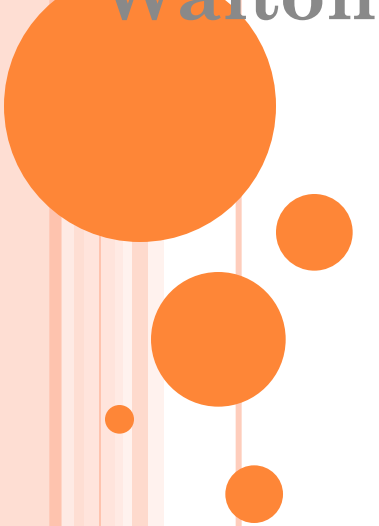
Improving Hospital Operations

Walton Hancock



What Systems Should We Improve?

- Inpatient Admissions
- Operating Room
- Nurse Daily Assignments
- Ancillary Staffing
- Outpatient Scheduling
- Transporters

Selection Rationale

- There are approximately 5,747 hospitals in the US.
- All of these hospitals need systems to do most of the work.
- Little attention has been focused on the best systems to do the work.

Selection Rationale Continued

- Many of the present systems result in poor quality, excess costs and chaotic environments for the patients and employees.
- On an annual basis, hospitals are 98% fixed costs, so, after we change the systems, we must change the staff and staffing patterns to fit the demand if we want to save money and achieve the highest quality.

Inpatient Admissions Systems

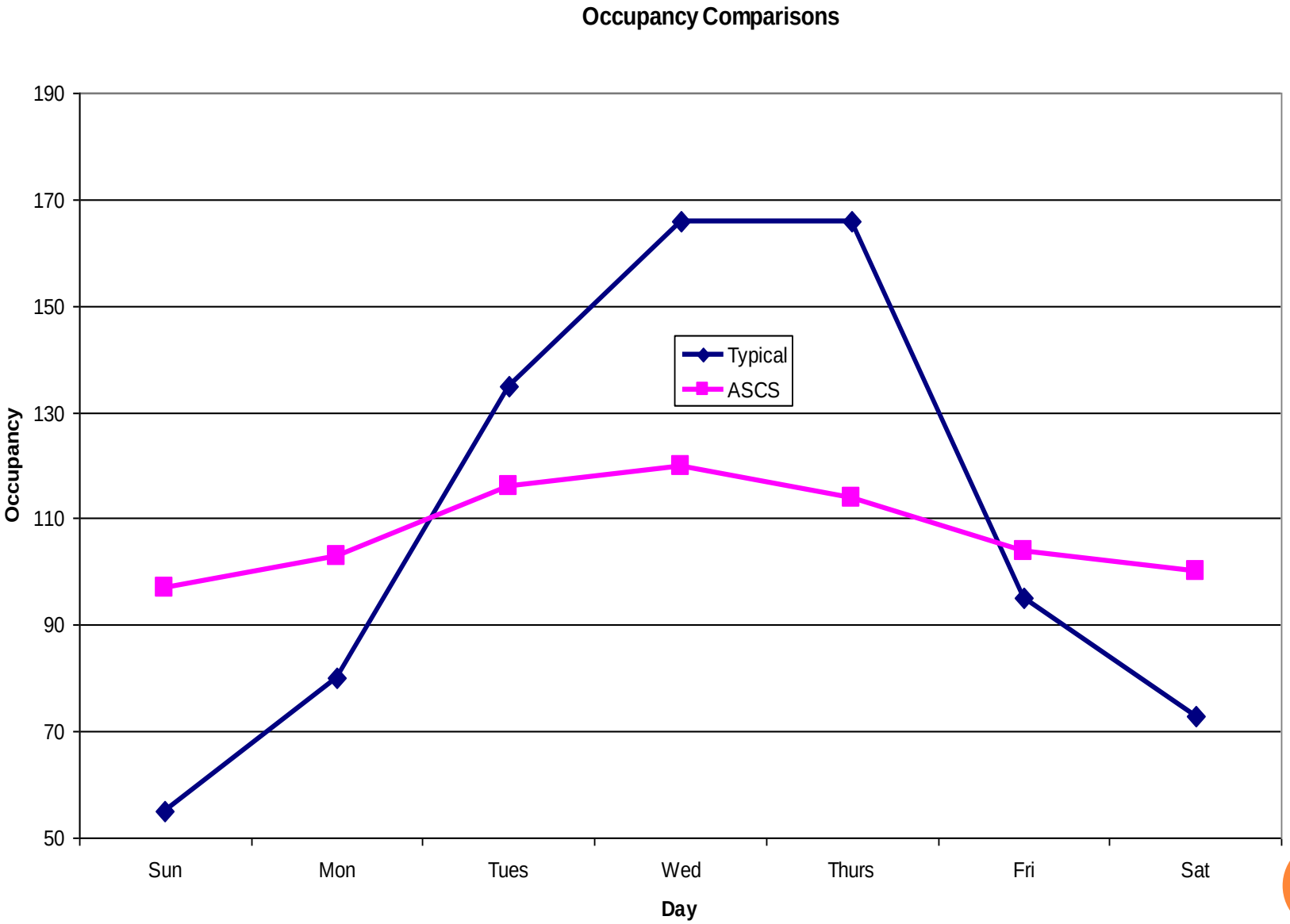
- This system determines how well we use the hospital resources.
- Emergencies are usually 30 to 50% of admissions. The rest are elective and can be scheduled to improve quality and minimize costs.
- A patient admission loads the nursing and ancillary services. Thus, optimum staffing and high quality are dependent on admissions procedures.

Inpatient Admissions Systems

- Usually, the OR's schedule patients with no communication with Admissions.
- OR's usually schedule 5 days per week. Thus occupancy falls on weekends.
- Most medical admissions occur on weekends, Monday and Tuesday. In many cases, physicians have to declare an emergency to get a medical patient admitted on Wednesday or Thursday.
- Without the proper systems, it is almost impossible for the admissions department to admit patients without incurring negative situations except when the facilities are oversized.

Inpatient Admissions Systems

- In many cases, there are no beds available for emergencies on Wednesdays and Thursdays.
- Surgical cancellations are frequent due to lack of beds.
- Patients are placed on the wrong units. A surgical patient placed on a medical floor increases the LOS by 1.0 days.


Occupancy Comparisons
190
170
150
130
110
90
70
50
Occupancy
Typical
ASCS
Sun
Mon
Tues
Wed
Thurs
Fri
Sat
Day

Inpatient Admissions Systems

- Admissions goals:
  - **Maximum average occupancy subject to:**
    - **All emergencies will be promptly admitted.**
    - **All elective surgery will have a bed available**
    - **All call-ins will be admitted within three days.**

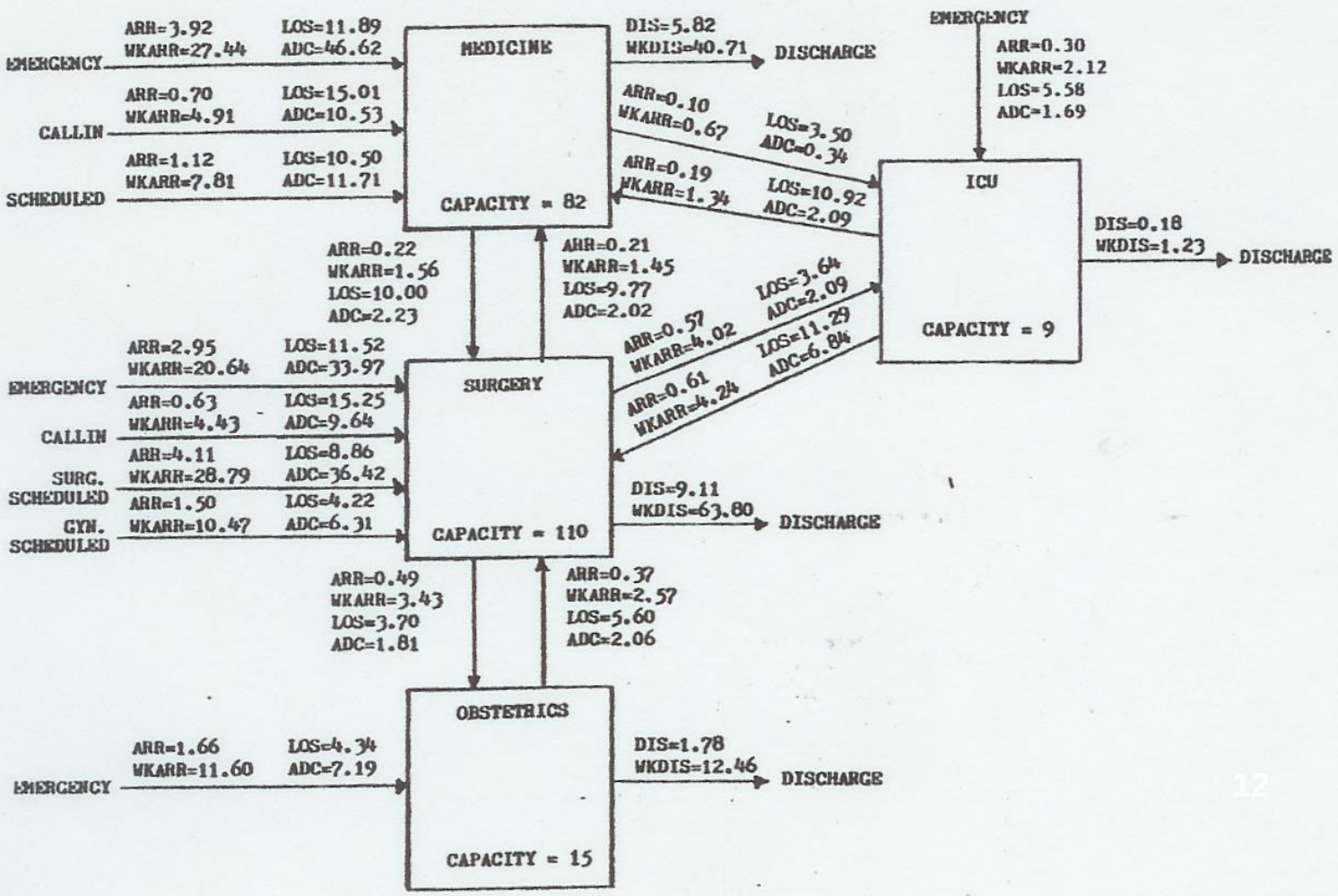
Inpatient Admissions Systems

- Analyze the patient admissions data for the past two years
- Use simulation to replicate the admissions process.
- Produce a vector diagram of the patient flows.
- Big Problems: errors in patient database. Examples: 30% of babies born to males, All discharges at midnight. Also, cumulative distributions have to be used for admissions and LOS because distribution assumptions cause errors.
- Simulation must match actual results of average occupancy within .5%

Inpatient Admissions Systems

- Load the admissions rates and their LOS into a digital simulator.
- Determining the admissions decision rules for 9:00 a.m., 11:00 a.m. and 2:00 p.m. for each day of the week.

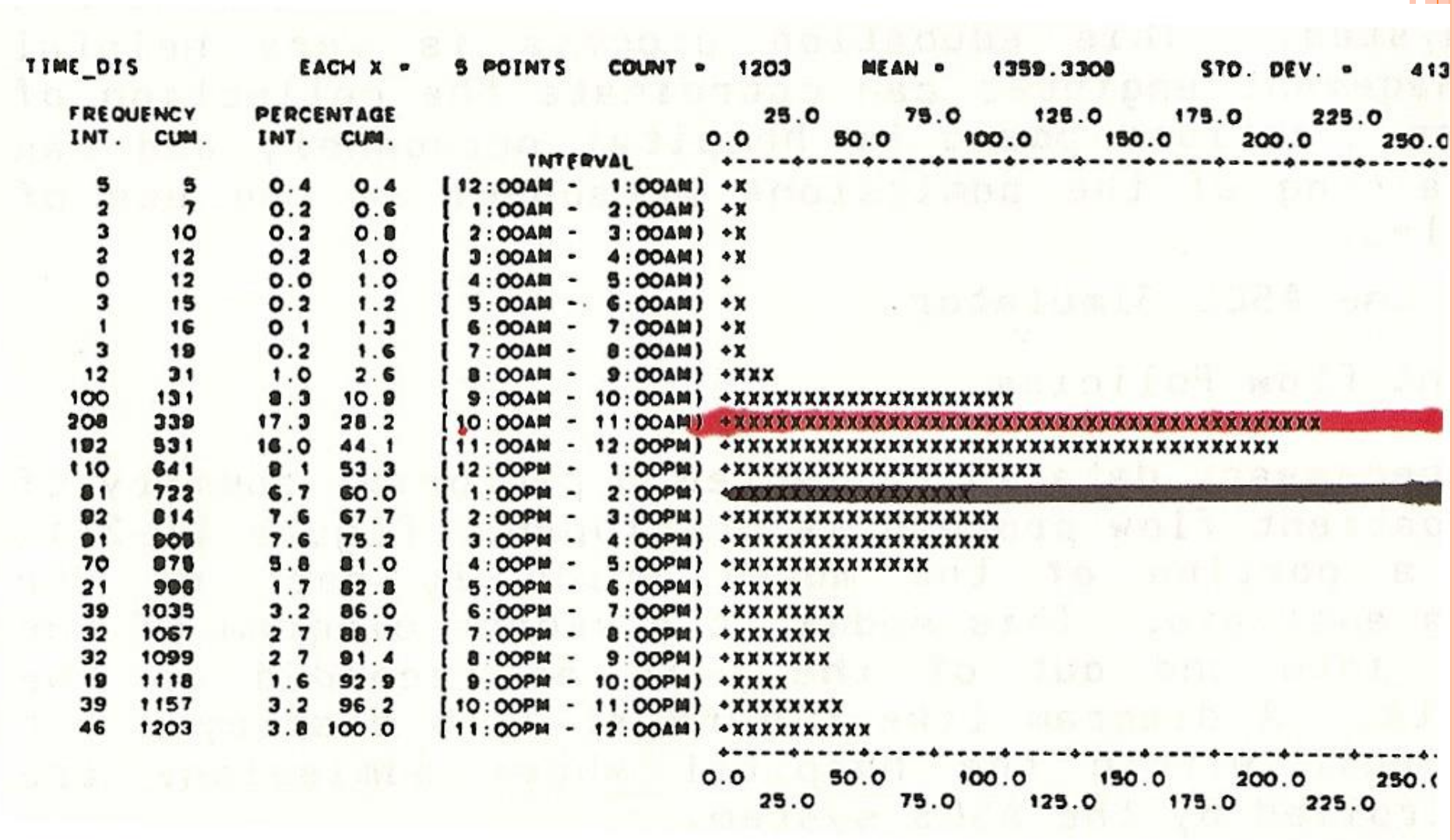
Patient Flow Diagram



Inpatient Admissions Systems

- Most hospitals have an 11:00 a.m. discharge time. None enforce it.
- Because discharges occur throughout the day and admissions are typically at 2:00 p.m., admissions decisions have to be made at 9:00 a.m.,11:00 a.m. and 2:00 p.m.

Typical Discharge Distribution



TIME_DIS EACH X = 5 POINTS COUNT = 1203 MEAN = 1359.3308 STD. DEV. = 413

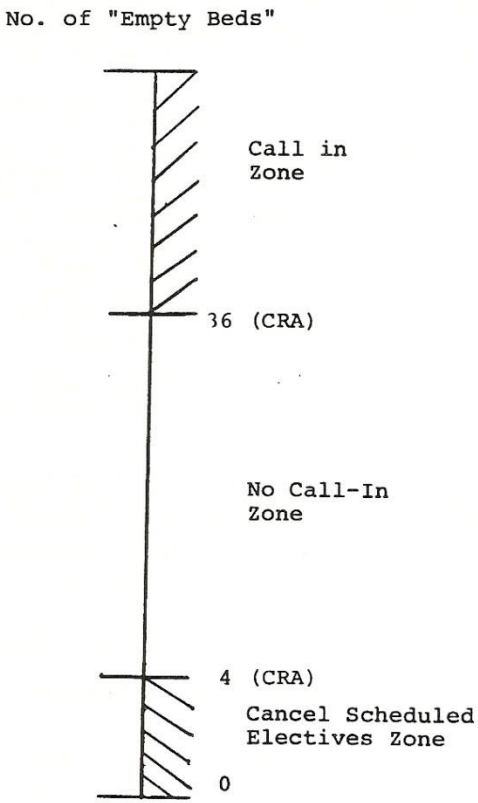
FREQUENCY INT.	FREQUENCY CUM.	PERCENTAGE INT.	PERCENTAGE CUM.	INTERVAL
5	5	0.4	0.4	[12:00AM - 1:00AM)
2	7	0.2	0.6	[1:00AM - 2:00AM)
3	10	0.2	0.8	[2:00AM - 3:00AM)
2	12	0.2	1.0	[3:00AM - 4:00AM)
0	12	0.0	1.0	[4:00AM - 5:00AM)
3	15	0.2	1.2	[5:00AM - 6:00AM)
1	16	0.1	1.3	[6:00AM - 7:00AM)
3	19	0.2	1.6	[7:00AM - 8:00AM)
12	31	1.0	2.6	[8:00AM - 9:00AM)
100	131	8.3	10.9	[9:00AM - 10:00AM)
208	339	17.3	28.2	[10:00AM - 11:00AM)
192	531	16.0	44.1	[11:00AM - 12:00PM)
110	641	9.1	53.3	[12:00PM - 1:00PM)
81	722	6.7	60.0	[1:00PM - 2:00PM)
92	814	7.6	67.7	[2:00PM - 3:00PM)
91	905	7.6	75.2	[3:00PM - 4:00PM)
70	975	5.8	81.0	[4:00PM - 5:00PM)
21	996	1.7	82.8	[5:00PM - 6:00PM)
39	1035	3.2	86.0	[6:00PM - 7:00PM)
32	1067	2.7	88.7	[7:00PM - 8:00PM)
32	1099	2.7	91.4	[8:00PM - 9:00PM)
19	1118	1.6	92.9	[9:00PM - 10:00PM)
39	1157	3.2	96.2	[10:00PM - 11:00PM)
46	1203	3.8	100.0	[11:00PM - 12:00AM)

0.0 25.0 50.0 75.0 100.0 125.0 150.0 175.0 200.0 225.0 250.0

Inpatient Admissions Systems

- In order to obtain maximum average occupancy, a medical call-in queue is established. These are patients who are not emergency, but need to be admitted within three days.

Decision Points based on empty Beds at 9am,11am, and 2pm.



Admissions Worksheet

- Specific numbers are obtained from the simulator for each day .
- A worksheet is prepared for the admissions clerk. It looks like an income tax form, but is easy to follow.
- Sometimes the worksheet is put on a computer, but not immediately because of possible changes.

Decision Worksheet for Admissions

3:30PM -- HOSPITAL "XYZ" -- PART 1 ADMISSION SCHEDULING AND CONTROL SYSTEM (ASCS) 3:30PM DECISION TABLE REV: 05/24/02 -- PAGE 6

TODAY'S DATE: _____ DAY OF THE WEEK: _____

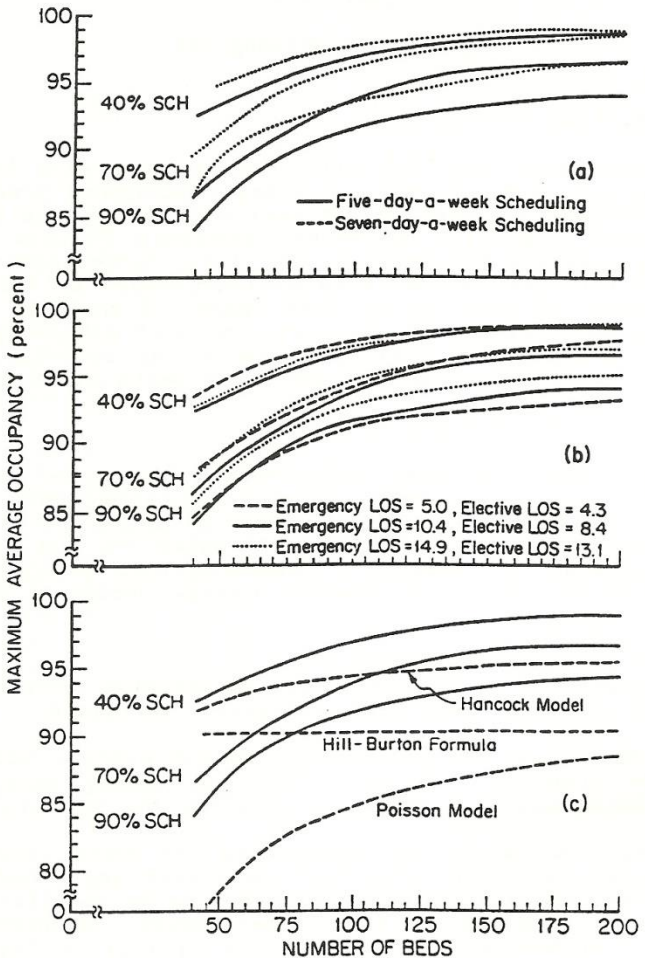
PREPARED BY: _____

LINE #	ITEM	COL 1 MED-B	COL 2 SURG	COL 3 MED-A	COL 4 ONC-A	COL 5 MED-MSU	COL 6 ONC-B	COL 7 FPR	COL 8 SWING	COL 9 ACUTE TOTALS
1	THE 1PM CALLIN MAXIMUMS (FROM PAGE 03, LINE 03)									
2	ENTER THE # OF PATIENTS SUCCESSFULLY CALLED IN BETWEEN 1PM AND 3:30PM									
3	THE 3:30PM CALLIN MAXIMUMS (LINE 1 - LINE 2)									
4	UNIT CAPACITY	91	304	156	79	80	39	13	20	
5	BEDS OUT OF SERVICE ON UNIT									
6	SERVICEABLE BEDS ON UNIT (LINE 4 - LINE 5)									
7	3:30PM CENSUS ON UNIT									
8	# OF SERVICEABLE EMPTY BEDS ON UNIT AT 3:30PM (LINE 6 - LINE 7)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(=)
9	ENTER THE EXPECTED # OF TRANSFER REQUESTS FROM ACUTE TO ICU BETWEEN 3:30PM TODAY AND 9AM TOMORROW									
10	SUBTOTAL (LINE 8 + LINE 9)									
11	ENTER THE # OF PATIENTS SCHEDULED FOR ADMISSION TODAY BUT NOT YET ADMITTED	(+)	(+)	(+)	(+)	(+)	(+)	(+)		(=)
12	ENTER THE # OF PATIENTS SUCCESSFULLY CALLED IN TODAY BUT NOT YET ADMITTED	(+)	(+)	(+)	(+)	(+)	(+)	(+)		(=)
13	ENTER THE EXPECTED # OF TRANSFER REQUESTS FROM ICU TO ACUTE BETWEEN 3:30PM TODAY AND 9AM TOMORROW									
14	SUBTOTAL (LINE 11 + LINE 12 + LINE 13)									
15	EMPTY BED COUNT DIFFERENCE (LINE 10 - LINE 14)									

Occupancy Curves

- Maximum average occupancy is a function of several factors: % emergency arrivals, hospital size, no. of days scheduled, elective and emergency los. .
- Curves were developed to show the relationships and to help understanding.
- More specific maximum average occupancy numbers are obtained using a 23 term regression equation.

Maximum Average Curves



Results

- Average occupancy can be increased. For a typical hospital, from 66.7% to 90.2%
- In the first implementation, average occupancy from 85% to 94% with no more than two times per month where no bed for emergencies.
- The advanced OR elective schedule is stabilized at a fixed amount for each day of the week.
- Medical electives can be scheduled every day of the week.
- Tensions between the physicians, admissions and OR scheduling are greatly reduced.

Implementation

- Implementation is greatly aided because all of the “powerful actors” benefit:
  - **Surgeons could do more procedures per week**
  - **Admissions personnel have a much easier time.**
  - **Administrators have increased revenue and/or lower costs.**
  - **Tension amongst staff is greatly reduced.**

Increased Revenues

- The typical hospital has 166 beds with a room rate of $1756 per day. Occupancy will increase by 23.3%
- 166*.235*1756*365= $24,790,277 increase in revenue if enough patients
- In first hospital, revenues were forecasted to increase by $10,000,000.
- In first hospital, plans to add a wing were cancelled because of the increased occupancy.

Hospital Planning

- This admission simulator was used to plan the new (1980) Michigan hospital.
  - **The size of each medical service was determined.**
  - **Changes in medical practice were forecasted and incorporated in the final numbers.**
  - **The issue of tertiary vs. secondary patients was painfully discussed and resolved.**

Hospital Planning

- The patient flow diagrams show the number of patients placed on the wrong units because of lack of beds on the primary unit.
- Units can be resized so that wrong patient placement is minimized.

Operating Room Systems

Scheduling OR's

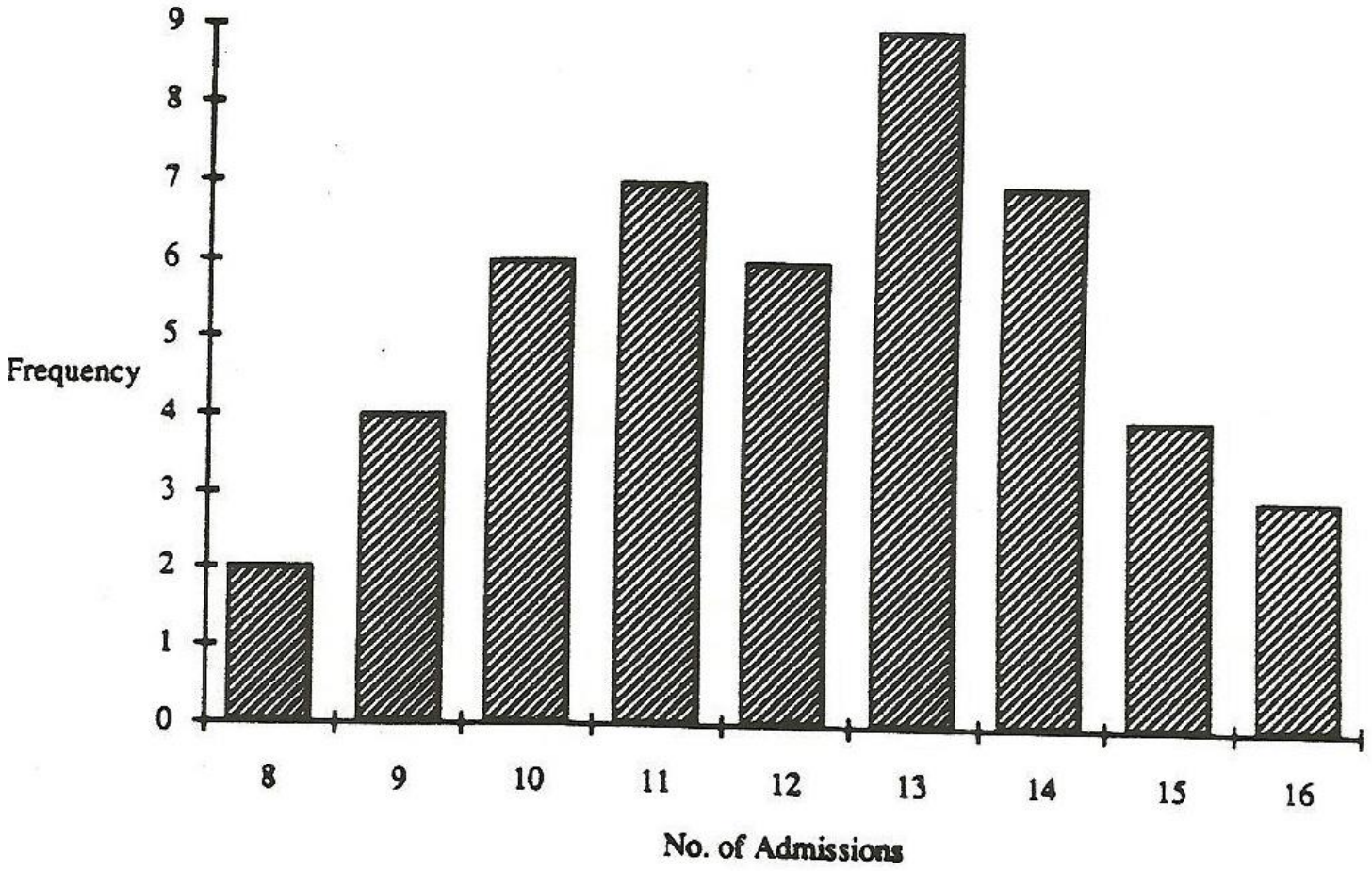
Operating Room Operations

- Average use of OR's is 52% with a six figure overtime bill.
- OR's are scheduled with no regard for available beds.
- Surgical cancellations due to lack of beds are frequent.
- OR's cost $50.00 to $85.00 per staffed minute.

Operating Room Operations

- Many OR's lack operational discipline:
  - **Procedures do not start on time 77%.**
  - **Clean up takes from 15 to 60 minutes.**
  - **Block schedules are not kept up to date.**
  - **Number of procedures per day show wide variation.**
  - **Case carts are not kept up to date. Supplies are wasted as a result.**
  - **Little or no attempt is made to standardize the case cart contents.**
  - **First procedure does not start on time.**
  - **High staff turnover due to end of shift overruns.**

Monday's Surgery admissions Distribution



Surgery Scheduling

- Specify the number of elective procedures of elective surgeries each day. This number can only be exceeded with permission of the Admissions Department.
- Example:
- Sun. Mon. Tues. Wed. Thur. Fri. Sat.
- 0 19 17 15 14 14 0

Negative Costs

- !4 beds are to be scheduled o Monday. What is the cost if only 13 have surgery?
- $2000/day*5.5 days avg. stay + *80/minute OR cost*60minutes OR time =$15,800 negative costs.
- Who cares? – no one

OR Scheduling

- We need means and variances for the following sub procedures by procedure and by surgeon:
  - **Induction**
  - **Setup**
  - **Procedure**
  - **Recovery**
  - **Room cleanup**
  - **Usually cannot use the historical database because of errors and because of inefficiencies. Need to implement system with no data. Use experiences nurses asyimates until data base is sufficient.**

Typical OR Results

- 27% average on time starts.
- 31.5 minutes average turnaround
- Clean up varies from 10 minutes to 45 minutes.
- !5 minutes in studied units. Circulation nurse activities are critical.
- Impossible to start on time if clean up is not standardized. Well run Ors take 15 minutes or less. Circulating nurse is not permitted to leave the or room.

OR Scheduling

- Unfortunately, the existing history files are full of poor information, so we need to build a new file where:
  - **The beginning and end points are defined for each procedure.**
  - **Any standardization attempts are done first. Examples: Room clean up should be 15 minutes or less.**
  - **Case cart loading is done the night before.**
  - **Case carts a big problem. Had to be updated prior to implementation**

Surgery Scheduling

- Objectives:
  - **Start procedures on time 95% of the time.**
  - **Finish in 8 hours 95% of the time.**
  - **Blocks finish on time 95% of the time.**
  - **Schedule with a phone call.**
  - **Procedures end prior to shift end unless advance notice is given to staff.**

On Time OR Schedule

Case #	Start Time(min)	End Time(min)	Probablity
1	0	76	0.99
2	76	143	0.99
3	143	208	0.98
4	208	273	0.97
5	273	336	0.96
6	336	400	0.95
7	400	463	0.94
8	463	526	
	526		
	Procedure = 60 Mins		
	Std Deviation = 7 mins		
	Utilization=	88%	

Nursing Operations

Staffing

Nurse Staffing

- 4.2 hours per day per patient is the most commonly used number for acute beds.
- This assumes that the nurse cares for all of the patients needs.
- For a 250 bed hospital, we need 181.25 nurses spread over 3 shifts.
- Usually, it is 2.0 hours for shift 1, 1.2 for shift 2 and 1.0 for shift 3.

Nurse Staffing

- Approximately 35% of a nurse's time is used to care for the patient's medical needs. 65% is for physical needs.
- What do we want the nursing staff do: take care of the medical needs or the total needs?
- If aides help the nurse by taking care of the physical needs, how is the budget affected?

Nurse Staffing

- Studies have indicated that 33% of a nurse's time each day is spent trying to find things. The inference is that their workplaces are not standardized. My estimate is that 25% of the 33% could be eliminated.
- 4.2 could be reduced to 3.15 NH/PD.
- $2,544,780 could be saved in 166 bed hospital
- $14,624,850,660 countrywide

Nurse Assignments

- Each patient needs certain care. How do we assign the nurses so there is a high probability needs will be met?
- We need to classify each patient at the end of the previous shift so that assignment takes place within the first five minutes of the next shift.
- We need to provide the admissions dept. with knowledge of where there is an excess of nursing staff.

Patient Classification (Yvonne Abdoo)

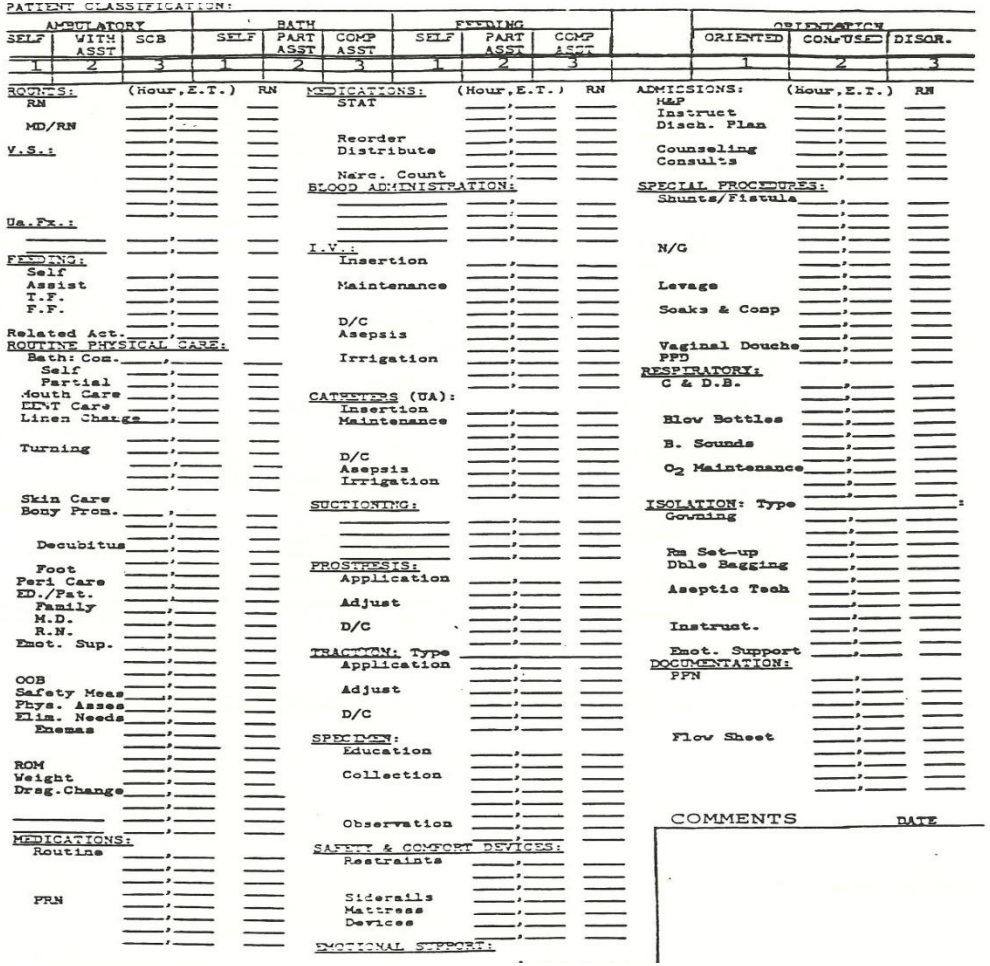
PATIENT CLASSIFICATION:

AMBULATORY			BATH			FEEDING			TPR/BP	ORIENTATION		
SELF	WITH ASST	SCB	SELF	PART ASST	COMP ASST	SELF	PART ASST	COMP ASST	Q2H OR OFTEN	ORIENTED	CONFUSED	DISOR.
A	B	C	A	B	C	A	B	C	C	A	B	C

Patient Classification Times

	SURGICAL			MEDICAL		
Class	Mean Time	Variance	Coef. of Var.	Mean Time	Variance	Coef. of Var.
1111	68.10	886.58	0.44	82.65	476.02	0.26
1112	116.89	1579.09	0.34	130.59	1402.33	0.29
1113	118.01	1720.51	0.35	158.41	1803.44	0.27
1121	103.25	1224.82	0.34	124.91	1118.53	0.27
1122	135.02	1752.65	0.31	144.98	1585.71	0.27
1123	132.85	1880.46	0.33	169.43	1896.84	0.26
1131	147.02	1954.44	0.30	169.14	2104.74	0.27
1132	149.24	2040.94	0.30	171.97	2117.78	0.27
1133	151.61	2177.01	0.31	180.22	2271.16	0.26
1211	92.68	1177.36	0.37	110.33	905.26	0.27
1212	132.56	1770.07	0.32	139.85	1497.92	0.28
1213	131.38	1925.97	0.33	165.40	1875.49	0.26

Nurse Data Collection Sheet



PATIENT CLASSIFICATION:

AMBULATORY			BATH			FEEDING				ORIENTATION		
SELF	WITH ASST	SCB	SELF	PART ASST	COMP ASST	SELF	PART ASST	COMP ASST		ORIENTED	CONFUSED	DISOR.
1	2	3	1	2	3	1	2	3		1	2	3

ROUTES: (Hour, E.T.) RN
RN
MD/RN
V.S.:
Ua.Fx.:
FEEDING:
Self
Assist
T.F.
F.F.
Related Act.
ROUTINE PHYSICAL CARE:
Bath: Com.
Self
Partial
Mouth Care
EENT Care
Linen Change
Turning
Skin Care
Bony Prom.
Decubitus
Foot
Peri Care
ED./Pat.
Family
M.D.
R.N.
Emot. Sup.
OOB
Safety Meas
Phys. Assess
Elim. Needs
Enemas
ROM
Weight
Drsg.Change
MEDICATIONS:
Routine
PRN

MEDICATIONS: (Hour, E.T.) RN
STAT
Reorder
Distribute
Narc. Count
BLOOD ADMINISTRATION:
I.V.:
Insertion
Maintenance
D/C
Asepsis
Irrigation
CATHETERS (UA):
Insertion
Maintenance
D/C
Asepsis
Irrigation
SUCTIONING:
PROSTHESIS:
Application
Adjust
D/C
TRACTION: Type
Application
Adjust
D/C
SPECIMEN:
Education
Collection
Observation
SAFETY & COMFORT DEVICES:
Restraints
Siderails
Mattress
Devices
EMOTIONAL SUPPORT:

ADMISSIONS: (Hour, E.T.) RN
H&P
Instruct
Disch. Plan
Counseling
Consults
SPECIAL PROCEDURES:
Shunts/Fistula
N/G
Levage
Soaks & Comp
Vaginal Douche
PPD
RESPIRATORY:
C & D.B.
Blow Bottles
B. Sounds
O_2 Maintenance
ISOLATION: Type
Gowning
Rm Set-up
Dble Bagging
Aseptic Tech
Instruct.
Emot. Support
DOCUMENTATION:
PPN
Flow Sheet

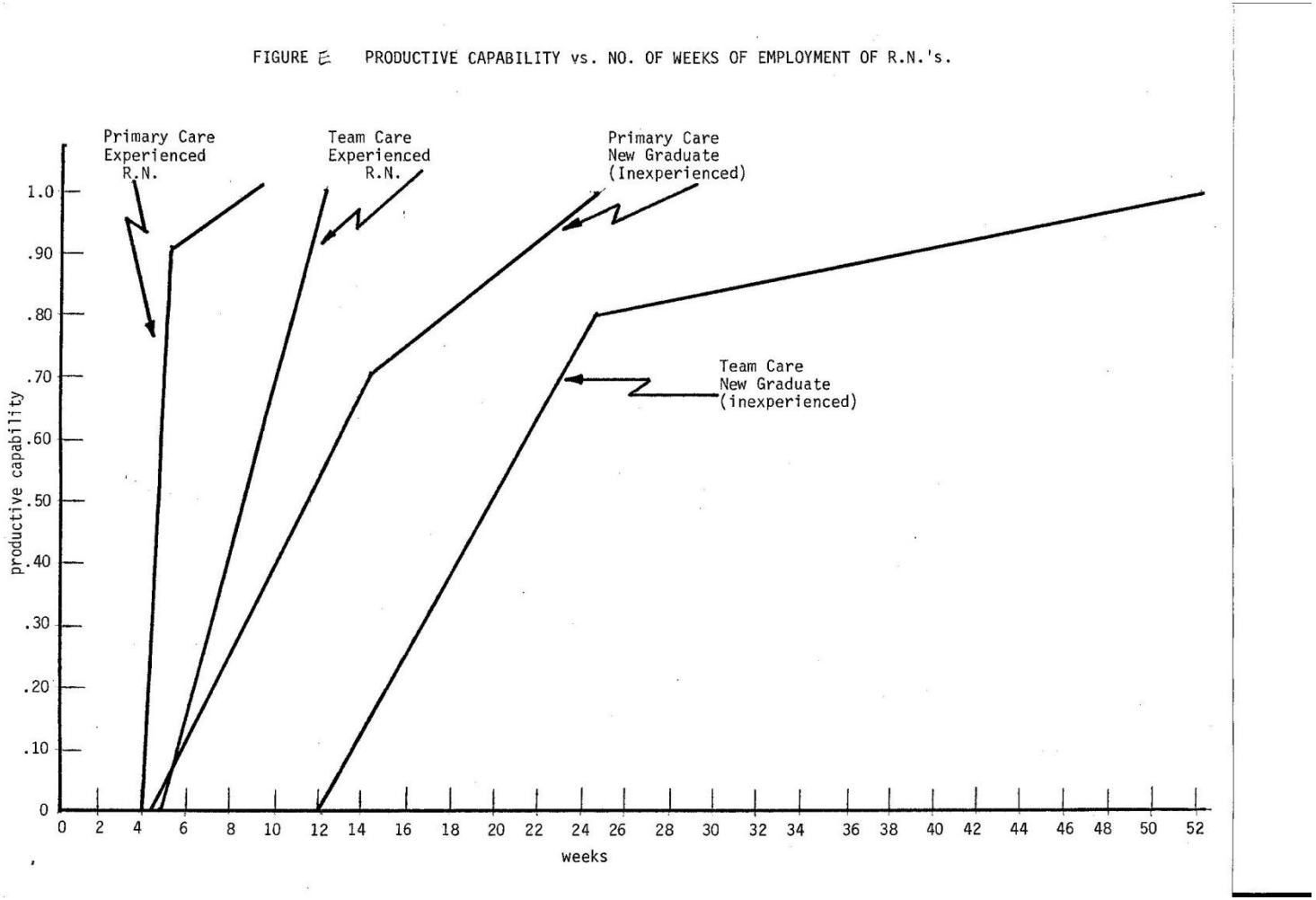
COMMENTS DATE

Staffing Report

Next Day - Day Shift

UNIT	11 AM CENSUS	PROJ. CENSUS	CRITICAL LEVEL	MAX LEVEL	PLANNED STAFFING					11 AM CENSUS OVER/UNDER (-)	PROJ. OVER/UND. (-)
					REG.	CONTRACT	O.T.	ON CALL	TOTAL		
1. 8TH REG	45	46	11.212	14.94	8.44	1.81	.00	.00	10.25	-.82	-.96
2. 7TH NORTH	34	36	9.29	12.39	6.56	.91	.00	.00	7.47	-1.55	-1.83
3. 7TH SOUTH	32	35	8.16	10.89	4.03	.91	.00	1.88	6.81	-.94	-1.35
4. 6TH M/S	47	51	8.24	10.99	8.53	.91	.00	.00	9.44	1.75	1.20
5. 5TH SOUTH	37	40	8.58	11.45	6.92	.91	.00	1.88	9.70	1.53	1.11
6. 5TH NORTH	37	40	8.98	11.97	5.63	.91	.00	1.88	8.41	-.15	-.57
7. GYN	33	34	6.57	8.76	6.56	.00	.00	.94	7.50	1.07	.93
8. 4TH WEST	16	20	4.77	6.36	3.75	.91	.00	.00	4.66	.45	-.11

Learning Curve Adjustments



Ancillary Staffing

Determination of Staffing Levels

First Day Load Ratios

Ancillary service	Approximate ratio of first or second day procedure rate to the average of the following 18 days of stay
Heart Station-EKG	10.0
Bacteriology/Microbiology Lab	2.4
Biochemistry Lab	2.3
Immunology Lab	7.5
Lab Test Panel	59.0
Hematology Lab	13.0
Pathology Lab	4.5
Ligand Assay Lab	2.0
SMI Coagulation Lab	4.8
Pediatrics Lab	3.3
Nuclear Medicine	4.9
Radiology – Main	4.8
Radiology – Mott	5.3
Blood Bank	4.4

Ancillary Staffing

- Ancillary professional groups have labor standards for procedures.
- These standards are generally “loose.”
- Part of the reason for the loose standards is because data were obtained on partially trained employees.
- There is usually no requirement that orders are completed within a specified time. Do the best you can is the typical philosophy.

Ancillary Staffing

- By extending the procedures to their labor hours, we can obtain an estimate of the hours needed on each shift.
- We know that people work at their maximum rate when highly motivated. Motivation is highest when there is a lot of work to do.
- A sustainable rate is 1/4 less than the maximum rate.

Ancillary Staffing

- Unfortunately, the number of procedure orders on the first shift are not uniformly received during the shift. Orders for blood work are received after the physician makes rounds. Thus, idleness may occur during the early part of the shift.
- The working hours of ancillary services need to be changed to reflect when orders are received.

Ancillary Staffing

- When work is standardized, output increases by 1/3. Except for certain laboratory procedures, very little of the work has been standardized.

Number of Procedures - Biochemistry

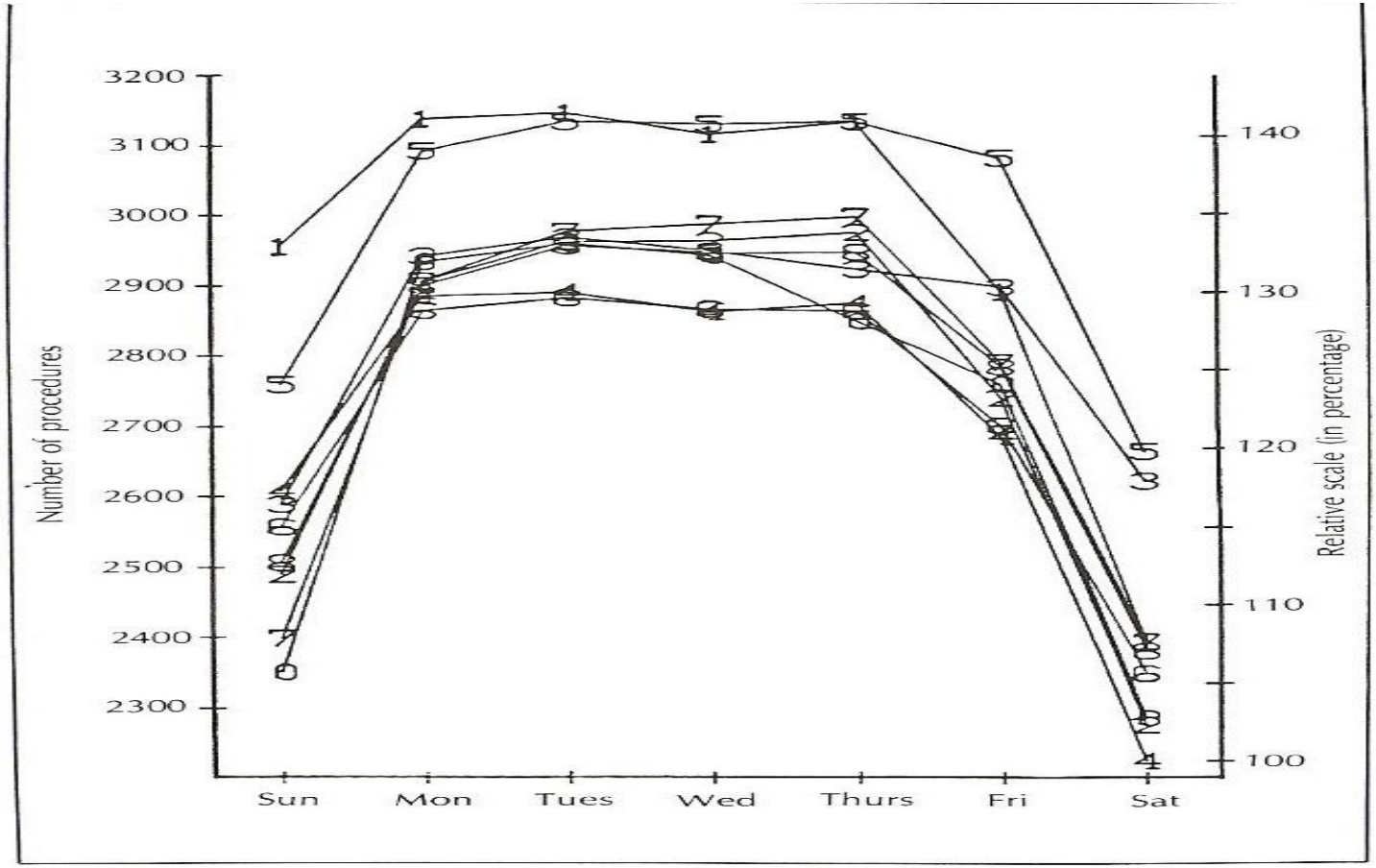


Figure 6. Total average number of procedures (inpatient plus outpatient) for

Laboratory staffing

- Weekend staffing is generally not sufficient. Results are thus delayed which may increase LOS.

Weekend Staffing

Ancillary department	Load range MON.-FRI.	SUN. load (as a percent of range midpoint)	SAT. load (as a percent of range midpoint)
Ligand Assay	48-53	61	61
Respiratory Therapy-Main	488-496	97	97
Respiratory Therapy-Mott	74-77	94	97
Physical Therapy	219-227	78	78
Pharmacy	950-970	72	72
Heart Station	82-110	80	57
Bacti/Micro	278-292	80	78
Biochemistry	2780-2960	87	83
Immunology	76-87	47	42
Lab Test Panel	130-168	48	27
Hematology	90-124	83	50
Pathology	132-144	45	44
SMI Coagulation	225-265	93	79
Pediatrics	173-191	64	60
Nuclear medicine	66-74	44	39
Hemodialysis	3.2-3.5	34	36
Radiology-Main	430-480	53	46
Radiology-Mott	96-110	62	53
Blood-Bank	470-560	97	78
Overall total (average) ancillary activity	6800-7400	80	74

Ancillary Staffing Analysis

Table 3. A Summary of the Staffing Methodology Application

Department	Col. 1 Present staff (FTE)	Col. 2 Near maximum productivity (%)	Col. 3 Suggested staff (FTE)	Col. 4 Difference col. 1–3 (FTE)	Col. 5 Actual achieved (%)	Col. 6 Expected productivity (%)
			Respiratory Therapy			
Shift 1—Respiratory	18.0	180.0	8.4	9.6	56.0	120.7
Shift 2—Respiratory	12.4	180.0	6.7	5.7	78.2	126.2
Shift 3—Respiratory	12.0	180.0	10.8	1.2	99.0	109.8
			Laboratories (1 Shift only)			
Hematology	9.5	130.0	3.7	5.8	51.2	119.9
Histology	7.5	130.0	3.8	3.7	61.1	109.6
Lab. STAT	5.4	150.0	2.0	3.4	51.7	122.0
Microbiology	10.0	100.0	6.3	3.7	87.3	132.4
Totals	74.8		41.7	34.1		

Ancillary Services

$2,796,299	Hospital savings
$16,070,330,353	Country Savings

Outpatient Scheduling

Patient Waiting

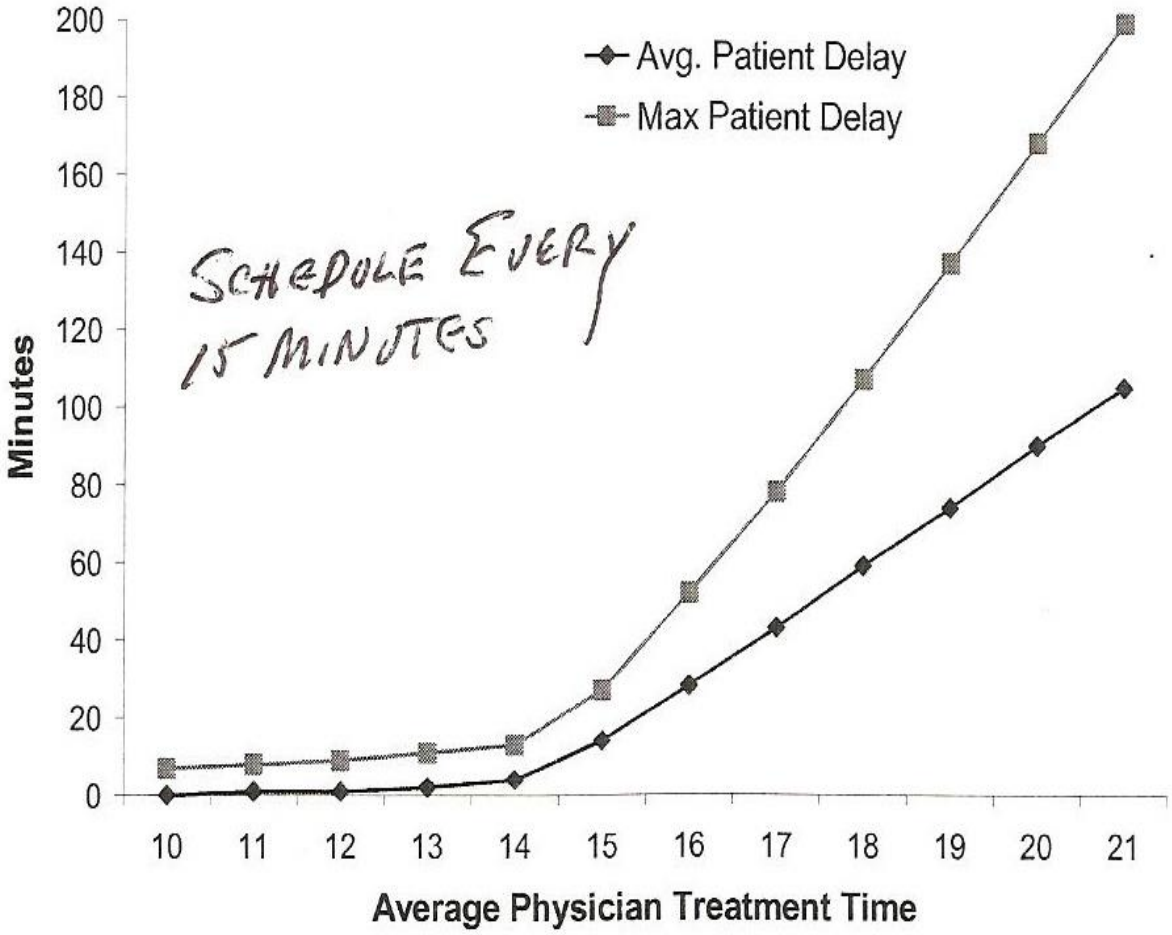
Outpatient Scheduling

- Objective:
  - **To reduce patient waiting while not incurring much physician idle time.**

Background for Outpatients

- Hospitals are shifting towards outpatient treatment.
- None of the clinics surveyed have collected data on physician treatment times.
- The answer so far--build bigger waiting rooms.
- Problem is aggravated when physicians are paid per treatment (not salary).

Patient Delays



Outpatient Scheduling Results

- Orthopedic Surgery – 52.9% reduction in patient waiting from an average of 27.8 minutes to 13.1minutes
- Plastic Surgery – 50% reduction in patient waiting, from 15.0 minutes to 7.5 minutes.
- Vascular Surgery – Experiment not complete, but a 64% reduction from 27.8 average minutes.

Outpatient Operations

- 15 clinics surveyed :
  - **90% use 15 minutes for most treatment times.**
  - **None have any data on actual times. Sample size- 25 outpatient clinics.**
  - **Standard solution to patient waiting is to increase the size of the waiting rooms.**
  - **Little rational to schedule slots.**
  - **Many use purposeful overbooking to compensate for no shows.**

Transporters

Limiting Factor to Service Flows

Transporters

- The lack of transporters affects ancillary loads and possibly length of stay.
- Transporter requests are usually immediate . Waiting line theory indicates that when the sum of transporter times over a period is greater than 50% of the transporter time available, waiting times increase greatly.

Academic Output

DOCTORAL COMMITTEES CHAIRED or CO-CHAIRED in Healthcare:

J. B. Martin, December 1974. *Computerized Monitoring of Physician- Provided Hospital Based Medical Care.* (Co-chairman with Beverly C. Payne)

R. J. Coffey May 1975. *Preadmission Testing of Hospitalized Surgical Patients and It's Relationship to Length of Stay.* (Chairman)

D. B. Magerlein, August 1978. *Maximum Average Occupancy and the Resultant Bed Size of Inpatient Hospital Units.* (Chairman)

P. A. Fuhs, August 1978. *Hospital Discharge Predictions and Their Effect on Admissions Scheduling Systems.* (Co-chairman with James B. Martin)

J. M. Magerlein, November 1978. *Surgical Scheduling and Admissions Control.* (Co-chairman with James B. Martin)

R. A. Hamilton, 1979. *The Relationship Between the Timeliness of Diagnostic Test Results and Length of Stay Patterns.* (Chairman)

P. W. Durance, 1987. *Application of Logical Design to Incomplete Medical Record Processing.* (Co-chairman with James B. Martin)

Y. Abdoo, 1987. *A Model for Nurse Staffing and the Impact of Inter-Rater Reliability of Patient Classification on Nurse Staffing Requirements.* (Chairman)

M-K. Kim, 1988. *Staffing and Scheduling Methodologies for Hospital Ancillary Units.* (Chairman)

J-W. Yoon, 1993. *Continuous Improvement of Process Control Using Regression Analysis of Observational Data.* (Chairman)

M.W.Isken, 1995. *Personnel Scheduling Models for Hospital Ancillary Units.* (Chairman)

Yu-Li Huang, 2008. *An Alternative Outpatient Scheduling System: Improving the Outpatient Experience, (Co Chairman with G.D. Herrin)*

BOOKS:

Cost Control in Hospitals. Health Administration Press, University of Michigan, Ann Arbor, Michigan, August 1976. (Coedited with J. Griffith and F. Munson)

The "ASCS" - Inpatient Admissions Scheduling and Control System. AUPHA Press, Ann Arbor, Michigan, 210 pp. 1983. (Co-authored with P. Walter)

PAPERS:

Problems in Implementing Change in Hospital Settings. *AIIE Transactions*, Vol. 4, No. 4, (December 1972). (Co-authored with Fred C. Munson)

Practical Ways to Contain Hospital Costs. *Harvard Business Review*, (Nov.-Dec. 1973). (Co-authored with John R. Griffith and Fred C. Munson). Also reprinted in *Hospital Financial Management*, January 1975, pp.46-54.

Measurement of Nursing Work Load Using Head Nurses' Perceptions. *Nursing Research*, Vol. 24, No. 5 (Sept.-Oct. 1975). (Co-authored with Vandankumar M. Trivedi)

Dynamics of Hospital Operational Control Systems. *Hospital Administration*, Vol. 21, No. 3 (August 1976). Also part of the book *Cost Control in Hospitals*, published by Health Administration Press, 1976.

New Systems Can Mean Real Savings. Part I, *Hospital Financial Management*, April 1978. (Co-authored with D. Magerlein, F. Butler, G. Mallett, and D. Young) Young)

Parameters Affecting Hospital Occupancy and Implications for Facility Sizing. *Health Services Research*, fall 1978. (Co-authored with D. Magerlein, R. Storer, and J. Martin)

A Procedure for the Design of Process Control Systems for Multi-stage Processes. *SAE Transactions*, February 1979. (Co-authored with F. Plonka and P. Sathe)

The Use of Length of Stay Distributions to Predict Hospital Discharges. *Medical Care*, Vol. 17, No. 4, April 1979. (Co-authored with P. Fuhs and J. Martin)