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**OPTIMIZATION OF INTERHOSPITAL TRANSFER OF PATIENTS TO
REDUCE EMERGENCY DEPARTMENT OVERCROWDING**

By

Brandi Marie Hill

B.S.I.E., University of Louisville, 2004

A Thesis

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**OPTIMIZATION OF INTERHOSPITAL TRANSFER OF PATIENTS TO
REDUCE EMERGENCY DEPARTMENT OVERCROWDING**

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August 16, 2005
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“And this is the confidence that we have in Him, that, if we ask anything according to His will, He heareth us: And if we know that He hear us, whatsoever we ask, we know that we have the petitions that we desire of Him.” (1 John 5: 14-15)

I feel so blessed to have made it to this point, and I am appreciative of everyone who has helped me along the way. A heartfelt thank you goes out to my family and friends who have been a constant source of encouragement to me. I thank you, Mother, for being such an inspiration in my life. Thank you, Prof. Brenda Hart, for your guidance throughout my college career. Thank you, Dr. Gail DePuy, for your support and patience as my Thesis Director. I sincerely appreciate the time you spent working with me in regards to my thesis, and also as a student in general. I would also like to thank Dr. Gerald Evans, and Dr. Eric Rouchka for their time as members of my thesis committee. Finally, I would like to thank my professors, and everyone I have had an opportunity to work with as a student of the University of Louisville; my experiences were very positive and truly unforgettable.

ABSTRACT

The purpose of this research project is to evaluate the feasibility of interhospital patient transfers (within a hospital corporation referred to as NESW Hospital Co.) as a means of reducing emergency department overcrowding. Customer satisfaction is a highly weighted factor in the event of interhospital transferring of patients, as providing quality health care is of the utmost importance to the NESW Hospital Co. Interhospital patient transfers are considered in times of high patient volumes when the referring hospital lacks an available bed to care for those patients whom, via the emergency department, must be admitted to a nursing unit.

NESW Hospital Co. consists of four hospitals within a metropolitan area. In order to maintain consistency, four nursing units were chosen from each hospital. The nursing units selected for observation provide the same type of care across the facilities, and each has generally high utilization according to data provided by the corporation. Additionally, costs associated with transferring patients between facilities were provided by the corporation. A linear programming model along with sensitivity analysis was used in evaluating the transfer of patients from the emergency department of one hospital to the appropriate nursing unit of another.

The evaluation yields positive results. The Model 2 objective function value was \$12,350. This method of assigning transfer patients is economically feasible. The amount of time a patient must spend in the waiting area of the emergency department, or in an emergency room waiting to be assigned a bed within a nursing unit was

significantly reduced. Additionally, transferring patients creates more space within the emergency departments and allows more patients to be treated.

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I. INTRODUCTION

A. Background Information

NESW Hospital Co.¹ has been in existence for decades and consists of four hospitals within a metropolitan area. The hospitals are labeled North Hospital, East Hospital, South Hospital, and West Hospital in accordance with their location.² NESW Hospital Co. desires to provide quality health care to patients, and customer satisfaction is very important in doing so. Each hospital acts under a uniform code of medical ethics and service methods in providing care to patients. Additionally, an adult patient base is common to each hospital.

Currently, the procedure for handling patients that arrive by ambulance to the emergency department is to place the patient in an emergency room and provide care immediately. Walk-in patients must first register, be assessed by a triage nurse, and then remain in the waiting area until they can be admitted into an emergency room. Subsequent to a physician evaluation within the emergency room, patients are either flagged for admission into a nursing unit within the hospital or properly discharged from the emergency department. In the event there are no beds available in the required nursing unit, patients occupy space in the emergency room until there is an opening.

1. In order to protect the privacy of the corporation, the title "NESW Hospital Co." is used in substitution of the official company name.
2. The hospital names have been changed to "North Hospital," "East Hospital," "South Hospital," and "West Hospital" for use in this research in order to protect their privacy.

B. Problem Definition

Due to an extremely high volume of visiting patients and relatively low capacities, NESW Hospital Co. has experienced overcrowding within the emergency departments. Overcrowding in the emergency departments is due, in part, to inability to transfer patients to an appropriate nursing unit within the hospital because the unit is filled to capacity. NESW Hospital Co. wants to investigate the feasibility of interhospital transfer of patients as a means of reducing emergency department overcrowding related to lack of available space in the nursing units. The corporation places a high priority on customer service and satisfaction, and expects this evaluation will uphold its standards.

C. Research Goal

The purpose of this research is to mathematically model interhospital transfers from the emergency department of one hospital to a nursing unit of another. Several transfer policies are considered within the math model. Sensitivity analysis is performed to make recommendations on interhospital transfers to NESW Hospital Co. In addition to the emergency departments, four nursing units with high utilization were selected for review at each of the hospitals within the corporation. The units chosen were the Intensive Care Unit (ICU), Medical/Surgical Unit (M/S), Transitional Care Unit (TCU), and the Oncology Department (Oncol).

II. LITERATURE REVIEW

Many emergency departments experience times of high utilization. In the United States alone, over 100 million patients visit an emergency department per fiscal year (Derlet, 2002). It is the overcrowding of most emergency departments that creates a problem for hospitals in the realm of emergency service. Often, hospitals employ creative methods to mitigate the effects of emergency department overcrowding. This literature review hones in on the causes, the effects, and the proposed methods of resolution of emergency department overcrowding. Additionally, specific attention will be given to interhospital transfer of patients as a method of resolution for emergency department overcrowding, and the general responses of patients will be duly noted.

A. Emergency Department Overcrowding

Inpatient services and nursing units at full capacity inhibit the ability of emergency departments to assign patients to the appropriate unit. As a result, the emergency department is the defaulted holding area for patients waiting for a bed to become available in a nursing unit (Derlet, 2002). The inability of a hospital nursing unit to serve multiple roles and provide service to a range of patient types is cited as a hindrance, since patients can not be transferred from the emergency department to any nursing unit with an available bed (Shih et al., 1999). Another contributing factor to the issue of overcrowding is that patients with illnesses/injuries that can be handled with home care methods (or in nursing homes) unnecessarily utilize space within emergency departments

(Walsh et al., 2003). Occasionally, visitors to the emergency department are not even in need of emergency care and could have simply scheduled an appointment with their own doctor.

Often, bed space within the emergency department is highly utilized, but overcrowding negatively effects productivity and limits the ability to treat in-coming patients. The amount of time a patient must spend in the waiting room or in the department as a whole is increased by overcrowding. Patients that are in pain suffer longer, and a diagnosis of symptoms is delayed. Periodically, patients will leave without being seen by a physician after spending several hours in the waiting room (Derlet, 2002). Additionally, quality of care within the department is directly affected by overcrowding, as the demand on departmental staff is heightened by the needs of arriving patients, critical patients, and those patients that could not be instantly transferred to a nursing unit (Shih et al., 1999). Unfortunately, the worst of many possible effects of overcrowding is the increased risk of fatalities (Derlet, 2002).

Methods of resolving emergency department overcrowding may vary from one facility to the next. Hospitals with tremendous overcrowding have been known to issue a critical care bypass, closing the emergency department to ambulances needing to deliver patients (Derlet, 2002). Typically, ambulance drivers deliver patients to the nearest emergency department, so critical care bypass forces them to go further out of the way. In addition to critical care bypass, several hospitals place those patients waiting to be admitted to a nursing unit into the hallway outside of the emergency department or near the nursing unit, as a means of creating space for others to be treated (McNamee & Kolb,

2004). Other emergency departments are turning toward interhospital transferring of patients, when in-hospital management strategies fall short (Shih et al., 1999).

In order to improve the efficiency of emergency departments, some hospitals are turning toward case managers (Walsh et al., 2003). Case management is often used to determine whether or not admission is necessary for patients entering the emergency department. This type of screening is similar to triage nursing, as a level of priority is assigned to patients. Also, case managers make arrangements for patients to be properly discharged when the services provided by an emergency department no longer suit the needs of the patient, or the patient can be treated from home (Walsh et al., 2003).

B. Results of Interhospital Patient Transfers

Queues form in emergency departments, as the rate of arriving patients is considerably greater than the rate of departing patients. Interhospital transfer of patients is one method of handling overcrowding. According to Shih et al (1999), interhospital transfers are recommended for patients with relatively minor illnesses/injuries who have an extended wait due to lack of available space in an inpatient unit. An agreement about proper procedures must be established between all participating hospitals in the event of interhospital patient transfers (Shih et al., 1999). Bed capacities, current occupancies, administrative contact information, and approval status must be clear before a transfer takes place (Shih et al., 1999).

As with most methods of resolution, drawbacks are associated with interhospital patient transfers. The disadvantages of transferring patients from one hospital to another must be compared to potential improvements in the quality of care for patients (Hosseini-

Nezhad et al., 1995). Shih et al (1999) explains that the income of the referring hospital decreases when emergency department patients are transferred out, and the possibility of rejection by a receiving hospital exists. Additionally, patients may be separated from their family in the event of transferring, which can add stress to an already stressful situation (Hosseini - Nezhad et al., 1995).

A number of considerations must be taken into account after the decision has been made to transfer patients from one hospital to the next. Transportation resources need to be properly allocated between participating hospitals (Hosseini - Nezhad et al., 1995). The mode of transportation (private ambulance, mobile intensive care unit, helicopter, etc.) must be decided as well (Hosseini - Nezhad et al., 1995). Additionally, staff must resolve multiple requests for transfers as only one patient can be transported at a time (Hosseini - Nezhad et al., 1995).

C. Response of Patients

Commonly, responses of patients vary when faced with the options for mitigating overcrowding. For example, McNamee and Kolb (2004) reported results from a survey regarding the preference of patients to board in the hallway outside of an emergency department or outside of an inpatient ward. Approximately two-thirds of the patients surveyed preferred to wait outside of the inpatient ward, and the other third preferred to wait outside of the emergency department (McNamee & Kolb, 2004). Reasons listed ranged from less traffic, noise, and commotion found outside of the inpatient ward to a more comfortable, safe, and quiet environment outside of the emergency department (McNamee & Kolb, 2004).

According to Shih et al (1999), the responses received from an implemented survey suggest that patients are highly dissatisfied with long waiting times in the emergency department. Dissatisfaction with having to wait extended periods of time is evident when registered patients leave the waiting room without being seen by an emergency department physician (Derlet, 2002). In general, patients are wary about being transferred to a hospital they know little or nothing about (Shih et al., 1999). However, such transfers may significantly reduce the amount of time a patient must wait.

D. Summary

Although emergency department overcrowding is an issue with negative effects, many hospitals have found creative ways to help nullify those effects. Hospitals must find and employ methods to resolve overcrowding that work for both their staff and their patient base. Surveys can be used to gather information regarding the willingness of patients to participate in the chosen method of resolution. Regardless of the method chosen, research needs to be carried out regarding proper procedures, and the safety and well-being of handling patients must be the top priority. Generally, as long as patients feel secure and well cared for, and time is saved in the process, they respect the method of resolution.

III. METHODOLOGY

A. Collection of Data

NESW Hospital Co. was instrumental in supplying data requested to investigate interhospital transfer of patients to reduce emergency department overcrowding when nursing units lack available space. Initially, results of a survey that had been distributed to stable patients in the emergency department of North Hospital, East Hospital, South Hospital, and West Hospital were shared and reviewed. The survey was intended to relay the response of patients in stable condition when faced with the option of being transferred from one hospital to another (Hurst, 2003). Survey results suggested that patients had little problem being transferred to another hospital within the corporation, as long as their waiting times were considerably reduced without any additional fees. In addition to the survey tool, NESW Hospital Co. provided data regarding the cost to transfer patients between hospitals, the departmental capacity information, and the data related to average volume and emergency department new arrivals.

Data regarding the cost to transfer patients by ambulance from the emergency department of one hospital to a nursing unit of another hospital was provided. The transfer costs to and from any two hospitals is equivalent. Additionally, the costs of transferring patients from the emergency department to a nursing unit within the same hospital were provided. Intrahospital transfer of patients is less expensive and preferred when possible, but is only an option when space is available within the nursing units. Transfer cost information is shown in TABLE I below.

TABLE I. Costs to Transfer Patients between Hospitals

Hospital	Transfer Cost
North↔North	\$75
North↔East	\$255
North↔South	\$275
North↔West	\$285
East↔East	\$75
East↔South	\$265
East↔West	\$275
South↔South	\$75
South↔West	\$285
West↔West	\$75

The ICU, M/S, TCU, and Oncol nursing units at each hospital within NESW Hospital Co. have individual capacity limits. Also, the number of patients who occupy bed space within each of the above mentioned units changes daily. However, the expected number of patients who occupy nursing unit bed space per day were provided and used for the purposes of this study. In TABLE II below, capacity information and volume data of each hospital nursing unit are shown.

TABLE II. Nursing Unit Capacity and Volume Information per Hospital

Hospital	Unit	Capacity	Average Volume
North	ICU	50	25
	M/S	89	63
	TCU	75	39
	Oncol	38	19
East	ICU	24	24
	M/S	59	58
	TCU	55	53
	Oncol	32	15
South	ICU	24	9
	M/S	60	60
	TCU	40	21
	Oncol	32	14
West	ICU	20	20
	M/S	40	39
	TCU	35	34
	Oncol	25	10

In addition to the average volume data, there are an expected number of new arrivals to the emergency departments of each hospital who must, in turn, be admitted to a nursing unit. The number of new arrivals to each emergency department who must be admitted to a nursing unit varies in type, meaning the patients are ICU, M/S, TCU, or Oncol patients. TABLE III below indicates the expected number of new arrivals of each type to the individual hospital emergency departments per day.

TABLE III. Emergency Department New Arrivals per Day of Each Type

Emergency Department	Type	New Arrivals
North	ICU	2
	M/S	6
	TCU	3
	Oncol	5
East	ICU	3
	M/S	4
	TCU	3
	Oncol	4
South	ICU	2
	M/S	10
	TCU	5
	Oncol	14
West	ICU	1
	M/S	8
	TCU	7
	Oncol	5

Once all of the necessary data was collected, it was then reviewed. The data was used to provide insight into the NESW Hospital Co. issue of emergency department overcrowding due to lack of available space in the nursing units. The next step was to detail and analyze the current method in which NESW Hospital Co. handles patients.

B. Overview of Current Method of Handling Patients

Currently, there are two ways in which NESW Hospital Co. handles emergency department arrivals. Patients who arrive at an emergency department by ambulance are immediately given an emergency room and provided with care. Walk-in patients must first register, sit through a triage nurse priority assessment, and then wait to be admitted into an emergency room. Subsequent to a physician evaluation within the emergency room, patients are either flagged for admission into a nursing unit within the hospital or properly discharged from the emergency department. In the event there are no beds available in the required nursing unit, patients occupy space in the emergency room until there is an opening. FIGURE 1 below shows a flow chart of the current process of handling patients in the emergency department.

FIGURE 1 – Flow Chart of the Emergency Department Current Process

In creating space for new patient arrivals, it is critical that the emergency departments continually discharge patients. In doing so, a drastic reduction must occur in the number of patients who are stalled in emergency departments waiting for a nursing unit bed to become available. The waiting time for patients needing to be transferred from an emergency department to a specific nursing unit that is already at full capacity is indefinite. Presently, there is no system in place to help remedy such a delay.

NESW Hospital Co. wants their North, East, South, and West Hospitals to collaborate on interhospital transfer of patients as an initiative to help reduce excessive waiting times in the emergency departments. Excessive waiting times are considered by NESW Hospital Co. to be three hours or more without the prospect of being transferred to a nursing unit. Such an initiative is an attempt to reduce emergency department overcrowding. The intent of the combined efforts of the hospitals is to create space for new patient arrivals, and in turn increase the productivity of the emergency departments. As an end result, NESW Hospital Co. wants their customers to be completely satisfied with the quality of services provided.

C. Linear Programming Model

In evaluating the transfer of patients from the emergency department of one hospital to the appropriate nursing unit of another, a set of two linear programming models were created. The main objective of the models is to minimize the cost of transferring patients from the emergency department to a nursing unit. These models include considerations for the number of patients being transferred out of the emergency department, the current number of patients in each nursing unit, and the capacity of the nursing units within each

hospital. The approach taken in each model varies in an attempt to give NESW Hospital Co. a couple of options from which to choose regarding the interhospital transfer policy.

The overall goal is to choose the option that best suits the needs of each facility within NESW Hospital Co. Initially, a model was created to balance the number of each type of patient (i.e., ICU, TCU, M/S, ONCOL) at all four hospitals. In Model 1, the intent was to evenly distribute patients among the nursing units at each of the four hospitals while remaining within the capacity limits. The decision variables, objective function, and constraints for Model 1 are shown in FIGURE 2 below.

Decision Variables

X_{ijk} = Number of ER patients at hospital i of type j transferred to a nursing unit within hospital k
where $i, j, k = \{1, \dots, 4\}$

Objective Function

$$\text{MIN } \sum_i \sum_j \sum_k C_{ijk} X_{ijk} \quad (1)$$

C_{ijk} = Per patient cost of transfers from ER of hospital i of type j to hospital k

Subject to

Constraints

B_{jk} = Capacity of unit j at hospital k

A_{jk} = Current number of patients of type j in hospital k

N_{ij} = Number of new patients of type j who arrive at the ER of hospital i

$$\sum_i X_{ijk} \leq B_{jk} - A_{jk} \quad \forall j, k \quad (2)$$

$$\sum_k X_{ijk} = N_{ij} \quad \forall i, j \quad (3)$$

$$A_{jk} + \sum_i X_{ijk} \geq 0.15 \left(\sum_k A_{jk} + \sum_i \sum_k X_{ijk} \right) \quad \forall j, k \quad (4)$$

FIGURE 2 – Linear Programming Model 1

The objective function (1), shown in FIGURE 2, involves the minimization of the total cost for all patients of type j transferred from the emergency department in hospital i to the appropriate nursing unit in hospital k . North, East, South, and West Hospitals are represented by i and k . ICU, M/S, TCU, and ONCOL are represented by j . Constraint (2) ensures that the capacity of each nursing unit is not exceeded in the event of transfers from the emergency department. Constraint (3) makes sure the new patients of type j who arrive at the emergency department of hospital i are indeed transferred to the appropriate nursing unit of hospital k . Finally, constraint (4) of Model 1 balances type j patients among each of the hospitals making sure every nursing unit has a least 15 percent of the specified type. The intended purpose of the 15 percent limiter is to ensure that each hospital is receiving patients without forcing the outcome by using a larger percentage.

A second model was created to limit the number of interhospital transfer patients accepted, so that the nursing unit beds are not counterproductively crowded with transfer patients. Model 2 makes sure intrahospital transfers are given top priority over transfers from a different facility. FIGURE 3 shows the decision variables, objective function, and constraints for Model 2.

Decision Variables

X_{ijk} = Number of ER patients at hospital i of type j transferred to a nursing unit within hospital k

where $i, j, k = \{1, \dots, 4\}$

Objective Function

$$\text{MIN } \sum_i \sum_j \sum_k C_{ijk} X_{ijk} \quad (1)$$

C_{ijk} = Per patient cost of transfers from ER of hospital i of type j to hospital k

Subject to

Constraints

B_{jk} = Capacity of unit j at hospital k

A_{jk} = Current number of patients of type j in hospital k

N_{ij} = Number of new patients of type j who arrive at the ER of hospital i

$$\sum_i X_{ijk} \leq B_{jk} - A_{jk} \quad \forall j, k \quad (2)$$

$$\sum_k X_{ijk} = N_{ij} \quad \forall i, j \quad (3)$$

$$\sum_{i \neq k} X_{ijk} \leq 0.80(B_{jk} - A_{jk}) \quad \forall j, k \quad (4)$$

FIGURE 3 – Linear Programming Model 2

Notice that the decision variable and objective function (1) for Models 1 and 2 respectively in FIGURE 1 and FIGURE 2, are the same. The models differ in the assortment of constraints applied in order to best meet the objective. Also, constraint (2) and constraint (3) of Model 2 are unchanged from Model 1 constraints. The difference between Model 1 and Model 2 is found in the constraint (4) of each model. In Model 2, constraint (4) states that the number of patients transferred to a different facility is less than or equal to 80 percent of the available space in the receiving hospital. The 80 percent limiter of the combined interhospital transfer patients arriving at the receiving hospital ensures that at least 20 percent of the available space is reserved for in-hospital

patient transfers. The purpose of creating the limiter was to reserve space for in-hospital patient transfers without significantly forcing the outcome.

In order to make a proper decision about the best model choice for the purpose of determining the feasibility of interhospital transfer of patients to reduce emergency department overcrowding, both Models 1 and 2 had to be tested. The section that follows addresses the results of both Model 1 and Model 2.

IV. RESULTS

The concepts in each of the aforementioned linear programming models were formulated using the MPL software program. The models were then solved with LINDO software for the purpose of conducting the sensitivity analysis. Sensitivity analysis was used in helping make recommendations regarding interhospital transfer of patients to NESW Hospital Co. A detailed listing of the MPL formulations and the LINDO sensitivity analysis are listed as a part of the appendices. The linear programming MPL formulation of Model 1 can be found in APPENDIX I. The Model 2 MPL formulation is detailed in APPENDIX II. In APPENDIX III, the LINDO sensitivity analysis of Model 1 is detailed. Additionally, the LINDO sensitivity analysis of Model 2 is listed in APPENDIX IV.

Particular attention was paid to the reduced cost and dual prices within each sensitivity analysis. In reviewing the reduced cost for each of the minimization models developed, a determination can be made as to how much the objective coefficient can be decreased before the optimal solution changes. The dual prices are indicative of an increase in profit for an additional unit of resource, as long as it is within the allowable ranges.

A solution was found for each linear programming model. The results in each case were specific to the given capacity limits and average volume of the nursing units, and to the expected number of emergency department new arrivals given. The cost of interhospital transfer of patients from the emergency room to a nursing unit was

minimized. In APPENDIX III and APPENDIX IV, the LINDO Sensitivity Analyses of Models 1 and 2, respectively, show that where a value is assigned to a variable the reduced cost is in turn 0.00.

Model 1 yielded an optimal solution of \$12,359. TABLE IV below summarizes the transfer results of Model 1. In APPENDIX III, the reduced cost section yields values ranging from 170.0 to 420.0 where there are no values assigned to the corresponding variable. Each of the values in the reduced cost section represent how much the objective coefficient can be decreased before a change will be evident in the optimal solution.

TABLE IV. Summary of Transfer Results for Model 1

Model 1			
Transferring Hospital (i)	Unit/Type (j)	Receiving Hospital (k)	X_{ijk}
1	1	1	2.00
2	1	1	2.10
1	2	1	6.00
2	2	1	3.00
3	2	1	10.00
4	2	1	7.00
1	3	1	3.00
2	3	1	1.00
1	4	1	5.00
2	2	2	1.00
2	3	2	2.00
2	4	2	4.00
2	1	3	0.90
3	1	3	2.00
4	1	3	1.00
3	3	3	5.00
4	3	3	6.00
3	4	3	14.00
4	2	4	1.00
4	3	4	1.00
4	4	4	5.00

Additionally, the sensitivity analysis of Model 1 indicates that where the slack or surplus is 0.00 the dual prices section reflects a nonzero value. There is an increase in the objective value for each unit of resource listed within the dual prices section as long as they are within the allowable ranges. In APPENDIX III, the objective coefficient ranges in which the basis is unchanged are listed. Allowable increase and decrease values of 0.00 were found in the output, therefore there are multiple optimal solutions for Model 1. Lastly, there is flexibility in the allowable ranges for the basis to remain feasible, shown in the righthand side ranges of APPENDIX III. A brief summary of the sensitivity analysis results for Model 1 are detailed in FIGURE 4 below.

Model 1				
a. Dual prices when slack or surplus is zero.				
Constraint	Unit/Type (j)	Receiving Hospital (k)	Slack or Surplus	Dual Prices
(2)	1	2	0.0	180.0
(2)	1	4	0.0	200.0
(2)	2	2	0.0	180.0
(2)	2	3	0.0	200.0
(2)	2	4	0.0	210.0
(2)	3	2	0.0	180.0
(2)	3	4	0.0	210.0
b. Allowable increase and decrease values of zero.				
Variable	Current Coefficient	Allowable Increase	Allowable Decrease	
X_{431}	285.0	∞	0.0	
X_{433}	285.0	0.0	210.0	

FIGURE 4 – Summary of Sensitivity Analysis Results for Model 1

The optimal solution of Model 2 is \$12,350. Within the reduced cost section of APPENDIX IV, values range from 170.0 to 420.0 as well. TABLE V below summarizes the transfer results of Model 2. Additionally, dual prices are reflected in the sensitivity

analysis of Model 2 in each instance where the slack or surplus is 0.00. There are multiple solutions for Model 2, as several of the allowable ranges listed in APPENDIX IV equal 0.00. The righthand side ranges of the Model 2 sensitivity analysis reflect the allowable ranges for the basis to remain feasible. A brief summary of the sensitivity analysis results for Model 2 are detailed in FIGURE 5 below.

TABLE V. Summary of Transfer Results for Model 2

Model 2			
Transferring Hospital (i)	Unit/Type (j)	Receiving Hospital (k)	X_{ijk}
1	1	1	2.00
2	1	1	3.00
4	1	1	1.00
1	2	1	6.00
2	2	1	3.00
3	2	1	10.00
4	2	1	7.00
1	3	1	3.00
2	3	1	1.00
1	4	1	5.00
2	2	2	1.00
2	3	2	2.00
2	4	2	4.00
3	1	3	2.00
3	3	3	5.00
4	3	3	6.00
3	4	3	14.00
4	2	4	1.00
4	3	4	1.00
4	4	4	5.00

Model 2

a. Dual prices when slack or surplus is zero.

Constraint	Unit/Type (<i>j</i>)	Receiving Hospital (<i>k</i>)	Slack or Surplus	Dual Prices
(2)	1	2	0.0	180.0
(2)	1	4	0.0	210.0
(2)	2	2	0.0	180.0
(2)	2	3	0.0	200.0
(2)	2	4	0.0	210.0
(2)	3	2	0.0	180.0
(2)	3	4	0.0	210.0

b. Allowable increase and decrease values of zero.

Variable	Current Coefficient	Allowable Increase	Allowable Decrease
X_{411}	285.0	0.0	210.0
X_{413}	285.0	∞	0.0
X_{431}	285.0	∞	0.0
X_{433}	285.0	0.0	210.0

FIGURE 5 – Summary of Sensitivity Analysis Results for Model 2

V. CONCLUSION AND RECOMMENDATIONS

Since the difference in the objective function values of Model 1 and Model 2 is only \$9 in favor of Model 2, and there is flexibility in the allowable ranges, the deciding factor in selecting the best model was not cost alone. Model 2 was selected as the best model for NESW Hospital Co. to choose in their effort to reduce emergency department overcrowding due to lack of available space in the nursing units. The results of Model 2 were less costly using the given capacity limits and average volume of the nursing units, and the expected number of emergency department new arrivals given. Additionally, Model 2 ensures that nursing unit beds are not counterproductively filled with interhospital transfer patients.

The evaluation results prove positive. In summary, the amount of time a patient must spend in the waiting area of the emergency department, or in an emergency room waiting to be assigned a bed within a nursing unit is considerably reduced. Additionally, transferring patients creates more space within the emergency departments and allows more patients to be treated. Both methods of assigning transfer patients are economically feasible. However, Model 2 is the best choice in meeting the overall goal, and ensuring intrahospital transfer is always given top priority.

VI. FUTURE RESEARCH

The linear programming model detailed in the preceding sections can be employed immediately to help reduce emergency department overcrowding within NESW Hospital Co. In the future, NESW Hospital Co. should consider increasing capacity within hospital nursing units that continuously prohibit in-hospital patient transfers. The objective should be to ensure every patient is provided a bed, while minimizing the number of patients needing to be transferred to a different facility.

In meeting the objective, attention must be given to those nursing units that are consistently at full capacity. Since creating space in an existing facility can be a complicated, costly and time consuming process, NESW Hospital Co. should continue to use the linear programming model as a resource during the transition. Additionally, nursing units that are considerably under capacity should be evaluated, and possibly used for additional space.

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APPENDICES

APPENDIX I – Linear Programming Model 1 MPL Formulation

North Hospital = 1, East = 2, South = 3, West = 4

ICU = 1, M/S = 2, TCU = 3, ONCOL = 4

TITLE

ThesisModel1;

INDEX

Hosp_i := 1..4;

Type_j := 1..4;

Hosp_k := 1..4;

DATA

Cost[Hosp_i,Type_j,Hosp_k] := (75, 255, 275, 285, 75, 255, 275, 285,
75, 255, 275, 285, 75, 255, 275, 285,
255, 75, 265, 275, 255, 75, 265, 275,
255, 75, 265, 275, 255, 75, 265, 275,
275, 265, 75, 285, 275, 265, 75, 285,
275, 265, 75, 285, 275, 265, 75, 285,
285, 275, 285, 75, 285, 275, 285, 75,
285, 275, 285, 75, 285, 275, 285, 75);

Current[Type_j,Hosp_k] := (25, 24, 9, 20,
63, 58, 60, 39,
39, 53, 21, 34,

19, 15, 14, 10);

Capacity[Typej,Hospk] := (50, 24, 24, 20,

89, 59, 60, 40,

75, 55, 40, 35,

38, 32, 32, 25);

New[Hospi,Typej] := (2, 6, 3, 5,

3, 4, 3, 4,

2, 10, 5, 14,

1, 8, 7, 5);

Percent := 0.15;

VARIABLES

Patients[Hospi,Typej,Hospk] -> Pats;

MODEL

MIN TotalCost = SUM(Hospi,Typej,Hospk: Cost * Patients);

SUBJECT TO

HospCapacity[Typej,Hospk] -> HospCap:

SUM(Hospi: Patients) + Current - Capacity <= 0;

HospTypes[Hospi,Typej] -> HospTyp:

SUM(Hospk: Patients) - New = 0;

HospMinimum[Typej,Hospk] -> HospMin:

Current + SUM(Hospi: Patients) - SUM(Hospi,Hospk: Percent*Patients) -

SUM(Hospk: Percent*Current) >= 0;

END

APPENDIX II – Linear Programming Model 2 MPL Formulation

North Hospital = 1, East = 2, South = 3, West = 4

ICU = 1, M/S = 2, TCU = 3, ONCOL = 4

TITLE

ThesisModel2;

INDEX

Hosp*i* := 1..4;

Type*j* := 1..4;

Hosp*k* := 1..4;

DATA

Cost[Hosp*i*,Type*j*,Hosp*k*] := (75, 255, 275, 285, 75, 255, 275, 285,
75, 255, 275, 285, 75, 255, 275, 285,
255, 75, 265, 275, 255, 75, 265, 275,
255, 75, 265, 275, 255, 75, 265, 275,
275, 265, 75, 285, 275, 265, 75, 285,
275, 265, 75, 285, 275, 265, 75, 285,
285, 275, 285, 75, 285, 275, 285, 75,
285, 275, 285, 75, 285, 275, 285, 75);

Current[Type*j*,Hosp*k*] := (25, 24, 9, 20,
63, 58, 60, 39,
39, 53, 21, 34,
19, 15, 14, 10);

Capacity[Type*j*,Hosp*k*] := (50, 24, 24, 20,

89, 59, 60, 40,
75, 55, 40, 35,
38, 32, 32, 25);

New[Hospi,Typej] := (2, 6, 3, 5,
3, 4, 3, 4,
2, 10, 5, 14,
1, 8, 7, 5);

Rate := .60;

VARIABLES

Patients[Hospi,Typej,Hospk] -> Pats;

MODEL

MIN TotalCost = SUM(Hospi,Typej,Hospk: Cost * Patients);

SUBJECT TO

HospCapacity[Typej,Hospk] -> HospCap:

SUM(Hospi: Patients) + Current - Capacity <= 0;

HospTypes[Hospi,Typej] -> HospTyp:

SUM(Hospk: Patients) - New = 0;

HospRates[Typej, Hospk] -> HospRat:

SUM(Hospi,Typej,Hospk = Hospi: Patients) - Rate * Capacity + Current >= 0;

END

APPENDIX III – LINDO Sensitivity Analysis of Model 1

LP OPTIMUM FOUND AT STEP 19

OBJECTIVE FUNCTION VALUE

1) 12359.00

<u>VARIABLE</u>	<u>VALUE</u>	<u>REDUCED COST</u>
PATS111	2.000000	0.000000
PATS112	0.000000	360.000000
PATS113	0.000000	190.000000
PATS114	0.000000	410.000000
PATS121	6.000000	0.000000
PATS122	0.000000	360.000000
PATS123	0.000000	400.000000
PATS124	0.000000	420.000000
PATS131	3.000000	0.000000
PATS132	0.000000	360.000000
PATS133	0.000000	200.000000
PATS134	0.000000	420.000000
PATS141	5.000000	0.000000
PATS142	0.000000	180.000000
PATS143	0.000000	200.000000
PATS144	0.000000	210.000000
PATS211	2.100000	0.000000
PATS212	0.000000	0.000000
PATS213	0.900000	0.000000
PATS214	0.000000	220.000000
PATS221	3.000000	0.000000
PATS222	1.000000	0.000000
PATS223	0.000000	210.000000
PATS224	0.000000	230.000000
PATS231	1.000000	0.000000
PATS232	2.000000	0.000000
PATS233	0.000000	10.000000
PATS234	0.000000	230.000000
PATS241	0.000000	180.000000
PATS242	4.000000	0.000000

PATS243	0.000000	190.000000
PATS244	0.000000	200.000000
PATS311	0.000000	210.000000
PATS312	0.000000	380.000000
PATS313	2.000000	0.000000
PATS314	0.000000	420.000000
PATS321	10.000000	0.000000
PATS322	0.000000	170.000000
PATS323	0.000000	0.000000
PATS324	0.000000	220.000000
PATS331	0.000000	200.000000
PATS332	0.000000	370.000000
PATS333	5.000000	0.000000
PATS334	0.000000	420.000000
PATS341	0.000000	200.000000
PATS342	0.000000	190.000000
PATS343	14.000000	0.000000
PATS344	0.000000	210.000000
PATS411	0.000000	10.000000
PATS412	0.000000	180.000000
PATS413	1.000000	0.000000
PATS414	0.000000	0.000000
PATS421	7.000000	0.000000
PATS422	0.000000	170.000000
PATS423	0.000000	200.000000
PATS424	1.000000	0.000000
PATS431	0.000000	0.000000
PATS432	0.000000	170.000000
PATS433	6.000000	0.000000
PATS434	1.000000	0.000000
PATS441	0.000000	210.000000
PATS442	0.000000	200.000000
PATS443	0.000000	210.000000
PATS444	5.000000	0.000000

<u>ROW</u>	<u>SLACK or SURPLUS</u>	<u>DUAL PRICES</u>
HOSPCA11)	20.900000	0.000000
HOSPCA12)	0.000000	180.000000
HOSPCA13)	11.100000	0.000000
HOSPCA14)	0.000000	200.000000
HOSPCA21)	0.000000	0.000000
HOSPCA22)	0.000000	180.000000
HOSPCA23)	0.000000	200.000000
HOSPCA24)	0.000000	210.000000
HOSPCA31)	32.000000	0.000000
HOSPCA32)	0.000000	180.000000
HOSPCA33)	8.000000	0.000000
HOSPCA34)	0.000000	210.000000
HOSPCA41)	14.000000	0.000000
HOSPCA42)	13.000000	0.000000
HOSPCA43)	4.000000	0.000000
HOSPCA44)	10.000000	0.000000
HOSPMI11)	16.200001	0.000000
HOSPMI12)	11.100000	0.000000
HOSPMI13)	0.000000	-10.000000
HOSPMI14)	7.100000	0.000000
HOSPMI21)	51.799999	0.000000
HOSPMI22)	21.799999	0.000000
HOSPMI23)	22.799999	0.000000
HOSPMI24)	2.800000	0.000000
HOSPMI31)	18.250000	0.000000
HOSPMI32)	30.250000	0.000000
HOSPMI33)	7.250000	0.000000
HOSPMI34)	10.250000	0.000000
HOSPMI41)	11.100000	0.000000
HOSPMI42)	6.100000	0.000000
HOSPMI43)	15.100000	0.000000
HOSPMI44)	2.100000	0.000000
HOSPTY11)	0.000000	-76.500000
HOSPTY12)	0.000000	-75.000000
HOSPTY13)	0.000000	-75.000000

HOSPTY14)	0.000000	-75.000000
HOSPTY21)	0.000000	-256.500000
HOSPTY22)	0.000000	-255.000000
HOSPTY23)	0.000000	-255.000000
HOSPTY24)	0.000000	-75.000000
HOSPTY31)	0.000000	-66.500000
HOSPTY32)	0.000000	-275.000000
HOSPTY33)	0.000000	-75.000000
HOSPTY34)	0.000000	-75.000000
HOSPTY41)	0.000000	-276.500000
HOSPTY42)	0.000000	-285.000000
HOSPTY43)	0.000000	-285.000000
HOSPTY44)	0.000000	-75.000000

NO. ITERATIONS = 19

RANGES IN WHICH THE BASIS IS UNCHANGED:

OBJ COEFFICIENT RANGES			
<u>VARIABLE</u>	<u>CURRENT COEF</u>	<u>ALLOWABLE INCREASE</u>	<u>ALLOWABLE DECREASE</u>
PATS111	75.000000	190.000000	INFINITY
PATS112	255.000000	INFINITY	360.000000
PATS113	275.000000	INFINITY	190.000000
PATS114	285.000000	INFINITY	410.000000
PATS121	75.000000	360.000000	INFINITY
PATS122	255.000000	INFINITY	360.000000
PATS123	275.000000	INFINITY	400.000000
PATS124	285.000000	INFINITY	420.000000
PATS131	75.000000	200.000000	INFINITY
PATS132	255.000000	INFINITY	360.000000
PATS133	275.000000	INFINITY	200.000000
PATS134	285.000000	INFINITY	420.000000
PATS141	75.000000	180.000000	INFINITY
PATS142	255.000000	INFINITY	180.000000
PATS143	275.000000	INFINITY	200.000000
PATS144	285.000000	INFINITY	210.000000
PATS211	255.000000	10.000000	180.000000

PATS212	75.000000	180.000000	INFINITY
PATS213	265.000000	190.000000	10.000000
PATS214	275.000000	INFINITY	220.000000
PATS221	255.000000	210.000000	170.000000
PATS222	75.000000	170.000000	INFINITY
PATS223	265.000000	INFINITY	210.000000
PATS224	275.000000	INFINITY	230.000000
PATS231	255.000000	10.000000	170.000000
PATS232	75.000000	170.000000	INFINITY
PATS233	265.000000	INFINITY	10.000000
PATS234	275.000000	INFINITY	230.000000
PATS241	255.000000	INFINITY	180.000000
PATS242	75.000000	180.000000	INFINITY
PATS243	265.000000	INFINITY	190.000000
PATS244	275.000000	INFINITY	200.000000
PATS311	275.000000	INFINITY	210.000000
PATS312	265.000000	INFINITY	380.000000
PATS313	75.000000	210.000000	INFINITY
PATS314	285.000000	INFINITY	420.000000
PATS321	275.000000	170.000000	200.000000
PATS322	265.000000	INFINITY	170.000000
PATS323	75.000000	200.000000	INFINITY
PATS324	285.000000	INFINITY	220.000000
PATS331	275.000000	INFINITY	200.000000
PATS332	265.000000	INFINITY	370.000000
PATS333	75.000000	200.000000	INFINITY
PATS334	285.000000	INFINITY	420.000000
PATS341	275.000000	INFINITY	200.000000
PATS342	265.000000	INFINITY	190.000000
PATS343	75.000000	190.000000	INFINITY
PATS344	285.000000	INFINITY	210.000000
PATS411	285.000000	INFINITY	10.000000
PATS412	275.000000	INFINITY	180.000000
PATS413	285.000000	10.000000	200.000000
PATS414	75.000000	200.000000	INFINITY
PATS421	285.000000	170.000000	210.000000
PATS422	275.000000	INFINITY	170.000000

PATS423	285.000000	INFINITY	200.000000
PATS424	75.000000	210.000000	INFINITY
PATS431	285.000000	INFINITY	0.000000
PATS432	275.000000	INFINITY	170.000000
PATS433	285.000000	0.000000	210.000000
PATS434	75.000000	210.000000	INFINITY
PATS441	285.000000	INFINITY	210.000000
PATS442	275.000000	INFINITY	200.000000
PATS443	285.000000	INFINITY	210.000000
PATS444	75.000000	200.000000	INFINITY

RIGHTHAND SIDE RANGES

	CURRENT	ALLOWABLE	ALLOWABLE
<u>ROW</u>	<u>RHS</u>	<u>INCREASE</u>	<u>DECREASE</u>
HOSPCA11	25.000000	INFINITY	20.900000
HOSPCA12	0.000000	2.100000	0.000000
HOSPCA13	15.000000	INFINITY	11.100000
HOSPCA14	0.000000	1.000000	0.000000
HOSPCA21	26.000000	INFINITY	0.000000
HOSPCA22	1.000000	3.000000	0.000000
HOSPCA23	0.000000	10.000000	0.000000
HOSPCA24	1.000000	7.000000	0.000000
HOSPCA31	36.000000	INFINITY	32.000000
HOSPCA32	2.000000	1.000000	2.000000
HOSPCA33	19.000000	INFINITY	8.000000
HOSPCA34	1.000000	6.000000	1.000000
HOSPCA41	19.000000	INFINITY	14.000000
HOSPCA42	17.000000	INFINITY	13.000000
HOSPCA43	18.000000	INFINITY	4.000000
HOSPCA44	15.000000	INFINITY	10.000000
HOSPMI11	-13.300000	16.200001	INFINITY
HOSPMI12	-12.300000	11.100000	INFINITY
HOSPMI13	2.700000	2.100000	0.900000
HOSPMI14	-8.300000	7.100000	INFINITY
HOSPMI21	-30.000000	51.799999	INFINITY
HOSPMI22	-25.000000	21.799999	INFINITY
HOSPMI23	-27.000000	22.799999	INFINITY

HOSPMI24	-6.000000	2.800000	INFINITY
HOSPMI31	-16.950001	18.250000	INFINITY
HOSPMI32	-30.950001	30.250000	INFINITY
HOSPMI33	1.050000	7.250000	INFINITY
HOSPMI34	-11.950000	10.250000	INFINITY
HOSPMI41	-10.300000	11.100000	INFINITY
HOSPMI42	-6.300000	6.100000	INFINITY
HOSPMI43	-5.300000	15.100000	INFINITY
HOSPMI44	-1.300000	2.100000	INFINITY
HOSPTY11	2.000000	13.999999	2.000000
HOSPTY12	6.000000	0.000000	6.000000
HOSPTY13	3.000000	32.000000	3.000000
HOSPTY14	5.000000	13.999999	5.000000
HOSPTY21	3.000000	24.588234	2.470588
HOSPTY22	4.000000	0.000000	3.000000
HOSPTY23	3.000000	32.000000	1.000000
HOSPTY24	4.000000	13.000000	4.000000
HOSPTY31	2.000000	1.058823	2.000000
HOSPTY32	10.000000	0.000000	10.000000
HOSPTY33	5.000000	8.000000	5.000000
HOSPTY34	14.000000	4.000000	14.000000
HOSPTY41	1.000000	1.058823	1.000000
HOSPTY42	8.000000	0.000000	7.000000
HOSPTY43	7.000000	8.000000	6.000000
HOSPTY44	5.000000	10.000000	2.470588

APPENDIX IV – LINDO Sensitivity Analysis of Model 2

LP OPTIMUM FOUND AT STEP 18

OBJECTIVE FUNCTION VALUE

1) 12350.00

<u>VARIABLE</u>	<u>VALUE</u>	<u>REDUCED COST</u>
PATS111	2.000000	0.000000
PATS112	0.000000	360.000000
PATS113	0.000000	200.000000
PATS114	0.000000	420.000000
PATS121	6.000000	0.000000
PATS122	0.000000	360.000000
PATS123	0.000000	400.000000
PATS124	0.000000	420.000000
PATS131	3.000000	0.000000
PATS132	0.000000	360.000000
PATS133	0.000000	200.000000
PATS134	0.000000	420.000000
PATS141	5.000000	0.000000
PATS142	0.000000	180.000000
PATS143	0.000000	200.000000
PATS144	0.000000	210.000000
PATS211	3.000000	0.000000
PATS212	0.000000	0.000000
PATS213	0.000000	10.000000
PATS214	0.000000	230.000000
PATS221	3.000000	0.000000
PATS222	1.000000	0.000000
PATS223	0.000000	210.000000
PATS224	0.000000	230.000000
PATS231	1.000000	0.000000
PATS232	2.000000	0.000000
PATS233	0.000000	10.000000
PATS234	0.000000	230.000000
PATS241	0.000000	180.000000
PATS242	4.000000	0.000000

PATS243	0.000000	190.000000
PATS244	0.000000	200.000000
PATS311	0.000000	200.000000
PATS312	0.000000	370.000000
PATS313	2.000000	0.000000
PATS314	0.000000	420.000000
PATS321	10.000000	0.000000
PATS322	0.000000	170.000000
PATS323	0.000000	0.000000
PATS324	0.000000	220.000000
PATS331	0.000000	200.000000
PATS332	0.000000	370.000000
PATS333	5.000000	0.000000
PATS334	0.000000	420.000000
PATS341	0.000000	200.000000
PATS342	0.000000	190.000000
PATS343	14.000000	0.000000
PATS344	0.000000	210.000000
PATS411	1.000000	0.000000
PATS412	0.000000	170.000000
PATS413	0.000000	0.000000
PATS414	0.000000	0.000000
PATS421	7.000000	0.000000
PATS422	0.000000	170.000000
PATS423	0.000000	200.000000
PATS424	1.000000	0.000000
PATS431	0.000000	0.000000
PATS432	0.000000	170.000000
PATS433	6.000000	0.000000
PATS434	1.000000	0.000000
PATS441	0.000000	210.000000
PATS442	0.000000	200.000000
PATS443	0.000000	210.000000
PATS444	5.000000	0.000000

<u>ROW</u>	<u>SLACK or SURPLUS</u>	<u>DUAL PRICES</u>
HOSPCA11)	19.000000	0.000000
HOSPCA12)	0.000000	180.000000
HOSPCA13)	13.000000	0.000000
HOSPCA14)	0.000000	210.000000
HOSPCA21)	0.000000	0.000000
HOSPCA22)	0.000000	180.000000
HOSPCA23)	0.000000	200.000000
HOSPCA24)	0.000000	210.000000
HOSPCA31)	32.000000	0.000000
HOSPCA32)	0.000000	180.000000
HOSPCA33)	8.000000	0.000000
HOSPCA34)	0.000000	210.000000
HOSPCA41)	14.000000	0.000000
HOSPCA42)	13.000000	0.000000
HOSPCA43)	4.000000	0.000000
HOSPCA44)	10.000000	0.000000
HOSPTY11)	0.000000	-75.000000
HOSPTY12)	0.000000	-75.000000
HOSPTY13)	0.000000	-75.000000
HOSPTY14)	0.000000	-75.000000
HOSPTY21)	0.000000	-255.000000
HOSPTY22)	0.000000	-255.000000
HOSPTY23)	0.000000	-255.000000
HOSPTY24)	0.000000	-75.000000
HOSPTY31)	0.000000	-75.000000
HOSPTY32)	0.000000	-275.000000
HOSPTY33)	0.000000	-75.000000
HOSPTY34)	0.000000	-75.000000
HOSPTY41)	0.000000	-285.000000
HOSPTY42)	0.000000	-285.000000
HOSPTY43)	0.000000	-285.000000
HOSPTY44)	0.000000	-75.000000
HOSPRA11)	16.000000	0.000000
HOSPRA12)	0.000000	0.000000
HOSPRA13)	12.000000	0.000000

HOSPRA14)	0.000000	0.000000
HOSPRA21)	0.800000	0.000000
HOSPRA22)	0.800000	0.000000
HOSPRA23)	0.000000	0.000000
HOSPRA24)	0.800000	0.000000
HOSPRA31)	27.799999	0.000000
HOSPRA32)	1.600000	0.000000
HOSPRA33)	9.200000	0.000000
HOSPRA34)	0.800000	0.000000
HOSPRA41)	15.200000	0.000000
HOSPRA42)	13.600000	0.000000
HOSPRA43)	14.400000	0.000000
HOSPRA44)	12.000000	0.000000

NO. ITERATIONS= 18

RANGES IN WHICH THE BASIS IS UNCHANGED:

OBJ COEFFICIENT RANGES			
VARIABLE	CURRENT	ALLOWABLE	ALLOWABLE
	COEF	INCREASE	DECREASE
PATS111	75.000000	200.000000	INFINITY
PATS112	255.000000	INFINITY	360.000000
PATS113	275.000000	INFINITY	200.000000
PATS114	285.000000	INFINITY	420.000000
PATS121	75.000000	360.000000	INFINITY
PATS122	255.000000	INFINITY	360.000000
PATS123	275.000000	INFINITY	400.000000
PATS124	285.000000	INFINITY	420.000000
PATS131	75.000000	200.000000	INFINITY
PATS132	255.000000	INFINITY	360.000000
PATS133	275.000000	INFINITY	200.000000
PATS134	285.000000	INFINITY	420.000000
PATS141	75.000000	180.000000	INFINITY
PATS142	255.000000	INFINITY	180.000000
PATS143	275.000000	INFINITY	200.000000

PATS144	285.000000	INFINITY	210.000000
PATS211	255.000000	10.000000	170.000000
PATS212	75.000000	170.000000	INFINITY
PATS213	265.000000	INFINITY	10.000000
PATS214	275.000000	INFINITY	230.000000
PATS221	255.000000	210.000000	170.000000
PATS222	75.000000	170.000000	INFINITY
PATS223	265.000000	INFINITY	210.000000
PATS224	275.000000	INFINITY	230.000000
PATS231	255.000000	10.000000	170.000000
PATS232	75.000000	170.000000	INFINITY
PATS233	265.000000	INFINITY	10.000000
PATS234	275.000000	INFINITY	230.000000
PATS241	255.000000	INFINITY	180.000000
PATS242	75.000000	180.000000	INFINITY
PATS243	265.000000	INFINITY	190.000000
PATS244	275.000000	INFINITY	200.000000
PATS311	275.000000	INFINITY	200.000000
PATS312	265.000000	INFINITY	370.000000
PATS313	75.000000	200.000000	INFINITY
PATS314	285.000000	INFINITY	420.000000
PATS321	275.000000	170.000000	200.000000
PATS322	265.000000	INFINITY	170.000000
PATS323	75.000000	200.000000	INFINITY
PATS324	285.000000	INFINITY	220.000000
PATS331	275.000000	INFINITY	200.000000
PATS332	265.000000	INFINITY	370.000000
PATS333	75.000000	200.000000	INFINITY
PATS334	285.000000	INFINITY	420.000000
PATS341	275.000000	INFINITY	200.000000
PATS342	265.000000	INFINITY	190.000000
PATS343	75.000000	190.000000	INFINITY
PATS344	285.000000	INFINITY	210.000000
PATS411	285.000000	0.000000	210.000000
PATS412	275.000000	INFINITY	170.000000
PATS413	285.000000	INFINITY	0.000000
PATS414	75.000000	210.000000	INFINITY

PATS421	285.000000	170.000000	210.000000
PATS422	275.000000	INFINITY	170.000000
PATS423	285.000000	INFINITY	200.000000
PATS424	75.000000	210.000000	INFINITY
PATS431	285.000000	INFINITY	0.000000
PATS432	275.000000	INFINITY	170.000000
PATS433	285.000000	0.000000	210.000000
PATS434	75.000000	210.000000	INFINITY
PATS441	285.000000	INFINITY	210.000000
PATS442	275.000000	INFINITY	200.000000
PATS443	285.000000	INFINITY	210.000000
PATS444	75.000000	200.000000	INFINITY

RIGHTHAND SIDE RANGES

	CURRENT	ALLOWABLE	ALLOWABLE
<u>ROW</u>	<u>RHS</u>	<u>INCREASE</u>	<u>DECREASE</u>
HOSPCA11	25.000000	INFINITY	19.000000
HOSPCA12	0.000000	3.000000	0.000000
HOSPCA13	15.000000	INFINITY	13.000000
HOSPCA14	0.000000	1.000000	0.000000
HOSPCA21	26.000000	INFINITY	0.000000
HOSPCA22	1.000000	3.000000	0.000000
HOSPCA23	0.000000	10.000000	0.000000
HOSPCA24	1.000000	7.000000	0.000000
HOSPCA31	36.000000	INFINITY	32.000000
HOSPCA32	2.000000	1.000000	2.000000
HOSPCA33	19.000000	INFINITY	8.000000
HOSPCA34	1.000000	6.000000	1.000000
HOSPCA41	19.000000	INFINITY	14.000000
HOSPCA42	17.000000	INFINITY	13.000000
HOSPCA43	18.000000	INFINITY	4.000000
HOSPCA44	15.000000	INFINITY	10.000000
HOSPTY11	2.000000	19.000000	2.000000
HOSPTY12	6.000000	0.000000	6.000000
HOSPTY13	3.000000	32.000000	3.000000
HOSPTY14	5.000000	14.000000	5.000000
HOSPTY21	3.000000	16.000000	3.000000

HOSPTY22	4.000000	0.000000	3.000000
HOSPTY23	3.000000	27.799999	1.000000
HOSPTY24	4.000000	13.000000	4.000000
HOSPTY31	2.000000	13.000000	2.000000
HOSPTY32	10.000000	0.000000	10.000000
HOSPTY33	5.000000	8.000000	5.000000
HOSPTY34	14.000000	4.000000	14.000000
HOSPTY41	1.000000	16.000000	1.000000
HOSPTY42	8.000000	0.000000	7.000000
HOSPTY43	7.000000	8.000000	6.000000
HOSPTY44	5.000000	10.000000	5.000000
HOSPRA11	20.000000	INFINITY	16.000000
HOSPRA12	0.000000	INFINITY	0.000000
HOSPRA13	12.000000	INFINITY	12.000000
HOSPRA14	0.000000	INFINITY	0.000000
HOSPRA21	20.799999	INFINITY	0.800000
HOSPRA22	0.800000	INFINITY	0.800000
HOSPRA23	0.000000	INFINITY	0.000000
HOSPRA24	0.800000	INFINITY	0.800000
HOSPRA31	28.799999	INFINITY	27.799999
HOSPRA32	1.600000	INFINITY	1.600000
HOSPRA33	15.200000	INFINITY	9.200000
HOSPRA34	0.800000	INFINITY	0.800000
HOSPRA41	15.200000	INFINITY	15.200000
HOSPRA42	13.600000	INFINITY	13.600000
HOSPRA43	14.400000	INFINITY	14.400000
HOSPRA44	12.000000	INFINITY	12.000000

CURRICULUM VITAE

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DOB: Louisville, Kentucky - May 28, 1980

EDUCATION: B.S. in Industrial Engineering
University of Louisville
J.B. Speed School of Engineering
1998 – 2004

MEng with specialization in the field of Industrial Engineering
University of Louisville
J.B. Speed School of Engineering
2004 – 2005

INTERNSHIP: Management Engineering Department of Norton Healthcare

AWARDS: 1st – National Student Material Handling Design Competition 2002 - 2003
1st – University of Louisville Technical Paper Competition 2003
UTA Resident Assistant of the Year 2004, 2005
Martin Luther King, Jr. Youth Service Award 1998

SCHOLARSHIPS: Woodford Porter Scholarship
Brown & Williamson Scholarship
John Mann Scholarship
BWISE Foundation Scholarship
Salome C. Worthington Scholarship
National Council of Negro Women Scholarship
Louis-Edward Nicklies Scholarship

STUDENT MEMBERSHIPS: National Society of Black Engineers
Institute of Industrial Engineers
Society of Porter Scholars
Housing and Residence Life Student Judicial Board