff of the two maternity wards with special thanks to Betty and Michal, head nurses of the two wards.

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§ INTRODUCTION

1. General Background

Rambam hospital is the largest hospital and the only major trauma center in the north of Israel, serving more than two million people. The hospital is the primary clinical facility of the Technion's School of Medicine. In recent years, the hospital has been involved in several joint projects with the Faculty of Industrial Engineering and Management in the Technion.

The hospital's Division of Obstetrics and Gynecology (OBGYN) treats roughly 4000 patients a year. The division has five wards: Gynecology Ward, Neonates Ward, Delivery Room, and two maternity wards. The division's head-nurse, Ms. Kranzler, is in charge of the division's 100 nurses.

As part of the Technion – Rambam cooperation, Ms. Kranzler addressed the Technion in request for assistance in a problem she faced in the division. This report deals with the problem, analysis and solution suggested.

2. Problem Definition

According to the head nurse of the OBGYN division, nurses from both maternity wards complained about injustice in the load distribution between the two wards. That is, nurses from each ward claim that the load cast on their ward is higher than the load cast on the other ward. If we consider load to be an objective construct, then these claims seem odd: If load has a clear unique objective meaning, then obviously it is impossible for both wards' nurses to be right. However it is indeed possible that the nurses *perceive* the load on their own ward as higher than the load on the other ward. Therefore, assuming everyone is telling the truth, it is possible that nurses in both wards perceive the distribution of load as unjust. In this case, we can consider load as a subjective construct and our goal in this setting will be to balance the perceptions of load between the wards.

3. Study Justification

Tasks create load for employees. However, load can be measured as an objective construct, by the length of time the task requires or it can be measured as a subjective construct, by the amount of emotional distress the task creates for employees. Yet, it is customary to use only the former definition of load in staffing and work algorithms. We think it is wise to adjust such algorithms to include the psychological component of distress. The algorithm would then allocate load not only based on work per time-unit but also based on a quantification of distress the task creates.

To make things clear, here is an example: Say a woman in advanced pregnancy requires clinical attention due to complications that endanger the fetus. The doctors and nurses who attend her should simultaneously treat both her and the fetus. Therefore the objective construct of the load is in fact twice the length of the treatment. Say that unfortunately treatment to the fetus was unsuccessful and the fetus died. The woman still requires clinical attention, but now the load on the treating staff is cut by half (they no longer have to treat the fetus). However, consider the amount of emotional distress this incident causes the treating staff while the task is not over. Clearly, measuring the task load in this case would be incomplete without the subjective construct; ignoring it implies that following the demise of the fetus the task became twice as easy for the treating staff.

This example demonstrates why the operational approach to load measurement, standing alone, may be insufficient in settings with humans as the primary resource. This is especially true in settings that have the potential to cause major distress to workers, such as a hospital. We therefore feel that research should consider a way to integrate the psychological approach of load perception with the traditional operational approach.

4. Fairness in Work Allocation

According to Adams's (1965) equity theory, workers assess levels of justice according to a subjective comparison of the worker's inputs (e.g. effort) to obtained outputs (e.g. recognition). Adams claimed that when assessing fairness, people are more interested in the subjective results of some allocation process than in the objective allocation itself: Their

subjective assessment is often made considering their perception of a relevant other's ratio of inputs to outputs. Colquitt, Conlon, Porter and Ng (2001) performed a meta-analysis on justice perceptions in organizational research and differentiate between Adams's definition of justice, which is named *Distributive Justice*, and a different form of justice, mainly attributed to Leventhal (1980), which is called *Procedural Justice*. Distributive justice is defined to be the perception of justice of the *results* of a process, while Procedural justice is defined as the perception of the *process itself.* Colquitt et al. (2001) found that these two constructs describe two different phenomena and should be examined separately. Leventhal (1980) listed six criteria for a process to be perceived as just. The process should be: (a) consistent across people and time, (b) free from bias, (c) based on accurate information collection and usage, (d) have an error-correction mechanism, (e) conform to standards of ethics and moral, and (f) ensure that opinions of different groups affected by the decision are considered. Colquitt et al. confirm that these criteria indeed capture well the notion of Procedural justice.

It is clear that the problem at hand deals with nurses' perceptions of justice in the allocation of load between the wards. The distributive construct may be relevant here since it seems that nurses compare their ratio of inputs to outputs to the ratio of nurses in the other ward: All nurses get the same outputs but some put in more work due to load imbalance. It is also very likely that the procedural justice is perceived as low: The process of patient routing (or load balancing) was a question mark to us when we started work on the project and seemed a question mark to the nurses as well. At least three of Levanthal's six criteria were very obviously missing in this process. The process is not based on accurate data collected; it does not have an error-correction mechanism nor does it take the nurses' opinions into account (For a description of the process see § Method, Part 2).

5. Study Overview

We will now describe two separate notions of load: emotional and operational. We begin by describing the context in which the project was held and then explain how we measured each construct of load. Then we will introduce integration between the two constructs that we call *Combined Load*. We will detail the results of measurements of each separate construct and their combination. We will then move to explain the process by which we came to build the

suggested solution to the problem. We finish with some open questions and suggestions for future research.

§ METHOD

1. Organizational Context

Meetings were held with hospital staff to assess patient profiles, ward profiles, ward constraints and the current patient routing algorithm.

1.1. Patient Types

The hospital classifies each new maternity patient to one of three different types: Regular birth – A patient hospitalized following a vaginal birth; C-Section birth – A patient hospitalized following birth in a surgical procedure; and High Risk – A patient hospitalized *prior* to birth. The patient types determine the type of care required (task types, task frequencies, treatment schedules, procedures); length of care required; and equipment required. Note that a patient can be classified as high risk before birth but as a regular or C-Section patient following birth.

1.2. Ward Profiles

The hospital's Division of Obstetrics & Gynecology includes, among others, two Maternity Wards, A and B, in which the project was held.

Maternity Ward A specializes in treating High Risk patients, and also accepts Regular Birth and C-Section patients.
Maternity Ward B specializes in treating C-section patients, and also accepts Regular Birth patients, but not High Risk patients.

The hospital's Gynecology Department functions as back-up for instances in which an arriving patient has no vacant bed in the Maternity Wards. However, since they require special treatment from specially-trained staff, this is a less desirable option for High Risk patients and efforts are made to eliminate sending high risk patients to Gynecology.

The staffing in the maternity wards includes 31 nurses—15 nurses in ward A and 16 in Ward B (the number of full-time nurses is 14 in each ward). Each ward has one head-

nurse. However, the number of beds in the wards differs: Ward A contains 32 patient-beds, while Ward B contains 29 patient-beds. These are the maximum numbers of beds each ward can contain physically, in its current location, due to structural constraints.

The work day in the maternity wards is divided into 3 shifts. Morning shift: between 7 am and 3 pm, includes 4 nurses; Afternoon: between 3 pm and 11 pm, includes 3 nurses; and night- between 11 pm and 7 am, includes 2 nurses.

2. Documentation of Current State

2.1. Operational State – Patient Routing

When a patient arrives she is classified into one of three types of patients (see 1.1) and is then routed to either Ward A or Ward B (or to Gynecology if both wards are full) according to the following rules: High Risk patients – sent to Ward A. If all beds are occupied, they are sent to Gynecology until a bed (which they have a priority for) becomes vacant; C-Section patients – the first four in a given day are sent to Ward B. The following arriving C-Section patients in a given day are sent to wards A and B alternately. If all beds are occupied, they are sent either to the other ward (A or B) if it has a vacant bed, or to Gynecology; Regular Birth patients - have no strict routing procedure, and are sent to the ward in which there are more vacant beds. If all beds in wards A and B are occupied, they are sent to Gynecology. Generally, they get lower priority than other patients waiting for wards A or B.

2.2. Psychological State – Staff Perceptions

2.2.1. Sample

Data was collected from 30 out of 31 nurses in both wards. Age (M=40.2, SD=11.76), and tenure as maternity nurse (M=14.31, SD=11.08) did not differ significantly between wards (T *age(28)*=-0.244, N.S; T *tenure(27)*=-1.76, N.S).

2.2.2. Tools

Interviews were conducted with 6 out of the 31 nurses, in order to get an initial understanding of the nurses' feelings regarding the atmosphere in their own ward, their perspective regarding the other ward, and the general work environment and relations between workers in both wards. The overall goal of the interviews was to get a first impression of the possible causes for the perceived injustice between wards. Interview questions are summarized in Appendix 1.

Structured surveys were conducted among 30 out of 31 nurses, measuring job satisfaction, work stress, and perceived justice. All tools were translated and back translated from English.

2.2.3. Measures

2.2.3.1. *Job satisfaction* – was measured using 18 items out of the JSS-Job Satisfaction Survey developed by Spector (1985). The scale includes a nine facets scale to assess employee attitudes about the job and aspects of the job. Each facet is assessed using four items, and a total score is computed from all items. Out of the nine facets the following seven facets were chosen: Pay and Benefits, Supervision, Contingent Reward, Operating Procedures, Coworkers, Nature of Work and communication. Coefficient Alpha based on a sample of 2870 was .91. For scale items see Appendix 2.

2.2.3.2. *Work Stress* – was measured using four 1–5 Likert-type items out of the *ICAWS - Interpersonal Conflict at Work Scale* developed by Spector and Jex (1998). Spector and Jex reported an average internal consistency (coefficient alpha) of .74 across 13 studies.

In addition, five 1–5 Likert-type items were chosen out of the *QWI - Quantitative Workload Inventory*. Spector and Jex (1998) reported an average internal consistency (coefficient alpha) of .82 across 15 studies. For scale items see Appendix 3.

2.2.3.3. *Job-related Affective Well-Being* – was measured using four 1–5 Likert-type items out of the JAWS - Job-related Affective Well-being Scale (Van Katwyk, Fox, Spector, & Kelloway, 2000) which is designed to assess people's emotional reactions to their job. It asks them to indicate for each emotion how often they have experienced it in the past 30 days. Internal consistency reliability estimates (coefficient alpha) are available from three studies (Bruk-Lee & Spector, 2006; Spector, Fox, Goh, & Bruursema, 2003; and Van Katwyk et al., 2000), ranging between .92–95. For scale items see Appendix 4.

2.2.3.4. *Perceived justice* - Distributive, procedural and Interpersonal justice were measured using the classic justice scales developed by Colquitt (2001). For scale items see Appendix 5.

3. Current Operational Load

3.1. Defining Operational Load

Operational Load is the objective component of system load. The Operational Load a task exhibits is directly proportional to its length as measured in time units. It is customary to measure Operational Load using the 'Offered Load' measure. The Offered Load is defined as the expectation of the load over a service system in time t, or the expectation of the amount of work in the system in time t. The Offered Load is measured in units of work-units per time, e.g. work-hours per hour. Note that if there are fewer servers than those that can handle the work in time t, a queue forms.

3.2. Measuring the Operational Load

The main source of data needed in order to measure operational load is direct observations. They are used to estimate the average length of a task (i.e. how long, on average, it takes a nurse to perform the task) and are also helpful in estimating the task's frequency (i.e. how often, on average, a nurse performs the task).

Each of the 22 observations (10 in Ward A) was carried out by two students, who followed a single nurse for an average of 151 minutes and documented every task the nurse did, according to the Time Study method (following Khabia, 2008). The students were given a stopwatch, a designated 'Observation Sheet', to allow easier documentation, and a prepared list of known nurse-tasks, to allow uniformity in the data. The Observation Sheet (Appendix 6) and the task list (Appendix 7) were based on the work of Marmor (2003) and on preliminary interviews (see 2.2). The task list was further updated following each observation.

It is of course best to perform as many observations as possible and to do so under diverse conditions, for example different nurses and different shifts. However, the complexity and diversity of a nurse's job hinders the ability to achieve accurate and significant data for every single task. Therefore, we used two complementary data sources: experts' estimations and data collected in the past and stored in the Technion's SEE Lab.

Experts, the two wards' Head-Nurses and the Head of Nursing in the division, estimated some task lengths and task frequencies. The data stored in the SEE Lab, arrivals to the ward for nearly four years (most recently from 2007), was used to estimate arrival rates (see 5.1)

3.3. Offered Load

In order to measure the total Operational Load associated with the patients in each ward, we used the Offered Load measure, first to measure the load each individual patient brings with her and then to measure the total load in the ward.

We denote the Offered Load exhibited by Patient i of Type j in time t by $R_j\left(t, A_i, T_i\right)$ where:

$j \in \{1,2,3\}$ - Type of patient (Regular Birth, C-Section Birth and High Risk respectively)

A_i - Arrival time of Patient i

T_i - Total Length of Stay of Patient i

By definition:

$$R_j\left(t, A_i, T_i\right) = E\left[L_j\left(t, A_i, T_i\right)\right]$$

where $L_j\left(t, A_i, T_i\right)$ is the amount of work Patient i of Type j, whose arrival time is A_i and length of stay is T_i, brings to the ward in time t.

To measure this work we first created, using experts' estimations and for each type of patient, an 'Occupational Profile' which is a list of nurse-tasks and their frequencies an average patient would require throughout the hospitalization. Therefore, in a certain time t, if a patient i requires a nurse-task (according to her occupation profile, A_i and T_i) we add work to the total ward work according to the task's length.

Next, we created a 'Ward Work Profile' which is a list of tasks that are carried out as part of the ward schedule in specific times and which lengths depend on the number of patients. An example for such a task is Patient-Rounds done every morning at 8am and can generally be said to have a length proportional to the number of patients in the ward. Therefore, if, in a certain time t, some task is scheduled as part of ward-work, we add to the total ward, for each patient present in the ward, the marginal increase in the task length associated with that patient.

Finally, we treated any other tasks, neither included in the Occupation Profiles nor in the Ward Work Profile, as tasks done as part of the regular, ongoing patient treatment. We computed the total amount of work added by these tasks, per time unit, by a patient of each Type j, and multiplied it by the number of patients of that type in the ward in time t to get the total added ward work of these tasks.

Any nurse-task which was not patient-related was not taken into account since any solution to the problem presented to us should have been based on routing of patients between wards, i.e. only patient-related tasks were relevant.

For detailed explanations on computing the Offered Load in each ward, see Appendix 8.

4. Development of Tool Integrating Two Measures of Load

4.1. Constructing a Combined Load Measurement

We created a new measure of system load that combines both the operational aspect of load and the emotional aspect of load. To keep the convenient properties of time when measuring load (additive, continuous), we decided to use the length of each task, i.e. the Operational Load, as a basis and adjust it to embody the Emotional Load.

4.1.1. Defining Emotional Load

The Emotional Load of a task differs according to the characteristics of a certain task and the type of patient on which the task is carried out - the same amount of time allocated to perform a certain task may lead to more or less emotional load, depending on the task characteristics and patient type. Therefore it is impossible to use the measurement of time as an indication of emotional load. Translation of all tasks to equal units, representing the emotional load each task brings, was necessary in order to quantify the emotional load and make it possible to compare different tasks performed on different patients.

Emotional Load was therefore measured by an Emotional Factor that transforms the length a task bears, as measured in (regular) time-units, to the load it bears. This was done by using as units the “easiest task time-units”. That is, we found which task is least emotionally stressful for the nurses (the “easiest task”), and translated the length of any other task to a new length which the task would have had if it bore the same emotional stress as the easiest task.

4.2. Assessing Emotional Load

Assessing the emotional load was done in several stages:

(a) Eleven task categories that represent the work with all types of patients were chosen, based on the categories used to measure the operational load. For example: intimate procedures is a task category that includes several tasks that are performed on all three types of maternity patients. For task categories see Appendix 9.

(b) Each nurse received a list of all 11 task categories, and was asked to rank the categories from the easiest (ranked as 1) to the most difficult (ranked as 11) category of tasks to perform. The ranking was done separately for each type of patient, resulting in an inner comparison of the emotional load of different tasks for the same type of patient. For survey format see Appendix 10.

(c) Task difficulty was then defined to the nurses as a combination of the time a task takes to perform and the emotional load a task brings. Each nurse received second surveys, in which she was asked to rate each task category, and indicate how difficult it is to perform the tasks in that category on each type of patient. In the first part of the survey she was asked to rate the difficulty of tasks in terms of time, from 1 (a task that takes the least amount of time) to 7 (a task that takes the most amount of time). In the second part each nurse was asked to rate the difficulty of tasks in terms of emotional load, from 1 (the easiest task to perform) to 7 (the most difficult task to perform). Emotional load was defined as a mental, emotional difficulty, that represents how hard, irritating or annoying a task is. For survey format see Appendix 11.

(d) The average rating of the difficulty of each task performed for each type of patient across all nurses was calculated, and the easiest and most difficult tasks to perform were identified.

(e) Nurses were interviewed, and asked to compare the easiest and most difficult tasks. In each comparison, we asked what is harder—to perform the most difficult task for X amount of time (the average amount of time the nurses allocated for the task in stage C) or the easiest task. As expected, the nurses all agreed it was harder to perform the task rated previously as more difficult. Then they were asked what is harder- to perform the more difficult task for X amount of time or the easier task for a longer amount of time. We increased the time intervals in equal steps, until the nurses agreed that the performance of both tasks, the most difficult task for *X* amount of time and the easiest task for a larger amount of time, were equally as difficult. The relationship between the amounts of time that equaled out the difficulty was then used as the emotional factors of the tasks.

A summary of the results allowed quantifying the difficulty of each task, into equal units. The unit of 1 represented the difficulty of the easiest task; while every other task was compared to it and received a score representing how much harder it was to perform that task, relative to the difficulty of the easiest task. These scores were used as an "Emotional Factor" of each task difficulty.

4.3. Defining (Im)Balanced Load Between the Wards

To balance the load between the wards, we tried to find a routing algorithm that minimizes the Mean Percent Difference Measure, defined:

$$Mean\,\%\,Difference = \frac{1}{n}\sum_{i=1}^{n}\frac{Load\ B_i - Load\ A_i}{Load\ B_i}$$

where:

$Load\ A_i$ - Average Hourly Load in Ward A in Day i.

$Load\ B_i$ - Average Hourly Load in Ward B in Day i.

However, this measure is only good for long-term load balance while feelings of injustice may well be related to short-term imbalance of load. Therefore, we also tried to minimize the MSE measure hereinafter, thus minimizing the variance of the difference function.

$$MSE = \frac{1}{n}\sum_{i=1}^{n}\left(Load\ B_i - Load\ A_i\right)^2 .$$

4.4. Measuring Wards Combined Load

For each measured task the nurses performe, we defined:

t_i - Length, in time units, of Task i.

E_i - Emotional Factor of Task i.

And $L_i = t_i \cdot E_i$ is then the load Task i bears in "easiest task time-units".

Since L_i was defined for every task, we could use the same procedure we used to measure Operational Load (see 3.3) in order to measure the Combined Load. That is, instead of computing the total Offered Load on a ward in time t, we computed the total 'Offered Combined Load' in time t.

5. Development of Simulation

We created a simulation program that generated Maternity Patients arriving to the hospital and used a routing algorithm to direct each patient to one of the wards. The program then measured the total Combined Load in each ward and reported the differences discovered over time.

5.1. Estimating Arrival Rates & Sojourn Times by Patient Type

To generate arriving patients, we first had to estimate, for each patient type, the arrival rate and average sojourn time.

We relied upon clinical regulations and experts' estimations, as well as on a small sample of actual High Risk Patients $(n=34)$, to derive estimated sojourn-time distributions (Triangular for Regular and C-Section and Lognormal for High Risk). Appendix 12 details the considerations we took into account and the resulting estimates.

We assumed that for each patient type, the daily patient arrival process is a Non-Homogenous Poisson Process, i.e. a Poisson Process in which the arrival rate changes in time. To estimate the rate of arrivals in each time-unit, λ_t, we used a combination of Little's Law and previous data. For each patient type, we had the average number of patients in the wards during the observations and the average sojourn times from our distributions estimations. Thus, we were able to use Little's Law to estimate the total daily arrival rate to the wards for each type. We then used previous data (collected from the hospital in 2007) stored in the Technion's SEE Lab to estimate the intra-day changes in the arrival rate. By multiplying the total daily arrival rate with the proportion of

arrivals in each time-unit, we computed λ_t. Further details on this process and results are given in Appendix 13.

5.2. A Simulator for Measuring Load and Its Division between Wards over Time

A preliminary simulation program, built using Arena Software, generated, for each patient type, a list of patients arriving for a total of 365 days (with warm-up time of 1500 days).

The main simulation program, built in Matlab, used the three lists produced by the preliminary simulation and a given patient routing algorithm to determine, for each time-unit, the Total Ward Combined Load in each ward. It also reported, in case there were patients in queue (i.e. patients lying in Gynecology Department waiting for a vacant bed), the number of patients in queue and their waiting times. The wards begin the simulation empty; thus the first 14 days of each run were not used in calculating measures.

Initially, the simulation was run with the current routing algorithm. Then, however, many other routing algorithms were tested to find one that best balances the load between wards (see 4.3).

Since the program includes a random number generator, each algorithm was run by the program 10 times and averages were computed, thus keeping a stochastic approach for the system. Furthermore, to neutralize the effect of random numbers generated on the measures computed for each algorithm, the random numbers generated while running the program with the current state routing algorithm were used in all later runs.

6. Developing an Adaptive Routing Algorithm

According to Leventhal Criteria (1980), in order to have procedural justice, a routing algorithm must "have some mechanism to correct flawed or incorrect decisions." Therefore an algorithm that does not take into consideration the actual status of the wards when making the routing decision cannot create a just process. Furthermore, such an algorithm will, at best, balance the load on the long term (e.g. on a yearly average) but not on the short term (e.g. on day-to-day basis), due to the stochastic nature of the system. Therefore, an adaptive

algorithm, i.e. an algorithm that adapts its routing decisions according to the current state of the system, has been produced.

The goal of the algorithm is to minimize the load difference between the two wards. Therefore, whenever a new patient arrives, the algorithm is run, and using the information of the current state in the wards, computes the two possible differences in loads between the wards in the following 24 hours: if the patient is sent to Ward A and if she is sent to Ward B. The patient is then sent to the ward in which the difference computed is lower.

Note that a limitation of the algorithm is that it ignores future arrivals to the ward, which may potentially affect the routing decision. However, a similar algorithm with forecasted arrivals has an exponential complexity while it can be shown that this simple algorithm does a very good job without the forecasts.

§ RESULTS

1. Documentation of Current State

1.1. Operational State

1.1.1. Patient Types

We found that for each patient type the 'Occupational Profile' is rather different. For Regular Birth and C-Section patients, the first 24 hours of treatment are most intense and for the rest of the patient's length of stay, treatment is far sparser. High Risk Patients, however, demand cyclic, almost constant care throughout their length of stay, although somewhat less treatment in the first 24 hours than the other types of patients. Appendix 14 lists the various Occupational Profiles.

As for regular, ongoing treatment, it was found that High Risk patients demand the most intense care of all types with C-Section patients far less demanding and Regular patients even less than that.

1.1.2. Ward Profiles

We found that the 'Ward Work Profile' (see Appendix 15) is similar in both wards, i.e. the profiles used for each ward were identical. Further, we found that the length of each task in the profiles was directly proportional to the number of in-house patients during the time of the task, however independent of the types of patients in the ward at that time.

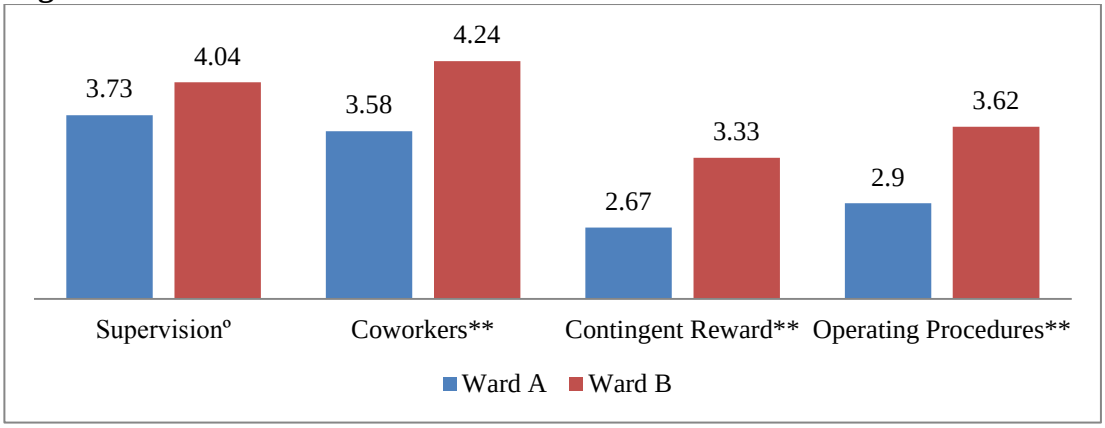
1.2. Psychological State

1.2.1. Job Satisfaction

As exhibited in Figure 1, a between-ward comparison of department-related job satisfaction variables indicated that the nurses of Ward A consistently report significantly lower job satisfaction compared to the nurses of Ward B. Satisfaction from the contingent reward, operation procedures and coworkers was significantly lower among nurses from

Ward A compared to Ward B ($p < 0.01$), and satisfaction from the supervisor was marginally significantly lower ($p < 0.07$).

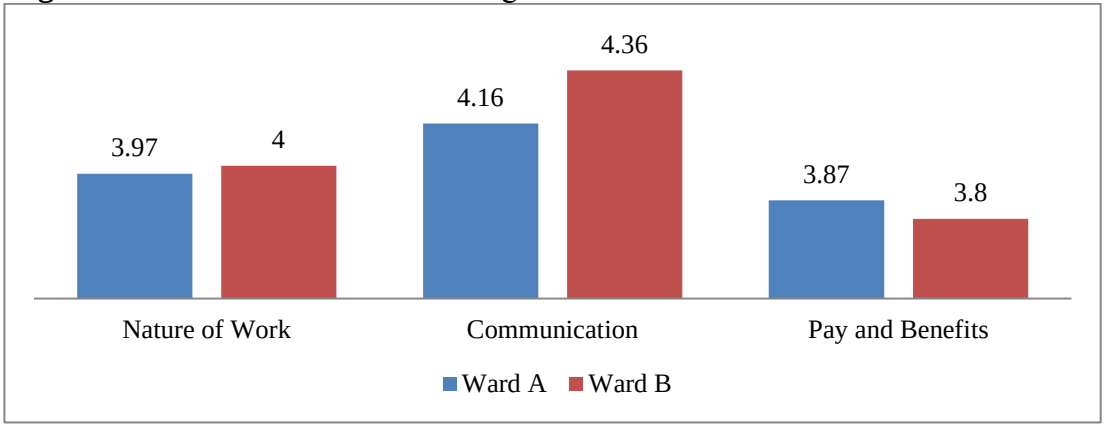
Figure 1. Nurses' Job Satisfaction: Job-related Variables



Note: See variables details in §Method, Part 2.2.3. Range of variables is 1-5.
**$p < 0.01$, º$p < 0.07$

A between-ward comparison of the organizational job satisfaction variables (satisfaction from pay and benefits, communication and nature of work) revealed no significant differences between the wards. Figure 2 exhibits these results.

Figure 2. Nurses' Job Satisfaction: Organization-related Variables



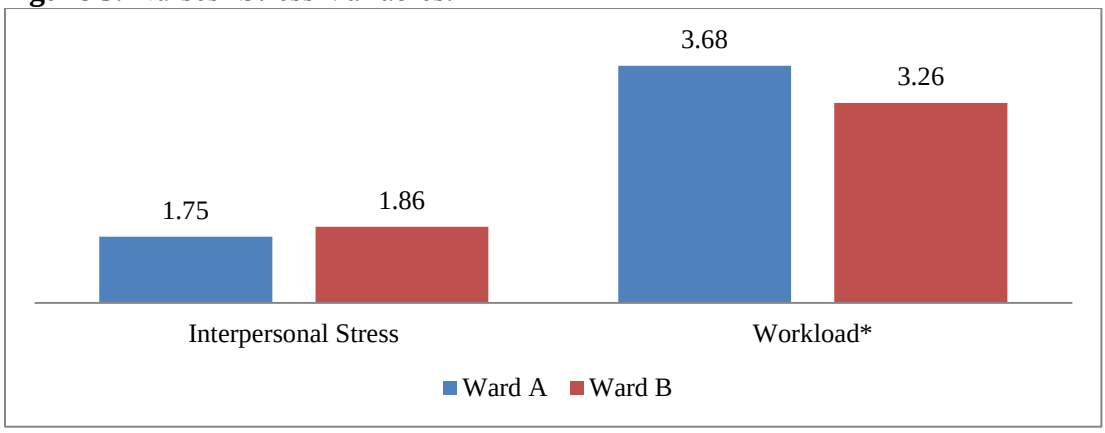
Note: See variables details in §Method, Part 2.2.3. Range of variables is 1-5. No significant differences found.

1.2.2. Stress

A between-ward comparison of work stress found no significant differences between the wards. However, significant differences were found in the comparison of the perceived

workload, such that the nurses from Ward A reported higher perceived work load compared to the nurses of Ward B ($p < 0.05$). Figure 3 exhibits these results.

Figure 3. Nurses' Stress Variables.

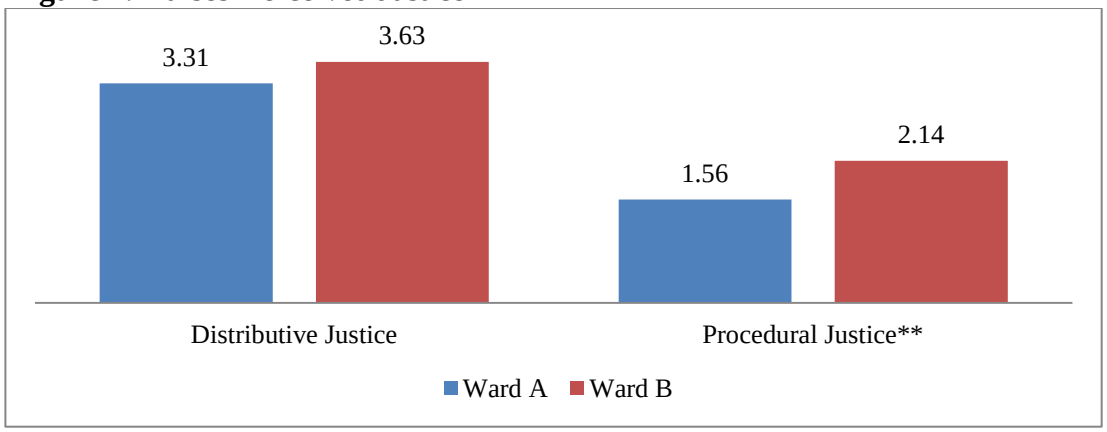


Note: See variables details in §Method, Part 2.2.3. Range of variables is 1-5.
*$p < 0.05$

1.2.3. Justice Perceptions

A between-ward comparison of justice perceptions between both wards revealed a significant difference in perceived procedural justice between both wards ($p < 0.01$), such that the nurses of Ward A consistently perceived the procedural justice as lower than the nurses of Ward B. However, no significant differences were found in the perceived distributive justice between the wards. Results are given in Figure 4.

Figure 4. Nurses' Perceived Justice



Note: See variables details in §Method, Part 2.2.3. Range of variables is 1-5.
**$p < 0.01$

1.3. Load

1.3.1. Operational Load

For each type of patient, *admitting a patient* was found to be the longest (that is, the most loading) task a nurse performs during treatment. Length of admission of Regular and of C-Section patients did not differ (both averaged 0.62 hours) but that of High Risk patients was lower (averaged 0.5 hours).

Of the different 'Occupational Profiles', C-Section patients exhibited the highest load in the first 24 hours of treatment, with an addition of 1.631 work-hours to ward work during that time. Regular patients exhibited 0.989 work-hours in the first day of treatment and High Risk patients exhibited only 0.806 work-hours during that time. In the following 24 hours of treatment High Risk patients exhibited a load of 0.531 work-hours per day while C-Section patients exhibited only 0.299 work-hours and Regular patients exhibited only 0.033 work-hours per day.

High Risk patients also contribute the most work when examining the regular, ongoing treatment: 1.826 work-hours per a 24-hour period while C-Section patients add 1.239 work-hours per day and Regular patients add 0.987 work-hours per day.

Finally, each patient staying in the ward (regardless of her type) added a load of 0.472 work-hours per 24 hours in the ward, as part of the 'Ward Work Profile'.

1.3.2. Emotional Load

Summarizing the emotional load ranking matrix exposed the relation between the emotional loads of various tasks by patient type (without taking into account the time variable). The outcome ranking varied between one and seven.

Overall ranking results (beyond patient type differences) indicated that the emotionally easiest task was 'Receiving a Ward' (קבלת מחלקה), while the emotionally most difficult task was 'Admitting a High Risk Patient' (קבלת יולדת בסיכון גבוה).

The overall relation between the most difficult task and the easiest task was 1.6, such that admitting a high risk patient into a ward was perceived as 1.6 times more difficult as receiving a ward.

Following the resulting relations between the emotional difficulties of the various tasks, we organized the tasks by their perceived difficulty, such that each task received an Emotional Factor (between 1 and 1.6) equivalent to its relative perceived difficulty. Results revealed that the emotional load of similar tasks varied by patient type:

For a Regular patient - the emotionally easiest task was 'Discharging a Patient' and the emotionally most difficult task was 'Conversation with Family Members'.

For a C-Section patient - the emotionally easiest task was 'Tasks Accompanying Treatment' (פעולות נלוות לטיפול) and the emotionally most difficult task was 'Conversation with Family Members'.

For a High Risk patient - the emotionally easiest task was 'Monitor Check' and the emotionally most difficult task was 'Admitting a Patient'.

The average emotional difficulty ranking for a High Risk patient was 3.78, for a C-Section patient was 3.57, and for a Regular patient was 3.25.

2. Simulation Results

For a summary of all results from the simulation, see Table 1 at the end of the section. Note that it also includes the proposed solution presented under Discussion.

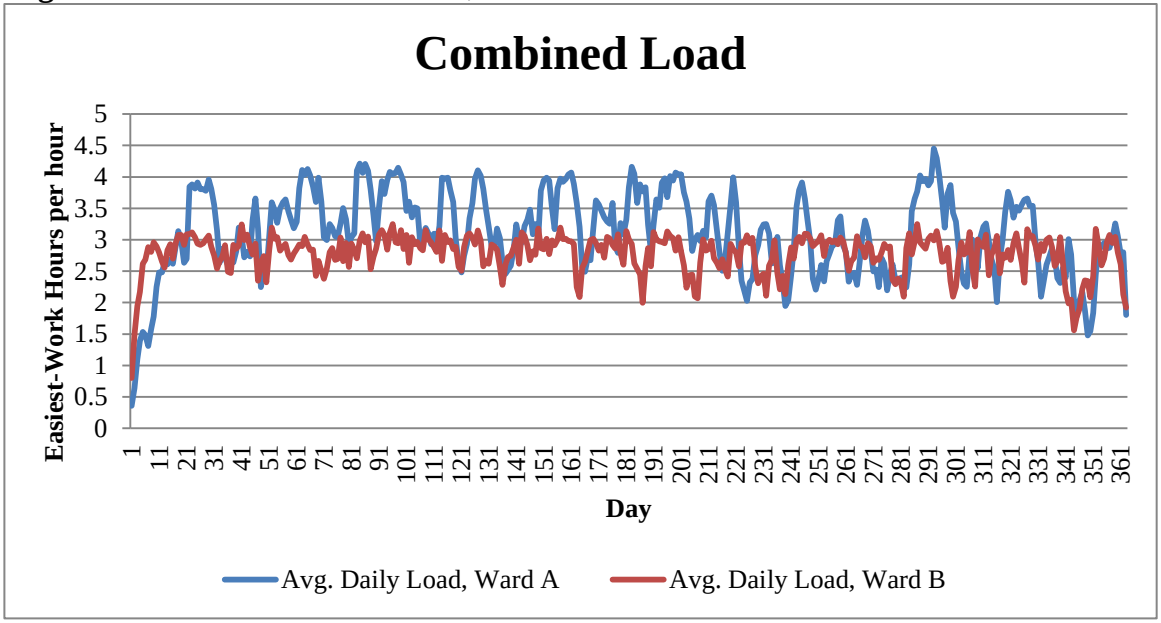
2.1. Current State

2.1.1. Combined Load

The Simulation results showed that Ward A's average daily Combined Load is 13.92% higher than that of Ward B. Moreover, in 23 out of 24 hours of an average day, Ward A's Combined Load is higher than that of Ward B.

However, in 98 out of 350 simulation days (28% of the days) the average daily Combined Load was higher in Ward B than in Ward A. The Mean Square Error was 0.45. The simulation results are presented in Figure 5.

Figure 5. Simulation: Current State, Combined Load

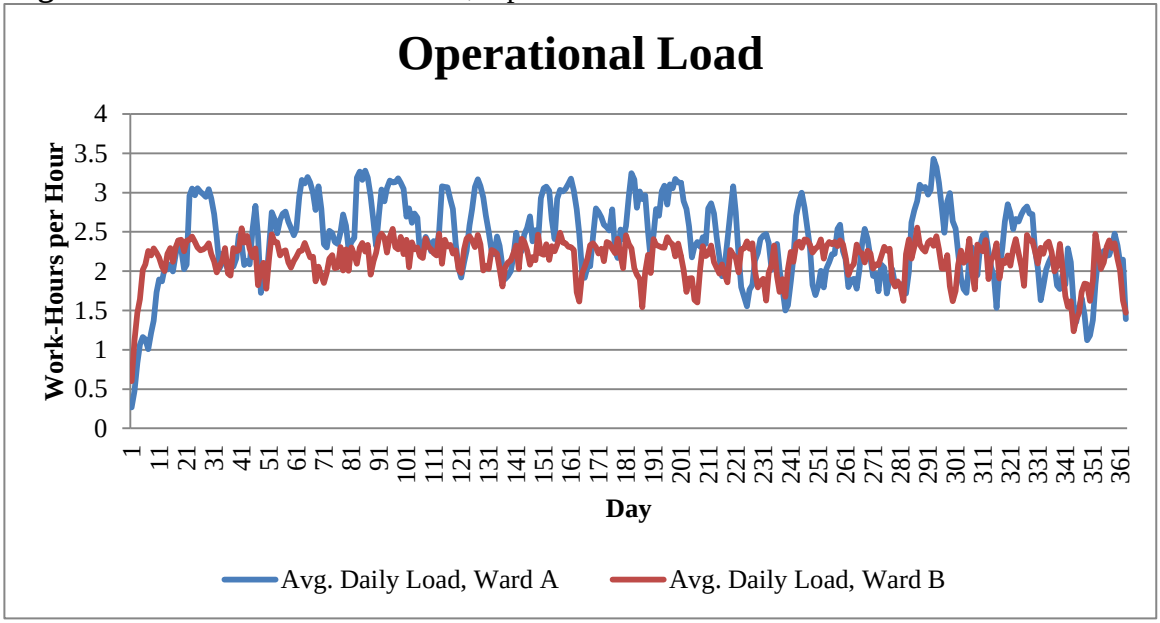


2.1.2. Operational Load Only

When running the simulation with operational loads only, namely without adding the Emotional Factors (and using the Combined Load), we discovered that the average daily load in Ward A is 12.9% higher than the load in Ward B, with 23 average-day hours more load in Ward A.

In 102 of 350 simulation days the average daily operational load was higher in Ward B than in Ward A. The Mean Square Error was 0.26. Figure 6 displays the results.

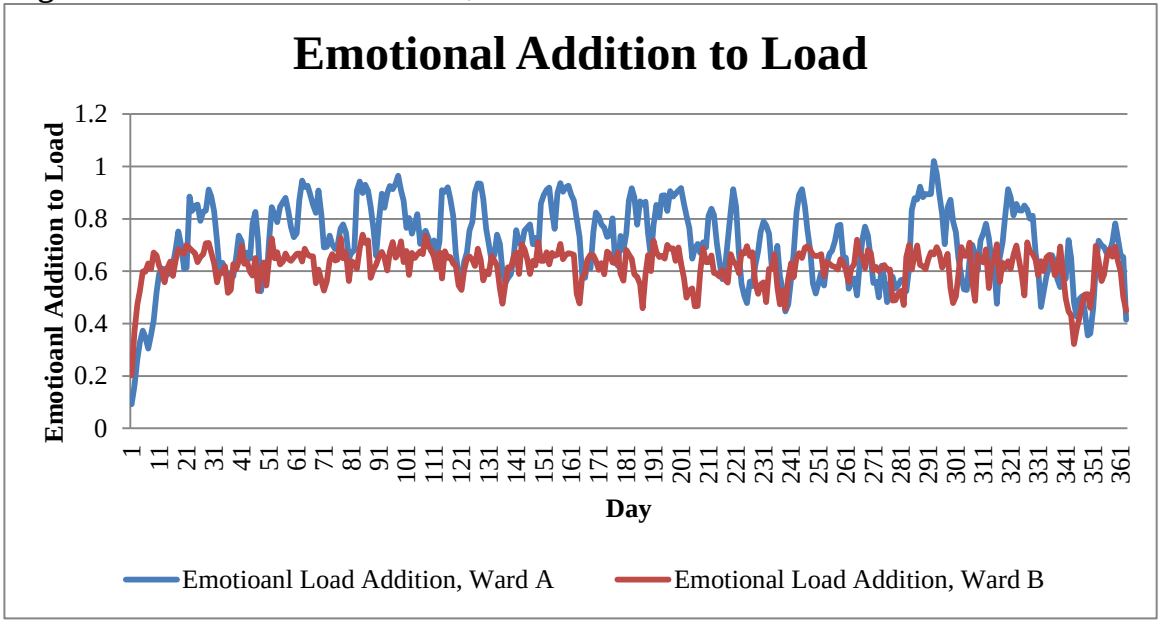
Figure 6. Simulation: Current State, Operational Load



2.1.3. Emotional Load Only

When observing the difference between the Combined Load and the Operational Load, that is, when observing the emotional addition to the load, we found that the Emotional Load in Ward A is higher by 17.61% than that in Ward B (MSE=0.026), with only 80 days in which the Emotional addition to load in Ward B was higher than that added in Ward A. Figure 7 shows the difference between the Combined Load and the Operational Load per day of the simulation, which captures, in fact, the Emotional Load.

Figure 7. Simulation: Current State, Emotional Addition to Load



2.2. State with Adaptive Algorithm Routing

2.2.1. Combined Load

When the simulation was run with the Adaptive Algorithm (see §Method, Part 6) as the algorithm giving the routing decisions, Ward A's average daily Combined Load was still higher than that of Ward B, but in only 10.8%. This time, in 20 of 24 hours of an average day, Ward A's Combined Load was higher than that of Ward B.

Using the Adaptive Algorithm made Ward B more loaded in 83 simulation days but the goodness-of-fit improved significantly with MSE of 0.27 (40% improvement from the current state of 0.45).

2.2.2. Operational Load Only

Using the Adaptive Algorithm as a routing decision maker based solely on operational load showed no real change in the average daily load difference, with Ward A more loaded in 12.89% on average and in 23 of 24 average-day hours. Furthermore, in only 73 of 350 simulation days the average load in Ward B was higher than that of Ward A. However, again, the goodness-of-fit measure made a significant improvement with MSE=0.19 (nearly 27% improvement from the 0.26 in the current state).

2.2.3. Emotional Load Only

It is also possible to run the algorithm based on the Emotional Load alone. That is, when the Adaptive Algorithm makes a routing decision it chooses the ward in which the additional Emotional Load created by the extra patient affects the Emotional Load between-ward difference the least.

In this case Ward A was more (Emotionally) loaded by 11.3% on average with 88 days in which Ward B was more loaded than Ward A. However, the MSE was 0.014, reflecting an improvement of over 46% in the goodness-of-fit (previously 0.026).

Table 1. Summary of Simulation Results for Different Routing Algorithms

	Current State		Adaptive Algorithm		Proposed Solution	
Load Type	Difference	MSE	Difference	MSE	Difference	MSE
Combined	13.9%	0.45	10.8%	0.27	1.5%	0.06
Operational	12.9%	0.26	12.9%	0.19	3.1%	0.04
Emotional	17.6%	0.026	11.3%	0.014	-3.3%	0.004

Note. Emotional Load refers to the difference between the Combined and the Operational Load. Difference is the percent by which Ward A is more loaded daily, on average, than Ward B. MSE is the mean square error. The Adaptive Algorithm is detailed in §Method, Part 6. The Proposed Solution is detailed in §Discussion, Part 2

§ DISCUSSION

1. Conclusions from Psychological State Analysis

A brief look at the results of the surveys reveals an obvious pattern: Nurses in Ward A are less satisfied, more stressed and perceive the routing procedure as less just, but only in measures that relate to the ward itself. For example, in measures of satisfaction which are Ward-related such as Operating Procedures and Coworkers, nurses in Ward A are scored less than those in Ward B. However, in organizational measures such as Pay & Benefits, scores did not differ. This pattern implies a sense of deprivation related to the ward itself rather than a general culture of complaints in the ward. These results are not surprising considering the large differences in the loads between the wards. Indeed, the procedural justice is perceived less right in the eyes of nurses from Ward A. The fact that nurses from Ward B also complained (according to the head nurse) is intriguing and could be a reflection of the human nature to take defensive actions when under attack. That is, Ward A could have been the origin of complaints, but once nurses from Ward B heard of it, they figured it would be better if they also complained. Yet, this is not to say that nurses from Ward B are satisfied and feel right with the routing procedures – they probably don't (according to the low values of procedural justice they ranked) – but they feel less deprived in comparison with those in Ward A.

2. Initial Conclusions from Simulation Runs

2.1. Adaptive Algorithm is Fine Under Low Joint Load

On observing the simulation results following the Adaptive Algorithm run, it seems that when the joint load in both Maternity wards is relatively low, the wards are far more balanced under the new routing than under the old one. This implies that the algorithm indeed does a decent job under these conditions. However, when the joint load on both wards is high, it seems that Ward A is still far more loaded than Ward B. Moreover, it seems that under this "high joint load" condition, the load in Ward B stays relatively

constant. Therefore, it seems that some exterior factors prevent the algorithm from fixing the problem at hand.

2.2. Exterior Constraints Prevent Adaptive Algorithm from Balancing Load

2.2.1. Constraints

There were three main constraints we had to deal with when developing the solution. The first was the fact that all High-Risk patients must be routed to Ward A. This was defined as extremely important by hospital staff due to clinical issues. The second constraint was the number of beds in each ward. Recall that Ward A contained 32 beds while Ward B contained only 29 beds. The third constraint was the need for patients to get a bed in one of the wards quickly. While the Gynecology Department can handle waiting patients for some time, it is important to transfer these patients to one of the wards when it is possible. Note that the first and last constraints have a clinical nature while the second one is more operational.

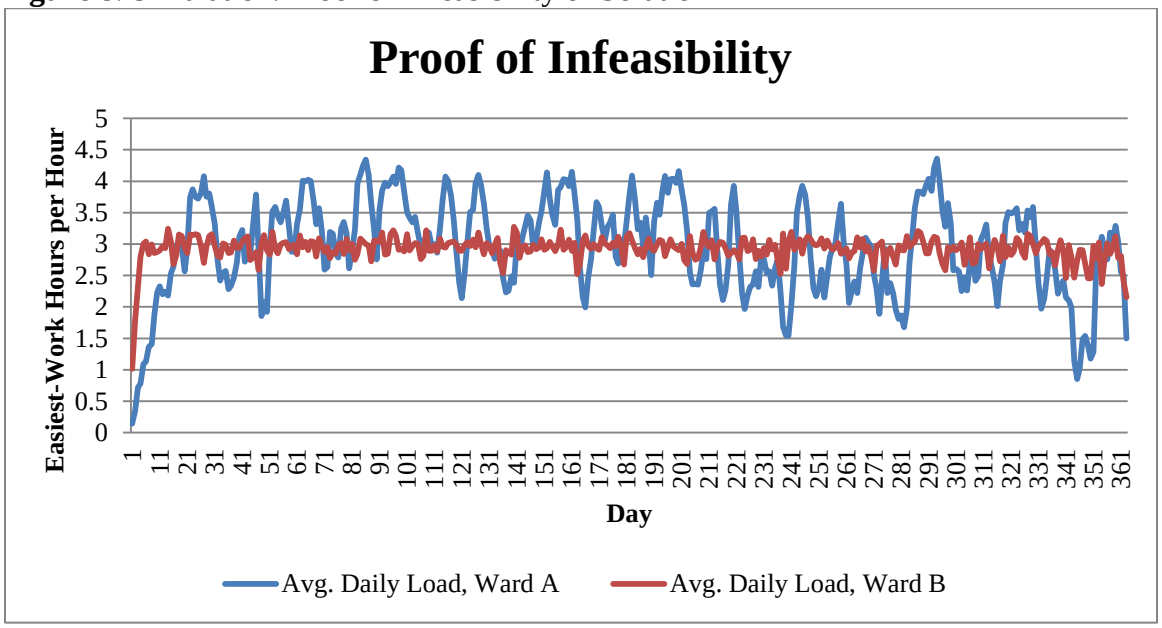
2.2.2. Proof of Infeasibility

To test the hypothesis that it is impossible to reach full balance under the above three constraints, we decided to simulate a situation in which all constraints are met while we attempt to transfer as much load as possible to Ward B (i.e. put the minimum load possible on the more loaded Ward A). To do so, we designed a routing algorithm in which all High-Risk patients are routed to Ward A and a patient of another type is sent to Ward B, unless this ward has no room. In that case, if Ward A has room the patient is sent there but only if Ward B is not expected to have room for the patient in the current shift (as a result of expected discharges).

Results for the algorithm showed that in the long run, Ward A was still nearly 3% more loaded than Ward B (see Figure 8). Therefore, it seems that indeed it was impossible to achieve proper balance with the given constraints. Note that the third constraint was even slightly violated since under this algorithm, Ward A may have room for a patient lying in Gynecology, waiting for a bed to vacate in Ward B (but only in the current shift). Further note in Figure 8 how the load on Ward B stays nearly constant throughout the simulated

year. The reason is that it is always full. However, when the joint load on both wards is high, there is no other choice than to put a heavy load on Ward A as well, as can be seen by the large peaks in the figure.

Figure 8. Simulation: Proof of Infeasibility of Solution

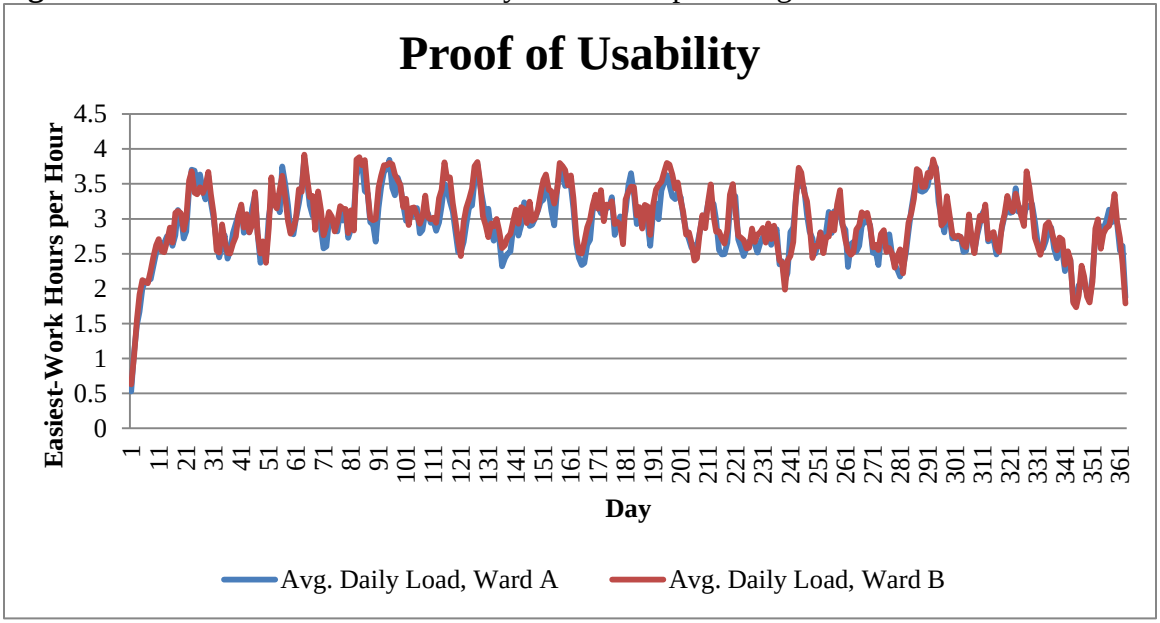


2.2.3. Adaptive Algorithm - Proof of Usability

While it was clear that no algorithm could balance the load between wards with the given constraints, it was still to be assessed whether the Adaptive Algorithm failed where it did due to these constraints or for some other reason. Since two of the three constraints have a clinical nature and one has a more operational nature, we decided to check if the Adaptive Algorithm can function fairly well without the one operational constraint, the limited number of beds.

A simulation was run with the Adaptive Algorithm (as described in the §Method, Part 6) but without the bed-constraint. According to the results (Figure 9), this time Ward B was more loaded on the average with less than 2% difference between the wards. Moreover, the short-term fit was excellent with MSE=0.029. These results suggest that the Adaptive Algorithm, though not perfect, does a very good job balancing the load and should be considered as part of the solution to the problem.

Figure 9. Simulation: Proof of Usability for the Adaptive Algorithm



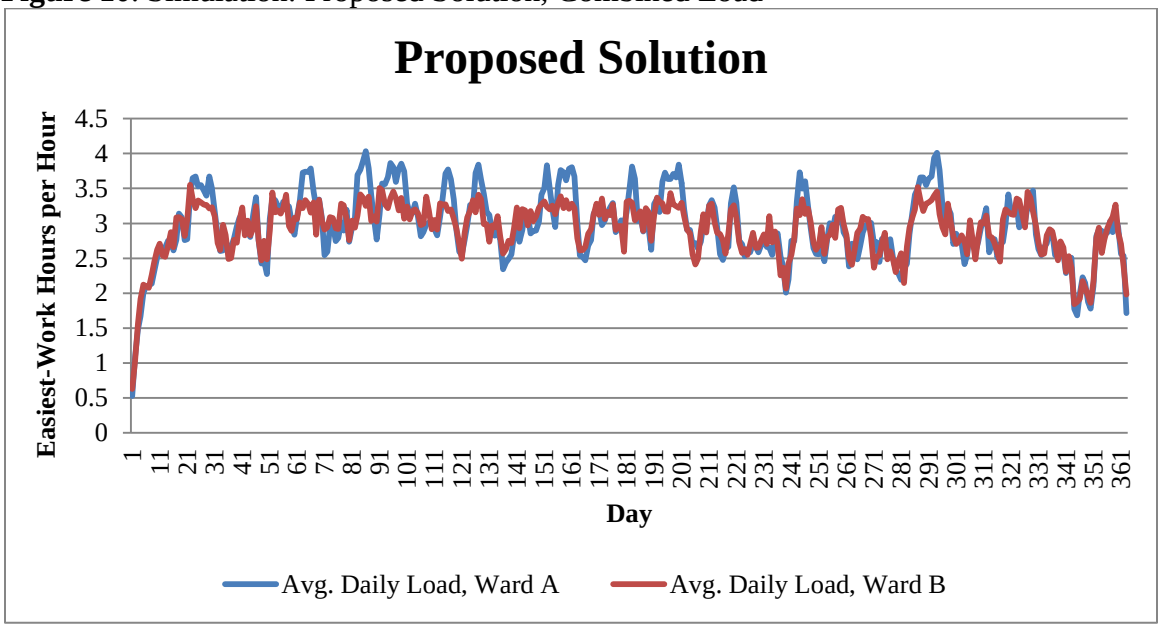
3. Proposed Solution

Following the results presented thus far, we decided to base the solution on the Adaptive Algorithm accompanied by a change to the number of beds in each ward. Since it is physically infeasible to use more than 29 beds in Ward B's current location and more than 32 beds in Ward A's current location, we decided to suggest a switch of locations between the wards. Ward A would therefore be located where Ward B is currently located, and will have 29 beds in it, while Ward B will be located in Ward A's current location and will contain 32 beds.

We examined via simulation how the changes in numbers of beds affect the load, without using the Adaptive Algorithm (i.e. using the current routing algorithm). Results showed that although the long-term year-long load was balanced with Ward A more loaded in only 1.75% on average, the short-term load was very poorly balanced with MSE=0.274. Therefore, although this change resulted in a significant long-term improvement, it is insufficient, considering the fact that frequent fluctuations in the load and especially in load difference between wards would most likely cause a perception of imbalanced load and may cause the nurses' exhaustion.

Therefore, the suggested solution is to both switch locations of the wards (and change the numbers of beds accordingly), and use the Adaptive Algorithm as the routing algorithm. Simulations (see Figure 10) show that the long-term load was best balanced by this method with only 1.5% more load on average in Ward A than in Ward B. Moreover, the short-term load was also greatly improved with MSE=0.06, second only to running the simulation without bed constraint at all. We conclude that this solution both balances the load between wards on average on the long-term and balances the load between wards on a daily basis.

Figure 10. Simulation: Proposed Solution, Combined Load



We further checked the balance in Operational Load and in Emotional Load (the emotional addition to the load that creates the Combined Load) following an implementation of the proposed solution. Results show that Ward A is more loaded, operationally, by 3.1% on average. However, using the proposed solution deflected more Emotional Load to Ward B. On average, it was more loaded than Ward A by 3.3%. Recall that in the current state the emotional addition to the load only made the load imbalance worse. This time, however, one of the wards is more loaded operationally and the other more loaded emotionally; therefore the Combined Load is more balanced.

4. Service Level

4.1. Service Measures

The fact that the proposed solution includes a change in the number of beds in each ward gives rise to the possibility that the service level provided by the ward whose capacity is lowered (Ward B) will be impaired. To make sure this does not happen, we must measure the service level in the current state and compare them to those under the proposed solution.

A patient who arrives to the hospital and is not admitted to either maternity ward (and is instead admitted to Gynecology) is considered a patient in queue. We consider the size of this queue and the average waiting time in the queue to be measures of service. Note that High Risk patients have a separate queue.

Therefore, the service measures we use to determine service level are:

$P(W > 0)$ - The probability that a patient arriving to the hospital will enter a queue.

$P_{HR}(W > 0)$ - The probability that an arriving High Risk patient will enter a queue.

$E(W \mid W > 0)$ - Expected waiting time for a patient, given waiting. (hrs.)

$E_{HR}(W \mid W > 0)$ - Expected waiting time for a High Risk patient, given waiting. (hrs.)

$P(L_q > 0)$ - Probability for a queue.

$P_{HR}(L_q > 0)$ - Probability for High Risk patients' queue.

$P(L_q > 5)$ - Probability for a queue with more than five patients waiting.

$P_{HR}(L_q > 2)$ - Probability for High Risk patients' queue with more than two patients waiting.

4.2. Results

We used simulations to find measures of service under four conditions: (a) Current state; (b) Adaptive Algorithm without change of beds; (c) change of beds with current routing algorithm; and (d) the proposed solution. Results are presented in Table 2 for Regular and C-Section patients and in Table 3 for High Risk patients.

Not only did the proposed solution not harm the service level provided, but it also improved the service level provided to the High Risk population. From a clinical point of view, High Risk patients should be transferred to Ward A as soon as possible; therefore the proposed solution also contributes to the ability to provide better care for those patients.

Table2 . Service Levels (Regular and C-Section patients) Following Various Routings

Routing	$P(W>0)$	$E(W \mid W>0)$	$P(L_q>0)$	$P(L_q>5)$
Current State	0.201	5.84	0.181	0.027
Adaptive Algorithm	0.245	5.43	0.206	0.028
Current Routing + Change Beds Number	0.168	6.40	0.158	0.026
Proposed Solution	0.177	6.25	0.151	0.028

Table3 . Service Levels (High Risk patients) Following Various Routings

Routing	$P_{HR}(W>0)$	$E_{HR}(W \mid W>0)$	$P_{HR}(L_q>0)$	$P_{HR}(L_q>2)$
Current State	0.148	9.92	0.067	0.006
Adaptive Algorithm	0.138	9.26	0.062	0.004
Current Routing + Change Beds Number	0.190	9.58	0.081	0.007
Proposed Solution	0.131	9.12	0.055	0.004

5. Why Combined Load?

The fact remains that without a strictly operational solution such as changing the number of beds between the wards, it would have been far harder, if even possible, to achieve a balance in the load. Therefore, one should ask whether a traditional strictly operational approach to the problem wouldn't have performed equally as well. To answer this question, we checked whether ignoring the emotional addition to the load would have generated an equally

reasonable solution. To do so, we used the same Adaptive Algorithm, only this time the routing decision was based solely on the Operational Load (i.e. the algorithm strived to balance the operational load alone).

We found that by changing the number of beds and using the Adaptive Algorithm, the Operational Load was 3.3% higher in Ward A than in Ward B and MSE of 0.04. Recall that using the Combined Load as a basis for routing decisions resulted in 3.1% heavier load in Ward A with the same MSE. The difference in load, although small, is still important to balance. It is also quite surprising that when the algorithm strives to balance the Combined Load it ends up doing a better job balancing the Operational Load than when it attempts only to balance the latter. Not surprisingly, the Emotional Load balance suffered as a result of ignoring it, with Ward B more loaded by 6.2% than Ward A on average and MSE of 0.085—a very significant change from the 3.3% difference and MSE of 0.004.

We therefore conclude that using the Combined Load (rather than just Operational Load) was not merely a theoretical contribution. It, in fact, helped to obtain a significantly better solution than one we had gotten without it, even if we only care about balancing the Operational Load.

6. General Discussion and Open Questions

The project presented here was not implemented in the hospital due to reasons over which the team members have no control (mainly bureaucratic). Therefore, first and foremost, it remains an open question if the suggested solution indeed achieves its goal: balancing justice perceptions and load between the wards (both combined and strictly operational).

It is long known that mere appearance of an intervention, especially when accompanied by the possibility of workers to speak their mind, may change perceptions of satisfaction and injustice. Therefore, prior to implementing the solution, it would have been interesting to examine the difference in perceived justice following the intervention. (Practically all nurses in the wards were well aware of the project and actively contributed to it.) Then, following the implementation of the suggested solution, it would be interesting to see how things changed, and whether staff perceptions have altered beyond the effects of the intervention (thus attributing to the implementation of the solution itself).

Section 5 details how the use of an emotional component to load helped solve the underlying problem and generate a better solution than a possible solution without the emotional component. However, it is unclear whether the use of emotional components significantly helped balance justice perceptions. In particular we wonder whether nurses indeed would have perceived justice differently without the emotional factors, although according to the simulation it is wise to use them.

Recall that a solution in which the number of beds in the two wards is changed (as suggested) but the routing algorithm remains the same generates a fine long-term balance of load but very poor short-term balance. That is, such a solution is fine on the average but has frequent fluctuations caused by a very high variance. It is interesting to understand the relevant importance of each of the two components – mean and variance – to the perceived justice. Our intuition is that variance is extremely important and such a solution as suggested above will change very little in nurses' perceptions, but it remains open whether this is true and to what extent.

It is also interesting to know how general our analysis is. First, we aggregate many types of patients into three coarse categories. For example, two regular patients could differ significantly in the required treatment according to background illnesses but our analysis assumes that each of them requires the same treatment. This assumption is obviously untrue, but we do not know its effect on the analysis. This also relates to the aforementioned mean versus variance discussion. However, while in the macro-level (aggregated ward load) we feel variance has a crucial effect; in the micro-level (individual patients load) it is intuitively of less importance, simply because a ward has usually more than 20 patients in it at any single moment. Still, we may be wrong by making this assumption and the generality and accuracy of the results could be compromised.

Second, another reservation regarding the analysis is the fact that data accumulated may have been insufficient. The diverse and hectic job of a nurse made it very difficult to get enough observations for each task. Although we verified results with experts (and thus feel fairly secure that the analysis is fine), it is still safer to make many more observations and use data from the hospital's data-systems wherever possible in order to have more accurate results.

Third, it is unclear what parts of our analysis could be easily extended to fit other settings. For example, is using the data we accumulated in our observations safe for use in a similar project done in a different hospital? In any case, we feel that at the very least the concept of Combined Load can be used extensively in many more settings: When measuring load in systems with humans as the main resource, we strongly suggest adding some reference to emotional factors.

Yet, we should emphasize that the way we decided to incorporate Emotional Load into the analysis is far from established. To our knowledge, this is the first time this combination of Operational Load and Emotional Load was made and the best methods for making the correct combination remains to be studied. For example, it is quite intuitive that emotions regarding a specific task do not end immediately following the completion of the task. Rather they may linger long after that. In other words, while the operational component of the task-related load ends, the emotional component could stay long after and affect perceptions of load and possible performance. In our analysis, however, we added the emotional component only while the task was made and may have missed important features of the Emotional Load.

Finally, we feel that this project could be a milestone to some intriguing lines of research in which Psychology and Operations Research are combined. One such promising line of research is the construction of a parallel to Offered Load in human-based systems: Combined Offered Load. One way to define Offered Load is the "amount of work, per time unit, in a system with an infinite number of servers". Following this definition, the Offered Load is the minimal number of servers required such that the system will be able to handle all work with no delays. We can then define Combined Offered Load as the "amount of work, per *easiest task* time unit, in a system with an infinite number of servers". Put differently, it will be the minimal number of agents required such that the system could handle all work and the servers will work, on average, at the same level of emotional difficulty required by the easiest task. We should note that a system in which the servers are required to provide high-level service ("service with a smile") would be much more reasonable to adjust load (and staffing), at least partially, according to the Combined Offered Load. In practice, we think that managers would be wise to settle staffing levels somewhere along the continuum of the recommendations made by using just the Offered Load and those made by using the

Combined Offered Load (the latter is always higher). The final decision should be based on the policy of the welfare of the system's servers (and its effects on service levels).

§ REFERENCES

Adams, J. S. (1965). Inequity in social exchange. In L. Berkowitz (Ed.), *Advances in Experimental Social Psychology* (vol.2, pp. 267–299). San Diego, CA: Academic Press.

Bruk-Lee, V., & Spector, P. E. (2006). The social stressors-counterproductive work behaviors link: Are conflicts with supervisors and coworkers the same? *Journal of Occupational Health Psychology, 11*(2), 145–156.

Colquitt, J. A. (2001). On the dimensionality of organizational justice: A construct validation of a measure. *Journal of Applied Psychology, 86*(3), 386–400.

Colquitt, J. A., Conlon, D. E., Wesson, M. J., Porter, C. O., & Ng, K. Y. (2001). Justice at the millennium: A meta-analytic review of 25 years of organizational justice research. *Journal of Applied Psychology, 86*(3), 425–445.

Khabia, O. (2008). Nursing man power allocation in hospitals' inpatients units—Staff vs. quality of care (Master's thesis, Technion—Israel Institute of Technology, Haifa, Israel).

Leventhal, G. S. (1980). What should be done with equity theory? New approaches to the study of fairness in social relationships. In K. Gergen, M. Greenberg, & R. Willis (Eds.), *Social Exchange: Advances in Theory and Research* (pp. 27–55). New York: Plenum.

Marmor, Y. (2010). Emergency-departments simulation in support of service-engineering: Staffing, design, and real-time tracking (Doctoral dissertation, Technion—Israel Institute of Technology, Haifa, Israel).

Spector, P. E. (1985). Measurement of human service staff satisfaction: Development of the Job Satisfaction Survey. *American Journal of Community Psychology, 13*, 693–713.

Spector, P. E., Fox, S., Goh, A. P. S., & Bruursema, K. (2003). Counterproductive work behavior and organizational citizenship behavior: Are they opposites? Paper presented at the meeting of the Society for Industrial and Organizational Psychology, Orlando, April 11–13.

Spector, P. E., & Jex, S. M. (1998). Development of four self-report measures of job stressors and strain: Interpersonal conflict at work scale, organizational constraints scale, quantitative workload inventory, and physical symptoms inventory. *Journal of Occupational Health Psychology, 3*, 356–367.

Van Katwyk, P. T., Fox, S., Spector, P. E., & Kelloway, E. K. (2000). Using the job-related affective well-being scale (JAWS) to investigate affective responses to work stressors. *Journal of Occupational Health Psychology, 5*, 219–230.

§ APPENDICES

Appendix 1: Interview Questions

ותק, ניסיון

1. כמה זמן במחלקה?
2. האם עבדת פעם במחלקה השנייה? ואם כן, איך שם? איך פה?
3. כמה את חשופה למה שקורה במחלקה השנייה?
4. האם עבדת פעם בבי"ח אחר (במחלקת יולדות או במחלקה אחרת?) או במחלקה אחרת ברמב"ם? אם כן, איפה? איך הייתה העבודה שם? איך היו התנאים שם?
5. האם את עובדת בכל המשמרות?

תנאי עבודה

6. מה את עושה במהלך היום?
7. תארי לי משמרת רגילה בעבודה?
8. מה ההבדל בין המשמרות? האם יש משמרת מועדפת עלייך?
9. כמה הפסקות יש לך? לכמה זמן?
10. מה התפקיד שאת עושה הכי הרבה?

שביעות רצון

11. האם את נהנית מהעבודה?
12. האם את מרגישה מסופקת?
13. איך הקשר שלך עם אחיות אחרות/ האחות הראשית?

תחושות בעבודה

14. מה הכי מעצבן אותך?
15. מה את הכי אוהבת בעבודה?
16. איך הקשר עם המחלקה השנייה?
17. האם היית רוצה לעבור למחלקה השנייה? למה?

ציפיות

18. האם הציפיות שלך לפני תחילת העבודה תואמות את המציאות מבחינת:
עומס, לחץ, יחס חולים, יחס אחות ראשית, יחס בין האחיות, שעות, שכר, ציוד, הפסקות...?

תפיסת התפקיד

19. באילו סוגי חולים את מטפלת?
20. אילו סוגי יולדות דורשות ממך יותר? יותר מה? (מאמץ, ריכוז, זמן...)
21. האם יש הבדל באינטנסיביות הטיפול בין סוגי היולדות (סיכון גבוהה, קיסרי, משך זמן, רגילות...)?
22. מה זה יולדת בסיכון גבוהה? איך טיפול בה משפיע עליך?

אם מעלות בעיה....

23. האם זה משהו שהתהווה רק בזמן האחרון?
24. מה היית רוצה שיקרה? איך את רואה שצריך להיות השינוי?
25. האם אתן חושבות שהחלוקה של סוגי היולדות הוגנת?

English Translation

Seniority, Experience

1. How long have you been working in the ward?
2. Have you ever worked in the other maternity ward? If so, how do the two compare?
3. How well do you know what is happening in the other ward?
4. Have you ever worked in another ward (other than the two here), whether in this hospital or otherwise? If so, in which ward and how was it there?
5. Do you work all shifts?

Work Conditions

6. What do you do throughout your shift?
7. Please describe a typical shift at work.
8. What are the main differences between the shifts? Which shift do you prefer best? Least?
9. How many breaks do you typically have? How long are they?
10. What is it you do most often?

Satisfaction

11. Do you like doing what you do?
12. Do you feel contentment?
13. How do you get along with other nurses? With the Head-Nurse?

Feelings at Work

14. What is most annoying to you at work?
15. What is it you like best at work?
16. How are your relations with the other ward?
17. Would you want to move to the other ward? Why?

Expectations

18. How did your expectations from working here match reality when considering: load; stress; patient attitude; Head-Nurse attitude; staff relations; working hours; pay; equipment; breaks?

Job Perception

19. What type of patients do you normally treat?
20. What type of patient is most demanding? Demanding in what way? (Effort, concentration, time...)
21. Is there a difference in the intensity of care for each type of patient?
22. Who is a High Risk Patient? How do you feel treating her?

In case the nurse raises a problem she's facing…

23. Was it something recent or has it been going on for long?
24. What would you wish happened? What do you think should change?
25. Do you think patient routing is fair?

Appendix 2: Job Satisfaction Survey (JSS)

Please circle the one number for each question that comes closest to reflecting your opinion about it.

1- Disagree very much
2- Disagree moderately
3- Disagree slightly
4- Agree slightly
5- Agree moderately
6- Agree very much

Pay and Benefits

I feel I am being paid a fair amount for the work I do.
I feel unappreciated by the organization when I think about what they pay me.
There are benefits we do not have which we should have.

Supervision

My supervisor is quite competent in doing her job.
My supervisor is unfair to me.
My supervisor shows too little interest in the feelings of subordinates.

Contingent Reward

When I do a good job, I receive the recognition for it that I should receive.
I do not feel that the work I do is appreciated.

Operating Procedures

Many of our rules and procedures make doing a good job difficult.
I have too much to do at work.
I have too much administrative work.

Coworkers

I like the people I work with.
I find I have to work harder at my job because of the incompetence of people I work with.
There is too much bickering and fighting at work.

Nature of Work

I like doing the things I do at work.
I feel a sense of pride in doing my job.

Communication

Communication seems good within this organization.
I often feel that I do not know what is going on within the organization.

Appendix 3: Stressors at Work Questionnaire

Interpersonal Conflict at Work Scale, ICAWS:

Please check on a 1–5 scale (1-never, 5-very often) **one** response for each item that best indicates how often you've experienced each event at work over the past 30 days.

How often do you get into arguments with others at work?
How often do other people yell at you at work?
How often are people rude to you at work?
How often do other people do nasty things to you at work?

Quantitative Workload Inventory, QWI:

Please use the following scale to indicate how often each of the below occur:

1-Less than once per month or never
2- Once or twice per month
3- Once or twice per week
4- Once or twice per day
5- Several times per day

How often does your job require you to work very fast?
How often does your job require you to work very hard?
How often does your job leave you with little time to get things done?
How often is there a great deal to be done?
How often do you have to do more work than you can do well?

Appendix 4: Job-Related Affective Well-Being (JAWS) Questionnaire

Below are a number of statements that describe different emotions that a job can make a person feel. Please check on a 1–5 scale (1-never, 5-Extremely often) one response for each item that best indicates how often you've experienced each emotion at work over the past 30 days.

My job made me feel angry.
My job made me feel anxious.
My job made me feel calm.
My job made me feel excited.
My job made me feel fatigued.

Appendix 5: Procedural, Distributive and Interpersonal Justice Questionnaire

Justice Measure Items: All items use a 5-point scale with anchors of 1 = *to a small extent* and 5 = *to a large extent*

Procedural Justice

The following items refer to the procedures used to arrive at your (outcome). To what extent:

1. Have you been able to express your views and feelings during those procedures?
2. Have you had influence over the (outcome) arrived at by those procedures?
3. Have those procedures been applied consistently?
4. Have those procedures been free of bias?
5. Have those procedures been based on accurate information?
6. Have you been able to appeal the (outcome) arrived at by those procedures?
7. Have those procedures upheld ethical and moral standards?

Distributive Justice

The following items refer to your (outcome). To what extent:

1. Does your (outcome) reflect the effort you have put into your work?
2. Is your (outcome) appropriate for the work you have completed?
3. Does your (outcome) reflect what you have contributed to the organization?
4. Is your (outcome) justified, given your performance?

Interpersonal Justice

The following items refer to (the authority figure that enacted the procedure). To what extent:

1. Has (he/she) treated you in a polite manner?
2. Has (he/she) treated you with dignity?
3. Has (he/she) treated you with respect?
4. Has (he/she) refrained from improper remarks or comments?

Appendix 6: Observation Sheet

מחלקה : **משמרת** : **תאריך** : **מיטות תפוסות בתחילת משמרת** :

שם אחות (אחראית?): **שם תצפיתן:**

מיטה מס' מיטה/מס' חדר	**סוג יולדת**	**שעת התחלה** hh/mm/ss	**שעת סיום** hh/mm/ss	**משך פעילות**	**פעולה**	**קוד פעולה**	**מתוכנן?**	**הערות**

English Translation

Ward: **Shift:** **Date:** **Occupied Beds at Start of Shift:**

Nurse Name: **Observer Name:**

Bed Bed#/ Room#	**Patient Type**	**Start** hh/mm/ss	**Finish** hh/mm/ss	**Duration**	**Task**	**Task Code**	**Planned?**	**Comments**

Appendix 7: Nurse Task List

(With English Translation)

פעולה	Code	Task
מדידת סימנים חיוניים- מדידת לחץ דם, חום ודופק (יש לכתוב בהערות איזה מדד נלקח)	1	**Measuring Vital Signs** – blood pressure, temp. and pulse (note which sign)
בדיקת שתן	2	**Urine Test**
בדיקת דם	3	**Blood Test**
בדיקות אינטימיות	4	**Intimate Examinations**
עזרה ליולדת בפעולות בסיסיות- לדוגמה בהליכה לשירותים, בשתייה, במאכל וכו'	5	**Assisting a Patient with Basic Activities** – in walking, drinking, eating, etc.
שטיפה אינטימית	6	**Intimate Wash**
נתינת עירויים	7	**Inserting a Transfusion**
מתן תרופות	8	**Distribution of Medications**
חבישה	9	**Bandaging**
אנמנזה	10	**Admission**
שיחה עם יולדת- לא הדרכה	11	**Talking with a Patient** – not guidance
שיחה עם מבקרים/ בעל/ בני משפחה	12	**Conversation with Visitors**
בדיקה שגרתית של יולדת בתחילת משמרת.	13	**Routine Examination of Patient**
קבלת קריאה מיולדת- מהחדר בעזרת זמזם	15	**Receiving call From Patient** – calling from the room
העברת ילוד לחדר יולדת	16	**Transporting a Newborn**
הדרכות שהייה באשפוז	20	**Hospitalization Guidance**
הדרכת הנקה	21	**Nursing Guidance**
הדרכה אחרת (יש לציין בהערות איזו)	22	**Other Guidance** (note which)
הדרכת שחרור	23	**Discharge Guidance**
הדרכת ניתוח	24	**Surgery Guidance**
עבודה לצד רופא- לא כחלק מהסבב	30	**Assisting a Physician** – not as part of rounds
ליווי סבב רופאים	31	**Escorting Patient Rounds**
שיחה עם אחות אחרת מהמחלקה (בנושא עבודה)	32	**Conversation with a Nurse** (work related)
עזרה לאחות אחרת	33	**Assisting Another Nurse**
תדרוך (מעבר משמרות)	34	**Shift Briefing**
ליווי יועץ או מתאמת, הוצאת דו"ח והעברתו לרופא (יש לציין בהערות איזה יועץ/מתאמת)	35	**Escorting a Counselor** (note which)
שיחה עם כח עזר (יש לציין איזה כח עזר)	36	**Conversation with Clinical Assistants** (note which)
שיחה עם רופא	37	**Conversation with a Physician**

שיחה עם אחות ממחלקה אחרת (יש לציין מאיזו מחלקה)	38	**Conversation with a Nurse from another ward** (work related, note which)
שינוע מכשור	41	**Transporting Equipment**
שינוע חומרים (תרופות, אינפוזיה וכו')	42	**Transporting Materials** (medication, infusion etc.)
טיפול /הכנת מכשור וציוד	43	**Handling Equipment**
בדיקה/קריאה של תיק חולה	45	**Reviewing Patient File**
הכנת מיטה ליולדת	46	**Preparing a Bed for a Patient**
שיחת טלפון בענייני עבודה	47	**Work-Related Phone Call**
שטיפת ידיים	48	**Washing Hands**
מילוי ידני של טפסים (יש לנסות לציין למה הטופס קשור)	49	**Manually Updating Files** (note which)
קבלת יולדת במחשב	50	**Admission in the System**
עבודה על תיק יולדת במחשב- לא כחלק מהקבלה	51	**Updating Patient File in the System** – not during admission
טיפול בבדיקות שתן	52	**Handling a Urine Test**
טיפול בבדיקות דם	53	**Handling a Blood Test**
הזמנת תורים בטלפון/מחשב (לציין את סוג התור)	54	**Booking Appointments via the System/Telephone** (note which)
הזמנת מתאמות ויועצים (יש לציין את סוג המתאמת/יועצת)	55	**Booking Counselors or Experts** (note which)
הוצאת בדיקות מהמחשב (יש לציין את סוג הבדיקה)	56	**Retrieving Test Results from the System** (note which)
קבלת יולדות למשמרת- בתחילת משמרת	57	**Reviewing Patient Data in the System**- at the start of every shift
הכנות אדמיניסטרטיבית לקבלת יולדת	58	**Administrative Actions Prior to Admission**
הזמנת רופא	60	**Booking a Physician**
מענה לטלפונים	61	**Answering Phone Calls**
מתן מענה למבקרים בדלפק	62	**Answering Visitors at the Desk**
שחרור יולדת	63	**Discharge**
ירידה לחדר לידה (יש לציין בהערות סיבה)	70	**Going Down to Delivery Room** (note reason)
הכנה לניתוח (יש לנסות לפרט מהן הפעולות שנעשות)	71	**Preparing for Surgery** (note which actions)
הליכה	72	**Walking**
חיפוש רופא	74	**Searching for a Physician**
חיפוש אחות ראשית	75	**Searching for Another Nurse**
חיפוש יולדת	76	**Searching for a Patient**
בלבול/טעות-יש לציין מקור הטעות	77	**Error** (note why)

הפסקה (כולל שיחת טלפון אישית/ אוכל)	80	**Break** (including eating and making personal calls)
נעדרת	81	**Absent**
ממתינה לסנכרון פעילות- במידה ולא מבצעות פעילות אחרת במקביל (יש לציין לאיזו פעילות ממתינה)	82	**Waiting for Another Task** – only if not doing anything else.
פנויה	83	**Free**
טיפול בעניינים אישיים הקשורים לעבודה- למשל רישום להסעה, שיחה אישית עם אחות ראשית של המחלקה	84	**Work-Related Personal Matters** (e.g. registering for ride home)
שיחה שלא בענייני עבודה	85	**Talking not on Work-Related Matters**
בדיקת מוניטור	102	**Monitor Check**

הערות כלליות:
במידה והפעולה נעשתה כחלק מקבלת היולדת או כחלק משחרורה (ולא כחלק מפעילות שוטפת), יש לציין זאת במפורש בהערות.
יש לסמן לצד הקוד את האות ח׳- אם העבודה נעשית ישירות לצד היולדת.
במידה ולפעולה המתבצעת אין קוד מתאים, יש להוסיפו ובסיום התצפית לעדכן את שאר הצוות ואת דף זה.

General Notes:
If the task is done as part of admission or discharge, note specifically.

Note if the task is done next to the patient.

If a task doesn't have a code, note and update everyone.

Appendix 8: Measuring Ward Offered Load

The total Offered Load in the ward in time t is the sum of the loads attributed to each patient present in the ward during time t and the load that is attributed with any non-patient related activities in that time. That is:

$$R_{Ward}(t) = \sum_{j=1}^{3} \sum_{i=1}^{n_j(t)} R_j(t, A_i, T_i) + WW(t)$$

where:

$j \in \{1,2,3\}$ - Patient Type

$n_j(t)$ - Number of Patients of Type j in the ward in time t

$WW(t)$ - Ward-Work, Independent of Patients, in time t

$R_j(t, A_i, T_i)$ - Offered Load Patient i of Type j, with arrival time A_i and LOS T_i, brings at time t

Since any solution to the problem we faced should have been based on routing of patients between wards, we neglected the element $WW(t)$ in all computations.

By definition, $R_j(t, A_i, T_i) = E\left[L_j(t, A_i, T_i)\right]$, where $L_j(t, A_i, T_i)$ is the amount of work Patient i of Type j, with arrival time A_i and LOS T_i, brings at time t.

This work could be attributed to three sources. The first source is activities which depend on the total time the patient spent since her arrival and until time t (e.g. Admission is always done in the first hour after arrival). We denote total work from these activities by Patient-Schedule Treatment (or PT).

The second source is activities which depend on the time of day (e.g. Patient-Rounds are done at 8am). The time of these activities is scheduled independently of the patients, but their length is proportional to the number of patients in the ward. We denote total work from these activities by Ward-Schedule Treatment (or WT).

The third source is nurse tasks which neither depend on the time passed since patient arrival nor depend on the time of day. These are done all throughout the patient's stay in the ward. We denote total work from these activities by Regular Treatment (or RT).

Then:

$$L_j\left(t, A_i, T_i\right) = PT_j\left(t, A_i, T_i\right) + WT_j\left(t\right) + RT_j$$

where:

$PT_j\left(t, A_i, T_i\right)$ - Patient-Schedule Treatment Patient i of Type j requires at time t

$WT_j\left(t\right)$ - Ward-Schedule Treatment required at time t by a patient of Type j

RT_j - Total Regular Treatment required by a patient of Type j

To compute Patient-Schedule Treatment, we used experts' estimations to create, for each patient type, an Occupational Profile, from Admission to Discharge. The length of each activity in the profile was estimated to be the average length of that activity during the observations.

To compute Ward-Schedule Treatment, we used experts' estimations to create a Ward Work Profile. We then estimated the marginal increase to activities' lengths from an extra patient by the average of the lengths of an activity, as measured in the observations, divided by the number of patients in the ward during the observation.

To compute the Regular Treatment, we first classified nearly 50 activities that were part of this treatment into nine categories. Each category included activities which are similar in nature and content according to our understanding and experts' comments. We then estimated the total amount of work added by each category per time-unit, for each type by:

$$K_{i,j} = \frac{1}{22}\sum_{l=1}^{22}\frac{T_{i,j,l}\cdot m_l}{n_{j,l}\cdot Length_l}$$

where:

$i \in \{1,...,9\}$ - Category Number

$j \in \{1,2,3\}$ - Patient Type

$l \in \{1,...,22\}$ - Observation Number

$K_{i,j}$ - Amount of Work, per Time Unit, added by Category i, from Type j

$T_{i,j,l}$ - Sum of Lengths of all Activities of Category i, from Type j measured in observation l (in time units)

m_l - Number of Nurses Working during Observation l

$n_{j,l}$ - Number of Patients of Type j in the ward during Observation l

$Length_l$ - Total Length of Observation l (in time units)

Note that this formula implies that each nurse does the same amount of work in a shift.

To compute $T_{i,j,l}$ we had to attribute each measured activity to a certain patient type. For some activities this was done while observing, but for others, such as activities labeled "Administrative", it was impossible to attribute each activity to a certain patient (for example because each time a nurse performs the activity, she does so for more than one patient). For these activities, we assumed that the proportion of activity length attributed to patients of Type j is the same as the proportion of patients of that type in the ward during the activity.

Appendix 9: Task Categories Results

קטגוריה	פעילויות
בדיקות חיצוניות	• מדידת סימנים חיוניים • טיפול יולדת בדלפק • בדיקת שתן • חבישה • טיפול ביולדת שהתעלפה • בדיקת עקומות סוכר
בדיקות פולשניות והוצאות	• בדיקת דם • הרכבת עירויים • מתן תרופות • הכנה לניתוח • הכנסת קטטר
בדיקות אינטימיות ושטיפה אינטימית	• בדיקות אינטימיות • שטיפה אינטימית
עזרה ליולדת בפעולות	• עזרה ליולדת בפעולות בסיסיות • שינוע ילוד • הכנת מיטה ליולדת
שיחות עם היולדת והדרכות	• שיחה עם יולדת • הדרכות שהייה באשפוז • הדרכת הנקה • הדרכה אחרת • הדרכה על ניתוח
פעולות נלוות לטיפול	• שינוע מכשור/ציוד • שינוע חומרים • הכנת/טיפול במכשור/ציוד • שטיפת ידיים • טיפול בבדיקת שתן • טיפול בבדיקת דם
קבלת מחלקה	• תדרוך משמרת • בדיקה שגרתית של יולדת בתחילת משמרת • קבלת יולדות למשמרת (מעבר על נתוני היולדות במחשב)

פעולות בלעדיות לHR	• בדיקת מוניטור
פעולות אדמיניסטרטיביות	• בדיקה/קריאה של תיק יולדת • מילוי ידני של טפסים • עבודה על תיק יולדת במחשב • הזמנת תורים בטלפון • הזמנת רופא • הזמנת מומחים/יועצים • הוצאת בדיקות מהמחשב • הזמנת תורים במחשב • שיחת טלפון בענייני עבודה
מענה לגורם מקצועי אחר	• ליווי סבב רופאים • שיחה עם כח עזר • שיחה עם רופא • שיחה עם אחות ממחלקה אחרת • עבודה לצד רופא • עזרה לאחות אחרת • ליווי יועץ או מתאם/ת
שיחות עם בני משפחה/מבקרים.	• שיחה עם מבקרים • מתן מענה למבקרים בדלפק
קבלה	• קבלה • קבלת יולדת במחשב
שחרור	• הדרכת שחרור • שחרור

English Translation

Category	Tasks
External Examinations	• Measuring Vital Signs • Treating a Patient at the Desk • Urine Test • Bandaging • Treating a Fainted Patient • Checking Glucose Scale
Invasive Examinations	• Blood Test • Inserting a Transfusion • Distribution of Medications • Preparations for Surgery • Inserting Catheter
Intimate Treatment	• Intimate Examinations • Intimate Wash
Assisting a Patient	• Assisting a Patient with Basic Activities • Transporting a Newborn • Preparing a Bed for a Patient
Conversations with a Patient	• Talking with a Patient • Hospitalization Guidance • Nursing Guidance • Surgery Guidance • Other Guidance
Tasks Accompanying Treatment	• Transporting Equipment • Transporting Materials • Handling Equipment • Washing Hands • Handling a Urine Test • Handling a Blood Test
Receiving a Ward	• Shift Briefing • Routine Examination of Patient • Reviewing Patient Data in the System

Monitor Check (High Risk only)	• Monitor Check
Administrative Actions	• Reviewing Patient File • Manually Updating Files • Updating Patient File in the System • Booking Appointments via the System/Telephone • Booking a Physician • Booking Counselors or Experts • Retrieving Test Results from the System • Work-Related Phone Call
Assisting Another Professional	• Escorting Patient Rounds • Conversation with Clinical Assistants • Conversation with a Physician • Conversation with a Nurse • Assisting a Physician • Assisting Another Nurse • Escorting a Counselor
Conversation with Family Members	• Conversation with Visitors • Answering Visitors at the Desk
Admitting a Patient	• Admission • Admission in the System
Discharging a Patient	• Discharge Guidance • Discharge

Appendix 10: Comparing task difficulty Questionnaire

אנו רוצים ללמוד עד כמה פעולות שונות בעבודה שלך קשות יותר או קשות פחות עבור האחות. הכוונה היא ללמוד את הקושי הכללי בהתייחס לסוג העבודה שצריך לבצע לסוג היולדת.

לפניך **11** קטגוריות של פעילויות שאת מבצעת במהלך יום עבודתך. הפעילויות הנ"ל מתייחסות לפעולות הנעשות על יולדת **בלידה רגילה**. אנא עברי עליהם ועל דף פירוט הפעילויות המצורף ודרגי אותן לפי כמה שהן קשות לאחות המבצעת. התחילי עם ציון 11 לפעולה הקשה ביותר וכך הלאה עד לציון 1 לפעולה הקלה ביותר.

קטגוריה	**דירוג** (לידה רגילה)
בדיקות חיצוניות	
בדיקות פולשניות והוצאות	
בדיקות אינטימיות ושטיפה אינטימית	
עזרה ליולדת בפעולות	
שיחות עם היולדת והדרכות	
פעולות נלוות לטיפול	
פעולות אדמיניסטרטיביות	
מענה לגורם מקצועי אחר	
שיחה עם בני משפחה/ מבקרים	
קבלת יולדת	
שחרור יולדת	

לפניך **11** קטגוריות של פעילויות שאת מבצעת במהלך יום עבודתך. הפעילויות הנ"ל מתייחסות לפעולות הנעשות על יולדת **בלידה קיסרית**. אנא עברי עליהם ועל דף פירוט הפעילויות המצורף ודרגי אותן לפי כמה שהן קשות לאחות המבצעת. התחילי עם ציון 11 לפעולה הקשה ביותר וכך הלאה עד לציון 1 לפעולה הקלה ביותר.

קטגוריה	**דירוג** (לידה קיסרית)
בדיקות חיצוניות	
בדיקות פולשניות והוצאות	
בדיקות אינטימיות ושטיפה אינטימית	
עזרה ליולדת בפעולות	
שיחות עם היולדת והדרכות	
פעולות נלוות לטיפול	
פעולות אדמיניסטרטיביות	
מענה לגורם מקצועי אחר	
שיחה עם בני משפחה/ מבקרים	
קבלת יולדת	
שחרור יולדת	

לפניך **12** קטגוריות של פעילויות שאת מבצעת במהלך יום עבודתך. הפעילויות הנ"ל מתייחסות לפעולות הנעשות על יולדת **HR**. אנא עברי עליהם ועל דף פירוט הפעילויות המצורף ודרגי אותן לפי כמה שהן קשות לאחות המבצעת. התחילי עם ציון **12** לפעולה הקשה ביותר וכך הלאה עד לציון 1 לפעולה הקלה ביותר.

קטגוריה	**דירוג** (HR)
בדיקות חיצוניות	
בדיקות פולשניות והוצאות	
בדיקות אינטימיות ושטיפה אינטימית	
עזרה ליולדת בפעולות	
שיחות עם היולדת והדרכות	
פעולות נלוות לטיפול	
פעולות אדמיניסטרטיביות	
בדיקת מוניטור	
מענה לגורם מקצועי אחר	
שיחה בני משפחה/מבקרים	
קבלת יולדת	
שחרור יולדת	

English Translation

We would like to know how a nurse experiences different tasks as more or less difficult.

Ahead are written **11** categories of tasks you normally perform during your work. These activities refer to those done when treating a **Regular** Patient. Please go over them and the attached Task Categories Sheet and rank them from the most difficult to the least difficult. Begin by scoring the most difficult task **11** and finish with scoring the least difficult task 1.

Category	**Score** Regular Patient
External Examinations	
Invasive Examinations	
Intimate Treatment	
Assisting a Patient	
Conversations with a Patient	
Tasks Accompanying Treatment	
Administrative Actions	
Assisting Another Professional	
Conversation with Family Members	
Admitting a Patient	
Discharging a Patient	

Ahead are written **11** categories of tasks you normally perform during your work. These activities refer to those done when treating a **C-Section** Patient. Please go over them and the attached Task Categories Sheet and rank them from the most difficult to the least difficult. Begin by scoring the most difficult task **11** and finish with scoring the least difficult task 1.

Category	**Score** C-Section Patient
External Examinations	
Invasive Examinations	
Intimate Treatment	
Assisting a Patient	
Conversations with a Patient	
Tasks Accompanying Treatment	
Administrative Actions	
Assisting Another Professional	
Conversation with Family Members	
Admitting a Patient	
Discharging a Patient	

Ahead are written **12** categories of tasks you normally perform during your work. These activities refer to those done when treating a **High Risk** Patient. Please go over them and the attached Task Categories Sheet and rank them from the most difficult to the least difficult. Begin by scoring the most difficult task **12** and finish with scoring the least difficult task 1.

Category	**Score** High Risk Patient
External Examinations	
Invasive Examinations	
Intimate Treatment	
Assisting a Patient	
Conversations with a Patient	
Tasks Accompanying Treatment	
Administrative Actions	
Monitor Check	
Assisting Another Professional	
Conversation with Family Members	
Admitting a Patient	
Discharging a Patient	

Appendix 11: Comparing Task Length and Emotional Load Questionnaire

עכשיו אנו מנסים להבין במספרים כמה קשה כל אחת מהפעולות. להבנתנו, יש 2 סוגים של קושי- קושי שנובע מהזמן שהפעולה לוקחת וקושי שנובע מהעומס הרגשי, הנפשי על האחות.

בשלב ראשון, נבקש ללמוד על קושי מבחינת עומס זמן. השתמשי בסולם מ-1 עד 7 לדרג את הקושי של כל פעילות מבחינה זו. פעולות הגוזלות ממך הכי הרבה זמן יקבלו את הציון 7. הפעולות שגוזלות הכי מעט זמן יקבלו ציון 1.

קטגוריה	**קושי מבחינת זמן** (מ-1 עד 7) **לידה רגילה**	**קושי מבחינת זמן** (מ-1 עד 7) **לידה קיסרית**	**קושי מבחינת זמן** (מ-1 עד 7) **HR**
בדיקות חיצוניות			
בדיקות פולשניות והוצאות			
בדיקות אינטימיות ושטיפה אינטימית			
עזרה ליולדת בפעולות			
שיחות עם היולדת והדרכות			
פעולות נלוות לטיפול			
קבלת מחלקה			
פעולות אדמיניסטרטיביות			
בדיקת מוניטור			
מענה לגורם מקצועי אחר			
שיחה עם בני משפחה/ מבקרים			
קבלת יולדת			
שחרור יולדת			

עכשיו, נשים בצד את שאלת הזמן ואנו רוצים להתמקד בכמה קשה לך הפעולה באופן נפשי, רגשי. השתמשי באותו סולם (מ-1 עד 7) לדרג כמה הפעולה קשה או מטרידה או מעיקה על האחות. הקושי יכול להיות בגלל אופי הפעולה או בגלל תחושות שנשארות איתך אחרי הפעולה.

קטגוריה	**קושי רגשי** (מ-1 עד 7) **לידה רגילה**	**קושי רגשי** (מ-1 עד 7) **לידה קיסרית**	**קושי רגשי** (מ-1 עד 7) **HR**
בדיקות חיצוניות			
בדיקות פולשניות והוצאות			
בדיקות אינטימיות ושטיפה אינטימית			
עזרה ליולדת בפעולות			
שיחות עם היולדת והדרכות			
פעולות נלוות לטיפול			
קבלת מחלקה			
פעולות אדמיניסטרטיביות			
בדיקת מוניטור			
מענה לגורם מקצועי אחר			
שיחה עם בני משפחה/מבקרים			
קבלת יולדת			
שחרור יולדת			

English Translation

Next, we would like to quantify the difficulty of each activity. To our understanding, there are two types of difficulty: one that follows from the length of the action and another that follows from the emotional or mental difficulty it bears.

For now, we only wish to know how difficult the tasks are time-wise. Please score each activity between 1 and 7 such that the most time consuming activities will receive the score 7 and the least time consuming will receive the score 1.

Category	**Time-Wise Difficulty** (1 to 7) **Regular**	**Time-Wise Difficulty** (1 to 7) **C-Section**	**Time-Wise Difficulty** (1 to 7) **High Risk**
External Examinations			
Invasive Examinations			
Intimate Treatment			
Assisting a Patient			
Conversations with a Patient			
Tasks Accompanying Treatment			
Receiving a Ward			
Monitor Check (High Risk only)			
Administrative Actions			
Assisting Another Professional			
Conversation with Family Members			
Admitting a Patient			
Discharging a Patient			

Next, we will ignore the length of the activity focus on how emotionally difficult each task is. Please use the same scale (between 1 and 7) and score how troubling or stressful each activity is for you. This difficulty may be the result of the nature of the activity itself or due to the feelings it may bear that remain after the activity itself is over.

Category	**Emotional Difficulty** (1 to 7) **Regular**	**Emotional Difficulty** (1 to 7) **C-Section**	**Emotional Difficulty** (1 to 7) **High Risk**
External Examinations			
Invasive Examinations			
Intimate Treatment			
Assisting a Patient			
Conversations with a Patient			
Tasks Accompanying Treatment			
Receiving a Ward			
Monitor Check (High Risk only)			
Administrative Actions			
Assisting Another Professional			
Conversation with Family Members			
Admitting a Patient			
Discharging a Patient			

Appendix 12: Estimation of Sojourn Time Distributions

The sojourn times of Regular and C-Section patients have strict lower bounds placed by the Ministry of Health. Moreover, only in extremely rare cases do the sojourn times exceed a certain upper bound and they also have a palpable mode. Therefore, we decided to estimate the sojourn times for these patients to be of Triangular distribution. The lower limit parameter was taken to be the lower bound stated in clinical regulations. The other two parameters were determined following experts' estimations.

The sojourn times of High Risk patients are distributed very differently as there is no obvious mode and the tail of the distribution could be very long. Since the nature of treatment is very similar to that of patients admitted in internal care units, and since empirical results show that the sojourn times of patients in internal care are distributed Lognormal, we estimated that the sojourn time distribution of High Risk patients would also be Lognormal. We further verified this hypothesis by speaking with experts. We used MLE as the estimated distribution's parameters based on a sample of 34 High Risk patients.

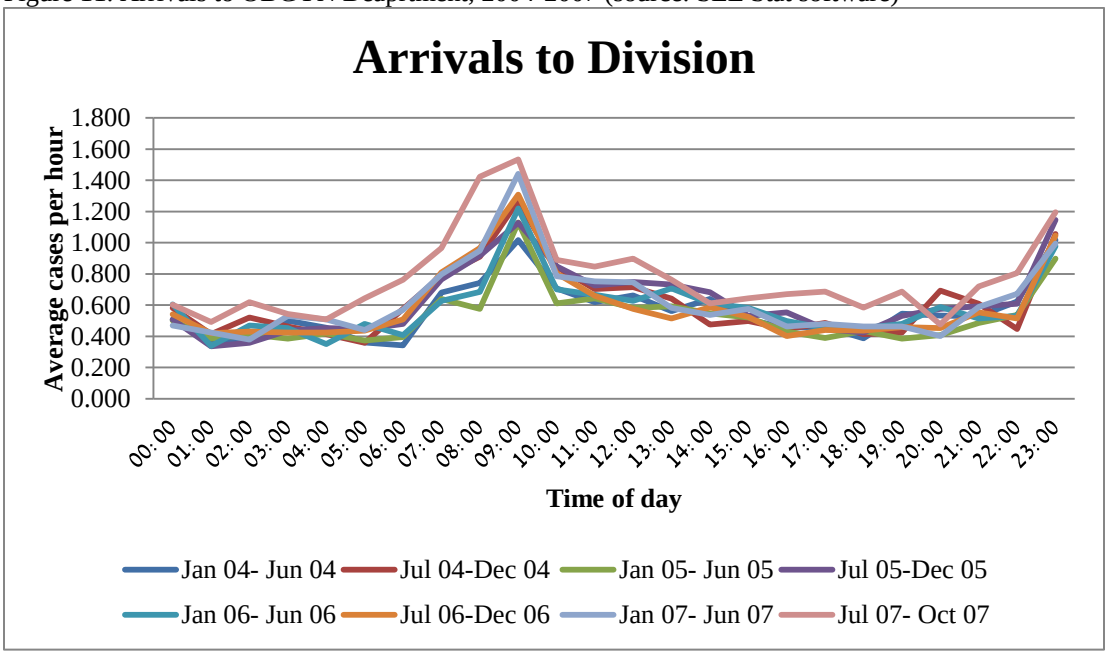
The derived distributions were (parameters in hours):

- Regular patients: Triangular (48, 54, 96)
- C-Section patients: Triangular (120, 120, 168)
- High Risk patients: Lognormal (4.182, 1.196)

Appendix 13: Estimation of Arrival Rates

Method of estimation of the arrival rates was $C \cdot \lambda\%$. That is, we estimated the total arrivals per day, *C*, and multiplied it by the relative percent of arrivals in each and every hour of the day. We therefore assume a fixed form of arrival rate change during different days. This assumption is reasonable given data attained from the Technion's SEE Lab (see Figure 11) in which one can see how the arrivals in the division had the same form throughout the years 2004–2007. We estimated the intra-day changes in arrival rates according to the average of the last four months of data present in the SEE Lab (July–October 2007).

Figure 11. Arrivals to OBGYN Deaprtment, 2004-2007 (source: SEE Stat software)



To estimate *C*, we used Little's Law using the average number of patients of each time in the system (taken from the observations and confirmed with experts) and the average sojourn times taken from the estimated sojourn time distributions (see Appendix 12). However, this estimation method neglects the patients lying in the Gynecology department; therefore the rates attained were only estimations and required further adjustments based on the results of the simulation using these rates (see Marmor, 2003). The simulation showed that under these rates there are many times in which the system cannot handle the load and in 14% of the time 10 or more maternity patients are in the Gynecology department which is completely

unreasonable. We therefore lowered the rates gradually until the simulation produced reasonable results that correspond to reality. We finally used 93% of the original rates computed using Little's Law.

The final daily rates were as follows:

- Regular patients: $\lambda = 6.155$
- C-Section patients: $\lambda = 3.332$
- High Risk patients: $\lambda = 1.674$

The proportions of arrivals per hour were as follows:

Time of Day	Regular patients	C-Section patients	High Risk patients
00:00-01:00	0.02	0.02	0.02
01:00-02:00	0.02	0.02	0.03
02:00-03:00	0.02	0.02	0.02
03:00-04:00	0.03	0.03	0.03
04:00-05:00	0.03	0.02	0.03
05:00-06:00	0.02	0.02	0.02
06:00-07:00	0.01	0.02	0.01
07:00-08:00	0.05	0.06	0.04
08:00-09:00	0.08	0.09	0.05
09:00-10:00	0.06	0.07	0.05
10:00-11:00	0.05	0.06	0.04
11:00-12:00	0.04	0.05	0.03
12:00-13:00	0.07	0.08	0.07
13:00-14:00	0.05	0.05	0.05
14:00-15:00	0.07	0.07	0.06
15:00-16:00	0.04	0.04	0.05
16:00-17:00	0.05	0.04	0.07
17:00-18:00	0.05	0.04	0.06
18:00-19:00	0.05	0.05	0.05
19:00-20:00	0.04	0.03	0.05
20:00-21:00	0.05	0.04	0.06
21:00-22:00	0.04	0.04	0.05
22:00-23:00	0.04	0.04	0.05
23:00-24:00	0.01	0.01	0.02

Appendix 14: Occupational Profiles of Patients

High Risk patient

In the first 24 hours of hospitalization:

פעולות לביצוע	Hours in System	Tasks to Perform
קבלה	0	Admission
מתן תרופות	4	Distribution of Medications
מדידת סימנים חיוניים	6	Measuring Vital Signs
מתן תרופות	8	Distribution of Medications
מוניטור + מדידת סימנים חיוניים + מתן תרופות	12	Monitor Check + Measuring Vital Signs + Distribution of Medications
תיאום עם יועץ	15	Booking a Counselor
מתן תרופות	16	Distribution of Medications
בדיקת דם + שליחת דם + בדיקת שתן + שליחת שתן + מדידת סימנים חיוניים	18	Blood Test + Handling Blood Test + Urine Test + Handling Urine Test
ליווי יועץ	21	Escorting a Counselor

Following the initial 24 hours of care, these tasks should be performed:

- Every 4 hours, starting Hour 24, Distribution of Medications
- Every 6 hours, starting Hour 24, Measuring Vital Signs
- Every 12 hours, starting Hour 24, Monitor Check
- Every 12 hours, starting Hour 27, Booking a Counselor
- Every 12 hours, starting Hour 30, Blood Test + Handling Blood Test
- Every 12 hours, starting Hour 33, Escorting a Counselor
- Every 24 hours, starting Hour 42, Urine Test + Handling Urine Test
- The night prior to discharge, Discharge Guidance
- The last hour of hospitalization, Discharge

C-Section patient

In the first 24 hours of hospitalization:

פעולות לביצוע	Hours in System	Tasks to Perform
קבלה	0	Admission
מדידת סימנים חיוניים + בדיקה אינטימית	1	Measuring Vital Signs + Intimate Examinations
מדידת סימנים חיוניים + בדיקה אינטימית	2	Measuring Vital Signs + Intimate Examinations
מדידת סימנים חיוניים + בדיקה אינטימית + מתן תרופות	3	Measuring Vital Signs + Intimate Examinations + Distribution of Medications
מדידת סימנים חיוניים + בדיקה אינטימית	4	Measuring Vital Signs + Intimate Examinations
מדידת סימנים חיוניים + בדיקה אינטימית + מתן תרופות	6	Measuring Vital Signs + Intimate Examinations + Distribution of Medications
מדידת סימנים חיוניים + בדיקה אינטימית	9	Measuring Vital Signs + Intimate Examinations
הוצאת קטטר + עזרה ליולדת בפעולות בסיסיות	12	Removing Catheter + Assisting Patient with Basic Activities
מדידת סימנים חיוניים + בדיקה אינטימית	16	Measuring Vital Signs + Intimate Examinations
מדידת סימנים חיוניים + עזרה ליולדת בפעולות בסיסיות	23	Measuring Vital Signs + Intimate Examinations

Following the initial 24 hours of care, these tasks should be performed:

- Every 8 hours, starting Hour 32, Measuring Vital Signs
- Every 16 hours, starting Hour 32, Intimate Examinations
- The night prior to discharge, Discharge Guidance
- The last hour of hospitalization, Discharge

Regular patient

In the first 24 hours of hospitalization:

פעולות לביצוע	Hours in System	Tasks to Perform
קבלה	0	Admission
הדרכת כלכלה והיגיינה	2	Hospitalization guidance
עזרה ליולדת בפעולות בסיסיות	4	Assisting Patient with Basic Activities
עזרה ליולדת בפעולות בסיסיות + בדיקה אינטימית + מדידת סימנים חיוניים	6	Measuring Vital Signs + Intimate Examinations + Assisting Patient with Basic Activities
מדידת סימנים חיוניים	18	Measuring Vital Signs

Following the initial 24 hours of care, these tasks should be performed:

- Every 24 hours, starting Hour 42, Measuring Vital Signs
- The night prior to discharge, Discharge Guidance
- The last hour of hospitalization, Discharge

Appendix 15: Ward-Work Profile

הפעולות המתבצעות	Time of Day	Tasks to Perform
קבלת יולדת למשמרת	00:00-01:00	Reviewing Patient Data in the System
	01:00-02:00	
	02:00-03:00	
	03:00-04:00	
	04:00-05:00	
	05:00-06:00	
	06:00-07:00	
תדרוך (מעבר משמרות) + קבלת יולדת למשמרת	07:00-08:00	Shift Briefing + Reviewing Patient Data in the System
ליווי סבב רופאים	08:00-09:00	Escorting Patient Rounds
ליווי סבב רופאים	09:00-10:00	Escorting Patient Rounds
	10:00-11:00	
	11:00-12:00	
	12:00-13:00	
	13:00-14:00	
	14:00-15:00	
תדרוך (מעבר משמרות)	15:00-16:00	Shift Briefing
קבלת יולדת למשמרת	16:00-17:00	Reviewing Patient Data in the System
	17:00-18:00	
	18:00-19:00	
	19:00-20:00	
	20:00-21:00	
	21:00-22:00	
	22:00-23:00	
תדרוך (מעבר משמרות)	23:00-24:00	Shift Briefing